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 the disciplines of Civil, Mechanical, Naval Architecture and Ship Building. 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 brodening their scope for a wide range of career possibilities.

PROGRAM OUTCOMES (POs)

After completion of the M.Tech program in **Computer Aided Structural Analysis and Design**, graduates will be able to

Program Outcomes (POs)	Description
PO 1	Acquire the capability to identify, formulate and solve engineering problems related, but not limited, to ocean engineering and evaluate solutions for practical engineering problems; demonstrate the ability to design and evaluate systems and components of offshore and onshore structures.
PO 2	Acquire the capability of independently carrying out research /investigation and development work related to ocean engineering by developing and applying research skills such as literature survey and review, use of appropriate techniques and tools, design and conduct experiments, analyse and interpret data and synthesize information to provide valid conclusions.
PO 3	Successfully engage themselves in engineering practice with an ability to assimilate undergraduate fundamentals as well as advanced knowledge to evaluate complex engineering solutions to practical problems by acquiring knowledge of advanced topics within the domain of structures in the ocean environment.
PO 4	Demonstrate the ability to use modern engineering tools and numerical modelling techniques for the analysis and design of structures
PO 5	Write and present a substantial technical report/document in the field of analysis and design of offshore and onshore structures.
PO 6	Capability of understanding the impact of increasing development of structures or platforms operating in ocean environment on a global, economic, environmental and societal context.

COURSE CONTENT

Semester I

Course Code	Course	C/E	Hrs/Week				Credits
			L	T	P	Total	
20-457-0101	Advanced Engineering Mathematics	C	4	2	0	6	4
20-457-0102	Computer Aided Design in offshore Engineering	C	4	2	0	6	4
20-457-0103	Advanced Structural Analysis	C	4	2	0	6	4
	Elective I	E	4	2	0	6	4
	Elective II	E	4	2	0	6	4
Total		**-**	**20**	**10**	**0**	**30**	**20**

Electives

20-457-0104 Marine Hydrodynamics
20-457-0105 Fracture Mechanics
20-457-0106 Application of Stochastic Process Theory in Ocean Engineering
20-457-0107 Stability of Structures
20-457-0108 Marine Corrosion and Prevention
20-457-0109 Marine Pollution and its effect
20-457-0110 Pollution Control Technique
20-457-0111 Advanced Joining Techniques

Semester II

Course Code	Course	C/E	Hrs/Week				Credits
			L	T	P	Total	
20-457-0201	Dynamics of Structures	C	4	2	0	6	4
20-457-0202	Finite Element Methods Applied to Offshore Engineering	C	4	2	0	6	4
	Elective III	C	4	2	0	6	4
	Elective IV	E	4	2	0	6	4
	Elective V	E	4	2	0	6	4
Total		**-**	**20**	**10**	**0**	**30**	**20**

Electives

20-457-0203 Ocean Waves and Effects 20-457-0204 Analysis of Special Structures 20-457-0205 Design of Offshore Structures 20-457-0206 Fatigue Problems in Ships and Marine Structures 20-457-0207 Computer Application in Ship Manoeuvring

Semester III

Course Code	Course	C/E	Credits
20-457-0301	Project Progress Evaluation	C	18

Semester IV

Course Code	Course	C/E	Credits
20-457-0401	Project Dissertation Evaluation and Viva Voce	C	18

SEMESTER I

20-457-0101 ADVANCED ENGINEERING MATHEMATICS

Course Description: (4 credit hours)

- To equip students with concepts of Fourier Series, Numerical Methods and Solution of Heat equation and Wave equation which has many applications in Engineering
- To understand basic theory of functions, complex variable and conformal transformation

20-457-0101	Advanced Engine Mathematics	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

Pre-requisites: Knowledge of periodic functions, Partial Differential Equations, Complex variable

Course objectives:

This course introduces the concepts and applications of Fourier series, Solution of Wave Equation and Heat Equation. The objective of this course is to familiarize concepts of functions complex variable and conformal transformation, Numerical Method and Calculus of variation which are invaluable for any engineer's mathematical tool box. The topics treated in this course have applications in all 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	To find solution of Wave equation and Heat equation
CO 3	Identify Analytic function, Harmonic function and Conformal Mapping
CO 4	To familiarize with numerical methods using finite difference operators
CO 5	To solve boundary value problems using Lagrange equation and Hamiltonian principle

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	1			
CO 2	1	1	1			
CO 3	2	2		2		
CO 4	2	1	1	2		
CO 5	2	1	2	1		

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	3	3	8
Understand	4	4	10
Apply	5	5	10
Analyze	5	5	7
Evaluate	3	3	5

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks
Internal Tests : 40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I

FOURIER ANALYSIS:
Fourier series – Euler Formulae – Functions having arbitrary period – Even and odd functions – Half range expansions- The Fourier integral – Fourier transforms.

