Curriculum and Syllabi

M.Tech Degree Programme

OFFSHORE STRUCTURES

(with effect from Academic Year 2010-2011)

Approved by DCC on 30/03/2010

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

CALICUT

Department of Civil Engineering

Curriculum for M.Tech Programme in OFFSHORE STRUCTURES

Semester 1

Sl. No.	Code	Title	L	T	P/S	C
1	CE6301	Wave Hydrodynamics	3	-		3
2	CE6302	Stochastic Processes in Structural Mechanics	3	-		3
3	CE6303	Design of Offshore Structures	3	-		3
4	CE6391	Computational Lab	0	-	2	1
5	CE6392	Offshore Engineering Lab	0	-	2	1
6	******	Elective	3	-		3
7	******	Elective	3	-		3
8	******	Elective	3	-		3
	Total credits - 11 (core) + 9 or 6 (electives)					

Semester 2

Sl. No.	Code	Title	L	T	P/S	C
1	CE6311	Offshore Structural Systems—Modelling and Behaviour	3	-		3
2	CE6312	Marine Foundations	3	-		3
3	CE6313	Stability of Structures	3	-		3
4	CE6393	Offshore Structures Design Studio	0	-	2	1
5	CE6397	Seminar	0	-	2	1
6	******	Elective	3	-		3
7	******	Elective	3	-		3
8	******	Elective	3	-		3
Total credits -11 (core) + 9 or 6 (electives)						

Semester 3

Sl. No.	Code	Title	L	T	P/S	C
1	CE7398	Project				8
2		Elective	3	0	0	3
3		Elective	3	0	0	3
	Total Credits – 8 (Core) + 0 to 6 (Electives)					

Semester 4

Sl. No.	Code	Title	L	T	P/S	C
1	CE7399	Project				12
2		Total credits				12

LIST OF ELECTIVES

Sl. No.	Code	Title	Credits
1	CE6321	Ship Hydrodynamics	3
2	CE6101	Theory of Elasticity and Plasticity	3
3	CE6102	Structural Dynamics	3
4	CE6121	Structural Optimisation	3
5	CE6122	Modelling, Simulation and Computer Application	3
6	CE6124	Analytical Dynamics	3
7	CE6322	Multibody Dynamics and Applications	3
8	CE6130	Structural Health Monitoring	3
9	CE6131	Structural Reliability	3
10	CE6225	Geographic Information System and Applications	3
11	CE6138	Advanced Finite Element Analysis	3
12	CE6139	Advanced Theory of Shells	3
13	CE6140	Theory of Plasticity	3
14	CE6323	Advanced Wave Hydrodynamics	3
15	CE6324	Dynamics of Floating Bodies	3
16	CE6111	Finite Element Method	3
17	CE6112	Theory of Plates and Shells	3
18	CE6133	Random Vibrations	3
19	CE6134	Engineering Fracture Mechanics	3
20	CE6136	Design of Plated Structures and Shells	3
* Any other subject offered in the Institute with approval from the Programme Coordinator/Faculty Advisor			

Minimum requirements:

1. A minimum of 60 credits have to be earned for the award of M.Tech degree in this programme.
2. Students to register for six electives in three semesters together with two or three electives each in the first two semesters and a maximum of two in the third semester. Fourth semester is for project work only.
3. Industrial Training (1 credit) during summer term is optional

COURSE ASSESSMENT METHODS

Assessment is carried out as per the Rules & Regulations framed by the Senate of the Institute.

Lecture based courses

Continuous Assessment based on:

- A minimum of two mandatory tests (of minimum one hour each)
- Assignments/ tutorials/ presentations/course projects/reports etc as decided by the course faculty
- Weightage: Normally between 40-60%, as decided by the course faculty

End Semester Assessment is based on:

- One end semester examination of minimum three hours duration
- Weightage: Normally between 40-60%, as decided by the course faculty

Laboratory/practical/drawing courses

- Assessment shall be based on tests and the performance of students in the regular laboratory/ practical/ drawing classes and will be decided by the course faculty.
- End semester examination is not mandatory.
- If end semester examination is planned, it shall be conducted before the last instructional day and the weightage for it should not exceed 40%.

Continuous Assessment : 50/ 60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. To prepare students for productive careers who will be capable of applying their expertise to contemporary problem solving, being engaged professionally and have continued to learn and adapt, and have contributed to their organizations through leadership and team work and will contribute to the ever increasing academic and research requirements of the country and worldwide.
2. To impart in-depth knowledge of the modern skills and tools related to offshore structural engineering to the students, so as to enable them to address the environmental aspects and sustainable issues related to infrastructure development of the country.
3. Provide a strong foundation in basic and advanced knowledge in areas related to exploration, exploitation and transportation of offshore resources enabling the students to excel in the various careers in offshore structural engineering field of Civil Engineering both in the National / International level.
4. Understand use of various modelling, programming and software skills.
5. Enrich the students with strong communication and technical writing skills.
6. Provide expertise in laboratory and experimental work.
7. Help the students to develop teaching skills through regular teaching assistance.
8. Prepare the students to face challenges in industry by encouraging interaction with industry, carrying out industry based projects, involving them in consultancy projects etc.

PROGRAMME OUTCOMES

PO1	Post-Graduates will develop confidence for taking up research and teaching as a profession
PO2	Post-Graduates will attain an ability to identify, formulate and solve complex Offshore Engineering problems
PO3	Post-Graduates will understand the impact of engineering solutions on the society and will also be aware of the environmental aspects and sustainablility issues related to infrastructure development of the country and worldwide.
PO4	Post-Graduates will be able to conduct investigations of complex problems in Offshore Engineering using research based knowledge and tests/ experiments
PO5	Post-Graduates will exhibit skills to use modern engineering tools, software and equipment to analyse various problems in the Offshore Engineering domain
PO6	Post-Graduates will be able to communicate effectively - both verbally and in writing
PO7	Post-Graduates will develop confidence to face fresh challenges in the industry
PO8	Post-Graduates will develop confidence for self-education and the ability for life-long learning

BRIEF SYLLABUS

CE6301 WAVE HYDRODYNAMICS

Pre-requisite:- Nil
Total Hours: 42

L	T	P	Cr
3	0	0	3

Review of basic Fluid Mechanics - Introduction to Wave Mechanics – Wave generation by Wind - Small Amplitude Wave Theory - Wave trains and Wave energy - Wave reflection, Wave refraction and Wave diffraction - Breaking of waves - Finite Amplitude Waves –Higher Order Wave Theories –Sea as a Stationary Random Process - Wave Spectral density - Wave Forces –Wave force on a Circular Cylinder, Submarine Pipelines – Froude Krylov theory - Diffraction theory - Wave forces on Sea walls and Breakwaters.

CE6302 STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite:- Nil
Total Hours: 42

L	T	P	Cr
3	0	0	3

Basic Probability Concepts - Random variables - Functions of Random variables, Common Probabilistic models - multivariate Models -Derived probability distributions and distributions of functions -Basic Theory of Stochastic Processes -spectral decomposition of a random process, power spectral density function-Some important random processes: Properties of Random Processes- Some models of random processes in nature

CE6303 DESIGN OF OFFSHORE STRUCTURES

L	T	P	Cr
3	0	0	3

Pre-requisite:- Nil
Total Hours: 42

Types of offshore structures and conceptual development - Materials and their behaviour under static and dynamic loads - Various design methods and Code Provisions - Construction of jacket and gravity platforms- Operational loads - Maximum wave force on offshore structure - Concept of Return waves - Principles of Static and dynamic analyses of fixed platforms - Design of structural elements- Introduction to tubular joints Parameters of in-plane tubular joints - Elastic stress distribution - Stress concentration - Fatigue of tubular joints - Fatigue behaviour - Design of tubular joints as per API Code- Corrosion - Offshore structure corrosion zones – Biological corrosion - Preventive measures of Corrosion - Principles of cathode protection systems - Online corrosion monitoring - Corrosion fatigue.

CE6391 COMPUTATIONAL LAB

Pre-requisite: -Nil
Total Hours: 42

L	T	P	Cr
0	0	2	1

Introduction to Engineering Software - Introduction to O/S–storage and time optimisation - General purpose packages in Civil Engineering – Program Implementation

CE6392 OFFSHORE ENGINEERING LAB

Prerequisite:– Nil
Total Hours: 42

L	T	P	Cr
0	0	2	1

Use of various transducers & pickups for static and dynamic measurements in ocean engineering - Data transmission and analysis using DACs – Non Destructive Testing-
Ocean Wave modeling –Measurement of regular and random waves - Wave force measurements on cylinders - Wave-current-structure interaction studies - Analysis of experimental results – response of fixed and floating structures

CE6311 OFFSHORE STRUCTURAL SYSTEMS—MODELLING AND BEHAVIOUR

Pre requisite: Structural Dynamics
Total Hours: 42

L	T	P	Cr
3	0	0	3

Structures in the offshore environment **-** Description of typical offshore structures - Solid fluid interaction parameters - Environmental forces - Dynamic characteristics and water depth capability of offshore structures - Response of offshore structures - single and multi degree freedom systems – effect of foundations - Coupled motions - Frequency domain analysis - Time domain analysis - Response analysis of jacket structures - complaint structures – non linear response and stability characteristics- Freely moving structures - Stability of submerged and floating structures - Motion of structure in response to excitation - Mooring line forces - Motion analysis of floating vessels- Motion analysis in random waves - Low frequency, High frequency oscillation - Wave drift forces - Springing forces - Non-linear sum forces - Damping at low and high frequencies - Dynamic positioning.

CE6313 STABILITY OF STRUCTURES

Prerequisite: -Nil
Total Hours: 42

L	T	P	Cr
3	0	0	3

Introduction:- Concept of stability – Static, Dynamic and Energy criterion of stability- Differential Equation of Equilibrium of Beam-Columns –The Effect of Initial Curvature on Deflections – Interaction formula- Elastic Buckling of Bars –Evaluation of Critical Loads of Column Using Determinant – Energy Method –Buckling of Bars with Changes in Cross Section- Effect of Shearing Force on the Critical Load – Buckling of Built up Columns – Various Empirical Formulae for Column Design- Stability of Rigid Bars having Linear or Rotational Springs - Stability of System of Rigid Bars Using Equilibrium and Principle of Stationary Potential Energy- Buckling of Frames:- Beams Subjected to Compressive Loads by Matrix Approach and Stability Functions- Pure Torsion of Thin walled Bars of Open Cross-section – Lateral Buckling of Beams in Pure Bending – Introduction to stability of Plates and Shells.

CE6393 OFFSHORE STRUCTURES DESIGN STUDIO

Pre requisite: Design of Offshore Structures
Total Hours: 42

L	T	P	Cr
0	0	2	1

Design Principles of Jacket platform tower, Jack up legs - Seismic analysis of Offshore Platforms - Offshore Platform Pile Foundations - Design of Concrete Gravity Platforms - Design of Raft Foundation- Design of offshore pipelines - Static and dynamic analyses - Structural and positional stability - Pipeline-soil interaction - Pipe laying methods like lay barge, bottom tow, floating, reel-ship & RAT methods - Trenching of pipelines- Design of Compliant towers - Articulated towers - Guyed towers - Cylindrical Buoys - Single point Moored Buoy systems - Statics of mooring lines without and with elasticity - Dynamics of mooring lines - Design of mooring cables

CE6397 SEMINAR

Prerequisite: -Nil
Total Hours: 42

L	T	P	Cr
0	0	2	1

Each Student shall prepare a Paper and present a Seminar on any topic related to the branch of specialisation under the guidance of a staff member. The student shall submit typed copy of the paper to the Department. Grades will be awarded on the basis of contents of the paper and the presentation.

CE6321 SHIP HYDRODYNAMICS

Prerequisite: - Nil
Total Hours: 42

L	T	P	Cr
3	0	0	3

Sea environment - Waves on the sea surface - Wind- Current - Hull forms of different types of ships and boats - Fluid pressure - Effects of ship on waves- Forward speed - Response of ship to wave excitation- Ship distortion in still water - Stability of ships - Hydrodynamic forces - Transient Loading - Slamming - Second order forces - Mean wave drift forces and moments - Slow drift forces in irregular waves - Slowly varying oscillation due to wind - Sum frequency effects - Ship response to regular seaway - uncoupled and coupled motions - Ship response to irregular seaway- Motion stabilisation - Effectiveness of motion stabilisation.

CE6322 MULTIBODY DYNAMICS AND APPLICATIONS

Prerequisite: - Nil
Total Hours: 42

L	T	P	Cr
3	0	0	3

Kinematics of Rigid Bodies- derivatives of a vector in multiple reference frames- Coriolis acceleration- Euler Angles- Momentum and Kinetic Energy of Rigid Bodies- Inertia Tensor and its Properties- Newtonian Dynamics: Moment-of-momentum equations for general motion of rigid bodies- Lagrangian Dynamics and Virtual Work- Introduction to Multibody System Dynamics- Systems of interconnected rigid bodies- kinematics for general multibody systems- Vibration analysis of multibody systems- dynamics of multibody systems with terminal flexible links- Lagrange’s equations of motion with constraints- Computational Methods for the dynamic behaviour of the mechanical systems- treatment of holonomic and nonholonomic constraints through various elimination and augmentation methods, extraction of data from equations of motion, computational issues.

