CURRICULUM AND SYLLABI

M.Tech.

in

OFFSHORE STRUCTURES

(With effect from Academic Year 2018-2019)

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

CALICUT - 673601

Programme Educational Objectives

1. To train students for productive careers where they 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. 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 various careers of offshore structural engineering field of Civil Engineering both at the National / International level.
3. 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.
4. To train the students in the use of various modelling, programming and software skills.
5. Provide expertise in laboratory and experimental work.
6. Help the students to develop teaching skills through regular teaching assistance.
7. Prepare the students to face challenges in industry by encouraging interaction with industry, carrying out industry based projects, involving them in consultancy projects etc.
8. Enrich the students with strong communication and technical writing skills.

Programme Outcomes

1. Post-Graduates will develop confidence in taking up research and teaching as a profession.
2. Post-Graduates will attain ability to identify, formulate and solve complex problems related to Offshore Engineering field.
3. Post-Graduates will understand the impact of engineering solutions on the society and will also be aware of the environmental aspects and sustainability issues related to infrastructure development of the country.
4. Post-Graduates will be able to conduct investigations of complex problems in Offshore Engineering using research based knowledge and tests/experiments.
5. Post-Graduates will exhibit skills to use modern engineering tools, software and equipment to analyse various problems in the Offshore Engineering domain.
6. Post-Graduates will be able to communicate effectively both verbally and written forms.
7. Post-Graduates will develop confidence to face newer challenges in Industry.
8. Post-Graduates will develop confidence for self-education and ability for life-long learning.

Department of Civil Engineering

Curriculum for M.Tech.in Offshore Structures

Semester 1

Sl No.	Code	Title	L	T	P/S	C
1	CE6301D	Wave Hydrodynamics	3	0	0	3
2	CE6302D	Stochastic Processes in Structural Mechanics	3	0	0	3
3	CE6303D	Design of Offshore Structures	3	0	0	3
4	CE6391D	Offshore Engineering Lab	0	0	2	1
5	******D	Elective	3	0	0	3
6	******D	Elective	3	0	0	3
	Total Credits – 10 (Core) + 6 (Electives)					

Semester 2

Sl No.	Code	Title	L	T	P/S	C
1	CE6311D	Modelling and Behaviour of Offshore Structures	3	0	0	3
2	CE6312D	Marine Foundations	3	0	0	3
3	CE6313D	Stability of Structures	3	0	0	3
4	CE6393D	Offshore Structures Design Studio	0	0	2	1
5	CE6397D	Seminar	0	0	2	1
6	******D	Elective	3	0	0	3
7	******D	Elective	3	0	0	3
8	******D	Elective	3	0	0	3
	Total Credits – 11 (Core) + 9 (Electives)					

Semester 3

Sl No.	Code	Title	L	T	P/S	C
1	CE7398D	Project – Part 1			20	10
	Total Credits – 10 (Core)					

Semester 4

Sl No.	Code	Title	L	T	P/S	C
1	CE7399D	Project – Part 2			28	14
	Total Credits – 14 (Core)					

LIST OF ELECTIVES

Sl No.	Code	Title	Credits
1	CE6321D	Ship Hydrodynamics	3
2	CE6322D	Advanced Wave Hydrodynamics	3
3	CE6323D	Dynamics of Floating Bodies	3
4	CE6324D	Coastal Engineering	3
5	CE6325D	Offshore Pipeline Design and Installation	3
6	CE6326D	Reliability Engineering and asset Risk Management	3
7	CE6327D	Offshore Renewable Energy and Technology	3
8	CE6328D	Hazard Mitigation Management	3
9	CE6101D	Theory of Elasticity and Plasticity	3
10	CE6102D	Structural Dynamics	3
11	CE6111D	Finite Element Method	3
12	CE6111D	Theory of Plates and Shells	3
13	CE6121D	Structural Optimisation	3
14	CE6122D	Modelling, Simulation and Computer Applications	3
15	CE6123D	Earthquake Analysis and Design of Structures	3
16	CE6124D	Analytical Dynamics	3
17	CE6127D	Forensic Engineering and Rehabilitation of Structures	3
18	CE6128D	Multi-body Dynamics and Applications	3
19	CE6130D	Structural Health Monitoring	3
20	CE6131D	Structural Reliability	3
21	CE6133D	Random Vibrations	3
22	CE6134D	Engineering Fracture Mechanics	3
23	CE6135D	Advanced Prestressed Concrete Design	3
24	CE6136D	Design of Plated Structures and Shells	3
25	CE6137D	Mechanics of Composite Structures	3
26	CE6138D	Advanced Finite Element Analysis	3
27	CE6139D	Advanced Theory of Shells	3
28	CE6140D	Theory of Plasticity	3
29	CE6221D	Geographic Information System and Application	3
30	CE6421D	Advanced Design of Foundations	3

Notes:

1. A minimum of 60 credits have to be earned for the award of M. Tech Degree in this Programme.
2. Students have to credit five electives in first two semesters. Communicative English and Audit courses are optional.
3. Industrial Training during summer is optional.

CE6301DWAVE HYDRODYNAMICS

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total hours: 39
Course Outcomes:

CO1. Establish a classical fluid mechanics knowledge base on fundamental principles.

CO2. Acquire knowledge on the generation of wind waves, various water wave theories of small amplitude, finite amplitude wave and higher order waves, regimes of application of wave theories and wave transformation in shoaling water and wave breaking.

CO3. Develop knowledge on random process and model the seaway using deterministic and probabilistic approximations.

CO4.Application of various methods of computation of wave force on small and large structures, wave force on pipelines, sea walls and breakwater.

Module 1 (8 hours)

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 (8 hours)

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 water depth- Orbital motions and pressure- Standing waves- Wave trains and wave energy- Wave reflection, refraction and diffraction- Breaking waves.

Module 3 (8 hours)

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 and long term wave statistics.

Module 4 (15 hours)

Wave forces- Morison Equation- Wave force on a circular cylinder- Vertical, inclined and oscillating-Wave force on submergedpipelines- 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. Dean, R.G., and Darlymple, R.A., Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing,2007.
2. Leo H Holthuijsen, Waves in Oceanic and Coastal Waters, Cambridge University Press, 2007.
3. Robert T. Hudspeth, Waves and Wave Forces on Coastal and Ocean structures, 2006.
4. USACE, Shore Protection Manual, 2002.
5. Chakrabarti, S.K., Hydrodynamics of Offshore Structures, Springer Verlag, 1987.
6. Ippen, A. T., Estuary and Coastline Hydrodynamics, McGraw Hill, Inc.1982.
7. Sarpkaya, T., and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand, 1981
8. Kinsman, B., Wind Waves, Prentice Hall, Inc, 1965.

CE6302D STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish deterministic and random variables associated with structural analysis and response.
CO2: Quantify the randomness or uncertainties in the variables associated with structural analysis and response.
CO3: Model different physical phenomena by appropriate stochastic processes.
CO4: Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage.

Module 1 (9 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 (9 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 (11 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 (10 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 &ShahramSarkani., 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.

CE6303D DESIGN OF OFFSHORE STRUCTURES

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Acquire knowledge and skills to carry out basic tasks regarding dimensioning and structural design of offshore structures.