2. 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.

3. 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.

4. Module IV

NUMERICALMETHOD:
Euler's Method, Runge- kutta method, Crack Nicholson Scheme, Finite Difference Method, Backward, Forward, Central Difference Method

5. Module V

CALCULUS OF VARIATIONS:
Euler's equation – Isoperimetric problems – Approximate solution of boundary value problems – Hamilton's principle –Lagrange's equation.

References:

1. Kreyszig . E, Advanced Engineering Mathematics, Wiley, New York(For sections 1, 2, 3, 4)
2. Grewal B.S, Higher Engineering Mathematics, Khanna Publishers, New Delhi. (For sections 4, 5)

20-457-0102 COMPUTER AIDED DESIGN IN OFFSHORE ENGINEERING

To give an understanding to computer aided design process which includes mathematical representation of curves and surfaces, Engineering Optimisation and Database systems.

20-457-0102	Computer Aided Design Offshore Engineering	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

Prerequisite: Matrix Algebra, Analytical Geometry, Linear Programming, Basics of Computers and Computer Programming

Course Outcome: After the Completion of the course the student will be able to

CO 1	Have an overall understanding of CAD concepts and CAD system developments
CO 2	Demonstrate the geometry transformation of 2D and 3 D models and its application in CAD systems
CO3	Have an understanding of mathematical representation of computational geometry by planar and space curves and surfaces defined by different boundary curves
CO 4	have knowledge of Engineering optimization using non-linear programming and to introduce stochastic search techniques
CO 5	To understand the importance of Data Base Systems in CAD systems

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

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	3	1	1			
CO 2	3	2	2			
CO 3	3	1	2		1	
CO4	2	2	2	2	1	
CO 5	1	2	1			

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand	5	5	10
Apply	5	5	10
Analyse	5	5	10
Evaluate	5	5	10

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment	:	20 marks
Internal Tests	:	40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I

Introduction and Review of CAD: Introduction, Conventional Engineering Design process and Computer Aided Engineering Design process, Software tools and functions, Graphics standards, Programming language CAD development.

Basics of Computer Graphics: Introduction to computer graphics technology – picture representation, graphic display devices, graphic input devices; Representation of points and lines, Geometric transformations, two & three dimensional transformations and projections.

2. Module II

Geometric Modelling: Types of mathematical representation of curves, wire frame models, wire frame entities, parametric representation of curves; Hermite cubic splines, Bezier curves, B-splines curves.

Surface Modelling: Mathematical representation surfaces, Surface model, Surface entities surface representation, Parametric representation, Surfaces of revolution, Sweep surface, Ruled & Developable surfaces, COONs Bi-cubic surface, Bezier surface, B- Spline surface.

3. Module III

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.

4. Module IV

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.

5. Module V

Fundamental Concepts Of Database Management: Introduction to DBMS, Data Models, Database Structure, Database languages, DBMS architecture, Database users and administrator, Entity-Relationship model, Relational model, SQL concepts, Object-Based databases and XML, Distributed databases, Integrity and Security to DBMS.