CE6323 ADVANCED WAVE HYDRODYNAMICS

Prerequisite: Wave Hydrodynamics
Total Hours: 42

L	T	P	Cr
3	0	0	3

Random waves- Random processes, Probability distributions- Auto correlation and Cross correlation- Applications- Spectral properties of ocean waves- Transformations of wave spectra to proposed frequency spectra - Estimation of short term wave statistics based on wind data and wave data- Estimation of extreme waves- Extreme value probability distributions - Methods of parameter estimation - Confidence intervals - Design wave selection- Random wave forces- Morison equation with arbitrary wave spectrum and with narrow band wave spectrum - Estimation of force coefficients - Effects of wave non-linearity - Random forces on large bodies - Long term force distribution- Introduction to analysis of multidirectional waves.

CE6324 DYNAMICS OF FLOATING BODIES

Prerequisite: Structural Dynamics
Total Hours: 42

L	T	P	Cr
3	0	0	3

Floating body dynamics – diffraction and radiation by large bodies –exciting and restoring forces – added mass and radiation damping –drift forces – transient motion of floating bodies- Behaviour of systems with time dependent characteristics- Non linear dynamics and instability of floating structures- Response analysis of floating structures –multi body structures- Station keeping– Wave drift oscillation – Dynamic positioning.

CE6101: THEORY OF ELASTICITY AND PLASTICITY

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Introduction to the mathematical theory of elasticity - Two-dimensional problems in rectangular coordinates - Two-dimensional problems in polar coordinates - Introduction to Cartesian Tensors - Stress and strain problems in three dimensions - Energy Theorems and Variational Principles of Elasticity - Torsion of straight bars- Introduction to plasticity: One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

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CE6102: STRUCTURAL DYNAMICS

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Over view:- Basic features of dynamic loading and response – models for dynamic analysis – lumped mass, generalized displacements and finite element models - Formulation of equation of motion - Degrees of freedom – mass moment of inertia - Generalized single degree of freedom systems - Free vibration of single degree of freedom system - Negative damping - Single degree of freedom system – Response to impulsive loads - Approximate analysis - Response to general dynamic loading - Numerical analysis in the frequency domain, fast Fourier transform analysis - Multi degree of freedom system - analysis of multi-degree of freedom system- mode superposition analysis - Distributed Parameter System-Practical Vibration Analysis - Framed structures

CE6111: FINITE ELEMENT METHOD

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Introduction - The element characteristic matrix – Element assembly and solution for unknowns – Basic equations of elasticity – Strain-displacement relations – Theory of stress and deformation – Stress-strain-temperature relations - The Direct Stiffness Method - Stationary Principles, Rayleigh-Ritz Method and Interpolation - Introduction to Weighted Residual Method -Displacement-based Elements for Structural Mechanics - Formulas for element stiffness matrix and load vector - Straight-sided Triangles and Tetrahedra - The Isoparametric Formulation - Coordinate Transformation- Topics in Structural Mechanics: - d.o.f. within elements – Condensation – Condensation and recovery algorithm – Substructuring – Structural symmetry.

CE6112: THEORY OF PLATES AND SHELLS

Prerequisite: -- Theory of Elasticity
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Introduction:- Assumptions in the theory of thin plates – Pure bending of Plates – Relations between bending moments and curvature - Particular cases of pure bending of rectangular plates, Cylindrical bending - immovable simply supported edges - Synclastic bending and Anticlastic bending – Strain energy - Laterally Loaded Circular Plates - Laterally Loaded Rectangular Plates- Navier solution for simply supported plates subjected to uniformly distributed load and point load – Levy's method of solution for plates having two opposite edges simply supported with various symmetrical boundary conditions along the other two edges loaded with u. d. l. - Approximate Methods. Effect of transverse shear deformation - plates of variable thickness – Anisotropic plates- thick plates- orthotropic plates and grids - Large Deflection theory - Deformation of Shells without Bending - shells in the form of a surface of revolution - displacements, unsymmetrical loading - General Theory of Cylindrical Shells.

CE6121: STRUCTURAL OPTIMISATION

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Problem formulation with examples- Single Variable Unconstrained Optimisation Techniques – Optimality Citeria - Interpolation methods -Gradient Based methods - Multi Variable Unconstrained Optimisation Techniques – Optimality Citeria. Unidirectional Search - Direct Search methods - Simplex method - Gradient based methods - Constrained Optimisation Techniques –Classical methods - Linear programming problem- Indirect methods- Direct methods- Specialized Optimisation techniques – Dynamic programming, Geometric programming, Genetic Algorithms.

CE6122: MODELLING, SIMULATION AND COMPUTER APPLICATION

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Numerical Solution of Nonlinear Equations - Fixed point iteration – Newton-Raphson method – Broyden's method - Functional Approximations-Finite Difference Method - Parabolic equations – Algebraic Eigenvalue Problem - Eigenvalue problem for a real symmetric matrix – Integral Equations - Simulation and Monte Carlo Methods - Random number generation –Random variate generation – inverse transform method – composition method – acceptance-rejection method - Simulation of random vectors - inverse transform method – multivariate transform method – multinormal distribution. Simulation of stochastic fields – one-dimensional and multidimensional fields.

CE6124: ANALYTICAL DYNAMICS

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Fundamentals of Newtonian Mechanics: Newton's laws, impulse and momentum - generalised coordinates, systems with constraints, stationary value of a definite integral, principle of virtual work, D'Alembert's principle - Motion Relative to Rotating Reference Frames: Transformation of coordinates, rotating coordinate systems, moving references - Rigid Body Dynamics -Behaviour of Dynamical Systems- Introduction to Advanced Topics- non-autonomous systems, perturbation techniques, transformation theory, Hamilton-Jacobi equation.

CE6128: MULTI BODY DYNAMICS AND APPLICATIONS

Prerequisite: -Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Prerequisite: - Nil Kinematics of Rigid Bodies - Momentum and Kinetic Energy of Rigid Bodies- Inertia Tensor and its Properties - Newtonian Dynamics: -Lagrangian Dynamics and Virtual Work- Introduction to Multibody System Dynamics - Computational Methods - Comparison of the different dynamic formulations for the determination of the equations of motion, investigation of their applicability to computer simulation of the dynamic behaviour of the mechanical systems, computer simulation using MATLAB, treatment of holonomic and nonholonomic constraints through various elimination and augmentation methods.

CE6130: STRUCTURAL HEALTH MONITORING

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures - review of Signals, Systems and Data Acquisition Systems - Frequency and time domain representation of systems - Sensors for Health Monitoring Systems- Health Monitoring/Diagnostic Techniques - Vibration signature analysis, modal analysis, neural networkbased classification techniques - Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, Neural network classification techniques- Information Technology for Health Monitoring - Project Based Health Monitoring Techniques- condition monitoring of other types of structures.
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CE6131: STRUCTURAL RELIABILITY

Prerequisite: - Nil
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Concepts of structural safety - Basic Statistics - Probability theory - Resistance distributions and parameters - Probabilistic analysis of loads - Basic structural reliability - computation of structural reliability - Level 2 Reliability methods - Reliability based design - Monte Carlo study of structural safety -Reliability of Structural system - reliability analysis of frames

CE6133: RANDOM VIBRATIONS

Prerequisite: Stochastic Processes in Structural Mechanics
Total Hours : 42h

L	T	P	Cr
3	0	0	3

Basic Theory of Stochastic Processes - Stochastic Response of Linear SDOF Systems - Linear systems with multiple inputs and outputs - Stochastic response of linear continuous system. - Response of nonlinear systems to random excitation - Fatigue damage of structure due to random loads.

CE6134: ENGINEERING FRACTURE MECHANICS

Prerequisite: A Course on Theory of Elasticity
Total Hours: 42h

L	T	P	Cr
3	0	0	3

Significance of fracture mechanics, Griffith energy balance approach, Irwin's modification to the Griffith theory, Stress intensity approach, Cack tip plasticity, Fracture toughness, sub-critical crack growth, Linear Elastic Fracture Mechanics (LEFM) - Cack Tip Plasticity - LEFM Testing - Plane strain and plane stress fracture toughness testing, Elastic Plastic Fracture Mechanics (EPFM)- Fatigue Cack Growth - Sustained Load Fracture:- Time-to-failure (TTF) tests, Cack growth rate testing, Experimental problems, Practical Problems

CE6136: DESIGN OF PLATED STRUCTURES AND SHELLS

Prerequisite: Nil
Total Hours: 42h

L	T	P	Cr
3	0	0	3

Cylindrical bending of plates – laterally loaded circular plates – uniformly loaded core with simple and fixed boundary conditions - Laterally loaded rectangular plate – differential equations – boundary conditions – Navier solution for simply supported plates subjected to uniform and point loads – Levy's method - Approximate methods of solution of plates – Rayleigh-Ritz method – Galerkin's method – finite difference method Orthotropic plates – stiffened plates – stability of plates – design of plated structures. Stressed skin surfaces – types – cylindrical shells thin shells – membrane theory – bending theory – theories due to Finster-Welder and Schorer – shells of revolution – membrane theory – paraboloid of revolution – analysis using polynomial stress function – hyperbolic paraboloids – rectangular hyperbolic paraboloid - Stiffened cylindrical shells – design curves for pressure hull buckling of cylindrical shells

CE6138: ADVANCED FINITE ELEMENT ANALYSIS

Prerequisite: A basic course on Finite Element Analysis
Total Hours: 42h

L	T	P	Cr
3	0	0	3

Plate Bending: Shells: three- and four-noded shell elements, curved isoparametric elements - Error, Error Estimation and Convergence: - adaptive meshing. Constraints, Penalty Forms, Locking and Constraint Counting - Finite Elements in Structural Dynamics and Vibrations - Modelling Considerations and Software Use - Physical behaviour versus element behaviour, element shapes and interconnections - Introduction to Nonlinear Problems - Stress Stiffening and Buckling: Stress stiffness matrices for beam, bar and plate elements, a general formulation for [kσ], bifurcation buckling, remarks on [kσ], its use, and on buckling and buckling analysis.

CE6139: ADVANCED THEORY OF SHELLS

Prerequisite: A basic course on Theory of Elasticity
Total Hours: 42h

L	T	P	Cr
3	0	0	3

General theory of shells, deformation of shell, compatibility conditions, forces and moments, equilibrium equations, constitutive laws, boundary conditions, solution methods of shell problems, Membrane theory - Shells of revolution - Bending theory - Shallow shells.

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CE6140: THEORY OF PLASTICITY

Prerequisite: A basic course on Theory of Elasticity
Total Hours: 42h

L	T	P	Cr
3	0	0	3

Basic equations of theory of elasticity - Framework of Plastic Constitutive Relations - Plastic behaviour in simple tension, generalisation of results in simple tension - Initial Yield Surfaces for Polycrystalline Metals - Plastic Behaviour under Plane Stress Conditions - Plastic Behaviour of Bar Structures - The Theorems of Limit Analysis - Limit Analysis in Plane Stress and Plane Strain - Limit Analysis as a Programming Problem.

DETAILED SYLLABUS

CE6301 Wave Hydrodynamics

L	T	P	C
3	0	0	3

Pre-requisite : Nil

Total Hours : 42

Course Objectives:

1. To understand and be able to apply basic concepts of fluid mechanics to problems of water waves
2. To understand the mechanics of water waves, modes of generation, various wave theories and regimes of applicability of these theories, and wave transformation in shallow waters and in the presence of obstructions/ bluff bodies
3. To understand basic concepts of modelling sea as a random process including wave statistics and spectral approach to waves
4. To understand methods of computation of wave forces on near shore and offshore structures and submarine pipelines

Module 1 (8h)

Review of basic Fluid Mechanics – Fluid kinematics – Steady, Unsteady, Rotational and Irrotational flows - Stream lines and Equipotential lines, Velocity potential and Stream function - Conservation of mass - Continuity equation - Euler's equation of motion – Bernoulli's equation

Module 2 (10h)

Introduction to Wave Mechanics – Wave generation by Wind - Small Amplitude Wave Theory ; Formulation and solution, Wave Celerity, Length and Period, Classification of waves based on relative depth, Orbital motions and Pressure - Standing waves - Wave trains and Wave energy - Wave reflection, Wave refraction and Wave diffraction - Breaking of waves.

Module 3 (10h)

Finite Amplitude Waves –Higher Order Wave Theories – Stokes Wave Theory, Cnoidal Wave Theory and Solitary Wave Theory - Wave interaction with Currents - Wave slamming and slapping - Sea as a Stationary Random Process - Wave Spectral density - Mathematical Spectrum models - Short term Wave statistics.

Module 4 (14h)

Wave Forces – Morison Equation; Wave force on a Circular Cylinder ; Vertical, Inclined and Oscillating - Wave Forces on Submarine Pipelines, Pipelines in proximity to seabed, Pipelines within the zone of wave influence – Froude Krylov theory - Diffraction theory; Closed form solutions of Large fixed vertical cylinder - Wave forces on Sea walls and Breakwaters - Applications of Wave force regimes.

