Appendix - V (A)

DEPARTMENT OF SHIP TECHNOLOGY

M.Tech Degree Programme in

COMPUTER AIDED STRUCTURAL ANALYSIS AND DESIGN

(4 SEMESTER DURATION) WITH EFFECT FROM 2024 UNDER OBE SYSTEM

Program Structure

&

Detailed Syllabus

(with effect from AY 2024-2025 onwards)

COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Ship Technology, CUSAT,
Kochi – 682022
Kerala, India
Phone: 0484 – 2862581
Website: www.cusat.ac.in,
https://shiptech.cusat.ac.in

M. Tech COMPUTER AIDED STRUCTURAL ANALYSIS AND DESIGN (CASAD)

The M. Tech Programme in **Computer Aided Structural Analysis and Design (CASAD)**, offered by the Department of Ship Technology, CUSAT, is a multidisciplinary programme designed to cater to students and professionals with a bachelor's degree in engineering from across Civil, Mechanical, Naval Architecture and Ship Building, and related disciplines. The two-years master's degree programme is an ideal specialization for candidates with technical interest in applying the knowledge and skills to the design, development, construction and operation of structures and systems that operate in a marine environment, thereby broadening their scope for a wide range of career possibilities.

Program Educational Objectives (PEOs)

It is expected that students of M.Tech Computer Aided Structural Analysis and Design will have acquired certain characteristics which will enable them utilize it in their careers. They are:

PEO 1	Utilizing strong technical aptitude and domain knowledge **to develop smart solutions for design and construction** of structures in marine environment and consequently **contribute to the economic progress** and general upliftment of the society.
PEO 2	Applying **research and development skills** augmented with a rich set of communication, teamwork and leadership skills to excel in their profession.
PEO 3	Showing **continuous improvement** in their professional career through life-long learning, appreciating human values and ethics.

Program Outcomes (POs)

After completion of the M.Tech program, post graduates will acquire:

PO 1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report/document.
PO 3	An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Program Specific Outcomes (PSOs)

After completion of the M.Tech program in Computer Aided Structural Analysis and Design, post graduates will acquire:

PSO 1	Ability to independently carry out research /investigation and development work to solve practical problems in the related area of the programme.
PSO 2	Ability to write and present a professional technical report/document.
PSO 3	Ability to perform in the profession with a more matured knowledge and confidence in the area of design of structures operating in marine environment. The training acquired on the related softwares and other computer applications make them to get easily adapted to the more demanding and challenging professional requirements of the current era.

Bloom's Category Assessment for Course Outcome

Level	Description	Sample
Remember	Recognizes students' ability to use rote memorization and recall certain facts	Define, cite, name, recall, list, state, write
Understand	Involves students' ability to read course content, understand and interpret important information and put other's ideas into their own words	Describe, explain, identify, summarise, discuss, outline
Apply	Students take new concepts and apply them to another situation	Demonstrate, illustrate, interpret, solve, use, examine
Analyze	Students have the ability to take new information and break it down into parts to differentiate between them	Compare, contrast, distinguish, examine, identify, categorise, investigate
Evaluate	Involves students' ability to look at someone else's ideas or principles and see the worth of the work and the value of the conclusions	Appraise, defend, support, value, justify, assess, inspect, recommend
Create	Students are able to take various pieces of information and form a whole creating a pattern where one did not previously exist	Assemble, construct, design, develop, create, plan, invent, synthesise.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

Total credits for completing M.Tech in Computer Aided Structural Analysis and Design: 76.

COURSE REQUIREMENTS

The effort to be put in by the student is indicated in the tables below as follows:

L: Lecture (One unit is of one-hour duration)

T: Tutorial (One unit is of one-hour duration)

P: Practical (One unit is of one-hour duration)

PROGRAMME STRUCTURE

SEMESTER 1

Course Code	Course	Core/Elective	Hours/week			Credits
			L	T	P	
24-457-0101	Advanced Engineering Mathematics	Core	4	2	0	4
24-457-0102	Introduction to Naval Architecture and Ocean Engineering	Core	4	2	0	4
24-457-0103	Marine Hydrodynamics	Core	4	2	0	4
	Elective – I*	Elective	3	1	0	3
	Elective – II*	Elective	3	1	0	3
24-457-0110	Seminar	Core	0	0	4	2
			18	**8**	**4**	**20**

SEMESTER 2

Course Code	Course	Core/Elective	Hours/week			Credits
			L	T	P	
24-457-0201	Structural Dynamics	Core	4	2	0	4
24-457-0202	Finite Element Methods Applied to Ocean Engineering	Core	4	2	0	4
24-457-0203	Dynamics of Floating Bodies	Core	4	2	0	4
	Elective – III*	Elective	3	1	0	3
	Elective – IV*	Elective	3	1	0	3
24-457-0210	Computational Laboratory	Core	0	0	4	2
			18	**8**	**4**	**20**

SEMESTER 3

Course Code	Course	Core/Elective	Hours/week			Credits
			L	T	P	
24-457-0301	Project Interim Report and Progress Evaluation†	Core	0	0	26	16
24-457-0302	Industrial Training/ Minor Project	Core	0	0	4	2
						18

† *The M.Tech project spans over two semesters (III and IV) and has a total of 32 credits. The students have to submit an interim report and make a presentation at the end of 3rd semester.*

SEMESTER 4

Course Code	Course	Core/Elective	Hours/week			Credits
			L	T	P	
24-457-0401	Dissertation Evaluation and Viva Voce†	Core	0	0	30	16
24-457-0402	Elective – MOOC **	Elective	-	-	-	2
						18

† *The students have to submit the complete project report/ dissertation, give a presentation and has to appear for a project viva voce examination at the end of 4th semester.*

* *Electives must be selected from the following list for the corresponding semester*

Electives I & II (I Semester)

24-457-0104	Advanced Structural Analysis
24-457-0105	Fracture Mechanics
24-457-0106	Experimental Methods & Measurements in Marine Technology
24-457-0107	Application of Stochastic Process Theory in Ocean Engineering
24-457-0108	Analysis and Design of Coastal Structures
24-457-0109	Marine Renewable Energy

Electives III & IV (II Semester)

24-457-0204	Design of Offshore Structures
24-457-0205	Machine Learning and Optimization
24-457-0206	Analysis of Special Structures
24-457-0207	Vibrations of Continuous Systems
24-457-0208	Fatigue Problems in Ships and Marine Structures
24-457-0209	CFD Applied to Ocean Engineering

*** In addition, one MOOC Course with minimum 2 credits as per Clause 3.1 of 'Regulations for conducting online courses (MOOC) w.e.f 2023 admission onwards (No. Ac.A3/UGC-NEP-Regulations/2023 dated 27.01.2024) has to be undertaken by the students during the programme.*

SEMESTER I

24-457-0101 ADVANCED ENGINEERING MATHEMATICS

Course Description: To equip students with concepts of Fourier Series, Numerical Methods and Solution of Wave equation which have many applications in Engineering. To understand basic theory of functions, complex variable and conformal transformation

24-457-0101	Advanced Engineering Mathematics	Category	L	T	P	Credit	Year of Induction
		C	4	2	-	4	2024

Pre-requisites: Knowledge of periodic functions, Partial Differential Equations, Complex variable, as covered in the undergraduate programme.

Course Objectives: This course introduces the concepts and applications of Fourier series, Solution of Wave Equation. The objective of this course is to familiarize concepts of functions complex variable and conformal transformation, and numerical methods which are essential for any engineer's mathematical toolbox. The topics treated in this course have applications in different branches of engineering.

Course outcome: After the completion of the course the students will be able to

CO 1	Compute Fourier series of a function
CO 2	Establish a fundamental familiarity with partial differential equations and their applications, and solution
CO 3	Identify Analytic functions, Harmonic functions and Conformal Mapping
CO 4	Familiarize with different numerical methods to solve engineering problems
CO 5	Use control volume method to solve different engineering problems

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	**2**		**2**
CO 2	**2**		**3**
CO 3	**2**		**3**
CO 4	**3**		**3**
CO 5	**3**		**3**

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	10
Apply (L3)	7	3	25
Analyze (L4)	8	5	15
Evaluate (L5)			
Create (L6)			

24-457-0101 ADVANCED ENGINEERING MATHEMATICS

Course Content
Module I
Fourier Analysis
Fourier series – Euler Formulae – Functions having arbitrary period – Even and odd functions – Half range expansions- The Fourier integral – Fourier transforms.

Module II
Partial Differential Equations
Basic concepts vibrating string – One dimensional Wave equation – separation of variables – D'Alemberts' solution of the wave equation – one dimensional Heat equation – Heat flow in an infinite bar equation – Application of Laplace Transform to Partial Differential equations.

Module III
Complex Analysis
Complex Analytic functions – Cauchy Riemann equations – Conformal Mapping – Line Integral Cauchy's integral theorem – Cauchy's integral formula – Derivatives of Analytic functions – Taylor's series – Laurent's series – Residues – the residue theorem – Evaluation of real integrals.

Module IV
Numerical Analysis
Numerics in general, Solutions by iteration of equations with one unknown, Numeric Integration and Differentiation, Methods to solve large matrix equations: Gauss elimination, LU Factorization (Doolittle, Cholesky), Iteration (Gauss-Seidel and Jacobi), Linear Systems: Ill-conditioned matrices, Residuals, Norms, Condition number, Curve fitting

Module V
Control Volume Method
System and Control Volume, Problem solving technique, Reynolds transport theorem for arbitrary but fixed control volume, One-dimensional flux term approximation, Conservation of mass, Linear momentum equation , Solution procedure, Discretisation in CFD, The Finite Volume Method in Computational Fluid Dynamics.

PRACTICALS TO BE CONDUCTED:
Assignments on the application of the theories covered here to solve typical engineering problems.

References:

1. Kreyszig . E, Advanced Engineering Mathematics, Wiley, New York (For modules 1, 2, 3, 4)
2. Grewal B.S, Higher Engineering Mathematics, Khanna Publishers, New Delhi. (For sections 4, 5)
3. F. M. White, Fluid Mechanics, For module 5
4. Cengel and Cimbala (Module 5)
5. F. Moukalled, L. Mangani, and M. Darwish, The Finite Volume Method in Computational Fluid Dynamics. Chap 4.

24-457-0102 INTRODUCTION TO NAVAL ARCHITECTURE AND OCEAN ENGINEERING

Course Description: The objective of the course is to provide the learners with a broad overview of Naval Architecture and Ocean Engineering. The learners would be able to have a clear understanding of the basic concept of a ship, underlying principles involved, definition of its geometry and various elements that constitute the ship as a whole, thus laying the foundation for more in depth studies in future. Emphasis is also given to ocean structures and the loads they are subjected to in the ocean environment.