CO2. Estimation of maximum forces on an offshore structure due to operational loads and conduct static and dynamic analyses of fixed platforms.

CO3. Acquire training in the design of jacket platforms, tubular joints and concrete gravity platforms.

CO4. Estimate the resistance of platforms against fatigue and accidental loads.

CO5. Attain knowledge in the physics of corrosion and methods to monitor and prevent corrosion.

Module 1 (7 hours)

Types of offshore structures and their conceptual development- Fixed, Compliant, Floating-Analytical models for offshore structures- Behaviour under static and dynamic loads- Materials and construction of jacket and gravity platforms- Statutory regulations- Allowable stresses- Design methods and Code Provisions- Design specification of API, DNV, Lloyd's and other Classification Societies.

Module 2 (12 hours)

Environmental loads- Wind, wave, current and ice loads- Calculation based on maximum base shear and overturning moments- Design wave height and spectral definition- 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- Principles of WSD and LRFD- Allowable stresses and partial safety factors- Design of structural elements.

Module 3 (12 hours)

Introduction to tubular members- Slenderness effect- Column buckling-Tubular joints- Possible modes of failure, Eccentric connections and offset connections-Cylindrical and rectangular structural members- Inplane and multi plane connections- Parameters of inplane 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 (8 hours)

Design against accidental loads- Fire, Blast and Collision- Behaviour of steel at elevated temperature-Fire rating for Hydrocarbon fire- Design of structures for high temperature- Blast mitigation-Blast walls- Collision of boats and energy absorption.

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. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
2. DNV-RP-C203- fatigue Design of Offshore Steel Structures, 2011.
3. DNV-RP-C204- Design Against Accidental Loads, 2010.
4. DNV-RP-B101-Corrosion Protection of Floating Protection and Storage Units, 2007.
5. API RP 2A. Planning, Designing and Constructing Fixed Offshore Platforms, API. 2000.
6. B.C Gerwick, Jr. Construction of Marine and Offshore Structures, CRC Press, Florida, 2000.
7. Clauss, G, Lehmann, E &Ostergaard, C, Offshore Structures, Vol. 1 & 2, Springer-Verlag, 1992.
8. Reddy, D. V and Arockiasamy, M., Offshore Structures Vol.1 & 2, Kreiger Publ. Co.1991.
9. Morgan, N., Marine Technology Reference Book, Butterworths, 1990.
10. McClelland, B and Reifel, M. D., Planning and Design of fixed Offshore Platforms, Van Nostrand, 1986.
11. Dawson, T. H., Offshore Structural Engineering, Prentice Hall, 1983.
12. Graff, W. J., Introduction to Offshore Structures, Gulf Publ. Co.1981.

CE6391D OFFSHORE ENGINEERING LAB

L	T	P	C
0	0	2	1

Prerequisite: Nil
Total hours: 39
Course Outcomes:

CO1. Acquire training in the use of various transducers and pickups for static and dynamic measurements in ocean engineering.
CO2. Develop knowledge in data transmission and analysis using DACs
CO3. Demonstrate ocean wave modelling, measurement of regular and random waves, wave force measurements on cylinders, wave-current-structure interaction.
CO4. Measurement of response of fixed and floating structures.

List of Experiments:

1. Ocean wave modelling-Modelling criteria-Modelling laws
2. Use of various transducers and pickups for static and dynamic measurements in ocean engineering- Data transmission and analysis using DACs
3. Calibration of instruments for the measurement of waves
4. Measurement of regular and random waves
5. Measurement of reflectivity and transmissivity
6. Wave force measurements on cylinders
7. Wave-current-structure interaction studies
8. Motion study on floating bodies

References

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

CE6311D MODELLING AND BEHAVIOUR OF OFFSHORE STRUCTURES

Prerequisite: Structural Dynamics
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Identify the types of offshore structures, parameters governing solid-fluid interaction and environmental forces acting on offshore structures.

CO2. Acquire training in the response analysis of offshore structures – single and multi-degree of freedom problems, frequency and time domain analyses.

CO3. Evaluate the stability of submerged and floating structures.

CO4. Assess the mooring line forces, wave drift and springing forces.

Module 1 (6 hours)

Classification of offshore structures- Dynamic characteristics and water depth capability of offshore structures- Environmental forces- Buoyancy and gravity-Solid fluid interaction parameters- Added mass and damping- Effect of viscosity on damping- Spring factor.

Module 2 (14 hours)

Modelling of offshore structures-.Single and multi-degree freedom systems- Dynamic amplification factor- Response of offshore structures- Coupled and uncoupled motions- Frequency domain analysis- Time domain analysis- New Mark-Beta method- Wilson θ method- Response analysis of fixed platforms- Response analysis of compliant platforms.

Module 3 (14 hours)

Floating and submerged bodies- Intact and dynamic stability- Stability at small and large angles- hydrodynamic analysis- Diffraction and radiation problems- Added mass-Damping- Wave exciting force- Strip theory- Response analysis of floating bodies- Tension Leg Platforms- Semi submersibles- Floating vessels- Static and dynamic analysis of Mooring lines.

Module 4 (5 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. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
2. Wilson, J. F., Dynamics of Offshore Structures, John Wiley, 2002.
3. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science Publications, 2002.
4. Clauss, G, Lehmann, E &Ostergaard, C., Offshore structures – Vol. 1 & 2, Springer-Verlag, 1992.
5. Patel, M.H., Compliant Offshore Structures, Butterworth Heinemann Ltd., Oxford, 1991.
6. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
7. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
8. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978.

CE6312D MARINE FOUNDATIONS

Prerequisite: Nil
Total hours:39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Introduce the students to the relevance of marine geotechnical engineering
CO2. Exposure to different types of marine sediments and their properties
CO3. Study the behaviour of marine deposits under static and cyclic loading conditions
CO4. To know the different methods/techniques adopted for offshore soil investigations
CO5. To understand the typical foundations for the different type of offshore structures
CO6. To expose the students to partial design of typical offshore foundation components
CO7. To provide an overall picture of foundations for ancillary offshore facilities.

Module 1 (12 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 subcontinent.

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 (8 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 (9 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 andDemars, K. R., Strength Testing of Marine Sediments - Laboratory and In-situ Measurements, ASTM, STP -883, 1985.
3. Poulos, H. G and Davis, E. H., Pile Foundation Analysis and Design, John Wiley, 1980.
4. Numerical Methods in offshore Piling, Proc. Conf. Inst. of Civil Engineers, London, 1980.
5. Le Tirant, Sea Bed Reconnaissance and Offshore Soil Mechanics for the Installation of Petroleum Structures, Gulf Publ. Co., 1979.
6. George, P and Wood, D, Offshore Soil Mechanics, Cambridge University Press, 1976.

CE6313D STABILITY OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39
Course Outcomes

L	T	P	C
3	0	0	3

CO1; Identify structures or structural elements where stability analysis is very relevant.
CO2: Perform stability analysis of beam-columns and design them.
CO3: Carryout stability analysis of bars/columns and simple frames and determine safe load.
CO4: Perform stability analysis of thin walled sections, beams undergoing lateral buckling, plated and shell structure.

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 (11 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 (9 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 (9 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 Ibeams. 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.