References

1. Ippen, A. T., Estuary and Coastline Hydrodynamics, McGraw Hill, Inc.1982.
2. Dean, R.G., and Darlymple, R.A., Water Wave Mechanics for Engineers and Scientists, Prentice Hall, Inc. 1993.
3. Chakrabarti, S.K., Hydrodynamics of Offshore Structures, Springer Verlag, 1987.
4. Sarpkaya, T., and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand, 1981.
5. Kinsman, B., Wind Waves, Prentice Hall, Inc, 1965.
6. USACE, Shore Protection Manual, 2002.

Method of Assessment:

Continuous Assessment : 50/60 Marks

(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)

End Semester Examination : 40/ 50 Marks

Course Outcomes:

1	Review of basic concepts of fluid mechanics and fluid dynamics, mathematical modelling of fluid flow problems and solutions.
2	Study of generation of wind waves, various theories of water waves, modelling of small amplitude waves, wave trains, wave energy, wave transformation in shoaling water and wave breaking.
3	To study finite amplitude wave theory, other higher order wave theories, regimes of application of various wave theories.
4	Review of random process, modelling water waves wave as a stationary and ergodic process, wave energy, spectral density of wave energy, wave spectrums.
5	Study methods of computation of wave forces on small and large structures, wave forces on sea walls, design of breakwaters.

CE6302 STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite: Nil

Total hours: 42 hours

L	T	P	C
3	0	0	3

Course Objectives:

1. To highlight importance of probabilistic analysis and stochastic dynamic analysis of structures.
2. To familiarize the stake holders with the basic probability concepts and basic theory of stochastic processes.
3. To acquire knowledge of various mathematical theories associated with stochastic processes which are essential for the stochastic dynamic analysis of structure and for finding important design properties of the stochastic processes.
4. To introduce different models of stochastic processes representing various physical phenomena that occurs in nature.

Module 1 (10 hours)

Basic Probability Concepts:- Sample space and events, probability measure, mathematics of probability.
Random variables: Probability distribution of a random variable, multiple random variables, main descriptors of a random variable – moments, expectation, covariance, correlation, conditional mean and variance. Functions of Random variables, expectation of a function of a random variable

Module 2 (8 hours)

Common Probabilistic Models:- Models from simple discrete random trails, models from random occurrences, models from limiting cases, other commonly used distributions, multivariate models.
Derived probability distributions and distributions of functions.

Module 3 (12 hours)

Basic Theory of Stochastic Processes: Introduction, statistics of stochastic processes, stationary, ergodic and non stationary processes, auto and cross correlation and co variance function, stochastic calculus and mean square limit, conditions for continuity, differentiability, integrability of a random process, spectral decomposition of a random process, power spectral density function, narrow band and broad band random process, Wiener-Khintchine equation

Module 4 (12 hours)

Some important random processes: Normal processes, Poisson processes, Markov processes. Properties of Random Processes: Level crossing peaks, fractional occupation time, envelopes, first-passage time, maximum value of a random process in a time interval. Some models of random processes in nature:

Earthquake, wind, atmosphere turbulence, random runways, road roughness, jet noise, ocean wave turbulence

References

1. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles, John Wiley & Sons, 1975.
2. J.R. Benjamin & C.A. Cornell., Probability, Statistics and Decision for Engineers, McGraw-Hill, 1970.
3. Papoulis, A., Probability, Random Variables and Stochastic Processes, McGraw Hill, 2002.
4. Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.
5. Loren D Lutes & Shahram Sarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, NJ, 1997.
6. J Solnes, Stochastic Processes & Random Vibration, Theory and Practice, John Wiley, 1997
7. Lin, Y. K., Probabilistic Theory in Structural Dynamics, McGraw Hill, 1995.
8. Bendat & Piesol., Random Data Analysis and Measurement Procedure, John Wiley,1991.
9. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, 1986.
10. R.W Clough & J. Penzien,. Dynamics of Structures, McGraw Hill, 1993.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

1. Distinguish deterministic and random variables associated with structural analysis and response.
2. Quantify the randomness or uncertainties in the variables associated with structural analysis and response.
3. Model different physical phenomena by appropriate stochastic processes.
4. Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage.

CE6303 DESIGN OF OFFSHORE STRUCTURES

Pre-requisite :- Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the behaviour of different types of offshore structures under static and dynamic loads, materials employed, design methods, and code provisions.
2. To determine operational loads and maximum wave forces on offshore structures.
3. To study the principles of static and dynamic analyses of fixed platforms.
4. To learn about design and fatigue of tubular joints
5. To understand the corrosion phenomenon in offshore structures and to various methods employed for prevention of the same.

Module 1 (10 hours)

Types of offshore structures and conceptual development - Analytical models for jacket structures - Materials and their behaviour under static and dynamic loads - Statutory regulations - Allowable stresses - Various design methods and Code Provisions - Design specification of API, DNV, Lloyd's and other classification societies - Construction of jacket and gravity platforms

Module 2 (12 hours)

Operational loads - Environmental loads due to wind, wave, current and buoyancy - Morison's Equation - Maximum wave force on offshore structure - Concept of Return waves - Principles of Static and dynamic analyses of fixed platforms - Use of approximate methods - Design of structural elements.

Module 3 (14 hours)
Introduction to tubular joints - Possible modes of failure - Eccentric connections and offset connections - Cylindrical and rectangular structural members – In plane and multi plane connections - Parameters of in-plane tubular joints - Kuang's formulae - Elastic stress distribution - Punching shear Stress - Overlapping braces - Stress concentration - Chord collapse and ring stiffener spacing - Stiffened tubes - External hydrostatic pressure - Fatigue of tubular joints - Fatigue behaviour - S-N curves - Palmgren-Miner cumulative damage rule - Design of tubular joints as per API Code

Module 4 (6 hours)
Corrosion - Corrosion mechanism - Types of corrosion - Offshore structure corrosion zones – Biological corrosion - Preventive measures of Corrosion - Principles of cathode protection systems - Sacrificial anode method and impressed current method – Online corrosion monitoring - Corrosion fatigue.

References

1. Dawson, T. H., Offshore Structural Engineering, Prentice Hall, 1983.
2. API RP 2A., Planning, Designing and Constructing Fixed Offshore Platforms, API., 2000.
3. McClelland, B & Reifel, M. D., Planning & Design of fixed Offshore Platforms, Van Nostrand, 1986.
4. Graff, W. J., Introduction to Offshore Structures, Gulf Publ. Co.1981.
5. Reddy, D. V & Arockiasamy, M., Offshore Structures Vol.1 & 2, Kreiger Publ. Co.1991.
6. Morgan, N., Marine Technology Reference Book, Butterworths, 1990.
7. B.C Gerwick, Jr. Construction of Marine and Offshore Structures, CRC Press, Florida, 2000.

Method of Assessment:
Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Review of types of offshore structures and conceptual development, materials and their behaviour under static and dynamic loads, various design methods and code provisions
2	Construction of jacket and gravity platforms, Determination of operational loads and maximum wave force on an offshore structure, study of the principles of Static and dynamic analyses of fixed platforms
3	Design of structural elements and tubular joints, stress concentration, fatigue of tubular joints
4	Study of corrosion in offshore structures and methods to monitor and prevent corrosion

CE6391 COMPUTATIONAL LAB

L	T	P	Cr
0	0	2	1

Pre-requisite: -Nil
Total Hours : 42
Course Objectives:
1. To introduce various engineering software.
2. To introduce O/S, storage and time optimisation.
3. To familiarize with general purpose packages in Civil and Offshore Engineering and Program Implementation.

Introduction to Engineering Software - Introduction to O/S–storage and time optimisation - General purpose packages in Civil Engineering – Program Implementation

Course Requirement:
Students are expected to know at least one high-level language. They will be imparted instructions for using available computer systems. Each student will be assigned a term project in his/her area of interest and shall develop an application program.

References
1. Rajaraman, A., Object oriented applications in engineering design, Narosa, India, 2003.
2. Heileman, G.L., Data structure, algorithms and object-oriented programming, McGraw Hill, New York, 1996.
3. Antia, H.M., Numerical Methods for Scientists and Engineers, Tata McGraw Hill, 2002.
4. Chapra, S.C., and Canale, R.P., Numerical Methods for Engineers, Tata McGraw Hill, 2002.

Method of Assessment:

Continuous Assessment (Test 1: 15; Test 2: 25)	: 40 Marks
Class work etc	: 60 Marks

Course Outcomes:

CO No.	COs
1	Introduction to engineering software and knowledge of at least one high-level language.
2	Develop computer programmes to solve typical problems in Offshore Engineering.
3	Use of various scientific computing tools/ software relevant to the field

CE6392 OFFSHORE ENGINEERING LAB

L	T	P	Cr
0	0	2	1

Prerequisite:– Nil
Total Hours : 42

Course Objectives:
1. To understand the use of various types of transducers for the static and dynamic measurements
2. To learn how to model ocean waves
3. To learn how to measure and model ocean waves and wave forces
4. To measure the response of fixed and floating structures

Use of various transducers & pickups for static and dynamic measurements in ocean engineering - Data transmission and analysis using DACs – Non Destructive Testing
Ocean Wave modeling – modeling criteria – modeling laws – model testing facility - Measurement of regular and random waves - Calibration of instruments for the measurement of waves - Measurement of reflectivity and transmissivity - Wave force measurements on cylinders - Wave-current-structure interaction studies - Analysis of experimental results – response of fixed and floating structures

References
1. Subrata Kumar Chakrabarati, Offshore Structural Modelling, World Scientific, 1994.
2. Steven, A. Hughes, Physical Models and Laboratory Techniques in Coastal Engineering, World Scientific, 1993.
3. Bendat, J.S, Piersol, A.G., Random Data: Analysis and Measurement Procedures, John Wiley, 2000.
4. Doebelin, E.O., Measurement Systems – Application & Deisgn, McGraw Hill Publishers, 2003.

Method of Assessment:

Continuous Assessment (Test 1: 15; Test 2: 25)	: 40 Marks
Class work etc	: 60 Marks

Course Outcomes:

CO No.	COs
1	Understanding the use of various transducers & pickups for static and dynamic measurements in ocean engineering.
2	Data transmission and analysis using DACs
3	Ocean wave modeling, measurement of regular and random waves, wave force measurements on cylinders, wave-current-structure interaction studies
4	Measurement of the response of fixed and floating structures

CE6311 OFFSHORE STRUCTURAL SYSTEMS—MODELLING AND BEHAVIOUR

Prerequisite: Structural Dynamics
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the typical types of offshore structures, environmental loads on structures and parameters governing soil-structrure interaction
2. To analyse the response of typical offshore structures for various degrees of freedom
3. To analyse the stability of submerged and floating structures
4. To learn how to compute mooring line, wind drift and springing forces

Module 1 (9 hours)
Structures in the offshore environment **-** Description of typical offshore structures - Fixed - Compliant-Floating - Solid fluid interaction parameters - Spring factor - Added mass and damping - Influence of viscosity and free surface effect on the added mass and damping - Environmental forces - Buoyancy and gravity - Dynamic characteristics and water depth capability of offshore structures - Dynamic amplification factor.

Module 2 (14 hours)
Response of offshore structures - Modelling of offshore structures – single and multi degree freedom systems – effect of foundations - Coupled motions - Frequency domain analysis - Time domain analysis - Newmark β method - Wilson θ method - Response analysis of jacket structures - Response analysis of complaint structures – non linear response and stability characteristics

Module 3 (10 hours)
Freely moving structures - Stability of submerged and floating structures - Stability at small and large angles - Motion of structure in response to excitation - Diffraction and radiation problems - Added mass – Damping - Wave exciting force - Strip theory - Mooring line forces - Motion analysis of floating vessels.

Module 4 (9 hours)
Motion analysis in random waves - Low frequency oscillation - High frequency oscillation - Wave drift forces - Springing forces - Non-linear sum forces - Damping at low and high frequencies - Dynamic positioning.

References

1. Wilson, J. F., Dynamics of Offshore Structures, John Wiley, 2002.
2. Clauss, G, Lehmann, E & Ostergaard, C., Offshore structures - Vols 1 & 2**,** Springer-Verlag, 1992.
3. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science Publ, .2002.
4. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
5. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
6. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978.
7. Patel, M.H., Compliant Offshore Structures, Butterworth Heinemann Ltd., Oxford, 1991.

Method of Assessment:

Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Review of typical offshore structures, parameters governing solid-fluid interaction, environmental forces on offshore structures
2	Analysis of the response of offshore structures – single and multi degree of freedom problems, frequency and time domain analyses
3	Analysis of the stability of submerged and floating structures, mooring line forces
4	Wave drift forces and springing forces, damping

CE6412 MARINE FOUNDATIONS

Prerequisite: - Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the typical types of offshore structures, environmental loads on structures and parameters governing soil-structrure interaction
2. To analyse the response of typical offshore structures for various degrees of freedom
3. To analyse the stability of submerged and floating structures
4. To learn how to compute mooring line, wind drift and springing forces

Module 1 (15 hours)

Introduction to Marine Geotechnical Engineering: Scope of marine geotechnical engineering - Marine and submarine soils - Classification of marine soils - Relative distribution of marine soils in the different marine regions - General characteristics of marine deposits in some specific locations and in the Indian sub-continent.