24-457-0102	Introduction to Naval Architecture and Ocean Engineering	Category	L	T	P	Credit	Year of Induction
		C	4	2	-	4	2024

Pre-requisites: Nil

Course Objectives: This course introduces the learner about the fundamentals of naval architecture and ocean engineering.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the basic terms and features associated with the ocean environment
CO 2	Explain physical fundamentals of ship and hull form, such as buoyancy, displacement and form co-efficients, and fundamentals of hydrostatics
CO 3	Understand the various components of ship resistance; application of dimensional analysis and similarity laws in determination of resistance.
CO 4	Estimate resistance of ships and effective power using statistical / methodical series, and estimation of ship propulsive power for various ship types and size, particularly at the preliminary design stages.
CO 5	Understand the types of offshore structures, their classification and functions.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	**2**		**2**
CO 2	**2**		**2**
CO 3	**2**		**2**
CO 4	**3**		**3**
CO 5	**2**		**3**

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	7	2	15
Apply (L3)	8	5	20
Analyze (L4)	5	3	15
Evaluate (L5)			
Create (L6)			

24-457-0102 INTRODUCTION TO NAVAL ARCHITECTURE AND OCEAN ENGINEERING

Course Content
Module I
Introduction to Ocean Environment
Tides: Classification, long term effects, basin oscillations, tsunamis, storm
Currents: Classification, behaviour and other effects of currents
Waves: Classification based on origin, water depth and apparent shape

Module II
Hydrostatics and Stability of Floating Platforms
General definitions and terminology of ships; Ship hull geometry and form coefficients; Basic stability and hydrostatic calculations; Definition of rigid-body motions of floating structures

Module III
Resistance of Ships
Components of ship resistance: frictional resistance, wave-making resistance, eddy-making resistance, air resistance; method of extrapolating model resistance to full-scale resistance.

Module IV
Propulsion of Ships
Types of propellers; propeller geometry; open water characteristics; Ship propulsion (propeller behind the ship) – wake fraction, thrust deduction fraction; Efficiency – open water efficiency, propulsive efficiency, hull efficiency; Propulsion versus Resistance

Module V
Offshore Structures
Offshore platforms – types of offshore platforms, fixed and floating platforms; Subsea systems, offshore pipelines; Buoys and mooring systems; Offshore renewable energy systems

PRACTICALS TO BE CONDUCTED:
Determination of hydrostatic data and floatation stability of typical ships and floating offshore structure using available software packages

References:

1. Randell, R. E., Elements of Ocean Engineering, The Society of Naval Architecture and Marine Engineers (SNAME), 2010
2. Sundar, V., Ocean Wave Mechanics: Applications in Marine Structures, Ane Books Pvt. Ltd., 2015.
3. Molland, A. F., Turnock, S. R., Hudson, D. A., Ship Resistance and Propulsion: Practical Estimation of Ship Propulsive Power, Cambridge University Press, 2011.
4. Reddy, D. V., Swamidas, A. S. J., Essentials of Offshore Structures: Framed and Gravity Platforms, CRC Press, 2014

24-457-0103 MARINE HYDRODYNAMICS

Course Description: This course is designed to lay the foundation for graduate students and researchers engaged in the field of ocean / coastal engineering to understand the basics of wave mechanics, develop the wave equations from the fundamentals of fluid dynamics and the application of these principles to the estimation of wave loading on marine structures.

24-457-0103	Marine Hydrodynamics	Category	L	T	P	Credit	Year of Induction
		C	4	2	-	4	2024

Pre-requisites: Engineering Mathematics and Basic Fluid Dynamics

Course Objectives: To provide the students with the fundamentals of ocean wave mechanics and coastal engineering such that the student may be able to understand the background of current literature in the hydrodynamics of offshore and coastal structures.

Course outcome: The students will be able to develop the necessary theoretical and experimental knowledge necessary to solve problems related to ocean wave interactions with ships, offshore and coastal structures. After the completion of course, the students will be able to

CO 1	Develop an understanding of the fundamental equations of fluid dynamics that governs the phenomenon of wave motion.
CO 2	Distinguish between various ocean phenomena such as waves, currents and tides; their classification and origin with particular focus on the generation, propagation and deformation of waves
CO 3	Learn about the different wave theories that describe wave motion with special emphasis on the linear wave theory or the small amplitude wave theory.
CO 4	Apply appropriate wave theories in estimating the wave loads on simple marine structures theoretically and numerically using computational tools.
CO 5	Learn about the different state-of-the-art hydrodynamic test facilities that facilitate the physical testing of scaled models of structures that operate in ocean environments.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**2**
CO 2	**2**		**2**
CO 3	**2**		**3**
CO 4	**3**		**3**
CO 5	**2**		**2**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	7	3	15
Analyze (L4)	8	5	20
Evaluate (L5)			
Create (L6)			

24-457-0103 MARINE HYDRODYNAMICS

Course Content
Module I
Basics of Fluid Dynamics
Fluid kinematics; Conservation of mass and momentum, Euler equation, Bernoulli's equation; Velocity potential and Stream function; Potential flow, boundary conditions, fixed and moving bodies, Green's theorem and distributions of singularities.

Module II
Linear Wave Theory
Introduction to wave mechanics - Small Amplitude Waves: Classification of water waves; Two dimensional wave equation and wave characteristics; wave classification by relative water depth, water particle kinematics, pressure under progressive wave, wave energy, power and wave group velocity; Standing wave theory.

Module III
Higher Order Wave Theories
Finite Amplitude Waves: Stokes wave theory, Cnoidal theory, Stream Function theory, Solitary theories; Wave deformation: reflections, diffraction and breaking of waves.

Module IV
Wave Forces on Structures
Wave forces, current forces, wave-current interaction, Morison equation, wave loads on offshore structures and pipe lines; Froude-Krylov theory, Diffraction theory; wave slamming and slapping.

Module V
Experimental Hydrodynamics
Modeling of offshore structures: Modeling laws, Non-dimensional numbers in fluid flow problems, wave mechanics scaling; Hydrodynamic Test Facilities – Wave flumes, wave basins, towing tanks, circulating water channels etc.

PRACTICALS TO BE CONDUCTED:
Estimation of wave forces on different ocean structures using any of a commercial/open-source softwares

References:

1. Newman, J.N., Marine Hydrodynamics, MIT Press, Cambridge, Massachusetts, 1997.
2. Sarpakaya,T. and Isaacson, M. Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, 1981,NY
3. Tucker M.J., Piyy EG: Waves in Ocean Engineering, Elsevier, 2001.
4. Dean, R. G. and Dalrymple, R. A. Water Wave Mechanics for Engineers and Scientists, Allied Publishers Ltd., 2001.
5. Mani, J. S. Coastal Hydrodynamics, PHI Learning Private Ltd., New Delhi, 2012.
6. Sorensen, R. M. Basic Coastal Engineering, Springer.
7. Sundar, V. Ocean Wave Mechanics: Applications in Marine Structures, Wiley, 2015.
8. Ananthakrishnan, P. Finite Difference Method for Nonlinear Wave Hydrodynamics, Wiley - Blackwell, 2017.

24-457-0104 ADVANCED STRUCTURAL ANALYSIS

Course Description: The aim of the course is to strengthen the knowledge of the students in advanced topics in theory of elasticity, matrix methods of structural analysis, and theory of plates and shells, which finds applications in the design of aircraft structures and pressure vessels. It also covers the various energy approaches which is essential for the interpretation of finite element analysis results. The course also includes the principles of structural stability for beam columns, the important theories of beams and the application of various approximate numerical techniques to solve the beam problems.

24-457-0104	Advanced Structural Analysis	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Background in graduate level courses such as mechanics of solids and structural analysis.

Course Objectives: The course focuses on strengthening the knowledge of the students in the analysis of structures employing different types of accurate and approximate methods of structural analysis.

Course outcome: After the completion of the course the students will be able to

CO 1	Recall the procedure to define the stress, strain and displacement acting at a point along any particular plane and relationship among these parameters to solve a particular structural problem.
CO 2	To familiarize with the theory of plasticity and to analyze structures using approximate energy methods, which can bypass the task for solving complex differential equations.
CO 3	Evaluate the stability criteria of structures using different methods such as matrix methods and energy approaches.
CO 4	Apply the theories of beams to solve for stress, strain and displacement fields in a structural problem; and the theory of plates and shells for understanding its applications to design of pressure vessels.
CO 5	To familiarize with numerical methods and their role in solving complex problems and for predictions in various fields of structural analysis and design.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	2		**2**
CO 2	2		**2**
CO 3	2		**3**
CO 4	3		**3**
CO 5	**3**		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	5	2	15
Analyze (L4)	10	6	20
Evaluate (L5)			
Create (L6)			

24-457-0104 ADVANCED STRUCTURAL ANALYSIS

Course Content

Module I
Theory of Linear Elasticity:
Stress, Principal Stress and strain. Concepts and definition of strain – displacement relation.
Equilibrium, Generalized Hooke's Law, Constitutive and compatibility equations.
Thin walled pressure vessels, Thick walled cylinders. Plane stress, plane strain and axisymmetric conditions.
Torsion – Torsion of circular elastic bars, Torsion of solid bars, Torsion of tubular members

Module II
Theory of plasticity: Elements of plasticity, Rate dependent and rate independent plasticity, yield criteria; Plastic stress-strain relationships.
Variational principles- Governing Equations, Functionals. Functional Derivatives, Extrema of the Functionals. Variational Principles. Euler-Lagrange Equations.
Classical Energy methods- Strain energy, Castigliano's theorems, Virtual Work, Potential Energy. Minimum Potential Energy Principle

Module III
Matrix methods of structural analysis
Indeterminancy, Determinate and indeterminate structures, Principle of superposition- Stiffness and flexibility matrices, Application of matrix method to beam column problems. Principles of Structural Stability: Methods of stability analysis – Column buckling – Euler equation, Frame instability – Energy approach. Buckling of beam columns .

Module IV
Theory of Beams – Analysis of Bernoulli and Timoshenko Beams, Beam on elastic foundation.

Theory of Plates and Shells:
Plate theory and background, Small deflection plate bending theory, Rectangular plates, Circular plates. Buckling of plates, Vibration of plates. Thin shells – fundamentals, Load-carrying mechanism of shells.