CE6393D OFFSHORE STRUCTURES DESIGN STUDIO

L	T	P	C
0	0	2	1

Prerequisite: Design of Offshore Structures, Dynamics of Floating Bodies, Modelling and Behaviour of Offshore Structures.

Total hours: 39

Course Outcomes:

CO1. Acquire training on the design of jacket platforms, compliant towers and floating platforms.
CO2. Evaluation of forces in mooring lines and offshore pipelines
CO3. Perform design of offshore structures.

Module 1 (12 hours)

Design of Jacket platforms- Deck framings, plating etc.- Design of deck- Supporting legs-braces- Design of deck legs, Design of platform derricks. (Using SACS software)

Module 2 (6 hours)

Stability analysis of floating bodies- Response analysis using strip theory and panel method

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.

Module 4 (11 hours)

Design of compliant towers- Articulated towers- Guyed towers- Cylindrical buoys- Single pointmoored buoy systems- Statics of mooring lines without and with elasticity- Dynamics of mooring lines-Design of mooring cables- Modelling and analysis of offshore floating platform using ANSYS.

References:

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

CE6397D SEMINAR

L	T	P	C
0	0	2	1

Prerequisite: Nil
Total hours: 28

Course Outcomes:

CO1. Identify and understand typical practical problems in the field of Offshore Engineering.
CO2. Compile the current research and field applications in Offshore Engineering.
CO3. Make a detailed presentation on the same.

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.

CE 7398D: PROJECT – PART 1

L	T	P	C
0	0	20	10

Pre – requisite - Nil

A student should have registered for all theory and laboratory courses in the first and second semester of the programme and secured a grade other than 'W'

The primary objective of the course 'Project' is to introduce the students to various sub-fields in Offshore Structures. It is aimed at exposing the students to current development and research activities in the above mentioned fields. The students are also trained to gather in-depth information on specified areas or topics. The students are made proficient to make proper technical documentation on the selected topic. Moreover, the course would also provide training to students to make effective technical presentations.

CE 7499D PROJECT – PART 2

Pre-requisite - **CE 7398D: PROJECT – PART 1**

L	T	P	C
0	0	28	14

This course is a continuation of the work initiated in third semester and the student is expected to submit a consolidated report of the work undertaken in the third and fourth semester, at the end of the fourth semester.

CE6321D SHIP HYDRODYNAMICS

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total hours: 39
Course Outcomes:

CO1. Compile the hull forms of ships and boats and effect of vessels on waves
CO2. Evaluate the stability of ships
CO3. Estimate the response of vessels to wave excitation and stability
CO4. Assess motion stability

Module 1 (10 hours)

Sea environment- Waves on the sea surface- Statistical description of waves- Wind- Current- Types of marine vehicles- Naval Architectural drawings and plans- Ship line plans- Introduction to the development of ship line plans- 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-Roll excitation- Influence of speed and headings.

Module 4 (5 hours)

Motion stabilisation- Roll stabilisation- Pitch stabilisation- Effectiveness of motion stabilisation- Manoeuvring

References:

1. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
2. Anthony F. Molland, The maritime engineering reference book, Elsevier, 2008.
3. Faltinsen, Sea loads on ships and offshore structures, Cambridge University Press- Cambridge, 1993.
4. Bishop and Price, Hydro elasticity of ships, Cambridge University Press, Cambridge, 1979.
5. Bhattacharya, R., Dynamics of marine vehicles, A Wiley Interscience Publication- John Wiley, 1978.
6. Comstock, Principles of Naval Architecture, New York: Society of Naval Architects and MarineEngineers, 1967.

CE6322 ADVANCED WAVE HYDRODYNAMICS

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total hours: 39
Course Objectives:

CO1. To review basic concepts of probability, statistics and random processes.
CO2. To understand the spectral representation of ocean wave data.
CO3. To compute hydrodynamic forces exerted by random waves and estimate extreme waves.
CO4. To analyse multidirectional waves

Module 1 (5 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 (8 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 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 (14 hours)

Random wave forces- Morison equation with arbitrary wave spectrum and with narrow band wave spectrum- Estimation of force coefficients- Effect of wave non-linearity- Random forces on large bodies- Long term force distribution- Introduction to analysis of multidirectional waves.

Course Outcomes:

1. Estimate the spectral characteristics of ocean waves and transformation of spectra
2. Calculation of extreme waves and design wave
3. Computation of random wave forces and estimation of force coefficients
4. Analysis of multidirectional waves

References:

1. Goda, Y, Random Seas and Design of Maritime Structures, John Wiley and Sons, 2010.
2. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science Publications, 2002.
3. Bendat, J.S, Piersol, A.G., Random Data: Analysis and Measurement Procedures, John Wiley, 2000.
4. Newland, D. E., Introduction to Random Vibrations and Spectral and Wavelet Analysis, Prentice Hall, 1993.
5. Davenport, An Introduction to the Theory of Random Signals and Noise, Wiley IEEE Press, 1987.
6. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
7. Sarpkaya, T. and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand, 1981.
8. Kinsman, B., Wind Waves, Prentice Hall, Inc.1965.

CE6323D DYNAMICS OF FLOATING BODIES

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Evaluate the response of floating bodies.
CO2. Estimate the behaviour of systems with time dependent characteristics.
CO3. Identify station keeping and dynamic positioning.
CO4. Apply Non-linear dynamics and examine the instability of floating structures.

Module 1 (12 hours)

Linearized equation of motion for a constrained floating body-Diffraction and radiation-Added mass and radiation damping effects-Exciting and restoring forces-Symmetric and unsymmetric coupled motions- Introduction to random response-Random response of linear systems under wave loading-Directional spectra for waves-Probabilistic design criteria- Oscillations of floating bodies.

Module 2 (10 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-Nonlinear dynamics and instability of floating structures.

Module 3 (12 hours)

Response analysis of floating structures- Articulated towers-Semi submersibles- Tension Leg platforms- Spar Buoy systems.

Module 4 (5 hours)

Station keeping- Mooring systems- Thruster forces- Springing forces- Wave drift oscillation-Dynamic positioning- Introduction to control and guidance of floating systems.

References:

1. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science, 2002.
2. Thompson and Stewart, Nonlinear Dynamics and Chaos, John Wiley, 2002.
3. Faltinsen, Sea loads on ships and offshore structures- Cambridge University Press, 1993.
4. Chiang C. M, TheApplied Dynamics of Ocean Surface Waves, World Scientific, 1992.
5. Minoo H Patel, Compliant Offshore Structures, Butterworth Heinemann Ltd., 1991.
6. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
7. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
8. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978

CE6324D COASTAL ENGINEERING

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total hours: 39

Course Objectives:

CO1. To study the coastal environment and its various processes.

CO2. To identify the need for coastal protection works, different types of coastal protection works, design of breakwaters as well as the basics of port planning.

CO3. To study the concept of force calculation on different coastal structures, their primary analysis and design.

Module 1 (8 hours)

Coastal environment and coastal zone: Origin of coasts- Coastal waves- winds, ocean currents and tides, Oceanography of the Arabian Sea and the Bay of Bengal.

Coastal erosion: Coastal processes- Sediments of shallow water environments- Sediment characteristics- Sediment transport, erosion under Coastal structures.

Module 2 (10 hours)

Coastal protection works: Seawalls, Bulkheads, Groins, Jetties, Breakwaters- Artificial beach nourishment.