Sedimentological characteristics of marine soils: Structure of marine soils - Cementation bonding - Morphology and genesis of marine and submarine sediments - Post-depositional changes - Effect of calcium carbonate in marine deposits.

Engineering behaviour of marine soils: Fine and coarse-grained deposits - Strength and deformation behaviour of fine - and coarse-grained marine deposits - Effect of cementation - Strength and deformation behaviour under static and cyclic loading

Module 2 (10 hours)

Offshore Soil Investigation: General characteristics of offshore soil exploration - Sampling using free corer, gravity corer, tethered systems and manned submersibles - Deep penetration sampling using wire line techniques - In-situ determination of strength of submarine soils - Penetrometer, piezocone, vane and pressure meter techniques - General reconnaissance procedure for installation of fixed structures (gravity and piled type), floating structures, sea bed anchors and submarine pipelines.

Module 3 (10 hours)

Foundations for Gravity Structures: Types of gravity structures - Installation techniques - Movement of gravity structures - Settlement of soil beneath gravity structures - Stress distribution beneath gravity structures - Stability of gravity structures under static and cyclic loads

Foundations for jacket type structures: Types - Installation techniques - Design considerations - Axial and lateral load capacity of piles - Lateral load deformation behaviour of piles - Calculation of bearing capacity of piles - Design of piles subjected to lateral loads - Reese-Matlock method & p-y curves method.

Module 4 (10 hours)

Foundations for jack up platforms: Types of jack up platforms - Piles and mat supported - Spud cans - Different types - Techniques for installation and removal of jack up - Stability of jack up platforms -

Determination of penetration of supports - Stability under lateral loads - Stability under static and cyclic load effects.
Sea bed anchors, submarine pipe lines: General introduction to sea bed anchors, moorings, submarine pipe line etc. - general design considerations (brief outline only) - geotechnical aspects in the design and installation of sea bed anchors, moorings, submarine pipelines etc.

References

1. Chaney, F. Marine geotechnology and nearshore/offshore structures, ASTM, STP-, 1986.
2. Chaney, R. C & Demars, K. R., Strength Testing of Marine Sediments - Laboratory and In-situ Measurements, ASTM, STP -883, 1985.
3. George, P & Wood, D., Offshore Soil Mechanics, Cambridge University Press.
4. Le Tirant, Sea Bed Reconnaissance and Offshore Soil Mechanics for the Installation of Petroleum Structures, Gulf Publ. Co., 1979.
5. Poulos, H. G & Davis, E. H., Pile Foundation Analysis and Design, John Wiley, 1980.
6. Numerical Methods in offshore Piling, Proc. Conf. Inst. of Civil Engineers, London, 1980.

Method of Assessment:

Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Introduce the students to the relevance of marine geotechnical engineering
2	Exposure to different types of marine sediments and their properties
3	Study the behaviour of marine deposits under static and cyclic loading conditions
4	To know the different methods/techniques adopted for offshore soil investigations
5	To understand the typical foundations for the different type of offshore structures
6	To expose the students to partial design of typical offshore foundation components
7	To provide an overall picture of foundations for ancillary offshore facilities.

CE6313 STABILITY OF STRUCTURES

Prerequisite: -Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To highlight importance of concept of stability in the structural analysis and design.
2. To familiarize with the stability analysis of beam-columns subjected to different loadings and to develop design interaction formula.
3. To acquire knowledge of buckling analysis of columns using different methods and to develop design formula as given in various design Codes of practice.
4. To perform stability analysis of simple framed structures.
5. To carryout stability analysis thin walled sections, lateral buckling of beams, plates and shells.

Module 1 (10 hours)

Introduction:- Concept of stability – Static, Dynamic and Energy criterion of stability
Beam Columns - Differential Equation of Equilibrium of Beam-Columns – Concentrated Loads – Continuous Uniformly Distributed Lateral Loads – Different End Conditions – The Effect of Initial Curvature on Deflections – Interaction formula.

Module 2 (12 hours)

Elastic Buckling of Bars – Review of Euler Column Theory for Four Different End Conditions – Evaluation of Critical Loads of Column Using Determinant – Approximate Methods of Evaluation of critical Loads of Columns – Energy Method – Rayleigh Ritz Method – Finite Difference Method – Newmark's Deflection Comparison Method - Buckling of Bars with Changes in Cross Section Using the Approximate Methods Such as Successive Approximations – The Effect of Shearing Force on the Critical Load – Buckling of Built up Columns – Various Empirical Formulae for Column Design.

Module 3 (10 hours)
Stability of Rigid Bars having Linear or Rotational Springs - Stability of System of Rigid Bars Using Equilibrium and Principle of Stationary Potential Energy
Buckling of Frames:- Portal, Rectangular and L-shaped Frames under Non-sway Conditions - Beams Subjected to Compressive Loads by Matrix Approach and Stability Functions

Module 4 (10 hours)
Pure Torsion of Thin walled Bars of Open Cross-section – Torsional Buckling – Determination for Warping displacement for a Thin Walled Channel Section – Examples of Section with Thin Elements in which there is no Warping.
Lateral Buckling of Beams in Pure Bending – Lateral Buckling of Simply Supported I- beams.
Introduction to stability of Plates and Shells: Buckling of plates, buckling of shells.

References

1. Timoshenko, S.P., and Gere, J.M., Theory of Elastic Stability, McGraw Hill, Singapore, 1963.
2. Chajes, A., Principles of Structural Stability Theory, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1974.
3. Brush, D.O., and Almorth, B.O., Buckling of Bars, Plates and Shells, McGraw Hill, 1975.
4. Kumar, A., Stability of Structures, Allied Publishers Limited, 1998.
5. Iyengar, N.G.R., Structural Stability of Columns and Plates, East West Press, 1986.
6. Simitses, G.J., Introduction to the elastic stability of structures, Prentice Hall Inc., New Jersey, 1976.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to
1. Identify structures or structural elements where stability analysis is very relevant.
2. Perform stability analysis of beam-columns and design them.
3. Carryout stability analysis of bars/columns and simple frames and determine safe load.
4. Perform stability analysis of thin walled sections, beams undergoing lateral buckling, plated and shell structure.

CE6393 OFFSHORE STRUCTURES DESIGN STUDIO

Pre requisite: Design of Offshore Structures
Total Hours : 42

L	T	P	Cr
0	0	2	1

Course Objectives:

1. To understand the principles and procedures employed in the design of various types of offshore structures such as jacket platforms, gravity platforms, compliant structures, mooring lines, pipelines etc

Module 1 (12 hours)
Design Principles of Jacket platform tower, Jack up legs - Design of decking - Design of supporting legs - Design of braces - Design of deck legs, Deck framings, Plating etc. - Design of platform derricks, Masts, Helipads etc. - Seismic analysis of Offshore Platforms - Offshore Platform Pile Foundations - Pile capacity - Soil-pile Interaction - Pile design as per API recommendations.

Module 2 (8 hours)
Design of Concrete Gravity Platforms - Ingredient materials and Protective Measures - Design of Side walls, Design of Decking - Design of Raft Foundation

Module 3 (10 hours)
Design of offshore pipelines - Design considerations - Structural aspects - Static and dynamic analyses - Approximate methods - Structural and positional stability - Pipeline-soil interaction - Pipe laying methods like lay barge, bottom tow, floating, reel-ship & RAT methods - Trenching of pipelines

Module 4 (12 hours)
Design of Compliant towers - Articulated towers - Guyed towers - Cylindrical Buoys - Single point Moored Buoy systems - Statics of mooring lines without and with elasticity - Dynamics of mooring lines - Design of mooring cables

Note: Each student shall design and submit designs and drawings of an offshore structure as a term project.

References

1. Dawson, T. H., Offshore Structural Engineering, Prentice Hall, 1983.
2. American Petroleum Institute, API RP-2A, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms, 2000.
3. McClelland, B & Reifel, M. D., Planning & Design of fixed Offshore Platforms, Van Nostrand, 1986.
4. Graff, W. J., Introduction to Offshore Structures, Gulf Publ. Co.1981
5. Reddy, D. V and Arockiasamy, M., Offshore Structures Vol. 1& 2, Kreiger Publ. Co.1991.
6. Morgan, N., Marine Technology Reference Book, Butterworths, 1990.

Method of Assessment:
Continuous Assessment : 40 Marks
(Test 1: 15; Test 2: 25)
Class Works : 60 Marks

Course Outcomes:

CO No.	COs
1	Understand design principles of jacket platforms – superstructure and foundation, offshore pipelines, compliant towers, and mooring lines, soil-structure interaction problems and stability issues.
2	Perform analysis of typical problems related to these structures.
3	Perform design of these structures.

CE6397 SEMINAR

L	T	P	Cr
0	0	2	1

Prerequisite: -Nil
Total Hours : 42

Course Objectives:
1. To improve communication skills.
2. To understand recent developments in the field of Offshore Engineering and to gain insight into practical problems encountered in the field.
3. To aid in identifying a good topic for PG dissertation work.

Each student shall prepare a Paper and present a Seminar on any topic related to the branch of specialisation under the guidance of a staff member. The student shall submit typed copy of the paper to the Department. Grades will be awarded on the basis of contents of the paper and the presentation.

Course Outcomes:

CO No.	COs
1	Identify and understand typical practical problems in the field of Offshore Engineering
2	Understand current research and field applications in this field
3	Make a detailed presentation on the same

CE6321 SHIP HYDRODYNAMICS

Prerequisite: - Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To learn about different hull forms and the effect of vessels on waves.
2. To understand about stability considerations in the design of vessels.
3. To assess the response of vessels subjected to water waves.
4. To understand methods of computing hydrodynamic forces on vessels

Module 1 (10 hours)
Sea environment - Waves on the sea surface - Statistical description of waves - Wind- Current - Hull forms of different types of ships and boats - Numerical techniques for ship calculations - Weight estimation, centre of gravity, effect of shifting weights - Fluid pressure, centre of pressure - Effects of ship on waves-Frequency of wave encounter - Smith correction - Forward speed - Response of ship to wave excitation.

Module 2 (12 hours)
Ship distortion in still water - Hydrostatic fluid actions - Stability of ships - Transverse and longitudinal stability - Metacentre - Metacentric height - Stability at small angles - heel, trim and angle of roll - Free surface effects - Inclining experiment - Stability at large angles - cross curves of stability - dynamic stability levers - Wind heeling moment, maximum allowable KG - Stability of grounded vessels - Submarine stability - Stability criterion for various types of crafts.

Module 3 (12 hours)
Hydrodynamic forces - Strip theory - Diffraction theory - Transient Loading - Slamming - Second order forces - Mean wave drift forces and moments - Slow drift forces in irregular waves - Slowly varying oscillation due to wind - Sum frequency effects - Ship response to regular seaway - uncoupled and coupled motions - Ship response to irregular seaway.

Module 4 (8 hours)
Motion stabilisation - Roll stabilisation - Pitch stabilisation - Effectiveness of motion stabilisation.

References

1. Bishop and Price, Hydroelasticity of ships, Cambridge University Press, Cambridge, 1979.
2. Faltinsen, Sea loads on ships and offshore structures, Cambridge University Press- Cambridge, 1993.
3. Bhattacharya, R., Dynamics of marine vehicles, A Wiley Interscience Publication- John Wiley, 1978.
4. Comstock, Principles of Naval Architecture, New York: Society of Naval Architects and Marine Engineers, 1967.

Method of Assessment:

Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Review of hull forms of ships and boats and effect of vessels on waves
2	Response of vessels to wave excitation and stability
3	Computation of forces and moments

CE6322 MULTIBODY DYNAMICS AND APPLICATIONS

L	T	P	Cr
3	0	0	3

Prerequisite: - Nil
Total Hours : 42

Course Objectives:

1. To study the kinematics of rigid bodies.
2. To understand the momentum of momentum equation and its applications.
3. To study Lagrangian and Eulerian dynamics
4. To understand computational methods for the dynamics behaviour of mechanical systems

Module 1 (8 hours)

Kinematics of Rigid Bodies: Angular velocity and acceleration, derivatives of a vector in multiple reference frames, addition rule for angular velocity, relative motion of two points fixed on a rigid body, motion of a point that is moving on a rigid body, Coriolis acceleration, orientation of a rigid body, Euler Angles.

Momentum and Kinetic Energy of Rigid Bodies: Angular momentum, kinetic energy.

Module 2 (12 hours)

Inertia Tensor and its Properties: Formal definition of inertia quantities, parallel axis theorem, rotation transformation, principal axes and principal moments of inertia.

Newtonian Dynamics: Moment-of-momentum equations for general motion of rigid bodies, Euler equations of motion, rotating mass imbalance, gyroscopic effects.

Lagrangian Dynamics and Virtual Work: Generalised forces and the principle of virtual work, Lagrange's equations of motion, linearisation of equations of motion about equilibrium points.