References:

1. Krishnamoorthy, C.S. & Rajeev, S.; Computer Aided Design- Software and Analytical Tools, Alpha Science International, 2005.
2. KhushdeepGoyal; Fundamental of computer aided design, S.K.Kataria& Sons, 2013
3. Sunil Kumar Srivastava; Computer Aided Design-a basic and mathematical approach, I.K. International publishing house, 2012.
4. Kernighan, B.W and Ritchie, D.M.; The Programming Language, Prentice – Hall, New Delhi. 2010
5. BjarneStroustrup; The C++ Programming Language, Addison-Wesley Publishing Company, 1995.
6. Rojers, D.F and Adams, J.A., Mathematical Elements Computer Graphics, McGraw Hill, New York. 2017
7. Vera B. Anand; Computer Graphics and Geometric Modelling for Engineers; John Wiley & Sons, Inc., 1993.
8. Steven Harrington: Computer Graphics-A Programming Approach; Second Edition, McGraw Hill International Edition, 1987.
9. Donald Hearn and M. Pauline Baker; Computer Graphics; Prentice Hall, 1997
10. Harrington, Computer graphics, McGraw Hill education, 2014
11. Newman, W.N. and Sproull R.F. Principles of Interactive Computer Graphics, McGraw Hill, New Delhi. Ed.2, 2010
12. Ammeral, L., Interactive 3D computer graphics, John Wiley, Singapore, 2010
13. Aoki, M. Introdution to Optimisation Techniques, TheMacmillian, Co., New York. 1991
14. Rao S.S.; Engineering Optimization Theory and Practice, John Wiley & Sons 2009
15. Rajesh Kumar Arora; Optimization, Algorithms and Applications, CRC Press, 2015
16. R. Pannerselvam; Operations Research, PHI Learning Private Ltd, 2017
17. Abraham Silberschatz, Henry F. Korth, S. Sudarshan; Database System Concepts,McGraw Hill Publications, 2013
18. Elmasri and Navathe, "Fundamentals of Database Systems", 7/e Addison – Wesley,2017.

20-457-0103 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 and approximate analysis techniques using various energy principles. It also compares the compatibility of applying the theory of elasticity and energy approaches for different types of structures. 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.

20-457-0103	Advanced Structural Analysis	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

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	Understand the different approximate numerical techniques for solving beam bending problems.
CO 3	Apply the theory of elasticity and/or theories of beams to solve for stress, strain and displacement fields in a structural problem.
CO 4	Analyze the structure using approximate energy methods, which can bypass the task for solving complex differential equations.
CO 5	Evaluate the stability criteria of structures using different methods such as matrix methods and energy approaches.

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

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	2	2	2	2		
CO 2	2	2	2	2		
CO 3	3	3	3	2		
CO 4	3	3	3	2		
CO 5	3	3	3	2	1	1

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand	5	5	10
Apply	5	5	10
Analyse	10	10	20
Evaluate			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks

Internal Tests : 40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1.Module I

Theory of Linear Elasticity:

Stress, Principal Stress and strain. Concepts and definition of strain – displacement relation. Equilibrium, constitutive and compatibility equations, St. Venant' principle, Plane stress, plane strain and axisymmetric conditions.

2. Module II

Energy Principles**:**

Principle of virtual work, principle of minimum potential, Castigliano's theorem – Numerical examples from frame and truss analysis

3. Module III

Principles of Structural Stability:

Methods of stability analysis – Column buckling – Euler equation, Frame instability – Energy approach. Application of matrix method to beam column problems

4. Module IV

Structural Mechanics:

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

5. Module V

Approximate Numerical Methods:

Application of Finite Difference Method, Raylegh Ritz method, Newton Raphson's method for solving beam bending problems.

References:

1. Timoshenko S.P. and Goodier, Theory of elasticity, McGraw Hill, New Delhi, 2010.

2. Tauchert T., Energy Principles in Mechanics. McGraw Hill, New Delhi 1994.
3. Gere and Weaver – Matrix Method of Structural analysis, McGraw Hill, New Delhi 1986.
4. L.S. Srinath, Advanced mechanics of solids, McGraw Hill, 2017
5. N. Krishna Raju, Advanced mechanics of solids and structures, McGraw Hill, Chennai 2019.
6. Reddy.C.S. Basic Structural Analysis TMH, 1996
7. Timoshenko SP and Gere, Theory of Elastic Stability, McGraw Hill,2017
8. Advanced mechanics of solids & structures-N Krishna Raju&D R Gururaja, narosa Publications,1997
9. Computational Elasticity-M Ameen, Alpha Science, 2011.

20-457-0104 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.