Berthing structures: Types, loads on berthing structures, Analysis and design of berthing structures.

Module 3 (13 hours)

Breakwaters: Types, vertical and sloped- Perforated- Floating- Energy generation- Analysis and design of Rubble mound breakwater.

Port planning: Classification of harbours, general planning, requirements, navigation channel, berth occupancy.

Module 4 (8 hours)

Coastal zone management:Coastal ecosystems-Coastal pollution and its implications- GIS and ANN in Coastal Engineering.

Course Outcomes:

1. Review of basic concepts of wave formation and transformation.
2. Examine coastal environment, sediments, sediment characteristics, transport and erosion.
3. Analyse different types of coastal protection works and forces acting on them.
4. Acquire training in GIS and ANN applied toCoastal Engineering.

References:

1. Sorenson R. M, Basic Coastal Engineering, Springer, 2006.
2. Joan Brown, Waves, Tides and Shallow water processes, Open University England, 2001
3. John B. Herbich, Handbook of Coastal Engineering, Mc GrawHill, 2000.
4. Komar P. D, Beach processes and sedimentation, Pearson, 1998.
5. Per Brunn, Port Engineering, Vol I, II, Gulf Publishing Co., 1989.
6. USACE, CERC, Shore Protection Manual,US Printing Office, Washington, 1984.
7. USACE, CERC, Shore Protection Manual, US Printing Office, Washington, 2006.

CE6325D - OFFSHORE PIPELINE DESIGN AND INSTALLATION

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Appreciate the issues affecting pipeline design and choose the appropriate route, diameter and materials selection processes.
CO2. Perform design calculations based on industry codes.
CO3. Evaluate the respective benefits of industry developments and new technologies.
CO4. Determine the most relevant corrosion protection methods.

Module 1 (8 hours)

Introduction-Basic equations for the flow of fluids through pipes- Different flow equations for laminar and turbulent flow of compressible and incompressible fluids- Introduction to the flow of Non-Newtonian fluids through pipes- Field layouts- Pipeline and cable uses- Subsea equipment- Platforms and floating production systems- Riser configurations- Route selection Survey techniques- Soil types-Routing of pipeline- Materials- Selection for strength-Selection for corrosion resistance- Clad and lined pipelines- External coatings- External corrosion protection- Cathodic protection- On-bottom stability.

Module 2 (14 hours)

Design of offshore pipeline-Loads –Functional loads- Environmental loads– Accidental loads-Installation loads-Design condition- Codes and standards- Serviceability limit states-Ultimate limit states- Partial safety factors- Wall thickness determination- Design methods- Wall thickness according to DNV OS-F101-Hydrodynamic stability- Design conditions and requirements- Static stability andDynamic stability design format- Pipe–soil interaction- Free span evaluation-Expansion and global buckling.

Module 3 (8 hours)

Seabed intervention- Pre-trenching- Pipeline supports- Crossings-Pipe laying- S-lay- J-lay-Reeling-Piggy-back installation- In-line components- Abandonment and recovery Towing, pulling and directional drilling- On-bottom towing and pulling- Off-bottom, surface and controlled depth towing-Pipeline bundles-Directional drilling- Trenching and backfilling- Jetting and cutting- Ploughing-Artificial backfilling- Protective covers-Pre-commissioning.

Module 4 (9 hours)

Corrosion prevention and insulation- Corrosion of steel in seawater-Internal corrosion prevention-External barrier coating- Thermal insulation-Cathodic protection-Protective potential and current requirements-Hydrogen embrittlement-Sacrificial anode design-Impressed current- Electrical isolation-Stray current interference- Flow assurance- Mitigation of flow blockage-Operation, maintenance and abandonment-Commissioning and operation- Maintenance- Changes to the design condition-Decommissioning and abandonment- Pipeline pigging- In-service inspection- Start-up inspection-Periodical inspection- Repair assessment-General- Pipe defects.

References:

1. Jan B Andersen, Lars W Andersen, Design and Installation of Marine Pipelines, John Wiley, 2009.
2. Andrew C Palmer and Roger King, Subsea Pipeline Engineering, PennWell Corp., 2008.
3. B. Guo, S. Song, A. Ghalambor and J. Chacko, Offshore Pipelines, Gulf Professional publishing, 2005.
4. Ellinas C P, Advances in Subsea Pipeline Engineering and Technology, Springer, 1990.
5. A. H. MousselliOffshore Pipeline Design, Analysis and Methods, PennWell Corp, 1981.

CE6326D RELIABILITY ENGINEERING AND ASSET RISK MANAGEMENT

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Identify and recognise the asset risk management techniques and maintenance strategies used in different industries.

CO2. Application of various proactive maintenance policies

CO3. Evaluate the financial implications involved with assessing the maintenance and risk factors of offshore projects.

Module 1 (8 hours)

Basic concepts of reliability- Availability and maintainability- Failure rates, failure modes, and reliability data- Introduction to classical reliability theories- Concepts of probability sampling statistics- Types of uncertainties- Modelling random variables like loads, material properties etc.

Module 1 (10 hours)

Levels of reliability- Reliability estimates- FOSM, AFOSM and application problems- Codes of practice of safety check- Reliability bounds of structural systems- Treatment of geometric variables- Probabilistic methods of code calibrations.

Module 1 (8 hours)

Asset integrity: Asset integrity management- Risk-based integrity- Through-life engineering.
Maintenance engineering: Maintenance regimes- Reactive vs. proactive maintenance- Age and block maintenance- Reliability-centred maintenance (RCM)- Risk-based maintenance (RBM).

Module 1 (13 hours)

Application to offshore structures- Stochastic process- Gaussian process- Risk assessment- Hazard identification- ETA, FTA- Risk modelling and Risk picture- Probabilistic risk assessment

References:

1. Srinivasan Chandrasekaran, Offshore Structural Engineering: Reliability and Risk Assessment. CRC Press, 2016
2. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
3. Gelman A, Carlin JB, Stern HS, Rubin DB, Bayesian Data Analysis, Chapman and Hall London, 1995.
4. Chakrabarti, S.K, Offshore Structure Modelling, World Scientific, Singapore, 1994.
5. Chakrabarti, S.K. Non-linear Method in Offshore Engineering, Elsevier Science Publisher, 1990.

CE6327D OFFSHORE RENEWABLE ENERGY AND TECHNOLOGY

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Review the basics of various offshore renewable energy techniques.
CO2. To compile the basic challenges in the offshore renewable energy field and provide a platform for further studies and researches.
CO3. Identify the risk and reliability assessment of offshore renewable energy industry

Module 1 (10 hours)

Wind energy: power in wind, wind data and energy estimation, wind resource assessments-Wind turbines: design, mounting/mooring arrangements, installation- Failure mechanisms, design of wind environment- aerodynamic characteristics of horizontal and vertical axis wind turbines- Design of foundation and support structures.

Module 2 (10 hours)

Wave energy: energy within water wave, description and operation of various systems proposed and in use for inshore and offshore application- Design of wave environment- Maximum power absorption from ocean waves- Hydrodynamic characteristics of wave energy converters- Fluid structure interaction- Time and frequency domain- Numerical methods in two and three dimension.

