M.Tech.

IN

OFFSHORE STRUCTURES

CURRICULUM AND SYLLABI

(Applicable from 2023 admission onwards)

Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of M. Tech. in Offshore Structures

PEO1	Demonstrate advanced knowledge in Offshore and Marine Engineering, so that they can effectively compete with their contemporaries at the National / International Level.
PEO2	Exhibit strong communication, technical writing and interpersonal skills to excel in career, along with a passion for lifelong learning.
PEO3	Execute projects with professional ethics, safety, sustainability and societal commitment.

Programme Outcomes (POs) & Programme Specific Outcomes (PSOs) of M. Tech. in Offshore Structures

PO1	Ability to independently carry out research/investigation and development work to solve practical problems.
PO2	Ability to write and present a substantial technical report/document.
PO3	Demonstrate a degree of mastery over the area as per the specialisation of the programme.
PSO 1	Apply ethical principles in discharge of their responsibilities to solve coastal and offshore problems considering economy, safety, social and environmental aspects for sustainable development.
PSO 2	Ability for life-long learning of new and innovative technologies related to offshore Engineering.

CURRICULUM

Total credits for completing M.Tech. in Offshore Structures is 75.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of M.Tech. programme shall have the following Course Categories:

Sl. No.	Course Category	Minimum Credits
1.	Program Core (PC)	23
2.	Program Electives (PE)	15
3.	Institute Elective (IE)	2
4.	Projects	35

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50 minute duration)
T: Tutorial (One unit is of 50 minute duration)
P: Practical (One unit is of one hour duration)
O: Outside the class effort/self-study (One unit is of one-hour duration)

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6301E	Wave Hydrodynamics	3	0	0	6	3	PC
2.	CE6302E	Stochastic Processes in Structural Mechanics	3	0	0	6	3	PC
3.	CE6303E	Design of Offshore Structures	3	0	0	6	3	PC
4.	CE6304E	Marine CFD	3	0	0	6	3	PC
5.	CE6391E	Offshore Engineering Lab	0	0	2	1	1	PC
6.	***E	Elective	3	0	0	6	3	PE
7.	***E	Elective	3	0	0	6	3	PE
8.		Institute Elective					2	IE
		Total					**21**	**--**

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6311E	Dynamics of Ocean Structures	3	0	0	6	3	PC
2.	CE6312E	Marine Foundations	3	0	0	6	3	PC
3.	CE6313E	Coastal Dynamics	3	0	0	6	3	PC
4.	CE6392E	Offshore Structures Design Studio	0	0	2	1	1	PC
5.	***E	Elective	3	0	0	6	3	PE

6.	***E	Elective	3	0	0	6	3	PE
7.	***E	Elective	3	0	0	6	3	PE
8.	CE6396E	Project Phase I				6	2	PC
		Total					**21**	**--**

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7397E	Project Phase II				*	3	PC
2.	CE7398E	Project Phase III				45	15	PC
		Total					**18**	**--**

Note
**Decided by the organisation in which the internship is done*

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7399E	Project Phase IV				45	15	PC
		Total					**15**	**--**

List of Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	CE6321E	Ship Hydrodynamics	3	0	0	6	3
2.	CE6322E	Advanced Wave Hydrodynamics	3	0	0	6	3
3.	CE6323E	Stability of Structures	3	0	0	6	3
4.	CE6324E	Offshore Pipeline Design and Installation	3	0	0	6	3
5.	CE6325E	Reliability Engineering and asset Risk Management	3	0	0	6	3
6.	CE6326E	Offshore Renewable Energy and Technology	3	0	0	6	3
7.	CE6327E	Hazard Mitigation Management	3	0	0	6	3
8.	CE6101E	Theory of Elasticity and Plasticity	3	0	0	6	3
9.	CE6102E	Structural Dynamics	3	0	0	6	3
10.	CE6111E	Finite Element Method	3	0	0	6	3
11.	CE6112E	Theory of Plates and Shells	3	0	0	6	3
12.	CE6121E	Structural Optimization	3	0	0	6	3
13.	CE6122E	Modelling Simulation and Computer Applications	3	0	0	6	3
14.	CE6123E	Earthquake Analysis and Design of Structures	3	0	0	6	3
15.	CE6128E	Analytical Dynamics	3	0	0	6	3
16.	CE6127E	Forensic Engineering and Rehabilitation of Structures	3	0	0	6	3