20-457-0104	Marine Hydrodynamics	Category	L	T	P	Credit	Year of Induction
		E	4	2	0	4	2020

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 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 program outcomes: Level - Low (1), medium(2) and high(3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	2			
CO 2	1	1	2			
CO 3	2	1	3	2		
CO 4	2	2	3			
CO 5	3	2	2	2		2

Assessment Pattern:

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	5	5	10
Apply	5	5	10
Analyse	10	10	20
Evaluate			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks
Internal Tests : 40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I

Basics of Fluid Dynamics: Conservation of mass and momentum, Euler equation, Bernoulli's equation, potential flow, boundary conditions, fixed and moving bodies, Green's theorem and distributions of singularities.

2. **Module II**

Waves: Classification of water waves; Two dimensional wave equation and wave characteristics; wave theories, small amplitude waves, finite amplitude wave, stokian, solitary theories; wave classification by relative water depth, water particle kinematics, pressure under progressive wave, wave energy power and wave group velocity, Standing Wave Theory; Wave deformation, reflections, diffraction and breaking of waves.

3. **Module III**

Tides: Classification, long term effects, basin oscillations, tsunamis, storm

4. **Module IV**

Currents: Classification, behaviour, design criteria, scour and other effects of currents.

5. **Module V**

Forces: Wave forces, current forces, wave-current-structure interaction, Morison equation, wave loads on offshore structures and pipe lines, diffraction theory, wave slamming and slapping. Hydrodynamic Test Facilities – Wave flumes, wave basins, towing tanks, circulating water channels etc

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 MJ, 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.

20-457-0105 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.

20-457-0105	Fracture Mechanics	Category	L	T	P	Credit	Year of Induction
		E	4	2	0	4	2020

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 program outcomes:Level - Low (1), medium (2) and high(3)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	1					
CO 2	2	1	2			
CO 3	2	2	2	2		
CO 4	2	2	2	1		
CO 5	2	2	2	2	2	2

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	-	-	-
Understand	5	5	10
Apply	5	5	10
Analyse	5	5	10
Evaluate	5	5	10
Total			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Assignment 1&2 : 20 marks

Internal Tests 1&2 : 40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper consists of 10 questions consisting of 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries a total of 8 marks.

Course content:

1. Basics of Elasticity and Plasticity

Types of Failures, Constitutive Models, Brittle and Ductile fracture, Fracture Mechanics and its applications.

2. Linear Elastic Fracture Mechanics

Inglis Concepts, Energy Release Rate, Griffith Contribution, Crack Resistance, R curve, Critical energy Release Rate, Stress Intensity Factor, Westergards –Approch, Edge cracks and Embedded cracks.

3 Nonlinear 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

4.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.

5.Fatigue and Computational Fracture Mechanics

Fatigue failure, Direct and Indirect methods to determine fatigue fracture parameters.

References:

1. Elements of Fracture Mechanics – Prasanth Kumar TMH, New Delhi, 2009.
2. Broek D., Elementary Engineering Fracture Mechanics, MartinusNijhoff Publishers., 2009
3. T L Anderson, Fracture Mechanics, Fundamentals& its applications, CRC press,2017
4. S Suresh, Fatigue of materials, Cambridge University Press,1998
5. Fracture Mechanics- An introduction-E E Gdoutos, Springer 2005
6. V G V Ukadgaonker, Theory of elasticity & Fracture Mechanics, Prentice Hall India,2016.

SEMESTER II

20-457-0201 DYNAMICS OF STRUCTURES

Course Description:

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

20-457-0201	Dynamics of Structure	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

Pre-requisites: Knowledge of Engineering Mechanics, Mechanics of Solids, Matrix Methods of 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 in of different civil, mechanical and offshore structures. It also introduces students to different mathematical and numerical methods in structural dynamics and the dynamic responses of civil, mechanical and offshore structures subjected to dynamic loads.

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

CO 1	Recognise various physical phenomena in the context of structural vibration.
CO 2	Identify and define key concepts related to structural dynamics, such as natural frequencies, modeshapes, damping and vibration characteristics of structures, by introducing SDOF systems.
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	Identify structures involving fluid-structure soil interaction
CO 5	Introduce concepts of stochastic structural dynamics and stochastic response of offshore structures.