Module 3 (10 hours)

Tidal energy: Basic physics and power generation- Current stream devices- Barrage systems-Hydrodynamics characteristics of tidal devices-Wave and current effects-Fluid-structure interaction.
OTEC: Ocean thermal energy sources-Principle of ocean thermal energy conversion-Power plant development-Closed and open cycles- Advantages and operating difficulties.

Module 4 (9 hours)

Energy storage-Transmission and distribution issues and solutions- Risk assessment techniques and reliability analysis techniques for offshore energy systems

References:

1. Manwell J F, McGowan, J G and Rogers, A L, Wind Energy explained: Theory, Design and Application. Wiley, 2010.
2. Cruz, J, Ocean Wave Energy: Current Status and Future Perspectives. Springer, 2007.
3. Falnes, J, Ocean Waves and Oscillating Systems, Cambridge University Press, 2002
4. Walker J and Jenkins N, Wind Energy Technology. Wiley UNESCO Energy Engineering Series, 1997.
5. Baker AC, Tidal Power, Peter Peregrinus Ltd. 1981.

CE6328D HAZARDS MITIGATION MANAGEMENT

Prerequisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1. Ability to apply knowledge from engineering, environmental and social science discipline to issues in coastal management.
CO2. Identify, formulate and solve the problems related to coastal management.
CO3. Design, conduct, organize, and interpret data analysis related to coastal zone management issues.

Module 1 (8 hours)

Introduction to Environmental and Human induced hazards- Natural vs. Man-made hazard-Hazard and disaster, vulnerability, resilience- Coping mechanisms

Module 1 (10 hours)

Coastal hazards- Cyclones, Earthquakes, Tsunami, Floods, Storm surges- Coastal erosion, Sea-Level Rise-Technological Hazards- Causes- Impacts- Responses- Mitigation strategies- Early warning systems

Module 1 (10 hours)

Disaster management law and policy in India- Hyogo framework- Changing paradigm of disaster management in India- Response and recovery framework- Enabling institutions- Institutional coordination.

Module 1 (11 hours)

Disaster risk response frameworks- Mapping and planning for disaster management- Capacity building- Risk transfer mechanisms- Bio shields- Community based disaster management systems-Indigenous knowledge for disaster management- NDMA guidelines- Building codes, land use planning and disaster management.

References:

1. David A McEntire, Disaster Response and Recovery, John Wiley, 2015.
2. Rajib Shaw and R R Krishnamurthy, Disaster Management: Global Challenges Local Solutions, University Press, 2009.
3. Bryant, E., Natural Hazards, Cambridge University Press, New York, 2006.
4. National Disaster Management Agency - Guidelines issued by NDMA such as for earthquakes, tsunamis, cyclones, chemical disasters etc., National Disaster Management Division, Ministry of Home Affairs, GoI
5. Asia Disaster Preparedness Centre. Publications specific to disaster preparedness and response.

CE6101D THEORY OF ELASTICITY AND PLASTICITY

L	T	P	C
3	0	0	3

Pre-requisite: - Nil
Total Hours: 39

Course Outcomes
CO1: Mathematically formulate elasticity problems as a well posed boundary value problem
CO2: Solve simple engineering problems with mathematical rigour. Such solutions can act as bench-mark solutions for testing computational methods and software.
CO3: Appreciate the Cartesian Tensor notation, thereby understand modern technical literature, which otherwise would have appeared intricate.
CO4: Develop simple approximate methods based on variational formulations
CO5: Will be able to begin to understand advanced books on theory of plasticity

Module 1 (11 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 (9 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 (11 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, OxfordUniversity Press, 1998.
9. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1998.

CE6102D STRUCTURAL DYNAMICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Mathematically model a structural system for dynamic analysis.
CO2: Carry out free vibration analysis of single degree of freedom.
CO3: Analyse a single degree of freedom systems to subjected to harmonic loading, periodic loading and general dynamic loadings.
CO4: Perform free vibration and forced vibration analyses of multi degree of freedom systems.
CO5: Learn to analyse a continuous system both as a distributed parameter system and as an approximate discrete parameter system with multiple degrees of freedom.

Module 1 (10hours)

Introduction to Dynamics of Structural Systems: continuous systems and discretisation; significance of single degree of freedom system in dynamic analysis of structural systems.
Free Response of Singe-Degree-of-Freedom Linear Systems: General considerations; characteristics of discrete system components; differential equation of motion of second-order linear systems; free vibration response of undamped and damped single degree of freedom systems; logarithmic decrement; critical, under- and over-damped systems.

Module 2 (10hours)

Forced Response of Singe-Degree-of-Freedom Systems: Response of second-order systems to harmonic excitation; harmonic motion of support; complex vector representation of harmonic motion; vibration isolation; vibration measuring instruments; energy dissipation and structural damping; superposition and response to periodic excitation; Fourier series; the unit impulse and impulse response; unit step function and step response; response to arbitrary excitation; the convolution integral; general system response.

Module 3 (10hours)

Multi-Degree-of-Freedom Systems: Equations of motion; generalised coordinates; matrix formulation; stiffness and mass matrices; linear transformations and coupling; undamped free vibration; eigenvalue problem; natural frequencies and mode shapes; orthogonality of modal vectors; expansion theorem; response to initial excitation; modal analysis; solution of eigenvalue problem by matrix iteration; power method; Rayleigh's coefficient; general response of discrete linear systems; modal analysis.

Module 4 (9hours)

Continuous System: Relation between discrete and continuous system; boundary value problem; free vibration; eigenvalue problem; axial vibration of rods; bending vibration of beams; orthogonality of natural modes; expansion theorem; Rayleigh's quotient; response of systems by modal analysis; introduction to approximate methods of analysis of continuous systems; Rayleigh-Ritz method; finite element method.
Introduction to Analytical Dynamics: Work and energy; principle of virtual work; D'Alembert's principle; Lagrange equations of motion.

References.

1. Meirovitch L, Elements of Vibration Analysis, McGraw Hill 1975
2. Clough R.W. and Penzien J, Dynamics of structures, McGraw Hill 1989
3. Chopra, A.K., Dynamics of structures – Theory and Application to Earthquake Engineering, Prentice Hall 1996
4. Thomson W.T. and Dahleh M.D, Theory of Vibration with Applications, Pearson Education 2005
5. Craig, Jr. R.R, Structural Dynamics, John Wiley 1981
6. Hurty, W.C. and Rubinstein M.F, Dynamics of Structures, Prentice Hall. 1967

CE6111D FINITE ELEMENT METHOD

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Develop stiffness matrices of one dimensional, two dimensional and solid elements.
CO2: Develop structure stiffness matrix, load vector and solve the same after applying boundary conditions.
CO3: Develop computer programs for analysing different types of structures using finite element methods.