Module 3 (12 hours)

Introduction to Multibody System Dynamics: Systems of interconnected rigid bodies, equations of motion for systems of rigid bodies, kinematics for general multibody systems, modelling of forces in multibody systems, equations of motion, handling of constraints in multibody systems dynamics, linearisation and vibration analysis of multibody systems, dynamics of multibody systems with terminal flexible links, dynamic analysis of multiple flexible-body systems, Lagrange's equations of motion with constraints.

Module 4 (10 hours)

Computational Methods: Comparison of the different dynamic formulations for the determination of the equations of motion, investigation of their applicability to computer simulation of the dynamic behaviour of the mechanical systems, computer simulation using MATLAB, treatment of holonomic and nonholonomic constraints through various elimination and augmentation methods, extraction of data from equations of motion, computational issues.

References

1. T. R. Kane and D. A. Levinson, Dynamics: Theory and Application, 1996.
2. J.H. Ginsberg, Advanced Engineering Dynamics, Second edition, 1999.
3. A.A. Shabana, Dynamics of Multibody Systems, Cambridge Press, 2nd Ed., 1998.
4. R. Huston, Multibody Dynamics, Butterworth-Heinemann, 1990;
5. F.M.L. Amirouche, Computational Methods in Multibody Dynamics, Prentice Hall 1991.

6. Meirovitch, L., Methods of Analytical Dynamics, McGraw-Hill, 1970.
7. Torok, J.S., Analytical Mechanics with an Introduction to Dynamical Systems, John Wiley, New York, 2000.
8. Baruh, H., Analytical Dynamics, McGraw-Hill, New York, 1999.
9. Greenwood, D.T., Classical Dynamics, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

CO No.	COs
1	Kinematics of rigid bodies
2	Moment of momentum equation and applications
3	Newtonian and Lagrangian dynamics
4	Computational methods for the dynamics behaviour of mechanical systems

CE6323 ADVANCED WAVE HYDRODYNAMICS

Prerequisite: Wave Hydrodynamics
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To review basic concepts, of probability, statistics, and random processes
2. To understand the spectral representation of ocean wave data.
3. To study how to compute hydrodynamic forces exerted by random waves and how to estimate extreme waves
4. To analyse multidirectional waves

Module 1 (8 hours)
Random waves: Review of basic statistical concepts, Random processes, Probability distributions such as Gaussian distribution and Rayleigh distribution; Auto correlation and Cross correlation; Applications.

Module 2 (10 hours)
Spectral properties of ocean waves: Alternate spectral representations - Transformations of wave spectra to proposed frequency spectra - Estimation of short term wave statistics based on wind data and wave data.

Module 3 (12 hours)
Estimation of extreme waves: Collection of data - Plotting formulae - Extreme value probability distributions - Methods of parameter estimation - Confidence intervals - Design wave selection.

Module 4 (12 hours)
Random wave forces: Morison equation with arbitrary wave spectrum and with narrow band wave spectrum - Estimation of force coefficients - Effects of wave non-linearity - Random forces on large bodies - Long term force distribution.

Introduction to analysis of multidirectional waves.

References

1. Sarpkaya, T. & Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand.
2. Bendat, J. S. & Piersol, A. G., Random Data: Analysis and Measurement Procedures, John Wiley & Sons.
3. Kinsman, B., Wind Waves, Prentice Hall, Inc.

4. Goda, Y., Random Seas and Design of Maritime Structures, John Wiley and Sons.
5. Davenport., An Introduction to the Theory of Random Signals and Noise, McGrawHill, Inc.
6. Newland, D. E., Introduction to Random Vibrations and Spectral Analysis, Longman.
7. Chakrabarti, S.K., Hydrodynamics of Offshore Structures, Springer Verlag.
8. Chakrabarti, S. K., Nonlinear Methods in Offshore Engineering, Elsevier Science Pub.

Method of Assessment:

Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Review of concepts of probability, distributions and random processes
2	Spectral properties of ocean waves and transformation of spectra
3	Estimation of extreme waves and design wave
4	Computation of random wave forces and estimation of force coefficients
5	Analysis of multidirectional waves

CE6324 DYNAMICS OF FLOATING BODIES

L	T	P	Cr
3	0	0	3

Prerequisite: Structural Dynamics
Total Hours : 42

Course Objectives:

1. To understand the dynamics of floating bodies
2. To understand the behaviour of systems with time dependent characteristics
3. To study about station keeping and dynamic positioning of wells
4. To analyse the instability of floating structures

Module 1 (12 hours)

Floating body dynamics – diffraction and radiation by large bodies – linearised equations of motion for a constrained floating body – simple harmonic motion – exciting and restoring forces – added mass and radiation damping – numerical solutions – drift forces – transient motion of floating bodies.

Module 2 (12 hours)

Behaviour of systems with time dependent characteristics- Undamped free motions of a system with time dependent spring characteristics – Damped free motions of a system with time dependent spring characteristics – Forced motions of a system with time dependent spring characteristics – Behaviour of systems with time dependent damping characteristics- Non linear dynamics and instability of floating structures.

Module 3 (8 hours)

Response analysis of floating structures – semi submersible, tension leg platforms – tower tanker systems – Floating production systems – multi body structures.

Module 4 (9 hours)

Station keeping– mooring systems – Thruster forces – Springing forces – Wave drift oscillation – Dynamic positioning.

References

1. Chiang C. M, Applied Dynamics of Ocean Surface Waves, John Wiley & Sons.
2. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science.
3. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley.

4. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag.
5. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley.
6. Faltinsen, Sea loads on ships and offshore structures- Cambridge University Press- Cambridge.
7. Minoo H Patel, Compliant Offshore Structures, Butterworth Heinemann Ltd., Oxford, 1991
8. Thompson and Stewart, Non linear dynamics and chaos, John Wiley.

Method of Assessment:

Continuous Assessment : 50/60 Marks
(Test 1 plus Test 2: 40 to 50marks; Assignments/ Tutorials etc: 10 to 20marks)
End Semester Examination : 40/ 50 Marks

Course Outcomes:

CO No.	COs
1	Understanding the dynamics of floating bodies
2	Wave deformation by large bodies
3	Understanding the behaviour of systems with time dependent characteristics
4	Non linear dynamics and instability of floating structures
5	Station keeping and dynamic positioning

CE6101 THEORY OF ELASTICITYAND PLASTICITY

L	T	P	Cr
3	0	0	3

Prerequisite: - Nil
Total Hours : 42

Course Objectives:

1. To understand the basis of mechanics of deformable solids with adequate mathematical vigour and thus appreciate the simplifying assumptions of *strength of materials theory*
2. To get familiarised with the index notation, a *language* extensively used in modern technical literature
3. To understand idealisations of elasticity as idealisations. The plane-stress, plane-strain, axisymmetric problems and their solutions based on the idealisations enable course registrants to comprehend the importance and necessity of such idealisations.
4. To understand energy theorems and variational formulations that provide an alternative problem formulation and that leads to a variety of numerical methods
5. To understand the behaviour of a non-circular prismatic bar subjected to torsion, thus appreciate the elementary torsion problem and its simple solution.
6. To get familiarised with the basic ingredients of theory of plasticity.

Module 1: (12 hours)

Introduction to the mathematical theory of elasticity**:** Elasticity, stress, strain, Hooke's law, two-dimensional idealisations, plane stress and plane strain problems, equations of equilibrium, strain-displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions.
Two-dimensional problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever, determination of displacements.
Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole on stress distribution in plates, concentrated force at a point on a straight boundary.

Module 2: (10 hours)

Introduction to Cartesian Tensors: Transformation laws of cartesian tensors, special tensors and tensor operations, the Kronecker's delta, the permutation tensor, the e-δ identity, symmetry and skew-symmetry, contraction, derivatives and the comma notation, Gauss' theorem, the base vectors and some special vector

operations, eigenvalue problem of a symmetric second order tensor, equations of elasticity using index notation.
Stress and strain problems in three dimensions: Principal stresses, principal strains, three-dimensional problems.

Module 3: (12 hours)
Energy Theorems and Variational Principles of Elasticity: Strain energy and complementary energy, Clapeyron's theorem, virtual work and potential energy principles, principle of complementary potential energy, Betti's reciprocal theorem, principle of linear superposition, uniqueness of elasticity solution.
Torsion of straight bars: Elliptic and equilateral triangular cross-section, membrane analogy, narrow rectangular cross-section, torsion of rectangular bars, torsion of rolled profile sections, hollow shafts and thin tubes.

Module 4: (8 hours)
Introduction to plasticity: One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

References

1. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, Mc Graw Hill, Singapore, 1982.
2. Srinath, L.S., Advanced Mechanics of Solids, Second Edition, Tata McGraw Hill, India, 2003.
3. Ameen, M., Computational Elasticity—Theory of Elasticity, Finite and Boundary Element Methods, Narosa Publishing House, 2004.
4. Leipholz, H., Theory of Elasticity, Noordhoff International Publishing, Layden, 1974.
5. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Tata Mc Graw Hill, India, 1974.
6. Xu, Z., Applied Elasticity, Wiley Eastern Ltd, India, 1992.
7. Chakrabarty, J, Theory of Plasticity, Elsevier, London, 2006.
8. Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1998.
9. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1998.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to
1. Mathematically formulate elasticity problems as a well posed boundary value problem
2. Solve simple engineering problems with mathematical rigour. Such solutions can act as bench-mark solutions for testing computational methods and software.
3. Appreciate the Cartesian Tensor notation, thereby understand modern technical literature, which otherwise would have appeared intricate.
4. Develop simple approximate methods based on variational formulations
5. Will be able to begin to understand advanced books on theory of plasticity

CE6102 STRUCTURAL DYNAMICS

L	T	P	Cr
3	0	0	3

Prerequisite: - Nil
Total Hours : 42
Module 1 (12 hours)

Course Objectives:
1. To understand the basics of dynamic loading and response and to mathematically formulate dynamic equation of equilibrium of structural systems.
2. To get familiarised with the free vibration analysis of single degree of freedom systems.

3. To understand response of single degree of freedom systems to harmonic loading, periodic loading and general dynamic loadings.
4. To understand free vibration analysis of multi degree of freedom systems and to study its response.
5. To get familiarised with dynamic analysis of distributed parameter systems.
6. To get familiarised with the practical vibration analysis viz. modelling of different types of structures, determination of natural frequency by approximate methods etc.

Over view:- Basic features of dynamic loading and response – models for dynamic analysis – lumped mass, generalized displacements and finite element models
Formulation of equation of motion – Direct equilibration, principle of virtual displacement and Hamilton's principle.

Degrees of freedom – Translational and rotational systems - mass moment of inertia

Generalized single degree of freedom systems- rigid body assemblage determination of characteristic properties.

Free vibration of single degree of freedom system:- Solution of equation of motion, undraped free vibration - Damped free vibration, critically damped, under damped and over damped systems, Negative damping.

Module 2 (12 hours)

Single degree of freedom system – Response:- Response to harmonic loading, Undamped system- damped system, Response to periodic loading -Fourier series expansion of the loading- response to Fourier series loading Exponential form of Fourier series loading and response- Complex frequency transfer functions

Response to impulsive loads :- Suddenly applied load, sine wave impulse, rectangular impulse, triangular impulse, spike loading, approximate analysis

Response to general dynamic loading:- Duhamel integral for undamped system – unit impulse response function – numerical evaluation, response of damped system- numerical evaluation, Numerical analysis in the frequency domain, fast Fourier transform analysis.

Module 3 (12 hours)

Multi degree of freedom system:- Two degree of freedom system – equation of motion, characteristic equation, frequencies and mode shapes, coordinate coupling and choice of degree of freedom, orthogonality of modes, natural coordinates, superposition of natural modes , response of two degree of freedom system to initial excitation, beat phenomenon, response to harmonic excitation

Multi- degree of freedom system – analysis of multi- degree of freedom system- mode superposition analysis.

Distributed Parameter System: Partial differential equation of motion - Axial vibration of prismatic bars - Elementary case of flexural vibration of beams - Beam flexure including axial force effects.

Module 4 (9 hours)

Practical Vibration Analysis:- Determination of frequency by Rayliegh's method, beam flexure – selection of shape- improved Rayleigh's method.

Framed structures – Shear building concept and models for dynamic analysis, discrete parameter system by Rayleigh's method , improvement of frequency, Stodola method for discrete parameter system, reduction of second and higher modes- Stodola method for continuous parameter system.

References

1. Clough,R.W. and Penzien, J., Dynamics of structures, McGraw Hill, 1993.
2. Chopra, A.K., Dynamics of structures – Theory and Application to Earthquake Engineering, Prentice Hall of India, 1996.
3. --IS 1893 – Criteria for Earthquake Resistant Design of Structures, 2002.
4. --SP 22: Explanatory Handbook on Codes for Earthquake Engineering.
5. Meirovitch L., Elements of Vibration Analysis, Mc.Graw Hill, 1986.
6. Thomson W.T., Theory of Vibration with Applications, Pearson Education Inc., 1998.