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	1			2
CO 2	2	1	2			
CO 3	2	2	2	2		
CO 4	2	2	1	2	2	2
CO 5	2	2	3	1	2	1

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	-	-	-
Understand	4	4	8
Apply	8	8	16
Analyse	8	8	16
Evaluate			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks

Internal Tests : 40 marks

End Semester Examination Pattern:

The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I

Free and forced vibration of SDOF Systems, time and frequency domain approaches,vibration isolation

2. Module II

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

3. 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.

4. Module IV

Vibrations of structures involving fluid-structure soil interaction, dynamic behaviour of offshore structures.

5. Module V

Stochastic response of offshore structures, frequency domain response of linear systems, time domain response Narrow band systems, spectral fatigue analysis for offshore structures; Response to wave, wind and earth quake.

References:

1. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, New Delhi., 1975
2. Den Hartog, J.P. Mechanical Vibration, McGraw Hill New York. 2007
3. Clough, R.W and Penzien, J. Dynamics of Structures, McGraw Hill, New York, 1975
4. Mario Paz, "Structural Dynamics – Theory and Computation", Van Nostrand Reinhold Ltd., New York, 1987
5. G.B.Warburton, "The Dynamical Behaviour of Structures" Pergamon Press., 1976
6. Roy R., Gaig Jr., "Structural Dynamics – An Introduction to Computer Methods", John Wiley and Sons, Inc , 1981
7. MinooH.Patel, "Dynamics of offshore structures", Butterworths, 1989.
8. Walter C Hurty and Moshe FR: Dynamics of Structures, Prentice Hall of India, 2007.
9. Anil K Chopra: Dynamics of Structures, Theory and applications in earthquake engineering, PHI, 2002.

10. W.T. Thomson, Theory of vibration with its applications, CRC Press,1996
11. Michael Geradin and Daniel J. Rixen. Mechanical Vibrations: Theory and Applications to Structural Dynamics, Wiley, 3rd. Ed., 2015.
12. Eduardo Kausel. Advanced Structural Dynamics, Cambridge University Press, 2017.

20-457-0202 FINITE ELEMENT METHODS APPLIED TO OFFSHORE 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.

20-457-0202	Finite Element Methods Applied to Offshore Engineering	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

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 analysing complex structures
CO 4	Analyse the problems involving soil structure and fluid structure interactions using FEM.
CO 5	Evaluate the FEA criteria to analyse offshore jacket platform and stiffened plate structures.

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	1			
CO 2	2	2	2	2		

CO 3	2	2	2	2		
CO 4	2	2	2	2	2	2
CO 5	2	2	2	2		2

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	-	-	-
Understand	5	5	10
Apply	5	5	10
Analyse	5	5	10
Evaluate	5	5	10

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Assignment 1&2 :20 marks

Internal Tests 1&2 :40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper consists of 10 questions consisting of 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries a total of 8 marks.

Course content:

1. Module I

Introduction to fem, definitions, General Procedure of Finite Element Analysis – Variational formulations

2. **Module II**

Shape functions, Convergence Criteria, derivation of property matrix for truss, beam, plane stress, plane strain, axisymmetric and solid elements.

3. **Module III**

Computer implementation of FEM, Organisation of Computer Code, Numerical methods for various property matrix calculation, Fundamentals of stability and dynamic analysis using FEM.

4. **Module IV**

Soil structure Interaction problem, Fluid Structure Interaction Problem – Heat conduction problems.

5. **Module V**

Structural Application Multistorey frames, Stiffened plated Structure, Pressure vessels, Offshore Jackets.

References:

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

20-457-0203 OCEAN WAVES AND EFFECTS

Course Description:

This is an advance 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.

20-457-0203	Ocean Waves and Effects	Category	L	T	P	Credit	Year of Induction
		C	4	2	0	4	2020

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 predict the wave induced motions and forces acting on floating platforms like ships and offshore structures.

CO 1	Understand the characterization of irregular waves in time and frequency domain;
CO 2	Learn the concepts 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;
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 forces and motion responses in an irregular seaway; analyze responses of floating structures using software tools.

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	1			
CO 2	2	1	2			
CO 3	2	2	2			
CO 4	2	2	2	2		
CO 5	2	2	2	3	2	2

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand	5	5	10
Apply	10	10	20
Analyse	5	5	10
Evaluate			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks

Internal Tests : 40 marks

End Semester Examination Pattern:
End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I
Wave in Open Sea
Origin and propagation, classification of sea state, 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, idealised spectral families.