17.	CE6130E	Structural Health Monitoring	3	0	0	6	3
18.	CE6131E	Structural Reliability	3	0	0	6	3
19.	CE6133E	Random Vibrations	3	0	0	6	3
20.	CE6134E	Engineering Fracture Mechanics	3	0	0	6	3
21.	CE6135E	Prestressed Concrete Design	3	0	0	6	3
22.	CE6136E	Mechanics of Composite Structures	3	0	0	6	3
23.	CE6137E	Advanced Finite Element Analysis	3	0	0	6	3
24.	CE6138E	Theory of Plasticity	3	0	0	6	3
25.	CE6226E	Geographic Information System and Its Application	3	0	0	6	3
26.	CE6403E	Advanced design of Foundations	3	0	0	6	3
		Total					**78**

List of Institute Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	IE6001E	Entrepreneurship Development	2	0	0	4	2
2.	MS6174E	Technical Communication and Writing	2	1	0	3	2
3.	ZZ6002E	Research Methodology	2	0	0	4	2

CE6301E WAVE HYDRODYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 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.

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.

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.

Finite Amplitude waves- Higher order wave theories- Stokes Wave Theory-Cnoidal Wave Theory and Solitary Wave Theory- Wave interaction with currents- Wave slamming - Sea as a stationary random process- Wave spectral density- Mathematical Spectrum models- Short term and long-term wave statistics.

Applications of Wave force regimes - Wave forces- Morison Equation- Wave force on on vertical, inclined and horizontal cylinders - Froude Krylov theory- Diffraction theory- Closed-form solutions of a large fixed vertical cylinder.

References

1. Dean, R.G., and Darlymple, R.A., Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing, 2007.
2. Robert T. Hudspeth, Waves and Wave Forces on Coastal and Ocean structures, World Scientific Publishing Company, 2006.
3. USACE (U.S. Army Corps of Engineers), Shore Protection Manual, Department of the Army, U.S. Corps of Engineers, Washington, DC 20314, 1984
4. Chakrabarti, S.K., Hydrodynamics of Offshore Structures, Springer Verlag, 1987.
5. Ippen, A. T., Estuary and Coastline Hydrodynamics, McGraw Hill, 1982.
6. Sarpkaya, T., and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand, 1981.

CE6302E STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Quantify the randomness or uncertainties in the variables associated with analysis and response of physical phenomena
CO2: Understand the basic theory of stochastic processes so that the uncertainties associated with the stochastic processes are quantified.
CO3: Apply the various mathematical theories associated with stochastic processes, to determine the response of SDOF and to find important properties that are useful at design stage.
CO4: Determine the response of MDOF systems to random excitation and to understand some models of random processes occurring in nature.

Fundamentals of probability theory with applications

Probability theory: Sample space and events, probability measure, mathematics of probability, conditional probability — Random variables: Continuous and discrete random variables, probability distribution and density functions, expected values and moments, multiple random variables, marginal and conditional distributions, dependent and independent variables — Functions of random variables: expectation of a function of a random variable — Common probabilistic models: Models from simple discrete random trials, models from random occurrences, models from limiting cases, other commonly used distributions, multivariate models — Derived probability distributions and distributions of functions.

Basic theory of stochastic processes

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.

Response of simple linear systems

Stochastic Response of Linear SDOF Systems: Deterministic dynamics, evaluation of impulse response function and frequency response function, stochastic dynamics, response to stationary excitation, time domain analysis, frequency domain analysis.
Properties of Random Processes: Level crossing peaks, fractional occupation time, envelopes, first- passage time, maximum value of a random process in a time interval — Fatigue failure.