7. Craig, Jr. R.R., Structural Dynamics, John Wiley, 1981.
8. Hurty, W.C. and Rubinstein M.F., Dynamics of Structures, Prentice Hall, 1964.
9.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Mathematically model a structural system for dynamic analysis of the system.
2. Carry out free vibration analysis of single degree of freedom.
3. Analyse a single degree of freedom systems to subjected to harmonic loading, periodic loading and general dynamic loadings.
4. Perform free vibration forced vibration analyses of multi degree of freedom.
5. Expose the students to the practical vibration analysis viz. modelling of different types of structures, determination of natural frequency by approximate methods etc.

CE6111 FINITE ELEMENT METHOD

Prerequisite :- Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To review basics of elasticity and introduce finite element method of analysis.
2. To get familiarised with direct stiffness method, element stiffness, its assembly, boundary conditions solutions techniques etc.
3. Appreciate energy principles and development of element stiffness of one dimensional elements.
4. Development of element stiffness of two dimensional and solid elements.
5. To introduce topics like coordinate transformations, condensation techniques, sub-structuring etc.

Module 1 (10 hours)

Introduction:- The Finite Element Method – The element characteristic matrix – Element assembly and solution for unknowns – Summary of finite element history.
Basic equations of elasticity – Strain-displacement relations – Theory of stress and deformation – Stress-strain-temperature relations.
The Direct Stiffness Method: - Structure stiffness equations – Properties of [K] – Solution of unknowns – Element stiffness equations – Assembly of elements – Node numbering to exploit matrix Sparsity – Displacement boundary conditions – Gauss elimination solution of equations – Conservation of computer storage – Computational efficiency – Stress computation – Support reactions – Summary of the finite element procedure.

Module 2 (12 hours)

Stationary Principles, Rayleigh-Ritz Method and Interpolation: - Principle of stationary potential energy – Problems having many d.o.f – Potential energy of an elastic body – The Rayleigh-Ritz method – Piecewise polynomial field – Finite element form of Rayleigh-Ritz method – Finite element formulations derived from a functional – Interpolation – Shape functions for C^0 and C^1 elements – Lagrangian and Hermitian interpolation functions for one dimensional elements – Lagrangian interpolation functions for two and three dimensional elements
Introduction to Weighted Residual Method: **-**Some weighted residual methods – Galerkin finite element method – Integration by parts – Axially loaded bar – Beam – Plane elasticity.

Module 3 (12 hours)

Displacement-based Elements for Structural Mechanics:- Formulas for element stiffness matrix and load vector – overview of element stiffness matrices – Consistent element nodal load vector – Equilibrium and compatibility in the solution – Convergence requirements – Patch test – Stress calculation – Other formulation methods.

Straight-sided Triangles and Tetrahedra:- Natural coordinates for lines, triangles and tetrahedra – Interpolation fields for plane triangles – linear and quadratic triangle – quadratic tetrahedron.

The Isoparametric Formulation:- Introduction – An isoparametric bar element – Plane bilinear element – Summary of Gauss quadrature – Quadratic plane elements – Direct construction of shape functions for transition elements – Hexahedral (solid) isoparametric elements – Triangular isoparametric elements – Consistent element nodal loads – Validity of isoparametric elements – Appropriate order of quadrature – element and mesh instabilities – Remarks on stress computation

Module 4 (11 hours)

Coordinate Transformation:- Transformation of vectors – transformation of stress, strain and material properties – Transformation of stiffness matrices – Transformation of Flexibility to Stiffness – Inclined support – Joining dissimilar elements to one another – Rigid links – Rigid elements.

Topics in Structural Mechanics: - D.o.f. within elements – Condensation – Condensation and recovery algorithm – Substructuring – Structural symmetry.

References

1. Cook, R.D., et al, Concepts and Applications of Finite Element Analysis, John Wiley, 2001.
2. Desai, C.S., Elementary Finite Element Method, Prentice Hall of India, 1998.
3. Chandrupatla, T.R., and Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India, 1998.
4. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1996.
5. Gallaghar, R.H., Finite Element Analysis: Fundamentals, Prentice Hall Inc, 1986.
6. Rajasekaran, S., Finite Element Analysis in Engineering Design, Wheeler Pub, 1998.
7. Krishnamoorthy, C.S., Finite Element Analysis – Theory and Programming, Tata Mc Graw Hill, 1996.
8. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. I and II, Mc Graw Hill, 1991.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Develop stiffness matrices of one dimensional, two dimensional and solid elements.
2. Develop structure stiffness matrix, load vector and solve the same after applying boundary conditions.
3. Develop computer programs for analysing different types of structures using finite element methods.

CE6112 THEORY OF PLATES AND SHELLS

L	T	P	Cr
3	0	0	3

Prerequisite: - Theory of Elasticity
Total Hours : 42

Course Objectives:

1. To understand the classical theory and background mathematics of plates and shells.
2. To get exposed to different type of plate problems and the numerical solution techniques to obtain their behaviour.
3. To appreciate the general solution of plate problems and relate them with their simplified counter parts in strength of materials.
4. To understand the geometry and behaviour of thin shells and obtain solutions to practical problems.

Module 1 (8 hours)

Introduction:- Assumptions in the theory of thin plates – Pure bending of Plates – Relations between bending moments and curvature - Particular cases of pure bending of rectangular plates, Cylindrical bending - immovable simply supported edges - Synclastic bending and Anticlastic bending – Strain energy in pure bending of plates in Cartesian and polar co-ordinates – Limitations.

Module 2 (8 hours)
Laterally Loaded Circular Plates:- Differential equation of equilibrium – Uniformly loaded circular plates with simply supported and fixed boundary conditions – Annular plate with uniform moment and shear force along the boundaries.

Module 3 (17 hours)
Laterally Loaded Rectangular Plates: - Differential equation of plates – Boundary conditions – Navier solution for simply supported plates subjected to uniformly distributed load and point load – Levy's method of solution for plates having two opposite edges simply supported with various symmetrical boundary conditions along the other two edges loaded with u. d. l. – Simply supported plates with moments distributed along the edges - Approximate Methods.

Effect of transverse shear deformation - plates of variable thickness – Anisotropic plates- thick plates- orthotropic plates and grids - Large Deflection theory .

Module 4 (12 hours)
Deformation of Shells without Bending:- Definitions and notation, shells in the form of a surface of revolution, displacements, unsymmetrical loading, spherical shell supported at isolated points, membrane theory of cylindrical shells, the use of stress function in calculating membrane forces of shells.

General Theory of Cylindrical Shells:- A circular cylindrical shell loaded symmetrically with respect to its axis, symmetrical deformation, pressure vessels, cylindrical tanks, thermal stresses, inextensional deformation, general case of deformation, cylindrical shells with supported edges, approximate investigation of the bending of cylindrical shells, the use of a strain and stress function, stress analysis of cylindrical roof shells.

References
1. S.P Timoshenko and S.W Krieger, Theory of Plates and Shells, McGraw Hill, 1989.
2. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall inc, 1974.
3. P.L Gould, Analysis of Shells and Plates, Springer-Verlag, New York, 1988.
4. H. Leipholz, *Theory of Elasticity*, Noordhoff International Publishers, Leyden, 1974.
5. A.C. Ugural, *Stresses in Plates and Shells*, Second Edition, McGraw Hill, Singapore, 1999.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields.
2. Use numerical techniques in solving special plate problems.
3. Address complex problems in plates and shells which require a rigorous mathematical background.
4. Identify different type of shells and analyse shell structures for the stress resultants leading to an optimal design.

CE6121 STRUCTURAL OPTIMISATION

Pre-requisite: - Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To acquaint students with the techniques of structural optimum problem formulations.
2. To familiarize with the principles of single variable and multi variable optimisation techniques.
3. To understand the basic principles of unconstrained and constrained optimisation techniques.
4. To expose the students to the various specialised optimisation techniques like linear programming, dynamic programming, geometric programming and genetic algorithm.

Module 1 (12 hours)

Introduction: Problem formulation with examples. Single Variable Unconstrained Optimisation Techniques: Optimality Criteria. Bracketing methods: Unrestricted search, Exhaustive search.
Region Elimination methods: Interval Halving methods, Dichotomous search, Fibonacci method, Golden section method. Interpolation methods: Quadratic Interpolation method, Cubic Interpolation method.
Gradient Based methods: Newton-Raphson method, Secant method, Bisection method.

Module 2 (12 hours)

Multi Variable Unconstrained Optimisation Techniques: Optimality Criteria. Unidirectional Search.
Direct Search methods: Random search, Grid search, Univariate method, Hooke's and Jeeves' pattern search method, Powell's conjugate direction method, Simplex method.
Gradient based methods: Cauchy's (Steepest descent) method, Conjugate gradient (Fletcher-Reeves) method, Newton's method, Variable metric (DFP)method, BFGS method.

Module 3 (11 hours)

Constrained Optimisation Techniques: Classical methods: Direct substitution method, Constrained variation method, method of Lagrange multipliers, Kuhn-Tucker conditions.
Linear programming problem: Standard form, Simplex method.
Indirect methods: Elimination of constraints, Transformation techniques, and Penalty function method.
Direct methods: Zoutendijk's method of feasible direction, Rosen's gradient Projection method.

Module 4 (10 hours)

Specialised Optimisation techniques: Dynamic programming, Geometric programming, Genetic Algorithms.

References

1. Rao S. S., Engineering Optimisation – Theory and Practice, New Age International, 1998.
2. Deb, K., Optimisation for Engineering Design – Algorithms and examples, Prentice Hall, 1995
3. Kirsch U., Optimum Structural Design, McGraw Hill, 1981.
4. Arora J S. Introduction to Optimum Design, McGraw Hill, 1989.
5. Rajeev S and Krishnamoorthy C. S., Discrete Optimisation of Structures using Genetic Algorithms, Journal of Structural Engineering, Vol. 118, No. 5, 1992, 1223-1250.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Distinguish different types of structural systems and to find the best concept design that meets the design requirement according to a preselected quantitative measure of effectiveness.

2. Exploit the available limited resources in a manner that maximises output and the structural performance in a manner that economises energy or minimise discomfort.
3. Select the best structural design from the large number of feasible designs in terms of minimum cost, minimum weight or maximum performance or combinations of these.
4. Analyse structures using optimisation techniques which replaces the time consuming and costly design iterations and hence reduces design development time and overall cost while improving design performance.

CE6122 MODELLING, SIMULATION AND COMPUTER APPLICATION

Prerequisite: -Nil.
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To numerically solve nonlinear equations using fixed point iteration and functional approximations method.
2. To use Finite Difference method to solve elliptic and parabolic equations.
3. To get familiarized with algebraic eigen value problems, integral equations, and Monte Carlo simulation methods

Module 1 (11 hours)
Numerical Solution of Nonlinear Equations - Fixed point iteration – Newton-Raphson method – Broyden's method

Functional Approximations: - Choice of norm and model – linear least squares – nonlinear least squares – discrete Fourier transform – fast Fourier transform – FFT in two or more dimensions – inversion of Laplace transform – Chebyshev approximations.

Module 2 (12 hours)
Finite Difference Method: - Elliptic equations – Laplace equation – solution techniques – boundary conditions – the control volume approach.

Parabolic equations – the heat conduction equation – explicit method – simple implicit method – parabolic equation in two spatial dimensions.

Module 3 (10 hours)
Algebraic Eigenvalue Problem: - Eigenvalue problem for a real symmetric matrix – inverse iteration – QL algorithm for a symmetric tridiagonal matrix – reduction of a general matrix to Hessenberg form – Lanczos method – QR algorithm for a real Hessenberg matrix – errors.

Integral Equations: - Fredholm equations of the second kind – expansion methods – eigenvalue problem – Fredholm equations of the first kind – Volterra equations of the second kind – Volterra equations of the first kind.

Module 4 (12 hours)
Simulation and Monte Carlo Methods
Random number generation – congruential generators – statistical tests of pseudorandom numbers.

Random variate generation – inverse transform method – composition method – acceptance-rejection method. Simulation of random vectors - inverse transform method – multivariate transform method – multinormal distribution. Simulation of stochastic fields – one-dimensional and multidimensional fields.

References

1. Antia, H.M., Numerical Methods for Scientists and Engineers, Tata McGraw Hill, 1991.
2. Chapra, S.C., and Canale, R.P., Numerical Methods for Engineers, Tata McGraw Hill, 2000.

3. Rubinstein, R.Y., Simulation and the Monte Carlo Method, John Wiley, 1982.
4. Press, W.H., et al., Numerical Recipes in C, Cambridge University Press, 1998.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Solve nonlinear equations.
2. Solve elliptic equations like Laplace equations and parabolic equations like heat conduction equations.
3. Solve algebraic eigenvalue problems
4. Introduced to important integral equations
5. Simulate random fields using Monte Carlo methods.