Module 1 (10hours)
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 (11hours)
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 (11hours)

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 (10hours)

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., Concepts and Applications of Finite Element Analysis, John Wiley. 1989
2. Desai, C.S., Elementary Finite Element Method, Prentice Hall of India. 1979
3. Chandrupatla, T.R., and Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India. 1991
4. Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice Hall of India. 1978
5. Gallagher, R.H., Finite Element Analysis: Fundamentals, Prentice Hall Inc. 1975
6. Rajasekaran, S., Finite Element Analysis in Engineering Design, Wheeler Pub. 1999
7. Krishnamoorthy, C.S., Finite Element Analysis– Theory and Programming, Tata Mc Graw Hill. 2007
8. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. I and II, Mc Graw Hill. 1991

CE6112D THEORY OF PLATES AND SHELLS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields.
CO2: Use numerical techniques in solving special plate problems.
CO3: Address complex problems in plates and shells which require a rigorous mathematical background.
CO4: Identify different type of shells and analyse shell structures for the stress resultants leading to an optimal design

Module 1:(8hours)

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: (8hours)

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: (14hours)

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
Plate vibration – free flexural vibration of rectangular and circular plates.

Module 4: (10hours)

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 Hill1987
2. Eduard Ventsel and Theodor Krauthammer, Thin plates and shells,Theory, Analysis and Applications, Marcel Dekker, Inc, New York 2001
3. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall inc 1974
4. N.K Bairagi, Plate Analysis, Khanna Publishers, New Delhi. 1986
5. P.L Gould, Analysis of Shells and Plates, Springer-Verlag, New York, 1988.

CE6121D STRUCTURAL OPTIMISATION

Pre-requisite: - Nil
Total Hours: 39
Course outcomes

L	T	P	C
3	0	0	3

CO1: To exploit the available limited resources in a manner that maximises output and the structural performance in a way that economises energy or minimise discomfort.
CO2: To 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.
CO3: To 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.

Module 1 (10hours)
Introduction.: Structural optimisation 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 (10hours)
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 (10hours)
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 (9hours)
Specialized Optimisation techniques: Dynamic programming, Geometric programming, Genetic Algorithms.

References

1. Rao S. S., Engineering Optimisation – Theory and Practice, New Age International. 1996
2. Deb, K.., Optimisation for Engineering Design – Algorithms and examples, Prentice Hall. 1995
3. KirschU., Optimum Structural Design, McGraw Hill.1981
4. Arora J S., Introduction to Optimum Design, McGraw Hill 1989
5. Spillers, W.R., MacBain K.M., Structural Optimisation, Springer 2009
6. Chirstensen P.,Klarbring A., An Introduction to Structural Optimisation, Springer 2008

CE6122DMODELLING, SIMULATION AND COMPUTER APPLICATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Solve nonlinear equations
CO2: Solve elliptic equations like Laplace equations and parabolic equations like heat conduction equations
CO3: Solve algebraic eigenvalue problems
CO4: Introduced to important integral equations
CO5: Simulate random fields using Monte Carlo methods

Module 1 (10hours)

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 (9hours)

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 (10hours)

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 firs kind.

Module 4 (10hours)

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. 1988
3. Rubinstein, R.Y., Simulation and the Monte Carlo Method, John Wiley. 2008
4. Press, W.H..,Numerical Recipes in C, Cambridge University Press. 1992

CE6123DEARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course outcomes

CO1: To assess the need for seismic analysis for a given Civil Engineering structural system
CO2: To perform seismic analysis of a structure
CO3: To carry out seismic design and detailing of different types of structure as per latest IS code of practice

Module 1 (10hours)
Introduction to engineering seismology: Causes of earthquakes - Seismic waves – Body and Surface waves- Measurement of an Earthquake – Magnitude and Intensity of earthquake - response of structure to earthquake motion - seismic zoning map of India -.Response Spectrum of Earthquake

Module 2 (10hours)
Concept of Seismic design : Approach to earthquake resistant design – General principles of a seismic design – Relevant IS codes – design earthquake loads - load combinations and permissible stresses - equivalent static analysis – vertical distribution of seismic forces and horizontal shears.
Dynamic analysis – Design spectrums – Seismic weights – Modal combination – Load combinations and permissible stresses – Guide lines for earthquake resistant design – Ductile detailing for seismic design - improving seismic behaviour of masonry, timber and steel buildings.

Module 3 (10hours)
Seismic design of water tanks – Elevated tower supported tanks- Hydrodynamic pressure in tanks – examples - Seismic design of towers – Stack like structures – Chimneys

Module 4 (9hours)

Seismic design principles of retaining walls – Concept of Seismic design of of bridges – Seismic design of bearings
Seismic Control of Structures : Base isolation- Tuned mass dampers

References

1. Agarwal, P., and Shirkhande, M., Earthquake Resistant Design of structures, Prentice-Hall of India, 2006.
2. Duggal, S. K., Earthquake Resistant Design of structures, Oxford University Press, 2007.
3. Datta, T.K., Seismic Analysis of Structures, John Wiley and sons (Asia) Pvt Ltd, 2010.
4. Brijesh, C.,Chandasekaran, Krishna Jai, A.R., Elements of Earthquake Engineering, South Asian Publishers Pvt.Ltd, 1994.
5. Gupta, A., Response Spectrum Method in Seismic Analysis and Design of Structures, CRC press, INC, 1992.
6. Relevant latest BIS Codes (IS: 1893, IS: 4326, SP:22, IS:13920)

CE6124DANALYTICAL DYNAMICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Formulate problems of dynamics using differential equation approach and variational approach.
CO2: Solve engineering problems with mathematical rigour. Such solutions can act as benchmark solutions for testing computational methods and software.
CO3: 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.
CO4: Formulate numerical solutions to mechanics problems based on variational formulations

Module 1 (10 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 (10 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:(10 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.

CE6127DFORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To expose the stake holders to the problems faced by the construction industry.
CO2: To understand the diagnosis and assessment of distress in structural members.
CO3: To understand the problems in buildings due to environmental effects and the durability of RCC structures.
CO4: To familiarise the principles of retrofitting of structural members.

Module 1 (13hours)

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading

Module 2 (13hours)

Diagnosis and Assessment of Distress: Visual inspection – non destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multistorey buildings -– Fibreoptic method for prediction of structural weakness

Module 3 (13hours)

Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and strengthening of buildings – provisions of BIS 1893 and 4326.

Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – strengthening by pre-stressing – case studies – bridges – water tanks – cooling towers – heritage buildings – high rise buildings.

References

1. Dovkaminetzky, Design and Construction Failures, Galgotia Publication, New Delhi,2001
2. Jacob Feld and Kenneth L Carper, Structural Failures, Wiley Europe.

CE6128DMULTI BODY DYNAMICS AND APPLICATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Determine relative motion of two points fixed on a rigid body, motion of a point that is moving on a rigid body, and Coriolis acceleration.
CO2: Determine inertia tensor of a rigid body and Moment-of-momentum equations for general motion of rigid bodies.
CO3: Carry out vibration analysis of multi-body systems. 4. Simulate the dynamic behaviour of the mechanical systems numerically.

Module 1 (9 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 (10 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 (10 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, 1985
2. J.H. Ginsberg, Advanced Engineering Dynamics, Second edition, 2008
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.

CE6130DSTRUCTURAL HEALTH MONITORING

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish different models for damage assessment
CO2: Understand systems and sensors for health monitoring of structures
CO3: Carry out different techniques for health monitoring of structures
CO4: Make use of IT concepts for health monitoring of structures such as multi-storied building, bridges, etc

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 (10 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 (10 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 (10 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. Philip, W., Industrial sensors and applications for condition monitoring, MEP, 1994.
2. Armer, G.S.T (Editor), Monitoring and assessment of structures, Spon, London, 2001.
3. Wu, Z.S. (Editor), Structured health monitoring and intelligent infrastructure, Volumes 1 and 2, Balkema, 2003.
4. Harris, C.M., Shock vibration handbook, McGraw-Hill, 2000.
5. Rao, J.S., Vibratory condition monitoring of machines, Narosa Publishing House, India, 2000.