Response of MDOF systems and models of stochastic processes

Stochastic Response of Linear MDOF Systems to random excitation, normal mode approach — Some models of random processes in nature: Earthquake, wind, atmosphere turbulence, random runways, road roughness, jet noise, ocean wave turbulence — Some important random processes: Normal processes, Poisson processes, Markov processes.

References:

1. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Basic Principles, John Wiley & Sons, 1975.

2. J.R. Benjamin & C.A. Cornell., Probability, Statistics and Decision for Engineers, McGraw-Hill, 1970.

3. Papoulis, A., Probability, Random Variables and Stochastic Processes, McGraw Hill, 2002.

4 Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.

5 Loren D Lutes & Shahram Sarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, 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. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, 1986.

9. R.W Clough & J. Penzien,. Dynamics of Structures, McGraw Hill, 1993.

10. James F Wilson, Dynamics of Offshore Structures, John Wiley & Sons, 2003.

CE6303E DESIGN OF OFFSHORE STRUCTURES

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Acquire knowledge and skills to carry out basic tasks regarding the evaluation of maximum forces on an offshore structure due to operational loads and conducting static and dynamic analyses.
CO2: Acquire training in the design of jacket platforms, tubular connections, and concrete gravity platforms.
CO3: Estimate the resistance of platforms against fatigue and accidental loads.
CO4: Attain knowledge of the physics of corrosion and methods to monitor and prevent corrosion.

Classification of offshore structures and their conceptual development- Fixed, Compliant, Floating- 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- Environmental loads- Wind, wave, current, seismic 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.

Analytical models for offshore structures- 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 in the deck- Introduction to tubular members- Slenderness effect- Column buckling- Design of tubular members for axial, and bending stresses and hydrostatic pressure.

Tubular connections- Possible modes of failure, Eccentric connections and offset connections- Inplane and multiplane 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 for static and cyclic loads as per API Code.

Design against accidental loads- Fire, Blast and Collision- Behaviour of steel at the elevated temperature-Fire rating for Hydrocarbon fire- Design of members 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. API RECOMMENDED PRACTICE 2A-LRFD: Planning, Designing, and Constructing Fixed Offshore Platforms- Load and Resistance Factor Design, 2019.

2. API RECOMMENDED PRACTICE 2A-WSD: Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design, 2014.

3. DNV-RP-B101-Corrosion Protection of Floating Protection and Storage Units, 2007.

4. DNV-RP-C203- Fatigue Design of Offshore Steel Structures, 2011.

5. DNV-RP-C204- Design Against Accidental Loads, 2010.

6. B.C Gerwick, Jr. Construction of Marine and Offshore Structures, CRC Press, Florida, 2007.

7. Clauss, G, Lehmann, E & Ostergaard, C, Offshore Structures, Vol. 1 & 2, Springer-Verlag, 1992.
8. Dawson, T. H., Offshore Structural Engineering, Prentice Hall, 1983.
9. Graff, W. J., Introduction to Offshore Structures, Gulf Publishing Company, 1981
10. McClelland, B and Reifel, M. D., Planning and Design of fixed Offshore Platforms, Van Nostrand, 1986.
11. Morgan, N., Marine Technology Reference Book, Butterworths, 1990.
12. Reddy, D. V and Arockiasamy, M., Offshore Structures Vol.1 & 2, Krieger Publishing Company, 1991.
13. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.

CE6304E MARINE CFD

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Knowledge of conservation equations, finite difference technique and its formulation
CO2: Acquire knowledge of finite volume methods, finite element methods and solution of finite difference equations
CO3: Knowledge of solving CFD problems using Navier-Stokes equation
CO4: Acquire knowledge on the application of Computational Fluid Dynamics in marine structures

Introduction - Conservation equation - mass, momentum and energy equations - convective form - Classification and Overview of Numerical Methods - boundary and initial conditions - Finite Difference Technique – formulation of finite difference equation - treatment of boundary conditions - accuracy of finite difference method.