CE6124 ANALYTICAL DYNAMICS

Pre- requisite: - Nil
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the basics of Newtonian and analytical dynamics
2. To get familiarised with formulation and methods of solution of problems of dynamics of rigid bodies
3. To understand energy theorems and variational principles of mechanics

Module 1 (12 hours)

Fundamentals of Newtonian Mechanics: Newton's laws, impulse and momentum, angular momentum, work and energy, systems of particles.
Fundamentals of Analytical Mechanics**:** Degrees of freedom, generalised coordinates, systems with constraints, stationary value of a definite integral, principle of virtual work, D'Alembert's principle, Hamilton's principle, Lagrange's equations of motion, Lagrange's equations for impulsive forces, conservation laws, Routh's method for the ignoration of coordinates, Rayleigh's dissipation function, Hamilton's equations.

Module 2 (9 hours)

Motion Relative to Rotating Reference Frames: Transformation of coordinates, rotating coordinate systems, moving references.

Module 3 (12 hours)

Rigid Body Dynamics: Kinematics of a rigid body, linear and angular momentum of a rigid body, translation theorem for angular momentum, kinetic energy of a rigid body, Euler's equations of motion, Euler's angles, moment-free inertially symmetric body, general case of moment-free body, symmetric top, equations of motion referred to arbitrary system of axes.

Module 4 (12 hours)

Behaviour of Dynamical Systems: Motion of single degree of freedom autonomous systems about equilibrium points, limit cycle, stability of linear multi-degree of freedom autonomous systems, Routh-Hurwitz criterion, Liapunov direct method, geometric interpretation, construction of Liapunov function.

Introduction to Advanced Topics: Introduction to the following topics: non-autonomous systems, perturbation techniques, transformation theory, Hamilton-Jacobi equation.

References

1. Meirovitch, L., Methods of Analytical Dynamics, McGraw-Hill, 1970.
2. Goldstein, H., Poole, C., and Safko, J., Classical Mechanics, Third edition, Pearson Education Inc., 2002.
3. Torok, J.S., Analytical Mechanics with an Introduction to Dynamical Systems, John Wiley, New York, 2000.
4. Baruh, H., Analytical Dynamics, McGraw-Hill, New York, 1999.
5. Greenwood, D.T., Classical Dynamics, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.
6. Shames, I.H., Engineering Mechanics: Dynamics, Fourth Edition, Prentice-Hall of India, 1996.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Formulate problems of dynamics using differential equation approach and variational approach.
2. Solve engineering problems with mathematical rigour. Such solutions can act as bench-mark solutions for testing computational methods and software.
3. Appreciate energy theorems and variational principles of mechanics, the most beautiful areas of mechanics. This will make the registrant more enthusiastic, both in studies and in dealing with real-life problems.
4. Formulate numerical solutions to mechanics problems based on variational formulations.

CE6130 STRUCTURAL HEALTH MONITORING

L	T	P	Cr
3	0	0	3

Prerequisite: - Nil
Total Hours : 42

Course Objectives:

1. Familiarise modelling for damage and failure behaviour of structures.
2. To understand signals, data acquisition systems and sensors.
3. To acquire knowledge of diagnostic techniques.
4. To expose the stake holders in the areas of information technology for health monitoring.

Module 1 (9 hours)

Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.

Module 2 (12 hours)

Review of Signals, Systems and Data Acquisition Systems: Frequency and time domain representation of systems, Fourier/Laplace transforms, modelling from frequency response measurements, D/A and A/D converters, programming methods for data acquisition systems.

Sensors for Health Monitoring Systems: Acoustic emission sensors, ultrasonic sensors, piezoceramic sensors and actuators, fibre optic sensors and laser shearography techniques, imaging techniques.

Module 3 (12 hours)

Health Monitoring/Diagnostic Techniques: Vibration signature analysis, modal analysis, neural network-based classification techniques.

Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, Neural network classification techniques, extraction of features from measurements, training and simulation techniques, connectionist algorithms for anomaly detection, multiple damage detection, and case studies.

Module 4 (12 hours)

Information Technology for Health Monitoring: Information gathering, signal analysis, information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation.

Project Based Health Monitoring Techniques: Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multistorey buildings, condition monitoring of other types of structures.

References

1. Armer, G.S.T (Editor), Monitoring and assessment of structures, Spon, London, 2001.
2. Wu, Z.S. (Editor), Structured health monitoring and intelligent infrastructure, Volumes 1 and 2, Balkema, 2003.
3. Harris, C.M., Shock vibration handbook, McGraw-Hill, 2000.
4. Philip, W., Industrial sensors and applications for condition monitoring, MEP, 1994.
5. Rao, J.S., Vibratory condition monitoring of machines, Narosa Publishing House, India, 2000.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Distinguish different models for damage assessment.
2. Understand systems and sensors for health monitoring of structures.
3. Carry out different techniques for health monitoring of structures.
4. Make use of IT concepts for health monitoring of structures such as multi-storied building, bridges, etc.

CE6131 STRUCTURAL RELIABILITY

L	T	P	Cr
3	0	0	3

Pre-requisite :- Nil
Total Hours : 42

Course Objectives:

1. To highlight the importance of probabilistic structural analysis.
2. To review the basic theory of probability, random variables and probability distribution/density functions.
3. To identify different random variables those occur in nature and to know its probability structures.
4. To familiarize with basic structural reliability theory and different methods of computing the same.
5. Development of reliability based design criteria and optimal safety factors.
6. To introduce structural system reliability and its computation.

Module 1 (9 hours)

Concepts of structural safety. Basic Statistics: Introduction, data reduction. Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions.

Module 2 (10 hours)

Resistance distributions and parameters: Introduction, Statistics of properties of concrete, steel and other building materials, statistics of dimensional variations, characterization of variables, allowable stresses based on specified reliability. Probabilistic analysis of loads: gravity loads, wind loads.

Module 3 (13 hours)
Basic structural reliability: Introduction, computation of structural reliability.

Level 2 Reliability methods: Introduction, basic variables and failure surface, first order second moment methods (FOSM).

Reliability based design: Introduction, determination of partial safety factors, development of reliability based design criteria, optimal safety factors.

Module 4 (13 hours)
Monte Carlo study of structural safety: General, Monte Carlo method, applications.

Reliability of Structural system: Introduction, system reliability, modelling of structural systems, bounds of system reliability, reliability analysis of frames.

References

1. R. Ranganathan., Reliability Analysis and Design of Structures, Tata McGraw Hill, 1990.
2. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles, John Wiley & Sons, 1975.
3. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. II Decision, Risks and Reliability, John Wiley & Sons, 1984.
4. Benjamin, J.R & Cornell, C.A., Probability, Statistics and Decision for Engineers, McGraw-Hill, 1982.
5. H. O. Madsen, S. Krenk & N. C. Lind, Methods of Structural Safety, Prentice-Hall, 1986.
6. R. E. Melchers. Structural Reliability - Analysis and prediction, Ellis Horwood Ltd, 1987.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:
The student will be able to

1. Identify deterministic and random variables associated with structures and quantify the degree of randomness.
2. Perform reliability basic structural elements under different safety criterion.
3. Develop reliability based design criteria of any structure and determine optimal safety factors.
4. Perform system reliability analysis of simple structures.

CE6225 GEOGRAPHIC INFORMATION SYSTEMS AND APPLICATIONS

L	T	P	Cr
3	0	0	3

Prerequisite:- Nil
Total Hours : 42

Module 1 (11 hours)
Introduction:- Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projection – geo referencing - data acquisition.

Module 2 (12 hours)
Geographic Data Representation, Storage, Quality and Standards:- Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards.

Module 3 (12 hours)
GIS Data Processing, Analysis and Modelling:- Raster based GIS data processing – Vector based GIS data

processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modelling – DTM.

Module 4 (10 hours)
GIS Applications:- (in one of the following areas)
Applications of GIS in Environment monitoring – Natural hazard management – Natural resources management urban planning – utility management – Land information – Business development

References

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2002.
2. Reddy, A.M., Remote Sensing and Geographical Information Systems, B.S.Publications, Hyderabad, 2001.
3. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersy, 2001.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2000.
6. Geo Information Systems – Applications of GIS and Related Spatial Information Technologies, ASTER Publication Co., Chestern (England), 1992
7. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990
8. Marble, D.F., Galkhs HW & Pequest, Basic Readings in Geographic Information Systems, Sped System Ltd., New York, 1984.

CE6133 RANDOM VIBRATIONS

L	T	P	Cr
3	0	0	3

Pre-requisite: Stochastic Processes in Structural Mechanics
Total Hours : 42

Course Objectives:
1. To highlight importance of probabilistic analysis and stochastic dynamic analysis of structures.
2. To familiarize the stake holders with the basic probability concepts and basic theory of stochastic processes.
3. To acquire knowledge of various mathematical theories associated with stochastic processes which are essential for the stochastic dynamic analysis of structure and for finding important design properties of the stochastic processes.
4. To introduce different models of stochastic processes representing various physical phenomena that occurs in nature.

Module 1 (9 hours)
Basic Theory of Stochastic Processes (A review): Introduction, statistics of stochastic processes, ergodic processes, some properties of the correlation functions, spectral analysis, Wiener-Khintchine equation

Module 2 (13 hours)
Stochastic Response of Linear SDOF Systems: Deterministic dynamics, evaluation of impulse response function and frequency response function, impulse response function and frequency response function as Fourier Transform pairs, stochastic dynamics, response to stationary excitation, time domain analysis, frequency domain analysis, level crossing, peak, first passage time and other characteristics of the response of SDOF Systems

Module 3 (12 hours)
Linear systems with multiple inputs and outputs: Linear MDOF Systems, uncoupled modes of MDOF systems, stochastic response of linear MDOF Systems – time domain and frequency analysis.
Stochastic response of linear continuous system.

Module 4 (11 hours)

Response of non-linear systems to random excitation: Approach to problems, Fokker-Plank equation, statistical linearization, perturbation and Markov Vector Methods.
Fatigue damage of structure due to random loads.

References

1. Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.
2. Loren D Lutes & Shahram Sarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, NJ, 1997.
3. J Solnes, Stochastic Processes & Random Vibration, Theory and Practice, John Wiley,1997
4. Lin, Y. K., Probabilistic Theory in Structural Dynamics, McGraw Hill, 1972.
5. Bendat & Piesol., Random Data Analysis and Measurement Procedure, John Wiley, 1991.
6. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, 1986.
7. Papoulis, A., Probability, Random Variables and Stochastic Processes, McGraw Hill, 1991.
8. Clough, R.W., and Penzien, J., Dynamics of Structures, McGraw Hill, 1993.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Distinguish deterministic and random variables associated with structural analysis and response.
2. Quantify the randomness or uncertainties in the variables associated with structural analysis and response.
3. Model different physical phenomena by appropriate stochastic processes.
4. Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage.

CE6134 ENGINEERING FRACTURE MECHANICS

Prerequisite: A course on Theory of Elasticity
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the basic principles of Fracture Mechanics
2. To familiarize with the concepts of Linear Elastic Fracture Mechanics (LEFM)
3. To incorporate the effects of plasticity at the tip of cracks
4. To use Energy Balance Approach, J-integral and Crack opening displacement (COD) approach to solve practical problems.
5. To get familiarized with the experimental methods for LEFM
6. To incorporate the effects of fatigue using stress intensity factor (SIF)

Module (11 hours)

Introduction:- Significance of fracture mechanics, Griffith energy balance approach, Irwin's modification to the Griffith theory, Stress intensity approach, Crack tip plasticity, Fracture toughness, sub-critical crack growth, Influence of material behaviour, I, II & III modes, Mixed mode problems.

Linear Elastic Fracture Mechanics (LEFM):- Elastic stress field approach, Mode I elastic stress field equations, Expressions for stresses and strains in the crack tip region, Finite specimen width, Superposition of stress intensity factors (SIF), SIF solutions for well known problems such as centre cracked plate, single edge notched plate and embedded elliptical cracks.

Module 2 (12 hours)

Crack Tip Plasticity:- Irwin plastic zone size, Dugdale approach, Shape of plastic zone, State of stress in the crack tip region, Influence of stress state on fracture behaviour.

Energy Balance approach:- Griffith energy balance approach, Relations for practical use, Determination of SIF from compliance, Slow stable crack growth and R-curve concept, Description of crack resistance.

LEFM Testing:- Plane strain and plane stress fracture toughness testing, Determination of R-curves, Effects of yield strength and specimen thickness on fracture toughness, Practical use of fracture toughness and R-curve data.

Module 3 (10 hours)

Elastic Plastic Fracture Mechanics (EPFM):- Development of EPFM, J-integral, Crack opening displacement (COD) approach, COD design curve, Relation between J and COD, Tearing modulus concept, Standard J_{Ic} test and COD test.

Fatigue Crack Growth:- Description of fatigue crack growth using stress intensity factor, Effects of stress ratio and crack tip plasticity – crack closure, Prediction of fatigue crack growth under constant amplitude and variable amplitude loading, Fatigue crack growth from notches – the short crack problem.

Module 4 (10 hours)

Sustained Load Fracture:- Time-to-failure (TTF) tests, Crack growth rate testing, Experimental problems, Method of predicting failure of a structural component, Practical significance of sustained load fracture testing.

Practical Problems:- Through cracks emanating from holes, Corner cracks at holes, Cracks approaching holes, fracture toughness of weldments, Service failure analysis, applications in pressure vessels, pipelines and stiffened sheet structures.