Module V
Approximate Numerical Methods:
Application of Finite Difference Method, Rayleigh Ritz method, Euler's method, Crank Nicolson method.

PRACTICALS TO BE CONDUCTED:
Numerical strength analyses of different offshore structural components using any of a commercial/open-source softwares

References:

1. Timoshenko, S.P. and Goodier. Theory of Elasticity, McGraw Hill, New Delhi, 2010.
2. Sadd, M.H. Elasticity: Theory, Applications, and Numerics, Academic Press Inc, 2014.
3. Chandrasekharaiah, D.S. and Debnath, L. Continuum Mechanics, Prism Books Pvt. Ltd., Bangalore, 1994.
4. Timoshenko, S.P. and Krieger, S.W. Theory of Plates and Shells, McGraw Hill International Ed, 1959
5. Shames, I. H. and Cozzarellie, F. A. Elastic and Inelastic Stress Analysis, Prentice Hall New Jersey 1992.
6. Tauchert T. Energy Principles in Mechanics. McGraw Hill, New Delhi 1994.
7. Gere and Weaver. Matrix Method of Structural analysis, McGraw Hill, New Delhi 1986.
8. Timoshenko, S.P. and Gere. Theory of Elastic Stability, McGraw Hill, 2017
9. Timoshenko, S. P. and Krieger, S. W. Theory of Plates and Shells, Mc-Graw Hill International, London, 1959
10. Zingoni. A. Shell Structures in Civil and Mechanical Engineering, Thomas Telford, 1997
11. Szilard, R. Theory and Analysis of Plates, Prentice Hall-INC, New Jersey, 1974

24-457-0105 FRACTURE MECHANICS

Course Description: The course deals with fundamental concepts of fracture development studies and the various methods to analyze the fracture propagation within the varying loading conditions.

24-457-0105	**Fracture Mechanics**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		E	3	1	-	3	2024

Pre-requisites: Knowledge in basic under-graduate courses such as Mechanics of Solids and Engineering Mechanics

Course Objectives: The objective of the course is to provide the basic knowledge to investigate the fracture initiation and propagation mechanism and crack arrest in different types of engineering materials.

Course outcome: After the completion of the course the students will be able to

CO 1	Recall the different types of fractures observed in brittle and ductile materials.
CO 2	Understand the basic concepts of linear elastic fracture mechanics and non linear elastic fracture mechanics
CO 3	Study the experimental methods to determine different parameters used in fracture mechanics such as stress intensity factor and J integral
CO 4	Analyze the fatigue failure in structural elements incorporating the fundamental concepts of fracture mechanics
CO 5	Evaluate the structural criteria to predict the different types of cracks and propose suitable measures to reduce the crack initiation mechanism in the structural elements

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**2**
CO 2	2		**2**
CO 3	2		**3**
CO 4	**2**		**3**
CO 5	3		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	7	3	20
Analyze (L4)	8	5	15
Evaluate (L5)			
Create (L6)			

24-457-0105 FRACTURE MECHANICS

Course Content

Module I
Basics of Elasticity and Plasticity
Types of Failures, Constitutive Models, Brittle and Ductile fracture, Fracture Mechanics and its applications.

Module II
Linear Elastic Fracture Mechanics
Inglis Concepts, Energy Release Rate, Griffith Contribution, Crack Resistance, R curve, Critical energy Release Rate, Stress Intensity Factor, Westergards –Approach, Edge cracks and Embedded cracks

Module III
Elastic Plastic Fracture Mechanics
Crack Tip stress for plane stress and place strain condition, Effective crack length, J Integral, Crack Tip Opening displacement, Mixed mode crack initiation and growth .

Module IV
Experimental Fracture Mechanics
Experimental determination of stress intensity factor, energy release rate, J integral. Crack detection through Non Destructive Testing : Liquid penetration, Ultrasound testing, Radiographic Imaging and Magnetic Particle Inspection.

Module V
Fatigue and Computational Fracture Mechanics
Fatigue failure, Direct and Indirect methods to determine fatigue fracture parameters.

PRACTICALS TO BE CONDUCTED:
Determination of fatigue strength of offshore structural components using any of a commercial/open-source softwares

References:

1. Kumar, P. Elements of fracture mechanics. McGraw-Hill Education LLC, 2009
2. Broek D., Elementary Engineering Fracture Mechanics, Martinus Nijhoff Publishers., 2009
3. Anderson, T. L. Fracture Mechanics, Fundamentals & its applications, CRC press, 2017
4. Suresh, S. Fatigue of materials, Cambridge University Press, 1998
5. Gdoutos, E.E. Fracture mechanics: an introduction (Vol. 263). Springer Nature, 2020.
6. Ukadgaonker, V.G. Theory of elasticity and fracture mechanics. PHI Learning Pvt. Ltd, 2015.
7. Janssen, M., Zuidema, J. and Wanhill, R. Fracture mechanics: fundamentals and applications. CRC Press, 2004.

24-457-0106 EXPERIMENTAL METHODS & MEASUREMENTS IN MARINE TECHNOLOGY

The course will provide an introduction to measurement methods relevant to experimental fluid dynamics in the domain of ocean structures. The course will provide an overview of analysis techniques commonly used in physical model studies.

24-457-0106	Experimental Methods & Measurements in Marine Technology	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Background in fluid dynamics and wave hydrodynamics

Course Objectives: The goal of this course is to familiarize the student with common measurement and analysis techniques for experimental fluid dynamics and physical model studies in wave flumes, towing tanks and other test facilities.

Course outcome: After the completion of the course the students will be able to

CO 1	Describe the governing factors of scaling and reproducibility
CO 2	Understand the various experimental facilities and instrumentation for ocean engineering applications
CO 3	Identify the purpose of physical model testing and the importance of setting up a model and testing the same
CO 4	Explain the concept of errors and uncertainty and its possible causes and methods of reducing it
CO 5	Describe the comparison between a model test case and numerical calculations

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**2**
CO 2	2		**1**
CO 3	**2**		**2**
CO 4	**2**		**3**
CO 5	**3**		**2**

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	7	3	15
Apply (L3)	8	3	20
Analyze (L4)	5	4	15
Evaluate (L5)			
Create (L6)			

24-457-0106 EXPERIMENTAL METHODS & MEASUREMENTS IN MARINE TECHNOLOGY

Course Content

Module I
Introduction to experimental methods in hydrodynamics – General Modelling Laws: Geometric similarity, Kinematic similarity, Dynamic similarity, Scaling ratios

Module II
Experimental Facilities and Instrumentation – Wave flume, Towing tank;
Generation of Ocean Environment; Instrumentation - Strain and displacement measurements. Pressure Transducers, Wave Measurements, Data Acquisition, Calibration

Module III
Physical Modelling and Testing
Purpose of physical model testing - Model set-up and operation - Measurement and observation techniques- Analysis procedures

Module IV
Error Analysis
Uncertainty analysis – Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty calculation – Uses of uncertainty analysis

Module V
Model test vs Numerical calculations
Generation of a computer code and validation using model test results – Identification of error sources for model tests and the numerical model

References:

1. Blevins, R.D. Applied fluid dynamics handbook. New York, 1984.
2. Coleman, H.W. and Steele, W.G. Experimentation, validation, and uncertainty analysis for engineers. John Wiley & Sons, 2018.
3. Faltinsen, O. Sea loads on ships and offshore structures (Vol. 1). Cambridge university press, 1993.

24-457-0107 APPLICATION OF STOCHASTIC PROCESS THEORY IN OCEAN ENGINEERING

This course provides an in-depth study of stochastic concepts as applied to the description and analysis of ocean waves. Students will explore the mathematical foundations of random seas, spectral analysis of wave characteristics, statistical properties of wave amplitudes and heights, estimation of extreme wave events, directional characteristics of random seas, and the analysis of special wave phenomena such as breaking waves and freak waves

24-457-0107	Application of Stochastic Process Theory in Ocean Engineering	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Basic terms in statistics, wave hydrodynamics

Course Objectives: Understand the stochastic nature of ocean waves and their mathematical representations. Analyze wave characteristics using spectral analysis techniques. Study the probability distributions of wave amplitudes, heights, and periods. Estimate extreme wave events and sea states from data. Evaluate directional characteristics and energy spreading of random seas. Examine special wave events including breaking waves, group waves, and freak waves.

Course outcome: After the completion of the course the students will be able to

CO 1	Apply stochastic concepts to model and analyze ocean wave characteristics.
CO 2	Perform spectral analysis to understand wave energy distributions.
CO 3	Estimate probability distributions of wave amplitudes, heights, and periods.
CO 4	Evaluate and predict extreme wave events and sea states.
CO 5	Analyze directional characteristics and energy spreading of random seas.
CO 6	Assess the statistical properties of special wave phenomena such as breaking waves and freak waves.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	2		2
CO 2	3		3
CO 3	3		2
CO 4	2		3
CO 5	3		3
CO 6	3		2

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	10	6	20
Analyze (L4)	5	2	15
Evaluate (L5)			
Create (L6)			

24-457-0107 APPLICATION OF STOCHASTIC PROCESS THEORY IN OCEAN ENGINEERING

Course Content

Module I

Introduction to Stochastic Ocean Waves: Description of random seas and stochastic concepts applied to ocean waves. Ocean waves as a Gaussian random process. Mathematical presentation of random waves and stochastic prediction of wave characteristics.

Spectral analysis of random waves-: Fundamentals of stochastic processes, auto-correlation function, and spectral density function, Wave-number spectrum and wave velocity/acceleration spectra, Characteristics of wave spectra and various spectral formulations- Pierson-Moskowitz spectrum, two-parameter spectrum, and six-parameter spectrum

Module II

Wave Amplitude and Height Analysis : Probability distribution of amplitudes with narrow-band Spectrum, Derivation of probability density function, Wave envelope process, Joint distribution of two wave amplitudes, Probability distribution of peak-to-trough excursions (wave height), Significant wave height, Probability distribution of half-cycle excursions , Long-term wave height distribution. Statistical analysis of amplitude and height from wave records- Maximum likelihood estimation

Wave height and associated period : Joint probability distribution of wave height and period, Joint probability distribution of positive maxima and time interval , Probability distribution of wave period Joint probability distribution of wave height and direction of wave energy travel

Module III

Sea severity: Statistical presentation of sea severity- Probability distribution of significant wave height, Joint probability distribution of significant wave height and period, Time series analysis of sea state data

Hurricane-associated seas- Sea severity measured during hurricanes, Wave spectra and wave height in hurricane-generated seas.