2. **Module II**
Forces and Response in Regular Waves
Formulation of diffraction and radiation problem for potential flow simplified head sea case, motion of regular waves strip theory, panel method and finite element method to compute hydrodynamic forces and coefficients.

3. **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.

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

5. **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*" *Principles of Naval Architecture*, Second Revision (Ed.) Lewis E.V. SNAME, Jersey City, New Jersey., 1988.
3. Price, W.G. and Bishop, R.E.D. *Probabilistic Theory of Ship Dynamics*, Chapman and Hall, London, 1974.
4. Peter Janssen ,The interaction of ocean waves and wind, 2004
5. Trilochan Sahoo, Mathematical techniques for waves interaction with flexible structures, IIT Kharagpur research monograph series, 2012.

6. Michel k Ochi, Ocean waves: The stochastic approach, 2005.
7. R. Bhattacharya, Dynamics of Marine Vehicles, A Wiley-Interscience Publication.
8. S. K. Chakrabarti, Hydrodynamics of Offshore Structures, Computational Mechanics Publication, 1987.
9. Srinivasan Chandrasekaran. Dynamic Analysis and Design of Offshore Structures, Springer, 2015.
10. Rajeev Dubey, Dynamics of Offshore Structures, Scitus Academics, 2016.

20-457-0205 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.

20-457-0205	Design of Offshore Structures	Category	L	T	P	Credit	Year of Induction
		E	4	2	0	4	2020

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

Course Objectives: Provide the students with an understanding of the design and construction of offshore platforms, specifically the theory and process of such designs and the use of current, applicable 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	Determination of environmental loads and the behaviour of offshore structures subjected to hydrodynamic loads
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 wave loadings
CO 5	Understand the concepts in marine geotechnics and the design of foundations for fixed offshore platforms with specific emphasis to the design of piles, spud cans and anchors

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1					
CO 2	2	2	2			
CO 3	2	2	2		2	
CO 4	2	2	2		2	1
CO 5	2	2	2			2

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand	5	5	10
Apply	5	5	10
Analyse	5	5	10
Evaluate	5	5	10

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	60	40	3 hours

Continuous Internal Evaluation Pattern:

Continuous Assessment : 20 marks
Internal Tests : 40 marks

End Semester Examination Pattern:

End Semester Examination Pattern: The paper carries a total of 40 marks. The exam will be of 3 hour duration. There will be questions from all the modules.

Course content:

1. Module I

Types of offshore structures – Bottom supported structures, compliant structures, Floating platforms. New-generation Offshore Platforms – Buoyant Leg Structures (BLS), Triceratops, Floating Storage and Regasification Units (FSRU) etc.

2. 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.

3. 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

4. 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

5. 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.

References:

1. API RP 2A WSD 1993
2. API RP 2A LRFD 2000
3. T.H. Dawson, *Offshore Structural Engineering*, PHI, USA, 1986
4. Teng H. *Applied Offshore structural Engineering*, PHI, 1996
5. K. Rajagopalan*Offshore Jacket structures*, Oxford and IBH, 1988
6. S.K.Chakrabarti, Hand book of Offshore Engineering (Vol I & II), Elsevier, 2005.
7. S.K.Chakrabarti, *Hydrodynamics of Offshore structures*, Southampton computational mechanics, 1989.
8. Ben C.Gerwick. *Construction of Mari-ne and Offshore structures*, CRC Press, London, 1999
9. W.J.Graff, *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.

Semester III

20-457-0301 Project Progress Evaluation

Course Outcomes:

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

- Identify structural engineering problems reviewing available literature.
- Identify appropriate techniques to analyze complex structural systems.
- Apply engineering and management principles through efficient handling of project

Course content:

Semester III (Project 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.

Semester IV

20-457-0401 Project Dissertation Evaluation and Viva Voce

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

1. Solve complex structural problems by applying appropriate techniques and tools.
2. Exhibit good communication and presentation skill to present his/her original work to the engineering community and society at large.
3. Demonstrate professional ethics and work culture.

Course content:

Semester IV (Project 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 seminar is conducted at the end of academic term, which will be monitored and approved by the departmental committee, after which the student has to 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.