Finite volume methods - different types of finite volume grids - approximation of surface and volume integrals - Finite Element Methods - Rayleigh-Ritz, Galerkin and Least square methods - interpolation functions - one and two dimensional elements - Methods of Solution - Solution of finite difference equations - Stability analysis

Numerical Grid Generation - transformation and mapping. Navier-Stokes Equations - Explicit and implicit methods - fractional step methods - Turbulence modelling - Reynolds averaged Navier-Stokes equations - Turbulence modelling - RANS modelling - DNS and LES.

Free surface modelling – interface tracking and interface capturing techniques – Grid independence analysis – CFD in marine applications – wave pattern calculations for steady ship flow - ship resistance estimation - seakeeping and manoeuvring simulations

References:

1. Ferziger, J. H. and Peric, M., Computational Methods for Fluid Dynamics, Springer-Verlag, 2003

2. Versteeg, H. K. and Malalasekara, W., Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education, 2008

3. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer. Taylor & Francis, 1997

4. John D. Anderson, Computational Fluid Dynamics: The Basics with Applications, 1995.

5. H. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Printice Hall, 2007

6. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques, Springer, 1988.

7. Pletcher, Richard H., John C. Tannehill, and Dale Anderson. Computational fluid mechanics and heat transfer, CRC Press, 2012

CE6391E OFFSHORE ENGINEERING LAB

Pre-requisite: Nil

L	T	P	O	C
0	0	2	1	1

Total Practical Sessions: 26

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.

CE6311E DYNAMICS OF OCEAN STRUCTURES

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the 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 freedom systems, 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.

Dynamic characteristics and water depth capability of ocean structures- Solid fluid interaction parameters- Added mass and damping- Effect of viscosity on damping- Spring factor- Diffraction and radiation problems- Wave exciting force.

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

Floating and submerged bodies- Intact and dynamic stability- Stability at small and large angles-hydrodynamic analysis- Strip theory- Response analysis of floating bodies- Tension Leg Platforms- Semi submersibles- Floating vessels- Static and dynamic analysis of Mooring lines.

Motion analysis in random waves- Response spectrum- Low and high frequency oscillations- Wave drift forces- Springing forces- Damping at low and high frequencies.

References:

1. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978.
2. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
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. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
6. Patel, M.H., Compliant Offshore Structures, Butterworth Heinemann Ltd., Oxford, 1991.
7. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
8. Wilson, J. F., Dynamics of Offshore Structures, John Wiley, 2002.

CE6312E MARINE FOUNDATIONS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

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

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.

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.

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.

Foundations for jack up platforms
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 and Demars, 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

CE6313E COASTAL DYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Acquire knowledge on the Basics of sediment transport and coastal processes.
CO2: Acquire knowledge on the basics of port planning and different coastal protection works.
CO3: Perform analysis and design of different coastal protection structures.

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- Shore protection measures.

Coastal protection works: Seawalls, Bulkheads, Groins, Jetties, Breakwaters- Artificial beach nourishment.
Breakwaters: Types, vertical and sloped- Perforated- Floating- Analysis and design of Rubble mound breakwater.

Port planning: Classification of harbours, general planning, requirements, navigation channel, berth occupancy.
Berthing structures: Types, loads on berthing structures, Analysis and design of berthing structures.

Coastal zone management: CRZ guidelines - Coastal ecosystem-Coastal pollution and its implications- GIS in Coastal Engineering- concepts of Wave Energy devices.

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. U.S. Army Corps of Engineers, Shore Protection Manual, Department of the Army, U.S. Corps of Engineers, Washington, DC 20314, 1984.
7. U.S. Army Corps of Engineers, Coastal Engineering Manual. Vicksburg, Mississippi: Coastal and Hydraulics Laboratory, Engineer Research and Development Center Report EM 1110-2-1100, 2006.