CE6131DSTRUCTURAL RELIABILITY

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Identify deterministic and random variables associated with structures and quantify the degree of randomness
CO2: Perform reliability basic structural elements under different safety criterion
CO3: Develop reliability based design criteria of any structure and determine optimal safety factors
CO4: Perform system reliability analysis of simple structures

Module 1 (9hours)
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 (9 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 (11 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 (10 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. Jack R. Benjamin & C. Allin Cornell., Probability, Statistics and Decision for Engineers, McGraw-Hill.1970
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.

CE6133D RANDOM VIBRATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish deterministic and random variables associated with structural analysis and response
CO2: Quantify the randomness or uncertainties in the variables associated with structural analysis and response
CO3: Model different physical phenomena by appropriate stochastic processes
CO4: Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage

Module 1 (9hours)
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 (10hours)
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 (10hours)
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 (10hours)
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 &ShahramSarkani., 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. 1967
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. Ray W Clough & Joseph Penzien,. Dynamics of Structures, McGraw Hill, 1993.

CE6134D ENGINEERING FRACTURE MECHANICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Solve problems of fracture mechanics using Energy approach, SIF, J-integral approach and COD approach

CO2: Determine fracture toughness experimentally

CO3: Analyse problems involving fatigue

CO4: Solve practical problems using the concepts of fracture mechanics

Module 1 (13 hours)

Introduction: Significance of fracture mechanics – Griffith energy balance approach – Irwin's modification to Griffith theory – stress intensity approach – crack tip plasticity – fracture toughness – subcritical crack growth – influence of material behavior – 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.

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 behavior.

Module 2 (13 hours)

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.

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.

Module 3 (13hours)

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 fromnotches – the short crack problem.

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.

References

1. Kumar, P. Elements of Fracture Mechanics, Tata McGraw Hill, 2009.
2. Maiti, S. K., Fracture Mechanics: Fundamentals and applications, Cambridge, 2015.
3. Jin, Z.H., Sun, C.T., Fracture Mechanics,Academis Press, 2005.
4. Anderson, T.L., Fracture Mechanics: Fundamentals and applications, CRC Press, 2011.
5. Broek, D. Elementary Engineering Fracture Mechanics, Sijthoff&Noordhoff International Publishers, 1982.
6. Janssen, M., Zuidema, J. and Wanhill, R., Fracture Mechanics, Spon Press, 2004.
7. Knott J.F, Fundamentals of Fracture Mechanics, Butterworth & Co, 1973.

CE6135D PRESTRESSED CONCRETE DESIGN

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Analyseprestressed concrete structural members and estimate the losses of prestress

CO2: Analyse and design of prestressed concrete structural elements as per IS 1343

CO3: Design prestressed concrete flexural members, composite members and statically indeterminate structures

Module 1 (13 hours)

Basic principles: Introduction – need for prestressed concrete – structural behaviour of prestressed concrete member – methods of prestressing – pre-tensioning and post-tensioning – anchorage systems – types of prestressed concrete – comparison with reinforced concrete.
Materials: High tensile steel – types of prestressing steel -high strength concrete – properties of high tensile steel and high strength concrete.
Losses in prestress: Immediate losses – time dependent losses – total losses.
Analysis of sections: Analysis at serviceability limit state – combined load approach – internal couple approach – equivalent load approach – concept of load balancing – decompression moment – cracking moment.
Design for flexure: Modes of failure in flexure – ultimate moment of resistance of sections with bonded tendons – strain compatibility method – IS code procedure.

Module 2 (13 hours)

Design for shear and torsion: Effect of prestress in shear strength – zones for shear design – shear resistance of sections – design for shear – failure modes in torsion – design for torsion.
Design of anchorage zones: Anchorage zones in pre-tensioned members – development length – end zone reinforcement – anchorage zones in post-tensioned members – bearing stresses – bursting forces – end zone reinforcement.
Control of deflections: Deflection in type I and type II beams– short term and long term deflections – IS code procedures.

Module 3 (13 hours)

Design of flexural members: Governing stress inequalities for uncracked sections – design of prestressing force – Magnel's diagram – allowable cable zone – flexural efficiency factor.
Composite members: Analysis at serviceability limit state – stresses due to differential shrinkage – ultimate moment of resistance.
Indeterminate structures: Primary and secondary moments and shears – effective cable line – linear transformation of cable profile – concordant cable – analysis of sections.

References:

1. Lin, T. Y., and Ned H. Burns, Design of Prestressed Concrete Structures, John Wiley and Sons, 2004.
2. Krishna Raju, N., Prestressed concrete, Tata McGraw Hill, 2000.
3. Nagarajan, P.,Prestressed concrete Design, Pearson,2013.
4. Dayaratnam, P., Prestressed Concrete, Oxford and IBH, 1982.
5. Rajagopalan, N., Prestressed Concrete, Narosa publishers, New Delhi, 2004.
6. Relevant BIS codes

CE6136D DESIGN OF PLATED STRUCTURES AND SHELLS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields
CO2: Use numerical techniques in solving special plate problems
CO3: Able to use approximate methods for the solution of plate problems
CO4: Identify different type of shells, analyse and design shell structures for the stress resultants leading to an optimal design
CO5: Confidently design special structures using shells combining aesthetics and cost effectiveness

Module 1 (10 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 (10 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 (10 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 1987
2. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall inc 1974
3. W. Flugge, Stresses in Shells, Stringer- Verlag 1960
4. Ramaswamy, G.S, Design and Construction of Concrete Shell Roofs, Tata McGraw Hill. 1968

CE6137D MECHANICS OF COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

Pre-requisite: - Nil
Total Hours: 39

Course Outcomes

CO1: Design composite beams with shear connectors
CO2: Analyse and design composite floors
CO3: Design composite columns using different materials
CO4: Analyse and design continuous beams

Module 1 (10hours)

Introduction: - Composite beams- Elastic behaviour of composite beams- No interaction case-Full interaction case-Shear connectors-Characteristics of shear connectors-Ultimate load behaviour-Serviceability limits-Basic design considerations-Design of composite beams.

Module 2 (9 hours)
Composite floors: - Structural elements-Profiled sheet decking-Bending resistance-Serviceability criteria-Analysis for internal forces and moments.

Module 3 (10 hours)
Composite columns: - Materials-Structural steel-Concrete-Reinforced steel-Composite column design-Fire resistance-Combined compression and uniaxial bending

Module 4 (10 hours)
Continuous beams and slab Hogging moment regions of composite beams-Vertical shear and moment-Shear interaction-Global analysis of continuous beams-Design strategies

Ref**erences**

1. Johnson,R.P, Composite Structures of Steel and Concrete,Vol.1Beams,Slabs,Columns anDFrames in Buildings, Oxford Blackwell Scientific Publications, London. 1994
2. INSDAG teaching resource for structural steel design, Vol 2, INSDAG, IspatNiketan, Calcutta.