Estimation of extreme wave height and sea state: Basic concept of extreme values, Probable and design extreme wave height, Estimation of extreme wave height and sea state from data, Extreme wave height in a non-stationary sea state .

Module IV
Directional characteristics of random seas: Principle of evaluation of directional wave spectra- Wave probe array, Floating buoys, Pressure and current meters. Analysis of directional energy spreading function, Estimation of directional energy spreading from data- Maximum likelihood method, Maximum entropy method, Application of a Bayesian method.

Module V
Special wave events: Breaking waves- Wave breaking criteria, Wave breaking criteria, Probability of occurrence of wave breaking, Energy loss resulting from wave breaking.
Group waves - Statistical properties through the envelope process approach, Statistical properties through the Markov chain approach. Freak waves

PRACTICALS TO BE CONDUCTED:
Ocean wave data analyses and determination of wave energy spectrum and statistical parameters.

References:

1. Ochi, M.K. OCEAN WAVES-The Stochastic Approach, CAMBRIDGE UNIVERSITY PRESS 1998
2. Hudspeth, R.T., Waves and Wave Forces On Coastal and Ocean Structures, World
3. Scientific Publishing Co. Pte. Ltd., Singapore, 2006
4. Lé Méhauté, B., An Introduction to Hydrodynamics and Water Waves, Springer Verlag, Berlin, 1976
5. Sundar, V., Ocean Wave Mechanics: Application on Marine Structures, John Wiley & Sons Ltd., Chichester, 2016
6. McCormick, M.E., Ocean Engineering Wave Mechanics, John Wiley & Sons Inc., New York, 1973

24-457-0108 ANALYSIS AND DESIGN OF COASTAL STRUCTURES

The aim of the course is to delve into the area of design of coastal protection structures and marine structures by introducing the design principles of breakwaters, shore protection structures and wave energy dissipating structures. This course also gives an introduction to port planning and design of port terminals.

.

24-457-0108	Analysis and Design of Coastal Structures	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Fluid Dynamics and Wave Mechanics

Course Objectives: The aim of this course is to expose the students to the dynamics of wave-structure interaction, and to select suitable structures for coastal protection, and to design the coastal structure by computing the various wave loads on the structure.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the complexities of wave action on the structure and its response
CO 2	Understand the coastal structures like, breakwaters, wharves, jetties, piers, and seawalls
CO 3	Exposure to the dynamics of wave-structure interaction
CO 4	Understand role of shipping in the economic development of the nation and identification of the needs at a port
CO 5	Design of port terminals for specialized cargo with regard to number of berths and storage areas using planning charts

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	2		**3**
CO 2	**2**		**3**
CO 3	**3**		**3**
CO 4	3		**3**
CO 5	3		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	5	3	15
Analyze (L4)	10	5	20
Evaluate (L5)			
Create (L6)			

24-457-0108 ANALYSIS AND DESIGN OF COASTAL STRUCTURES

Course Content

Module I
Wind-Generated Waves - Waves at Sea - Wave Record Analysis- Wave Spectral Characteristics & Models

Module II
Coastal Structures - Hydrodynamic Forces in Unsteady Flow - Floating Breakwaters - Rubble Mound Structures - Armor Unit Stability – Groynes, Port and harbour breakwaters, Sea walls, Wharves, Piers, Bulkheads - Quay walls

Module III
Wave–Structure Interaction - Wave reflection, wave runup, wave overtopping, and transmission - Selection of Design Waves - Wave overtopping and crest elevation - Calculation of overtopping rates

Module IV
Introduction to Port Planning - Ship Motions, Channels, and Harbor Areas - Traffic and Hinterland studies, Site investigation - Principles and Design of berths

Module V
Design of Port Terminals – Conventional general cargo terminals, Container terminals, Oil & liquid gas terminals, Dry bulk cargo terminals, Fishing terminals, Dry bulk terminals, Ferry and passenger terminals, Marinas, Ports and terminals for inland water transport.

PRACTICALS TO BE CONDUCTED:
Basic design of some typical coastal protection system and determination of wave transformation.

References:

1. Young, C.K. Design of Coastal Structures and Sea Defenses, World Scientific, 2014.
2. Mohammad, L.A. A Practical Design Guide for Coastal Rubble Mound Structures, World Scientific, 2023.
3. Dean, R.G and Dalrymple, R.A. Water Wave Mechanics for Engineers and Scientists, World Scientific, 1991
4. Svendsen, I.A. Introduction to nearshore hydrodynamics (Vol. 24). World Scientific Publishing Company, 2005.

5. Kamphuis, J.W. Introduction to Coastal Engineering and Management, World Scientific, 2020
6. Sundar, V and Sannasiraj, S.A. Coastal Engineering - Theory and Practice, World Scientific, 2019
7. Per Bruun. Port Engineering - Harbor Planning, Breakwaters, and Marine Terminals, Gulf Publishing Co., 1989
8. Allsop, W., Cuomo, G. and Polidoro, A. Piers, Jetties and Related Structures Exposed to Waves. ICE Publishing, 2004.
9. Velsink, H. Ports and terminals: planning and functional design, TU Delft, Department Hydraulic Engineering, 1993.

24-457-0109 MARINE RENEWABLE ENERGY

This course provides an in-depth exploration of renewable energy sources in marine environments. Students will study the principles, technologies, and applications of solar, wind, wave, tidal energy, as well as energy storage and management systems.

24-457-0109	**Marine Renewable Energy**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		E	3	1	-	3	2024

Pre-requisites: Nil

Course Objectives: Compare and contrast solar, wind, wave, and tidal energy technologies. Analyze the environmental impacts and sustainability of marine renewable energy. Design integrated systems incorporating multiple marine renewable sources.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the fundamentals of marine renewable energy sources and the environmental impacts and sustainability of marine renewable energy.
CO 2	Analyse the design principles behind marine solar arrays, including considerations for floating platforms, mooring systems, and dynamic marine conditions
CO 3	Analyse wind energy systems, including their operational principles, efficiency characteristics, aerodynamic design considerations, and the integration of offshore wind technologies.
CO 4	Understand the fundamentals of wave energy conversion and analyse the design principles behind wave energy harvesting and optimization
CO 5	Analyse and design tidal energy systems, including understanding the physics of tidal power generation, hydrodynamic characteristics of tidal devices and Ocean Thermal Energy Conversion systems
CO 6	Evaluate energy storage and management solutions for marine applications.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	2		2
CO 2	3		3
CO 3	3		3
CO 4	3		3
CO 5	3		3
CO 6	3		2

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	5	2	15
Apply (L3)	5	2	15
Analyze (L4)	10	6	20
Evaluate (L5)			
Create (L6)			

24-457-0109 MARINE RENEWABLE ENERGY

Course Content

Module I

Renewable Energy: Environmental Aspects of Energy- Greenhouse Effect-Global Warming- Economy-Energy and Sustainable development-Kyoto Protocol , Conventional and Non-Conventional Energy Resources

Solar Energy : Introduction,–General description and characteristics –Flat plate collectors –Heat transfer processes Solar concentrators Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Solar panel technologies for marine applications, Floating solar arrays-Effect of shadowing Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system, offshore solar installations

Module II

Wind Energy–Introduction–Wind Turbine ,Wind power curve-Betz's Law-Power from a wind turbine, Wind energy conversion system(WECS) – Fixed–speed drive scheme Variable speed drive scheme.-system integration, Design of wind environment-aerodynamic characteristics of horizontal and vertical axis wind turbines- Offshore wind turbine technologies, Wind resource assessment in marine environments , Floating wind platforms- Design of foundation and support structures

Module III

Wave energy: Wave energy fundamentals ,energy within water wave, description and operation of various systems proposed and in use for onshore and offshore application- Design of wave environment-Maximum power absorption from ocean waves, wave energy converters : capture and conversion mechanisms, Hydrodynamic characteristics of wave energy converters- Fluid structure interaction-Case studies: Wave energy projects worldwide .

Module IV

Tidal energy: Basic physics and power generation- Current stream devices- Barrage systems-Hydrodynamic characteristics of tidal devices-Wave and current effects-Fluid-structure interaction.

OTEC: Ocean thermal energy sources-Principle of ocean thermal energy conversion-Power plant development-Closed and open cycles- Advantages and operating difficulties.

Module V

Energy storage- Importance of energy storage in marine, Battery technologies for marine applications, Emerging Energy Storage Technologies, Flywheel energy storage systems, Supercapacitors and ultracapacitors ,Thermal energy storage for marine renewables- Transmission and distribution issues and solutions- Risk assessment techniques and reliability analysis techniques for offshore energy systems.

PRACTICALS TO BE CONDUCTED:

Data collection of different renewal energy projects across globe. Detailed study and presentation of any one of the systems or platforms covering its design and operational aspects

References:

1. Andrew I.L. Payne, Mark A. Shields Marine Renewable Energy Technology and Environmental Interactions, Springer, 2014
2. Manwell J F, McGowan, J G and Rogers, A L, Wind Energy explained: Theory, Design and Application. Wiley, 2010.
3. Cruz, J, Ocean Wave Energy: Current Status and Future Perspectives. Springer, 2007.
4. Falnes, J, Ocean Waves and Oscillating Systems, Cambridge University Press, 2002
5. Walker, J and Jenkins, N. Wind Energy Technology. Wiley UNESCO Energy Engineering Series, 1997.
6. Baker, A.C. Tidal Power, Peter Peregrinus Ltd. 1981.
7. Díaz-González, F., Sumper, A. and Gomis-Bellmunt, O. Energy storage in power systems. John Wiley & Sons, 2016.

24-457-0110 SEMINAR

Course Description: This course focuses on the ability of students to identify relevant information based on current published papers, journals and books, and to demonstrate the ability to explain the topic selected for discussion. The topic can also be on the environment, design, operation, repair and maintenance of major offshore projects.

24-457-0110	Seminar	Category	L	T	P	Credit	Year of Induction
		C	0	0	4	2	2024

Prerequisite: Basic knowledge of structural engineering and hydrodynamics applied to ocean engineering

Course outcome: At the end of the course, the student will be able to

CO 1	Identify a topic of relevance by conducting a thorough and systematic review of literature
CO 2	Identify and prioritize the research gaps in the present topic of seminar
CO 3	Demonstrate a sound technical knowledge of their selected seminar topic and the ability to explain the topic
CO 4	Prepare a technical report in the current topic undertaken for seminar

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	2		**1**
CO 2	**2**		**2**
CO 3	**3**	**3**	**3**
CO 4	**2**	**3**	**3**

Mark distribution ***

Total Marks	CIE
50	50

Assessment Pattern:

Bloom's Taxonomy Level	Quality and content of the work (30 marks)	Viva Voce (20 marks)
Remember (L1)		
Understand (L2)	**5**	**4**
Apply (L3)	**15**	**10**
Analyze (L4)	**10**	**6**
Evaluate (L5)		
Create (L6)		

SEMESTER II

24-457-0201 STRUCTURAL DYNAMICS

Course Description: To provide necessary knowledge to establish the equations of motion and determination of structural response of a structure subjected to dynamic loads and to model and calculate dynamic response for different systems

24-457-0201	**Structural Dynamics**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		C	4	2	-	4	2024

Pre-requisites: Knowledge of Engineering Mechanics, Mechanics of Solids, Structural Analysis.