CE6392E OFFSHORE STRUCTURES DESIGN STUDIO

Pre-requisite: Design of Offshore Structures

Total Practical Sessions:26

L	T	P	O	C
0	0	2	1	1

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.

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)

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

Design of offshore pipelines- Design considerations- Structural aspects- Static and dynamic analyses- Approximate methods- Structural and positional stability- Pipeline-soil interaction- Pipe laying methods.

Design of compliant towers- Articulated towers- Guyed towers- Cylindrical buoys- Single point moored buoy systems- Statics of mooring lines without and with elasticity- Dynamics of mooring lines-Design of mooring cables- 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

CE6396E: PROJECT – PHASE I

Pre-requisite: Nil

L	T	P	O	C
0	0	0	6	2

Course Outcomes:

CO1: Identify a relevant problem, carry out literature review and identify the research gaps
CO2: Propose a methodology for solving the problem
CO3: Document and present the work done

The primary objective of the course ‘Project Phase I’ is to introduce the students to the various areas of research in Offshore Structures. The students will identify a problem, carry out a systematic and exhaustive literature review and identify the research gaps. The students will propose a methodology for solving the identified problem. The students need to document their work and make a presentation before the designated “Evaluation Committee”.

CE7397E: PROJECT – PHASE II

Pre-requisite: Nil

L	T	P	O	C
0	0	0	9	3

Course Outcomes:

CO1: Identify a relevant problem, carry out literature review and identify the research gaps
CO2: Propose a methodology for solving the problem
CO3: Document and present the work done

The student will identify a relevant problem in the broad area of Offshore Structures and work on it. The study could be experimental, analytical, or computational. The students need to document their work and make a presentation before the designated "Evaluation Committee". This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship, course outcomes will depend on the actual work performed during the internship.

CE7398E: PROJECT – PHASE III

Pre-requisite: Nil

L	T	P	O	C
0	0	0	45	15

Course Outcomes:

CO1: Demonstrate their theoretical and research skills to become independent researchers with high ethical values
CO2: Demonstrate a degree of originality in research emphasizing the concept of sustainability
CO3: Develop professional documentation and presentation skills

The student will identify a relevant problem in the broad area of Offshore Structures and work on it. The study could be experimental, analytical, or computational. The students need to document their work and make a presentation before the designated "Evaluation Committee". This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship, course outcomes will depend on the actual work performed during the internship.

CE7399E: PROJECT – PHASE IV

Pre-requisite: Nil

L	T	P	O	C
0	0	0	45	15

Course Outcomes:

CO1: Demonstrate their theoretical and research skills to become independent researchers with high ethical values
CO2: Demonstrate a degree of originality in research emphasizing the concept of sustainability
CO3: Develop professional documentation and presentation skills

The student will identify a relevant problem in the broad area of Offshore Structures and work on it. The study could be experimental, analytical, or computational. The students need to document their work and make a presentation before the designated "Evaluation Committee". This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship, course outcomes will depend on the actual work performed during the internship.

CE6321E SHIP HYDRODYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand the hydrostatics and stability of ship in small and large angle.
CO2: Evaluate stress and deflection of ship hull in still water and in wave.
CO3: Understanding seakeeping and response of ship to surface waves
CO4: Understand the directional stability and maneuverability

Ship hydrostatics and stability

Types of marine vehicles, ship particulars, lines plan, coefficients of form, numerical integration, transverse stability of ships at small and large angle of heel, inclining experiment, longitudinal stability of ships, effect of free surface on GZ, dynamic stability, stability of grounded vessels, stability of submarine, Stability criterion for various types of crafts.

Ship structure

Loading, shear force and bending moment of ship hull, stresses, deflection, flexural and torsional vibration, propeller induced vibration.

Seakeeping

Seakeeping qualities, ship motions in still water and in waves, seakeeping criteria, overall seakeeping performances, data for seakeeping assessments, non-linear effects, numerical prediction of seakeeping, experiments and trials.