Text Book:

References

1. Broek, D. Elementary Engineering Fracture Mechanics, Sijthoff & Noordhoff Int. Pub., 1988.
2. Broek, D. The Practical Use of Fracture Mechanics, Kluwer Academic Pub., 1990.
3. Ewalds, H.L. & Wanhill, R.J.H., Fracture Mechanics – Edward Arnold Edition
4. Hellan, D. Introduction to Fracture Mechanics, McGraw Hill Book Company, 1985.
5. Kumar, P. Elements of Fracture Mechanics, Wheeler Publishing, 1998.
6. Simha, K.R.Y. Fracture Mechanics for Modern Engineering Design, University Press, 1996.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Solve problems of fracture mechanics using Energy approach, SIF, J-integral approach and COD approach.
2. Analyse problems involving fatigue.
3. Solve practical problems like Service failure analysis, applications in pressure vessels, pipelines, stiffened sheet structures, etc.

CE6136 DESIGN OF PLATED STRUCTURES AND SHELLS

L	T	P	Cr
3	0	0	3

Prerequisite: -Nil
Total Hours : 42

Course Objectives:

1. To understand the classical theory and background mathematics of plates and shells.
2. To get exposed to different type of plate problems and the numerical solution techniques to obtain their behavior.
3. To get familiarity with the approximate methods for plate problems.
4. To learn the theoretical background of orthotropic plates and plate stability problems.
5. To understand the geometry and behavior of shells and obtain solutions to practical problems.

Module 1 (12 hours)

Cylindrical bending of plates – laterally loaded circular plates – artificial systems of equilibrium – uniformly loaded core with simple and fixed boundary conditions.

Laterally loaded rectangular plate – differential equations – boundary conditions – Navier solution for simply supported plates subjected to uniform and point loads – Levy's method

Module 2 (12 hours)

Approximate methods of solution of plates – Rayleigh-Ritz method – Galerkin's method – finite difference method

Orthotropic plates – stiffened plates – stability of plates – design of plated structures.

Module 3 (12 hours)

Stressed skin surfaces – types – cylindrical shells thin shells – membrane theory – bending theory – theories due to Finster-Welder and Schorer – shells of revolution – membrane theory – paraboloid of revolution – analysis using polynomial stress function – hyperbolic paraboloids – rectangular hyperbolic paraboloid.

Module 4 (9 hours)

Stiffened cylindrical shells – design curves for pressure hull buckling of cylindrical shells

References

1. S.P Timoshenko and S.W Krieger, Theory of Plates and Shells, McGraw Hill, 1989.
2. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall inc, 1974.
3. P.L Gould, Analysis of Shells and Plates, Springer-Verlag, New York, 1988.
4. H. Leipholz, *Theory of Elasticity*, Noordhoff International Publishers, Leyden, 1974.
5. A.C. Ugural, *Stresses in Plates and Shells*, Second Edition, McGraw Hill, Singapore, 1999.
6. W. Flugge, Stresses in Shells, Stringer- Verlag
7. Ramaswamy, G.S, Design and Construction of Concrete Shell Roofs, Tata McGraw Hill.

Assessment Methods:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields.
2. Use numerical techniques in solving special plate problems.

3. Able to use approximate methods for the solution of plate problems.
4. Identify different type of shells, analyse and design shell structures for the stress resultants leading to an optimal design.
5. Confidently design special structures using shells combining aesthetics and cost effectiveness.

CE6138 ADVANCED FINITE ELEMENT ANALYSIS

L	T	P	Cr
3	0	0	3

Prerequisite: A basic course on Finite Element Analysis

Total Hours : 42

Course Objectives:

1. To develop element stiffness matrix of shell elements.
2. To get familiarised with error estimates and convergence in finite element method of analysis.
3. To apply finite element method in structural dynamics and vibration problems.
4. To get familiarised with various modelling consideration and software use.
5. To introduce finite element method for solving non-linear problems.

Module 1 (12 hours)

Plate Bending: Plate behaviour, Kirchhoff and Mindlin plate elements, boundary conditions.

Shells: Shells of revolution, general shells, three- and four-noded shell elements, curved isoparametric elements.

Module 2 (9 hours)

Error, Error Estimation and Convergence: Sources of error, ill-conditioning, condition number, diagonal decay test, discretisation error, multimesh extrapolation, mesh revision methods, gradient recovery and smoothing, a-posteriori error estimate, adaptive meshing.

Constraints**,** Penalty Forms, Locking and Constraint Counting: Explicit constraints, transformation equations, Lagrange multipliers, penalty functions, implicit penalty constraints and locking, constraint counting, modelling incompressible solids.

Module 3 (12 hours)

Finite Elements in Structural Dynamics and Vibrations: Dynamic equations, mass and damping matrices, consistent and lumped mass, natural frequencies and modes, reduction of the number of degrees of freedom, modal analysis, Ritz vectors, harmonic response, direct integration methods, explicit and implicit methods, stability and accuracy, analysis by response spectra.

Modelling Considerations and Software Use: Physical behaviour versus element behaviour, element shapes and interconnections, test cases and pilot studies, material properties, loads and reactions, connections, boundary conditions, substructures, common mistakes, checking the model, critique of computed results.

Module 4 (12 hours)

Introduction to Nonlinear Problems: Nonlinear problems and some solution methods, geometric and material nonlinearity, problems of gaps and contacts, geometric nonlinearity, modelling considerations.

Stress Stiffening and Buckling: Stress stiffness matrices for beam, bar and plate elements, a general formulation for $[k_\sigma]$, bifurcation buckling, remarks on $[k_\sigma]$, its use, and on buckling and buckling analysis.

Reference:

1. Cook, R.D., et al, Concepts and Applications of Finite Element Analysis, Fourth Edition, John Wiley & Sons Inc., Singapore, 2003.
2. Desai, C.S., and Kundu, T., Introductory Finite Element Method, CRC Press, London, 2001
3. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1996.
4. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, Mc Graw Hill, 1991.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Develop element stiffness matrix of shell elements.
2. Carry out error estimates and convergence study in finite element method of analysis.
3. Apply finite element method in structural dynamics and vibration problems.
4. Study various modelling consideration and software use.
5. Solve non-linear problems using finite element method.

CE6139 ADVANCED THEORY OF SHELLS

Prerequisite: A course on Theory of Elasticity
Total Hours : 42

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand the general shell theory and advanced topics in the analysis of shells.
2. To carry out a detailed study of membrane theory for shells of revolution.
3. To learn the geometry of shells of revolution in detail and obtain the solutions for general problems.
4. To learn the beam theory for cylindrical shells, circular shells and shallow shells.

Module 1 (9 hours)

General Properties of Stress Systems in Shells: Stress resultants, membrane forces, membrane forces in arbitrary directions, rectangular coordinates, oblique coordinates and skew forces, transformation of moments.

Module 2 (12 hours)

Direct Stresses in Shells of Revolution: General differential equations, equilibrium of shell element, axisymmetric loads, spherical dome, pressure vessel, pointed shells, toroidal shells, conical shells, shells of constant strength.

Loads without axial symmetry, spherical shell, distributed load, edge load, concentrated forces, couples.

Solution for shells of arbitrary shape, solution by an auxiliary variable, solution by numerical integration, shell formed as a one-sheet hyperboloid.

Deformation, strains and displacements, inextensional deformation, differential equation, finite solution for spherical shell, solution for arbitrary shape of meridian, toroidal shell, strain energy.

Module 3 (12 hours)

Direct Stresses in Cylindrical Shells: Statically determinate problems, general theory, tubes and pipes, barrel vault, deformation, differential equations, Fourier solution for circular cylinder, statically indeterminate structures.

Polygonal domes, folded plate structures.

Direct Stresses in Shells of Arbitrary Shape: Conditions of equilibrium, elliptic problems, paraboloid of revolution, triangular shell, elliptic paraboloid, solution by relaxation method, hyperbolic problems.

Membrane forces in affine shells, general theory, applications, deformation.

Module 4 (12 hours)

Bending of Circular Cylindrical Shells: Differential equations, equilibrium, deformation, differential equations for the displacements.

Solution of the inhomogeneous problem, loads applied to the edges x = constant, loads applied to the edges phi = constant, exact solution, barrel vaults, simplified theory, examples.

Cylindrical tanks and related problems, anisotropic shells, folded plate structures.

Bending stresses in shells of revolution.

References

1. Flügge, W., Stresses in Shells, Springer-Verlag, 1960.
2. Novozhilov, V.,V., Thin Shell Theory, Noordhoff, Groningen 1964.
3. Gould, P. L., Analysis of Shells and Plates, Springer-Verlag, New York 1988.
4. A.C. Ugural, *Stresses in Plates and Shells*, Second Edition, McGraw Hill, Singapore, 1999.

Assessment Methods:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Deal with the advanced topics in the analysis of shells.
2. Apply the concepts of membrane theory for all types of shells of revolution.
3. Able to appreciate all kinds of geometry of shells or revolution and will be able to analyse such shells.
4. Apply beam theory for varieties of geometries including cylindrical, circular and shallow shells.

CE6140 THEORY OF PLASTICITY

L	T	P	Cr
3	0	0	3

Pre-requisite: A course on Theory of Elasticity
Total Hours : 42

Course Objectives:

1. To review basic equations of theory of elasticity and introduce framework of plasticity.
2. To get familiarised with yield surfaces for polycrystalline metals and plastic behaviour under plane stress conditions.
3. To study plastic behaviour of one dimensional structures.
4. To understand limit analysis of bodies in plane stress and plane strain conditions.

Module 1 (12 hours)

Preliminaries: Basic equations of theory of elasticity:- Index notation, equations of equilibrium, constitutive relations for isotropic bodies, strain-displacement relations, compatibility, displacement and traction boundary conditions, admissibility of displacement and stress fields, plane stress and plane strain problems.

Framework of Plastic Constitutive Relations:- Plastic behaviour in simple tension, generalisation of results in simple tension, yield surfaces, uniqueness and stability postulates, convexity of yield surface and normality rule, limit surfaces.

Module 2 (13 hours)

Initial Yield Surfaces for Polycrystalline Metals:- Summary of general form of plastic constitutive equations, hydrostatic stress states and plastic volume change in metals, shear stress on a plane, the von Mises initial yield condition, the Tresca initial yield condition, consequences of isotropy.

Plastic Behaviour under Plane Stress Conditions:- Initial and subsequent yield surfaces in tension-torsion, the isotropic hardening model, the kinematic hardening model, yield surfaces made of two or more yield functions, piecewise linear yield surfaces, elastic perfectly plastic materials.

Module 3 (11 hours)

Plastic Behaviour of Bar Structures:- Behaviour of a three bar truss, behaviour of a beam in pure bending, simply supported beam subjected to a central point load, fixed beams of an elastic perfectly plastic material, combined bending and axial force.

The Theorems of Limit Analysis: Introduction, theorems of limit analysis, alternative statement of the limit theorems, the specific dissipation function.

Module 4 (9 hours)

Limit Analysis in Plane Stress and Plane Strain:- Discontinuities in stress and velocity fields, the Tresca yield condition in plane stress and plane strain, symmetrical internal and external notches in a rectangular bar, the punch problem in plane strain, remarks on friction.

Limit Analysis as a Programming Problem:- Restatement of limit theorems, application to trusses and beams, use of finite elements in programming problem, incremental methods of determining limit load.

References

1 Martin, J.B., Plasticity: Fundamentals and General Results, MIT Press, London, 1988.

2 Kachanov, L.M., Fundamentals of the Theory of Plasticity, Mir Publishers, Moscow. 1981.

3 Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York, 1998.

4 Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1981.

5 Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1988.

Method of Assessment:

Continuous Assessment : 50 Marks
(Test 1: 15/20; Test 2: 25/20; Assignments/Tutorials etc: 10)
End Semester Examination : 50 Marks

Course Outcomes:

The student will be able to

1. Understand Constitutive Relations of a material under plastic state.
2. Understand different failure theories and plastic behaviour of metals under plane stress condition.
3. Cary out plastic analysis of bars under tension and bars under flexure.
4. Carry out limit analysis of bodies in plane stress and plane strain conditions.
5. Carry out limit analysis of trusses and beams, apply finite elements limit analysis problem, and incremental methods of determining limit load.

CE7398/CE7399 Project

Course Objectives:

1. To formulate a focussed offshore engineering research question that can be investigated within the normally available time period for the project work.
2. To conduct an extensive literature survey on the problem selected and to identify the scope and objective(s) of the work and to formulate the methodology.
3. To plan and design a suitable experimental/ analytical procedure, obtain data, perform analysis, interpret the results obtained with appropriate methods/ tools and derive conclusions.
4. To draft research reports, power point presentations, technical papers etc.

Course Outcomes:

The student will be able to

1. Develop personal, organisational, management, theoretical and research skills that will help the student to develop into an independent researcher
2. Demonstrate a degree of analysis and a degree of originality in advanced investigations.

3. Develop understanding of research philosophies, design and terminology as well as interpersonal skills.
4. Describe a process that has previously been unexplained, poorly/ partially understood and to conduct an active, systematic process of inquiry.
5. Prepare professional documentation of the research work performed.