Course Objectives: The objective of this course is to provide a fundamental understanding of the dynamics of structures and to inculcate problem solving ability for the dynamic response of different mechanical systems. It also introduces students to different mathematical and numerical methods in structural dynamics and the dynamic responses of offshore and ocean structures subjected to dynamic loads.

Course outcome: After the completion of the course the students will be able to

CO 1	Identify and define key concepts related to structural dynamics, such as natural frequencies, mode shapes, damping and vibration characteristics of structures, by introducing SDOF systems.
CO 2	Apply fundamental theory of structural dynamics and EoM to field problems
CO 3	Formulate the equation of motion for dynamic analysis of different MDOF systems and solve engineering problems in the context of structural dynamics with special emphasis on Eigen value problems and the use of numerical methods for solution of MDOF systems
CO 4	Introduce concepts of stochastic structural dynamics and stochastic response of offshore structures.
CO 5	Identify structures involving fluid-structure soil interaction

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	2		**2**
CO 2	**2**		**2**
CO 3	**3**		**3**
CO 4	3		**3**
CO 5	3		**3**

Mark distribution***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**5**	**2**	**15**
Apply (L3)	**5**	**2**	**15**
Analyze (L4)	**10**	**6**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0201 STRUCTURAL DYNAMICS

Course Content
Module I
Free and forced vibration of SDOF Systems, time and frequency domain approaches, vibration isolation

Module II
Formulation of equations of motion, Hamilton's Principle, Lagrange's equation of motion, continuous and discrete systems.

Module III
Study of MDOF System, Equation of Motion, Concept of Normal Mode, Matrix methods for dynamic analysis Eigen solution and mode superposition, Approximate methods - Dunkerley, Rayleigh-Ritz, Stodola and Holtzer methods.

Module IV
Statistical descriptions of offshore waves – Wave height distributions – Wave energy spectra
Statistical responses for SDOF linear structures – MDOF Linear structures
Frequency domain response of linear systems, time domain response

Module V
Behaviour of piles supporting offshore structures - Spectral fatigue analysis for offshore structures; Response Amplitude Operators (RAOs); Wave-induced Load Components -

PRACTICALS TO BE CONDUCTED:
Determination of different frequencies and mode shapes of typical offshore structure vibration using any of a commercial/open-source softwares

References:

1. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, New Delhi., 1975
2. Rao, S.S. Mechanical Vibrations. 2001.
3. Den Hartog, J.P. Mechanical Vibration, McGraw Hill New York. 2007
4. Inman, D.J. Engineering Vibration, Pearson, 2014
5. Thomson, W. Theory of vibration with applications, CRC Press, 2018.
6. Inman, D.J., Vibration with control, John Wiley & Sons, 2017
7. Clough, R.W and Penzien, J. Dynamics of Structures, McGraw Hill, New York, 1975

8. Paz, M. Structural Dynamics – Theory and Computation, Van Nostrand Reinhold Ltd., New York, 1987
9. Warburton, G.B. The Dynamical Behaviour of Structures, Pergamon Press., 1976
10. Roy, R., Gaig Jr. Structural Dynamics – An Introduction to Computer Methods, John Wiley and Sons, Inc , 1981
11. Patel, M.H. Dynamics of offshore structures, Butterworths, 1989.
12. Hurty, W.C. and Moshe, F.R. Dynamics of Structures, Prentice Hall of India, 2007.
13. Chopra, A.K. Dynamics of Structures, Theory and applications in earthquake engineering, PHI, 2002.
14. Wilson, J.F. Dynamics of Offshore Structures, John Wiley & Sons, 2003.

24-457-0202 FINITE ELEMENT METHODS APPLIED TO OCEAN ENGINEERING

Course Description: The course will make the students proficient in advanced structural analysis methods using finite element approach. The course describes the scope of employing the finite element analysis approach to solve complex engineering problems such as stress analysis, heat transfer analysis, soil structure interaction and fluid structure interaction problems.

24-457-0202	**Finite Element Methods Applied to Ocean Engineering**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		C	4	2	-	4	2024

Pre-requisites: Knowledge in basic under-graduate courses such as Mechanics of Solids and Analysis of Structures

Course Objectives: The objective of the course is to make the students able to solve complex engineering real life problems using the wide range scope of numerical method using finite element analysis in a very efficient manner with the help of most advanced FEA software packages.

Course outcome: After the completion of the course the students will be able to

CO 1	Recall the general methodology of finite element analysis
CO 2	Understand the basic concepts of formulating the shape functions and property element stiffness matrices for structural elements s in 1D,2D and 3D domain
CO 3	Apply the FEM for the analyzing complex structures
CO 4	Analyze the problems using FEM Software Packages.
CO 5	Evaluate the FEA criteria to analyze marine structures.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**3**
CO 2	**2**		**3**
CO 3	**3**		**3**
CO 4	3		**3**
CO 5	3		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	3	2	15
Apply (L3)	7	3	15
Analyze (L4)	10	5	20
Evaluate (L5)			
Create (L6)			

24-457-0202 FINITE ELEMENT METHODS APPLIED TO OCEAN ENGINEERING

Course Content

Module I
Introduction to FEM, definitions, General Procedure of Finite Element Analysis – Finite Element method Starting from Governing differential Equations: Weighted Residual Method, Collocation method, Weak form of weighted residual Method, Shape functions.

Module II
Convergence Criteria for finite element solutions, h convergence and P convergence, derivation of property matrix for bar, truss, beam, plane stress, plane strain, axisymmetric elements.

Module III
Computer implementation of FEM, Numerical methods for various property matrix calculation using MATLAB platform.

Module IV
Finite Element method analysis using commercial package : 1D,2D and 3D problems , Case studies, Validation with analytical/experimental methods.

Module V
FEM application to marine structures : Boat and Ship Hulls, Offshore Jacket Platforms.

PRACTICALS TO BE CONDUCTED:
Strength analyses of simple structures using any of a commercial/open-source FE software packages

References:

1. Zienkiewicz, O.C. Finite Element Method, Fourth edition, McGraw Hill, 2006
2. Cook, R.D. Concepts and Application of FE Analysis – John Wiley &Sons., 2011
3. Krishnamoorthy, C.S. Finite Element Analysis TMH New Delhi., 2010
4. Rajasekaran, S. Finite Element Analysis, Wheeler publishing Company
5. Bathe, K.J. Finite Element Procedure in Engineering Analysis, Prentice Hall, 2009
6. Reddy, J.N. An Introduction to the Finite Element Method, Tata McGraw Hill, 2005.

7. Thomas J.R.Hughes – The Finite Element Method – Linear static and Dynamic Finite Element Analysis, Dover publications, New York, 2007.
8. Desai and Abel. Introduction to FEM, CBS Publications, 2005.
9. Seshu, P. Textbook of Finite element Analysis, Prentice Hall India ,2003
10. Kwon, Young W., and Hyochoong Bang. The finite element method using MATLAB. 2nd Ed., CRC press, Third Indian Reprint 2015
11. Rockey, K.C., Evans, H. R., Griffiths, D.W, and Nethercot, D.A. The Finite Element Method, Crosby Lock wood Staples, 1975

24-457-0203 DYNAMICS OF FLOATING BODIES

Course Description: This is an advanced course in marine hydrodynamics designed to provide the basic knowledge of characterizing the real ocean environment that is random in nature – random waves. Having understood the linearity of periodic wave forms, statistical tools are used to decode the parameters of random waves where both time domain and frequency domain analysis of 2D and 3D waves are discussed. The responses of the structures in regular and irregular waves are also covered in this course.

24-457-0203	**Dynamics of Floating Bodies**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		C	4	2	-	4	2024

Pre-requisites: Engineering Mathematics, Fluid Mechanics and Basic Probability Theory

Course Objectives:
To introduce the concepts of characterizing irregular waves in time domain and frequency domain.
To provide basic knowledge on analyzing the response of structures in regular and irregular waves.
To develop skills required to predict the seakeeping behaviour of ships and offshore structures.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the characterization of irregular waves in time and frequency domain;
CO 2	Learn the concepts of wave spectrum representation, encounter frequency;
CO 3	Understand concepts of added mass, damping and hydrodynamic reaction forces on floating structures; Uncoupled motions of a floating structure in regular waves
CO 4	Evaluate forces and motion responses in a regular seaway; derivation and solution of motion response equations in regular waves; determination of natural frequencies in heave, roll and pitch
CO 5	Evaluate responses in an irregular seaway; analyze responses of floating structures using software tools.

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**3**
CO 2	**2**		**3**
CO 3	**3**		**3**
CO 4	3		**3**
CO 5	**3**		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	3	2	12
Apply (L3)	7	2	20
Analyze (L4)	10	6	18
Evaluate (L5)			
Create (L6)			

24-457-0203 DYNAMICS OF FLOATING BODIES

Course Content
Module I
Wave in Open Sea
Origin and propagation, classification of sea state; Sea as a stationary random process – elements of probability theory and random process, short-term model with constant amplitude components, generation theory of ocean waves, characteristics of point and directional spectra, wave slope spectrum, encounter frequency spectrum, ocean wave data analysis, idealized spectral families.

Module II
Forces and Response in Regular Waves
Motions in waves; Uncoupled heave, pitch and roll motions; formulation of diffraction and radiation problem for potential flow; motions in regular waves, strip theory; panel method to compute hydrodynamic forces and coefficients.

Module III
Forces and Response in a Seaway
Linear random theory, long crested sea with and without forward speed, short-crested sea case, statistics of maximum long-term performance predictions, local and relative motions, added resistance, wave loads.

Module IV
Hydrodynamic Exciting Forces
Excitation forces due to steady flow, linearized wave forces inviscid fluid, influence of viscosity on wave-excitation forces, wave drift forces.

Module V
A minor project on determination of forces on Ocean Structures. [Computational and programming software packages may be utilized for implementing the project].