Ship maneuvering

Directional stability, stability and control of ships, ship maneuverability, different ship maneuvers, IMO regulations, free-running model tests, nonlinear equations of motion, captive model tests.

References:

1 Biran, Adrian, and Rubén López-Pulido. Ship hydrostatics and stability. Butterworth-Heinemann, 2013.

2 Rawson, Kenneth John, and Eric Charles Tupper. Basic Ship Theory Volume 1. Vol. 1. Butterworth-Heinemann, 2001.

3 Rawson, Kenneth John, and Eric Charles Tupper. Basic Ship Theory Volume 2. Vol. 2. Butterworth-Heinemann, 2001.

4 Molland, Anthony F., ed. The maritime engineering reference book: a guide to ship design, construction and operation. Elsevier, 2011.

5 Faltinsen, Odd. Sea loads on ships and offshore structures. Vol. 1. Cambridge university press, 1993.

6 Bhattacharyya, R. Dynamics of marine vehicles,A Wiley Interscience Publication- John Wiley, 1978.

7 Lewis, Edward V., Principles of naval architecture Volume 2, SNAME, 1988.

8 Lewandowski, Edward M. The dynamics of marine craft: maneuvering and seakeeping. Vol. 22. World scientific, 2004.

CE6322E ADVANCED WAVE HYDRODYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Estimate the spectral characteristics of ocean waves and the transformation of spectra
CO2: Demonstrate theoretical skills in calculations of extreme waves and design wave
CO3: Demonstrate theoretical skills in the estimation of random wave forces
CO4: Understand the analysis of multidirectional waves

Random waves- Review of basic statistical concepts- Random processes- Probability distributions such as Gaussian distribution and Rayleigh distribution- Auto correlation and Cross correlation- Applications.

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.

Estimation of extreme waves- Collection of data- Plotting formulae- Extreme value probability distributions- Methods of parameter estimation- Confidence intervals- Design wave selection

Random wave forces- Morison equation with arbitrary wave spectrum and with narrow band wave spectrum- Estimation of force coefficients- Effect of wave non-linearity- Random forces on large bodies- Long term force distribution- Introduction to 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. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
6. Sarpkaya, T. and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand, 1981.
7. Kinsman, B., Wind Waves, Prentice Hall, Inc.1965.

CE6323E STABILITY OF STRUCTURES

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand basic concepts of stability and perform stability analysis of beam columns.
CO2: Perform stability analysis of bars/columns by different methods.
CO3: Carryout stability analysis of simple frames and determine safe load.
CO4: Perform stability analysis of thin walled sections, beams undergoing lateral buckling, plated and shell structure.

Beam - Columns

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, effect of initial curvature on deflections — Interaction formula.

Elastic buckling of bars

Elastic buckling of bars: Review of Euler column theory for 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, effect of shear force onthe critical load, buckling of built up columns — Various empirical formulae for column design.

Elastic buckling of simple frames

Stability of rigid bars having linear or rotational springs: Stability of system of rigid bars using equilibrium and principle of stationary potential energy — Bulking of frames: Portal, rectangular and L-shaped frames under non-sway conditions, matrix approach and stability functions.

Torsional buckling and buckling of plates and shells

Pure torsion of thin walled bars of open cross-section: Torsional Buckling, determination for warping displacement for a thin walled channel section, examples of section with thin elements in which there is no warping — Lateral buckling of beams in pure bending: Lateral buckling of simply supported I-beams — Introduction to stability of plates and shells: Buckling of plates, buckling of shells.

References:

1 Timoshenko, S.P., and Gere, J.M., Theory of elastic stability, McGraw Hill, Singapore, 1963.
2 Chajes, A., Principles of structural stability theory, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1974.
3 Brush, D.O., and Almorth, B.O., Buckling of bars, plates and shells, McGraw Hill, 1975.
4 M L Gambhir, Stability analysis and design of structures, Springer, 2010.
5 Chai H Yoo and Sung Lee, Stability of structures – Principles and applications, Elsevier, 2011.
6 Kumar, A., Stability of structures, Allied Publishers Limited, 1998.
7 lyengar, N.G.R., Structural stability of columns and plates, East West Press, 1986.
8 Simitses, G.J., Introduction to the elastic stability of structures, Prentice Hall Inc., 1976.