CE6138D ADVANCED FINITE ELEMENT ANALYSIS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Develop element stiffness matrix of shell elements
CO2: Carry out error estimates and convergence study in finite element method of analysis
CO3: Apply finite element method in structural dynamics and vibration problems
CO4: Study various modelling consideration and software use
CO5: Solve non-linear problems using finite element method

Module 1 (10 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 (10 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 (10 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.

References

1. Cook, R.D., 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. 1997
4. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, Mc Graw Hill. 1977

CE6139D ADVANCED THEORY OF SHELLS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Deal with the advanced topics in the analysis of shells
CO2: Apply the concepts of membrane theory for all types of shells of revolution
CO3: Able to appreciate all kinds of geometry of shells or revolution and will be able to analyse such shells
CO4: Apply beam theory for varieties of geometries including cylindrical, circular and shallow shells

Module 1(10hours)

Theory of surfaces:- general theory of shells, Kirchhoff-Love's assumptions, deformation of shell, compatibility conditions, forces and moments, equilibrium equations, constitutive laws, boundary conditions, solution methods of shell problems, basic equations of Reissner-Mindlin's shell theory.

Module 2(10hours)

Membrane theory:- basic equations, membrane theory of shells of revolution.

Module 3(10hours)

Shells of revolution:- differential equations, symmetrical deformation of shells of revolutions, integration of differential equation, internal forces and displacements.

Module 4(9 hours)

Bending theory:- basic equations, circular cylindrical shells, shells of revolution, shallow shells.

References

1. Novozhilov, V.,V., Thin Shell Theory, Noordhoff, Groningen 1964.
2. Gould, P. L., Analysis of Shells and Plates, Springer-Verlag, New York 1988.
3. Flügge, W., Stresses in Shells, Springer-Verlag, 1960.

CE6140D THEORY OF PLASTICITY

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understand Constitutive Relations of a material under plastic state
CO2: Understand different failure theories and plastic behaviour of metals under plane stress condition
CO3: Carry out plastic analysis of bars under tension and bars under flexure
CO4: Carry out limit analysis of bodies in plane stress and plane strain conditions
CO5: Carry out limit analysis of trusses and beams, apply finite elements limit analysis problem, and incremental methods of determining limit load

Module 1 (10hours)

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 (11hours)

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 (9 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 (9hours)

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. 1975
2. Kachanov, L.M., Fundamentals of the Theory of Plasticity, Mir Publishers, Moscow. 2004
3. Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York. 1988
4. Hill, R., Mathematical Theory of Plasticity, Oxford University Press. 1960
5. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag. 1988

CE6221D GEOGRAPHIC INFORMATION SYSTEM AND APPLICATION

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understanding the GIS components and reference systems for mapping and data acquisition
CO2: Selecting suitable data representation tools and methods for analysis
CO3: Processing the data to derive meaningful inferences for decision making
CO4: Applying the tools and techniques for the selected practical applications

Module I (9 Hours)
Introduction: Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo referencing - data acquisition.

Module 2 (10 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 (10 Hours)
GIS Data Processing, Analysis and Modeling: 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 modeling – 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, 2006.
2. Anji Reddy, 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, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.
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.

CE6302D STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish deterministic and random variables associated with structural analysis and response.
CO2: Quantify the randomness or uncertainties in the variables associated with structural analysis and response.
CO3: Model different physical phenomena by appropriate stochastic processes.
CO4: Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage.

Module 1 (9 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 (9 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 (11 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 (10 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 &ShahramSarkani., 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.

CE6421D ADVANCED DESIGN OF FOUNDATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes
CO1: Acquire knowledge of soil structure interaction and various models
CO2: Familiarize with design of pile foundation and pile testing
CO3: To analyses and design of foundation subjected to vibrations
CO4: To utilize vibration isolation technique for design of foundations.
CO5: Design of deep foundation subjected various types of loads.

Module 1: (10 Hours)
Soil -Structure Interaction
Introduction to Soil -Structure interaction problems -Contact pressure distribution – factors influencing Contact pressure distribution beneath rigid and flexible footings – concentrically and eccentrically loaded cases – contact pressure distribution beneath rafts - Modulus of up grade reaction – Determination of modulus of sub grade reaction – Factors influencing modulus of subgrade reaction

Module 2: (10 Hours)
Pile Foundations
Introduction – Estimation of pile capacity by static and dynamic formulae – Wave equation method of analysis of pile resistance – Load -Transfer method of estimating pile capacity – Settlement of single pile – Elastic methods. Laterally loaded piles – Modulus of sub grade reaction method – ultimate lateral resistance of piles. Pile Groups – Consideration regarding spacing – Efficiency of pile groups – Stresses on underlying soil strata – Approximate analysis of pile groups –Settlement of pile groups Pile caps –Pile load tests – Negative skin friction.

Module 3: (9 Hours)
Introduction to Machine Foundations
Introduction -nature of dynamic loads -stress conditions on soil elements under earthquake loading - dynamic loads imposed by simple crank mechanism -type of machine foundations special considerations for design of machine foundations – Criteria for a satisfactory machine foundation - permissible amplitude of vibration for different type of machines -methods of analysis of machine foundations -methods based on linear elastic weightless springs methods based on linear theory of elasticity (elastic half space theory) -degrees of freedom of a block foundation –definition of soil spring constants -nature of damping -geometric and internal damping -determination of soil constants – methods of determination of soil constants in laboratory and field based on IS code provisions.

Module 4: (10 Hours)
Design of Machine Foundations
Vertical, sliding, rocking and yawing vibrations of a block foundation -simultaneous rocking, sliding and vertical vibrations of a block foundation -foundation of reciprocating machines -design criteria - calculation of induced forces and moments -multi-cylinder engines -numerical example (IS code method).
Foundations subjected to impact loads - design criteria - analysis of vertical vibrations computation of dynamic forces - design of hammer foundations (IS code method) - vibration isolation – active and passive isolation - transmissibility -methods of isolation in machine foundations.

References

1 Lambe and Whitman, “Soil Mechanics”, Wiley Eastern., 1976.
2 Das B.M., “Advanced Soil Mechanics”, Mc. Graw-Hill, NY, 1985.
3 Winterkorn H.F. and Fang H.Y. Ed., “Foundation Engineering Hand Book”, Van-Nostrand Reinhold, 1975.
4 Bowles J.E., “Foundation Analysis and Design” (4Ed.), Mc.Graw –Hill, NY, 1996
5 Poulose H.G. and Davis E.H., “Pile foundation Analysis and Design”, John-Wiley & Sons, NY, 1980.
6 Leonards G. Ed., “Foundation Engineering”, Mc.Graw-Hill,NY, 1962.
7 BowlesJ.E.,“Analyticaland Computer Methods in Engineering “Mc.Graw-Hill,NY,1974.
8 Shamsher Prakash, “Soil Dynamics”, McGraw Hill.
9 Alexander Major, “Dynamics in Soil Engineering”
10 Sreenivasalu&Varadarajan, “Handbook of Machine Foundations”, Tata McGraw Hill
11 IS 2974 -Part I and II, “Design Considerations for Machine Foundations”
12 IS 5249: “Method of Test for Determination of Dynamic Properties of Soils”