References:

1. Heoft, J.P. Advanced dynamics of Marine Structure, Wiley-Interscience, New York., 1982.
2. Beck R.F., Cummins. W.E. Dalzell J.F., Mandel and Webster, W.C. "Motions in waves"
3. Principles of Naval Architecture, Second Revision (Ed.) Lewis E.V. SNAME, Jersey City, New Jersey., 1988.

4. Price, W.G. and Bishop, R.E.D. Probabilistic Theory of Ship Dynamics, Chapman and Hall, London, 1974.
5. Janssen, P. The interaction of ocean waves and wind, 2004
6. Sahoo, T. Mathematical techniques for waves interaction with flexible structures, IIT Kharagpur research monograph series, 2012.
7. Ochi, M.K. Ocean waves: The stochastic approach, 2005.
8. Bhattacharya, R. Dynamics of Marine Vehicles, A Wiley-Interscience Publication.
9. Chakrabarti, S. K. Hydrodynamics of Offshore Structures, Computational Mechanics Publication, 1987.
10. Chandrasekaran, S. Dynamic Analysis and Design of Offshore Structures, Springer, 2015.
11. Dubey, R. Dynamics of Offshore Structures, Scitus Academics, 2016.
12. Naess, Arvind and Moan, Torgeir. Stochastic Dynamics of Marine Structures, Cambridge University Press

24-457-0204 DESIGN OF OFFSHORE STRUCTURES

Course Description: This course is designed to introduce the graduate students to the fundamentals of all types of offshore structures (fixed and floating) and in specific focus on applying the principles to the design, construction and installation of fixed offshore platforms.

24-457-0204	**Design of Offshore Structures**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		E	3	1	-	3	2024

Pre-requisites: Structural Analysis, Sea loads, Probability concepts, Statistical methods

Course Objectives: Provide students with an understanding of the design and construction of offshore platforms, specifically the theory and principles of such designs and the use of current, engineering methods in the design of fixed offshore platforms.

Course outcome: Provide the students with the knowledge and skills to carry out basic tasks involved in structural analysis and design of offshore structures.

CO 1	Understand the types of offshore structures, their classification and functions
CO 2	Discuss the different design philosophies adopted in offshore structure design; discuss the different types of loads acting on the offshore structures and the methods to estimate the different loads and load combinations for design of offshore structures.
CO 3	Apply the structural analysis principles for the design of steel tubular members for axial compression, biaxial bending, hydrostatic implosion and their combinations
CO 4	Apply structural engineering principles to design of tubular joints; fatigue analysis of the framed structure subjected to cyclic loadings
CO 5	Understand the concepts in marine geotechnics and the design of foundations for fixed offshore platforms with specific emphasis on the design of piles, spud cans and anchors

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**2**
CO 2	2		**2**
CO 3	**3**		**3**
CO 4	**3**		**3**
CO 5	**3**		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	3	2	10
Apply (L3)	7	2	20
Analyze (L4)	10	6	20
Evaluate (L5)			
Create (L6)			

24-457-0204 DESIGN OF OFFSHORE STRUCTURES

Course Content

Module I

Types of offshore structures; functional and structural requirements of an offshore platform; Components of offshore structures: fixed, bottom supported and floating platforms.

Module II

Planning of Offshore structures; Design criteria and procedures – WSD and LRF, Design loads – dead loads and live loads, load combinations; Determination of Environmental loads - wave, wind and current loads.

Module III

Structural Design of tension and compression members, stiffened plates and built up beams. Design of cylindrical members - axial compression, biaxial bending and combined load; Hydrostatic implosion.

Module IV

Design of Tubular joints – Punching shear method and calculation of allowable joint capacity; Stress Concentration Factor, Fatigue analysis and Design – SN curve method.

Module V

Pile Design – Pile Capacity for axial bearing loads and axial pull out loads; Soil reaction for axially loaded piles and laterally loaded piles; structural design of piles. Design of spud cans and anchors.

PRACTICALS TO BE CONDUCTED:

Develop the basic design of any one of the offshore structures using API codes

References:

1. API RP 2A WSD 1993
2. API RP 2A LRFD 2000
3. Dawson, T.H. Offshore Structural Engineering, PHI, USA, 1986
4. Teng H. Applied Offshore structural Engineering, PHI, 1996
5. Rajagopalan, K. Offshore Jacket structures, Oxford and IBH, 1988
6. Chakrabarti, S.K. Hand book of Offshore Engineering (Vol I & II), Elsevier, 2005.
7. Chakrabarti, S.K. Hydrodynamics of Offshore structures, Southampton computational mechanics, 1989.

8. Gerwick, B.C. Construction of Mari-ne and Offshore structures, CRC Press, London, 1999
9. Graff, W.J. Introduction to Offshore structures – Design Fabrication, Installation, Gulf Publishing, London, 1981.
10. Reddy, D. V. and Swamidas, A. S. J. Essentials of Offshore Structures: Framed and Gravity Platforms, CRC Press, Taylor & Francis Group, 2013.
11. Chandrasekaran, S. Advanced Marine Structures, CRC Press, Taylor & Francis Group, 2016.

24-457-0205 MACHINE LEARNING AND OPTIMIZATION

Course Description: Goal of this course is to expose the students to the fundamental concepts of Machine Learning and Optimization techniques for engineering problems

24-457-0205	Machine Learning and Optimization	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Knowledge of Matrix Algebra, Analytical Geometry, Linear Programming, Basics of Computers and Computer Programming

Course Objectives: This course introduces the concept of solving engineering optimization problems by developing linear and non-linear mathematical models involving objectives and constraints in terms of the relevant design variables. The course includes introduction of machine learning, Artificial neural network and Support vector machine techniques.

Course outcome: After the completion of the course the students will be able to

CO 1	Develop a knowledge of Engineering optimization using non-linear programming and unconstrained optimization techniques
CO 2	Apply classical optimization techniques and algorithms to solve constrained optimization problems and to introduce stochastic search techniques
CO 3	Develop and Evaluate performance of various machine learning algorithms on various data sets of a domain
CO 4	Learn the ideological basics of artificial neural networks and perform the training of neural networks using various learning rules
CO 5	Explore the capabilities of Support Vector Machine to solve classification and regression tasks

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	3		2
CO 2	3		3
CO 3	3		3
CO 4	3		3
CO 5	2		3

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**5**	**2**	**15**
Apply (L3)	**5**	**3**	**15**
Analyze (L4)	**10**	**5**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0205 MACHINE LEARNING AND OPTIMIZATION

Course Content

Module I
Engineering Optimisation: Introduction, Engineering applications of Optimization, Review of single and multivariable optimization methods with and without constraints, Non-linear one-dimensional minimization problems, Examples.
Unconstrained Optimization: Techniques: Introduction, Direct search method - Random, Univariate and Pattern search methods, Descent methods - Steepest Decent methods- Quasi-Newton's and Variable metric method, Examples.

Module II
Constrained Optimization: Techniques: Introduction, Direct methods - Cutting plane method and Method of Feasible directions, Indirect methods - convex programming problems, Penalty function method, Examples and problems. Search Techniques: Introduction, Genetic Algorithm, Simulated Annealing, Artificial Neural Networks, Examples.

Module III
Introduction to Machine Learning: Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Basics of parameter estimation.
Regression - Linear regression with single and multiple variables, gradient descent algorithm and matrix method, Overfitting and Underfitting, . Linear Methods for Classification- Logistic regression, Naive Bayes, Decision tree

Module IV
Artificial Neural Networks (ANN) Artificial Neural Networks: Perceptron , ANN Architectures, learning strategies, supervised, and unsupervised learning, reinforcement learning, Hebb Network, Training Algorithm, Perceptron Model, Single Layer Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm. Multilayer feed forward network, Activation functions ,Backpropagation algorithm.

Module V
Support Vector Machines (SVM) - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification, Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF).

PRACTICALS TO BE CONDUCTED:
Study and present machine learning applications in various activities related to offshore engineering problems

References:

1. Aoki, M. Introduction to Optimization Techniques, The Macmillian, Co., New York. 1991
2. Rao S.S. Engineering Optimization Theory and Practice, John Wiley & Sons 2009
3. Arora, R.K. Optimization, Algorithms and Applications, CRC Press, 2015
4. Pannerselvam, R. Operations Research, PHI Learning Private Ltd, 2017
5. Deisenroth, M.P, Faisal,A.A., Ong, C.S. Mathematics for Machine Learning, Cambridge University Press, 2020.
6. Mitchell, T.M. Machine Learning - McGraw Hill Education, International Edition
7. Murphy, K.P. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
8. Goodfellow, I., Bengio, Y. and Courville, A. Deep Learning MIT Press Ltd, Illustrated edition
9. Haykin, S. Neural Networks Comprehensive Foundation, 2nd ed., Pearson Education, 2005.
10. Freeman, J.A., Skapura, D.M. Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991
11. Steinwart, I. and Christmann, A. Support vector machines, Springer Publishing Company, 2008
12. Shigeo Abe. Support Vector Machines for Pattern Classification, Springer Publishing Company,2005
13. Silberschatz, A., Korth, H.F. and Sudarshan, S. Database System Concepts, McGraw Hill Publications, 2013
14. Elmasri and Navathe, “Fundamentals of Database Systems”, 7/e Addison – Wesley, 2017.

24-457-0206 ANALYSIS OF SPECIAL STRUCTURES

Course Description: Goal of this course is to expose the students to the fundamental concepts of theory of plates and shells applied to design of engineering structures.

24-457-0206	Analysis of Special Structures	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Structural analysis

Course Objectives: This course is intended to achieve fundamental understanding of the classical theories of elastic plates and shells, present analytical and numerical solution techniques, and their application to real engineering problems

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the basic plate theory and its applications as components in structures
CO 2	Understand the structural action of plate components in structures
CO 3	Apply the theory of plates to buckling and thin walled structures
CO 4	Understand the fundamentals shell theories
CO 5	Analyze plate and shell structures analytically and by numerical methods

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	**2**		2
CO 2	**2**		**3**
CO 3	3		3
CO 4	**2**		3
CO 5	**3**		3

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**3**	**2**	**10**
Apply (L3)	**7**	**2**	**20**
Analyze (L4)	**10**	**6**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0206 ANALYSIS OF SPECIAL STRUCTURES

Course Content
Module I
Classical Plate Theory: Basic Assumptions, Formulations, Boundary Conditions, Governing Equations

Module II
Pure Bending, Plates with Various Loadings and Boundary Conditions, Navier's Solution for Rectangular Plates, Levy's Solution

Module III
Buckling of plates. Analysis of stiffened plates , Buckling of Stiffened plates.
Thin walled Structures – Torsion of Thin walled Structures , Theory of restrained torsion.