CE6324E OFFSHORE PIPELINE DESIGN AND INSTALLATION

Pre-requisite: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

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.

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.

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 and Dynamic stability design format- Pipe–soil interaction- Free span evaluation-Expansion and global buckling.

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.

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. Mousselli Offshore Pipeline Design, Analysis and Methods, PennWell Corp, 1981.

CE6325E RELIABILITY ENGINEERING AND ASSET RISK MANAGEMENT

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	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.

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 viz. loads, material properties etc.

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.

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).

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.

CE6326E OFFSHORE RENEWABLE ENERGY AND TECHNOLOGY

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	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

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.

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

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

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.

CE6327E HAZARDS MITIGATION MANAGEMENT

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	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.

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

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

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

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.

CE6101E THEORY OF ELASTICITY AND PLASTICITY

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand mathematical formulation of elasticity problem 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 elegantly
CO4: Introduction to plasticity will enable understanding advanced books on theory of plasticity

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.

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-strain Problems in Three Dimensions: Principal stresses, principal strains, three- dimensional problems.

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.

Introduction to Plasticity

One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

References:

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

CE6102E STRUCTURAL DYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

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

Introduction-SDOF system fundamentals

Introduction to dynamics of structural systems: continuous systems and discretization; significance of single degree of freedom system in the dynamic analysis of structural systems. Free vibration 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; critically damped, under damped and overdamped systems.

SDOF System-Forced vibration response

Forced Response of Singe-Degree-of-Freedom Systems: Response to a harmonic excitation force, response to support motion; 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 general dynamic loading - the convolution integral.

Multi Degree of Freedom Systems

Multi-Degree-of-Freedom Systems: Equations of motion, generalized coordinates, matrix formulation; stiffness and mass matrices; linear transformations and coupling, undamped free vibration response. the matrix 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.

Continuous systems, Analytical Dynamics

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, 1986
2. Clough R.W. and Penzien J, Dynamics of structures, McGraw Hill, 2015.
3. Chopra, A.K., Dynamics of structures – Theory and Application to Earthquake Engineering, Prentice Hall, 2015.
4. Thomson W.T. and Dahleh M.D, Theory of Vibration with Applications, Pearson Education,1998.
5. Craig, Jr. R.R, Structural Dynamics, John Wiley, 1981.
6. Hurty, W.C. and Rubinstein M.F, Dynamics of Structures, Prentice Hall, 1964.
7. Jagmohan L. Humar, Dynamics of Structures 2nd Edition, Balkema Publishers, 2002.

CE6111E FINITE ELEMENT METHOD

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To formulate finite element model of a physical system
CO2: To derive element stiffness matrix for a given problem
CO3: To write a computer code and analyse a structure using the finite element method
CO4: To use latest commercial FE software

Introduction: Finite element analysis, Problem classification, Modelling and discretization, interpolation, elements, nodes and D.O.F, Example applications, History of FEA.

One-Dimensional Elements: Bar element, Beam element, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Exploiting sparsity, Mechanical loads, Thermal loads, Stresses, Structural symmetry.

Basic Elements: Interpolation and shape functions, Linear triangle, Bilinear rectangle, Rectangular solid element, Nodal loads, Stress calculation, Nature of finite element solution.

Formulation Techniques: Variational Methods: Principle of stationary potential energy, Problems having many D.O.F., Potential energy of an elastic body, Rayleigh-Ritz method, Strong and weak forms, Finite element form of Rayleigh-Ritz method, Convergence of finite element solutions.

Formulation Techniques: Galerkin and Other Weighted Residual Methods: Methods of weighted residuals, Galerkin FEM in one dimension, Integration by parts, Galerkin FEM in two dimensions.