Module IV
Introduction to Elastic Shells
Differential Geometry, Theory of Surfaces, Coordinates Systems, Cylindrical shell roof, pressure vessels

Module V
Thin Elastic Shells
Basic Assumptions, Strain-Displacement Relations, Love Shell Theory, Axisymmetric Shells And Cylindrical Shells, Membrane Theory of Shells

PRACTICALS TO BE CONDUCTED:
Numerical analysis of stiffened plates using any of a commercial/open-source softwares

References:

1. Donnel, L.H. Beam, Plates and Shells ,McGraw Hill, NewYork
2. Timoshenko SP and Kruger .W. Theory of plates and Shells, McGraw Hill
3. Szilard, R.,"Theory and Analysis of Plates: Classical and Numerical Methods", Prentice Hall, New York
4. Srinath L.S – Advanced Mechanics of Solids TMH, New Delhi
5. Gould, P. L., Analysis of Shells and Plates, Springer-Verlag

24-457-0207 VIBRATIONS OF CONTINUOUS SYSTEMS

Course Description: The aim of this course is to set up initial-boundary value problems for the structural members: bars, beams, membrane, plates and shells, and to find analytical and approximate solutions, for various loading and boundary conditions.

24-457-0207	Vibrations of Continuous Systems	Category	L	T	P	Credit	Year of Induction
		E	3	1	-	3	2024

Pre-requisites: Structural analysis, Structural Dynamics

Course Objectives: This course intended to achieve fundamental understanding of the vibrations of continuous systems, specifically, vibrations in bars, beams, thin and thick beams, membranes, thin plates, and shells.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand analytical methods for analyzing axial vibrations of rods
CO 2	Analyze continuous vibratory beams
CO 3	Examine the vibrational behavior of circular and rectangular membranes
CO 4	Understand the fundamentals beam theories and the vibrations in thin plates
CO 5	Analyze vibratory behaviour of shell structures

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	**2**		2
CO 2	3		3
CO 3	3		3
CO 4	**2**		3
CO 5	**3**		3

Mark distribution ***

Total Marks	CIE	ESE	ESE Duration
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**3**	**2**	**10**
Apply (L3)	**7**	**3**	**20**
Analyze (L4)	**10**	**5**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0207 VIBRATIONS OF CONTINUOUS SYSTEMS

Course Content
Module I
Axial vibrations of rods - Free vibration, Forced Vibration

Module II
Transverse vibrations of beams - Free vibration, Forced Vibration

Module III
Vibrations of membranes - Circular membranes, Rectangular membranes

Module IV
Vibrations of thin plates - Circular plates, Rectangular plates

Module V
Vibrations of cylindrical shells - Infinite cylindrical shells, Finite cylindrical shells

References:

1. Rao, S. S. Vibration of Continuous Systems, John Wiley & Sons, 2007.
2. Hegedorn, P. and DasGupta, A. Vibration and Waves in Continuous Mechanical Systems, Wiley, 2007.
3. Graff, K. F. Wave Motion in Elastic Solids, Dover Publications, 1991
4. Shabana, A.A. and Ling, F.F. Vibration of discrete and continuous systems (Vol. 2). New York: Springer, 1997.

24-457-0208 FATIGUE PROBLEMS IN SHIPS AND MARINE STRUCTURES

Course Description: Goal of this course is to provide a background for the most common recommendations in design standards for fatigue assessment of dynamically loaded marine structures.

24-457-0208	**Fatigue Problems in Ships and Marine Structures**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		E	3	1	-	3	2024

Pre-requisites: Structural analysis, Fracture mechanics

Course Objectives: This course is intended to achieve relevant education in fatigue assessment as the basis for design of reliable and optimal structures.

Course outcome: After the completion of the course the students will be able to

CO 1	Understand fatigue and the importance of study of fatigue loading on marine structures
CO 2	Understand the fundamentals of fatigue loading and fracture
CO 3	Differentiate the different types of fatigue loading
CO 4	Analyze the mechanisms of corrosion fatigue, and growth of corrosion fatigue cracks.
CO 5	Analyze various cases of fatigue loading on marine structures, with reference to pipelines, risers, storage tanks, jacket and floating structures

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		2
CO 2	**2**		3
CO 3	3		3
CO 4	3		3
CO 5	**3**		3

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**3**	**2**	**15**
Apply (L3)	**7**	**3**	**15**
Analyze (L4)	**10**	**5**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0208 FATIGUE PROBLEMS IN SHIPS AND MARINE STRUCTURES

Course Content

Module I
Introduction to fatigue : ships and marine structures
Overview of fatigue, Importance of study of fatigue loading, low cycle and high cycle fatigue, Source of fatigue stresses.

Module II
Fundamentals of fatigue loading and fatigue fracture:
Fatigue on ferrous and non ferrous materials, SN curve, fatigue fracture - cause and effects

Module III
Types of Fatigue loading
Wave induced fatigue, machine induced vibrations on ships and offshore platforms, fatigue life and structural integrity

Module IV
Environmental interactions: corrosion fatigue and creep fatigue
Mechanisms of corrosion fatigue, Nucleation and growth of corrosion fatigue cracks, Fatigue crack growth and low and high temperature

Module V
Fatigue analysis of ships and offshore platforms:
Stresses at Welds in Pipelines, Risers, and Storage Tanks, fatigue analysis of jacket and floating structures, Inservice inspection of fatigue cracks, Case studies of fatigue loading

PRACTICALS TO BE CONDUCTED:
Fatigue strength analysis of a typical component of offshore structures using any of a commercial/open-source softwares

References:

1. Lotsberg, I. Fatigue Design of Marine Structures, Cambridge University Press, 2016
2. Tada, H., Paris, P. C. and. Irwin, G. R. The Stress Analysis of Cracks Handbook. Del Research Corporation, Hellertown, P A, 1973.
3. Ehlers, S. and Braun, M. Fatigue and Fracture Mechanics of Marine Structures, MDPI, 2023
4. Petinov, S.V. Fatigue analysis of ship structures. Backbone Publishing Company, 2003.

24-457-0209 CFD APPLIED TO OCEAN ENGINEERING

Course Description: This course introduces the application of Computational Fluid Dynamics applied to Ocean Engineering and numerically solving the Navier Stokes equation for incompressible flows

24-457-0209	**CFD Applied to Ocean Engineering**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Induction**
		E	3	1	-	3	2024

Pre-requisites: Fluid mechanics, Hydrodynamics

Course Objectives: This course is intended to introduce finite difference methods as a means of solving different types of differential equations in fluid dynamics and numerically solving the NSE and RANSE

Course outcome: After the completion of the course the students will be able to

CO 1	Understand the governing equations and boundary conditions for fluid flow problems
CO 2	Understand turbulence and its numerical modelling
CO 3	Understand and apply finite volume method for steady flow cases
CO 4	Understand and apply finite volume method and its various implementation schemes for unsteady flow
CO 5	Understand various meshing strategies, techniques to present post processed results; and error analysis

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**2**		**2**
CO 2	**2**		**3**
CO 3	**2**		**3**
CO 4	**3**		**3**
CO 5	**3**		**3**

Mark distribution ***

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	50	50	3 hours

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		End Semester Exam (50 marks)
	(Internal Tests: Test 1 (20 marks)/ Test 2 (20 marks)	Assignment (10 marks)	
Remember (L1)			
Understand (L2)	**4**	**2**	**12**
Apply (L3)	**6**	**3**	**18**
Analyze (L4)	**10**	**5**	**20**
Evaluate (L5)			
Create (L6)			

24-457-0209 CFD APPLIED TO OCEAN ENGINEERING

Course Content

Module I
Conservation laws of fluid motion and boundary conditions. Reynolds-Averaged Navier-Stokes Equations.

Module II
Turbulence and its modeling. Mixing length model. k-ϵ model. k-ω SST model. Large eddy simulation.

Module III
The finite volume method. Solution algorithms for pressure-velocity coupling in steady flows – SIMPLE, SIMPLER, PISO. Solution algorithms for pressure-velocity coupling in steady flows.

Module IV
The finite volume method for unsteady flows. Explicit scheme, Crank-Nicolson scheme, Implicit scheme. Transient SIMPLE and PISO algorithms.

Module V
Meshing. Implementation of boundary conditions. Errors and uncertainty

PRACTICALS TO BE CONDUCTED:
Estimation of wave loads on ships/ free floating semi-submersible and their motions using any of a commercial/open-source softwares

References:

1. Versteeg, H. K., and Malalasekera, W. An introduction to computational fluid dynamics: The Finite Volume Method (2nd ed.). Prentice Hall, 2007.
2. White, F. M. Fluid mechanics (8th ed.). McGraw-Hill education, 2016.
3. John, D., and Anderson, J. R. Computational fluid dynamics: the basics with applications. Mechanical engineering series, 261-262, 1995.
4. Renilson, M. Submarine Hydrodynamics. Second Edition. Springer, 2018.
5. Voller, V. R. Basic control volume finite element methods for fluids and solids. IISc Press, 2009.

24-457-0210 COMPUTATIONAL LABORATORY

Course Description: This lab course gives an introduction to basic computational methods, with focus on geometric modelling, computer implementation of various numerical techniques applied to ocean structures

<table>
<tr><td rowspan="2">24-457-0210</td><td rowspan="2">Computational Laboratory</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>Credit</td><td>Year of Induction</td></tr>
<tr><td>C</td><td>0</td><td>0</td><td>4</td><td>2</td><td>2024</td></tr>
</table>

Prerequisite: Structural analysis, fluid mechanics, and numerical methods in engineering

Course outcome: After the completion of the course the students will be able to

CO 1	Apply the concepts of geometric and surface modeling of basic geometries and complex structures using fundamentals of curve fitting and modelling
CO 2	Apply in practice the logical steps in computer implementation of numerical methods in engineering.
CO 3	Develop different types of mesh and perform 2D analysis of various external flow problems
CO 4	Acquire hands on experience in executing and implementing the numerical methods as computer codes
	Develop the ability to work in teams.
CO 5	Prepare laboratory reports that clearly communicate information in a logical and scientific manner.

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	3		2
CO 2	3		3
CO 3	3	**2**	3
CO 4	3		3
CO 5	2	**3**	3

Mark distribution ***

Total Marks	CIE
50	50

Assessment Pattern:

Bloom's Taxonomy Level	Continuous Assessment (50 marks)		
	Lab assessment (20 marks)	Final Examination (20 marks)	Viva (10 marks)
Remember (L1)			
Understand (L2)	2	2	2
Apply (L3)	5	5	2
Analyze (L4)	8	8	4
Evaluate (L5)	5	5	2
Create (L6)			

24-457-0210 COMPUTATIONAL LABORATORY

List of Experiments

1. Modelling: Geometric modelling and surface modelling of ships and offshore structures
2. Mesh generation in CFD, for the study of external flows around a body, and Structural FEA, for structural analysis.
3. Best practices for meshing - Mesh Geometry, mesh density, convergence study.
4. Study of basic external flows around a body - Boundary layer over a flat plate - Flow past a sphere. – Introduction to fluid forces acting on bodies in external fluid flows. - Concepts of lift and drag forces
5. FE Analysis of Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load.
6. Stress analysis of stiffened rectangular plates and panels.
7. Practical Introduction to Frequency-Domain Analysis – Conversion of time domain signal to its frequency domain equivalent and vice versa.
8. Dynamic Analysis to find a) Fixed – fixed beam for natural frequency determination b) Bar subjected to forcing function c) Fixed – fixed beam subjected to forcing function.

References:

1. Cotton, H. Advanced Electrical Technology, Reem Publications, 2011.
2. Golding, E.W. Electrical Measurements and Measuring Instruments, 5th ed. Reem Publications,2011.
3. Clayton, A.E and Hancock, N.N, Performance and Design of DC Machines, ELBS,1971
4. Nagarath, I. J and Kothari, D. P. Electric Machines, Tata McGraw Hill, 1999.
5. Say, M.G. The Performance and Design of AC Machines, CBS, 1983.

****

***** MARK DISTRIBUTION & ASSESSMENT PATTERN**

1. **For all theory courses:**

Continuous Assessment:

Internal Tests – Test 1 (20 marks), Test 2 (20 marks), Assignment (10 marks)

End Semester Examination:

The paper carries a total of 50 marks. The exam will be of 3-hour duration. There will be questions from all the modules.

The distribution of questions is according to Bloom's Taxonomy Levels (L2 to L5; ref. Page 3)

2. **For Seminar**

Internal Continuous Evaluation only - 50 marks

3. **For Laboratory**

Internal Continuous Evaluation only- 50 marks

(Lab assessment - 20 marks; Final Examination - 20 marks; Viva-voce - 10 marks)

Semester III

24-457-0301 PROJECT INTERIM REPORT AND PROGRESS EVALUATION

Course Description: The objective of this course is to open up students to the real-life engineering solutions, to identify the gaps and instill an inclination towards research. Students are required to read research papers, understand new topics, develop research prototypes in the domain of ocean structures

24-457-0301	Project Interim Report and Progress Evaluation	Category	L	T	P	Credit	Year of Induction
		C	-	-	26	16	2024

Course outcome: After the completion of the course the students will be able to

CO 1	Support independent learning, research and innovative attitude.
CO 2	Select and utilize information from literature sources upholding ethics.
CO 3	Habituate to critical thinking and use problem solving skills.
CO 4	Organize the work and present results in written as well as communicate them effectively to the stakeholders

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	3	**3**	**3**
CO 2	**2**	**2**	**2**
CO 3	**3**	**3**	**3**
CO 4	**3**	**3**	**3**

Mark distribution

Total Marks	**CIE**
100	100

Assessment Pattern:

Bloom's Taxonomy Level	Presentation of the work (40 marks)	Quality and content of the work (40 marks)	Viva Voce (20 marks)
Remember (L1)			
Understand (L2)	**5**	**5**	**2**
Apply (L3)	**5**	**5**	**2**
Analyze (L4)	**15**	**15**	**10**
Evaluate (L5)	**10**	**10**	**4**
Create (L6)	**5**	**5**	**2**

Course content:

Semester III (Project Interim Report and Progress Evaluation) will have mid semester presentation and end semester presentation.

Mid semester presentation is a Research Proposal Presentation which includes identification of the problem based on the literature with special focus on the latest literature available.

End semester presentation should essentially reflect the identification of topic for the project work and the methodology adopted, involving scientific research, collection and analysis of data, determining solutions and must bring out the individual contribution of the student. An interim report on the above aspects and the work done needs to be submitted and the information should be presented before the evaluation committee.

The progress evaluation of the project shall be done by a team of minimum 3 internal examiners including the project guide and the coordinator. The evaluation shall be based on (i) Presentation of the work, (ii) Quality and content of the work carried out and (iii) Viva Voce. The allocation of marks for the project progress evaluation will be out of 100, which consists of the continuous assessment done by the project guide, and the marks awarded by the internal/external examiners and the project co-ordinator, during the evaluation session.

24-457-0302 INDUSTRIAL TRAINING/ MINOR PROJECT

Course Description: The objective of this course is to impart students the application of theoretical knowledge on practical work related to Ocean structures. Work experience is cooperatively planned by the department and industry/company/organization to fulfill the student's objectives.

24-457-0302	Industrial Training/ Minor Project	Category	L	T	P	Credit	Year of Induction
		C	0	0	4	2	2024

Course outcome: After the completion of the course the students will be able to

CO 1	Apply classroom and laboratory concepts and principles in an industry/ organization related to structural engineering/ hydrodynamics.
CO 2	Establish goals by working with supervision to define work objectives for the industrial training experience.
CO 3	Demonstrate time and project management skills by completing the work objectives within the specified time limits.
CO 4	Demonstrate the ability to effectively present ideas and solutions in the context of written, oral, and electronic media.
CO 5	Demonstrate the ability to work as a team member to successfully complete the assigned work objectives in an assigned company work group.
CO 6	Demonstrate and promote proper work ethics.

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3
CO 1	**2**		**3**
CO 2	**2**	**2**	3
CO 3	**2**	**3**	3
CO 4	**2**		3
CO 5	2	**3**	3
CO 6	2	**3**	3

Mark distribution

Total Marks	CIE
50	50

Assessment Pattern:

Bloom's Taxonomy Level	Internship Workbook (20 marks)	Viva voce (20 marks)	Final Report (10 marks)
Remember (L1)			
Understand (L2)	**2**	**2**	**2**
Apply (L3)	**3**	**3**	**2**
Analyze (L4)	**10**	**10**	**4**
Evaluate (L5)	**5**	**5**	**2**
Create (L6)			

Course content:

Assessment Pattern & Assessment Criteria:

Each student will work with their supervisor from the concerned company/organization to jointly develop projects / activities, which will be accomplished during the internship program. The projects/activities should be unique and must be related to the knowledge and/or skills attained during their degree program in Computer Aided Structural Analysis and Design of Ocean Structures and related areas. The projects must be approved by the instructor/supervisor from the concerned industry/company and/or lead faculty member from the Department of Ship Technology, CUSAT.

Each student is required to maintain a comprehensive daily work log detailing their activities. This log should be generated using a word processing software such as Word or a database program like Excel. Emphasis should be placed on maintaining a professional and well-organized format. It is essential to record major activities undertaken on each day of work, ensuring that adequate detail is provided to sufficiently describe the performed tasks.

The assessment will remain exclusively internal. The allocation of marks for the training program adheres to a scale of 50, categorized as follows: 20 marks attributed to the internship workbook, endorsed by the supervisor; 20 marks assigned to the viva voce examination; and 10 marks designated for the final report submitted during the viva voce session.

Semester IV

24-457-0401 DISSERTATION EVALUATION AND VIVA VOCE

Course Description: The objective of this course is to open up students to the real-life engineering solutions, to identify the gaps and instill an inclination towards research. Students would have acquired the ability to read research papers, understand new topics, develop research prototypes, and analyze and design real life problems in the domain of ocean structures.

24-457-0401	Dissertation Evaluation and Viva Voce	Category	L	T	P	Credit	Year of Induction
		C	0	0	30	16	2024

Course outcome: After the completion of the course the students will be able to

CO 1	Support independent learning, research and innovative attitude.
CO 2	Select and utilize information from literature sources upholding ethics.
CO 3	Habituate to critical thinking and use problem solving skills.
CO 4	Organize the work and present results in written as well as communicate them effectively to the stakeholders

Mapping of course outcomes with PO: Level - Low (1), medium (2) and high (3)

	PO1	**PO2**	**PO3**
CO 1	**3**	**3**	**3**
CO 2	**2**	**2**	**2**
CO 3	**3**	**3**	**3**
CO 4	**3**	**3**	**3**

Mark distribution

Total Marks	**CIE**
100	100

Assessment Pattern:

Bloom's Taxonomy Level	Presentation of the work (40 marks)	Quality and content of the work (40 marks)	Viva Voce (20 marks)
Remember (L1)			
Understand (L2)	**5**	**5**	**2**
Apply (L3)	**5**	**5**	**2**
Analyze (L4)	**15**	**15**	**10**
Evaluate (L5)	**10**	**10**	**4**
Create (L6)	**5**	**5**	**2**

Course content:

Semester IV (Dissertation Evaluation and Viva Voce) will be an extension of the work identified in Semester III.

Continuous assessment of the work is done by adopting the methodology decided in the Research Proposal presentation. The project work is evaluated for the numerical analysis/ experiment conducted, collection and analysis of data, etc.

A project presentation seminar is conducted at the end of academic term, which will be monitored and approved by the departmental committee, after which the student must submit the detailed report of the project work carried out. An external examiner is called for the viva-voce to assess the student's work.

The students shall aim to prepare a technical paper for a peer reviewed journal /international/national conferences organized by reputed institutions/organizations/professional bodies.

The final evaluation of the project shall be done by a panel of examiners consisting of Project guide, Course coordinator and an External examiner. The evaluation shall be based on (i) Presentation of the work, (ii) Quality and content of the dissertation and (iii) Viva Voce. The allocation of marks for the final project dissertation will be out of 100, which consists of the continuous assessment done by the project guide, and the marks awarded by the internal/external examiners and the project co-ordinator, during the viva voce session.

24-457-0402 ELECTIVE – MOOC

In addition, one MOOC Course with minimum 2 credits as per Clause 3.1 of 'Regulations for conducting online courses (MOOC) w.e.f 2023 admission onwards (No. Ac.A3/UGC-NEP-Regulations/2023 dated 27.01.2024) has to be undertaken by the students during the programme (including amendments, if any).

The MOOC courses selected should be hosted in SWAYAM platform/ offered by CUSAT/ platforms in online mode by other post graduate institution in INDIA or abroad, be taken by students after approval from Department Council (DC).

Mark distribution

Total Marks	ESE
100	100