Isoparametric Elements: Bilinear quadrilateral, Quadrature for obtaining [k] by numerical integration, Quadratic isoparametric elements, Hexahedral isoparametric elements, Stress calculation, Patch test, Validity of isoparametric elements.

Isoparametric Triangles and Tetrahedra: Reference coordinates, shape functions, analytical integration, area and volume coordinates, numerical integration.

Coordinate Transformation and Selected Topics: Displacement, strain, stress, material property and stiffness matrix transformations, Changing the direction of restraints, Connecting dissimilar elements, Structural modification, Reanalysis.

Modelling Considerations: Repetitive symmetry, Static condensation, Substructures.

References:

1. Cook, R.D., et al, Concepts and Applications of Finite Element Analysis, John Wiley, 2003.
2. Krishnamoorthy, C.S., Finite Element Analysis – Theory and Programming, Tata McGraw Hill, 1996.
3. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1996.
4. Desai, C.S., Elementary Finite Element Method, Prentice Hall of India, 1998.
5. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. I and II, Mc Graw Hill, 1991.
6. Buchanan, G.R., Finite Element Analysis, Schaum's Outlines, Tata McGraw-Hill, India, 1995.
7. Rajasekaran, S., Finite Element Analysis in Engineering Design, Wheeler Pub, 1998.

CE6112E THEORY OF PLATES AND SHELLS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields
CO2: Employ 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

Introduction-Plate fundamentals and basic equations

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 and simply supported edges - Synclastic bending and Anticlastic bending – Strain energy in pure bending of plates in Cartesian and polar co-ordinates – Limitations.

Rectangular Plates and Advanced Topics

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

Circular plates and advanced topics

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.

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

Theory of shells

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. Timoshenko, S.P., and Krieger, S.W., Theory of Plates and Shells, McGraw Hill, 1987.
2. Ventsel, E., and Krauthammer, T., Thin plates and shells, Theory, Analysis and Applications, Marcel Dekker, Inc, New York, 2001.
3. Szilard, R., Theory and Analysis of Plates – Classical Numerical Methods, Prentice Hall Inc., 1974.
4. Bairagi, N.K., Plate Analysis, Khanna Publishers, New Delhi, 1986.
5. Gould, P.L., Analysis of Shells and Plates, Springer-Verlag, New York, 1988.

CE6121E STRUCTURAL OPTIMIZATION

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To exploit the available limited resources in a manner that maximizes output and the structural performance in a way that economizes energy or minimize 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 analyze structures using optimization techniques which replaces the time consuming and costly design iterations and hence reduces design development time and overall cost while improving design performance.

Introduction: Structural optimization problem formulation with examples. Single variable unconstrained optimization 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.

Multi variable unconstrained optimization 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.

Constrained optimization 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.

Specialized optimization techniques: dynamic programming, geometric programming, genetic algorithms.

References:

1. Rao S. S., Engineering optimization – theory and practice, John Wiley & Sons, Inc., New Jersey, 2009.
2. Deb, K.., Optimization for engineering design – algorithms and examples, Second edition, PHI Learning Pvt. Ltd., New Delhi, 2012.
3. Kirsch, U., Optimum structural design – concepts, methods and applications, McGraw-Hill, New York, 1981.
4. Arora J. S., Introduction to optimum design, Fourth edition, Academic Press Inc., 2016.
5. Spillers, W.R., and MacBain, K.M., Structural optimization, Springer, New York, 2009.
6. Christensen, P.W., and Klarbring, A., An Introduction to Structural Optimization, Springer, New York, 2009.

CE6122E MODELLING, SIMULATION AND COMPUTER APPLICATIONS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand the role of computational modeling as a solution for various applications.
CO2: Fundamentals of deterministic and probabilistic simulations.
CO3: Basics of data generation, analysis and computing.
CO4: Introduction to algorithms and coding.

Numerical Solution of Nonlinear Equations

Algebraic equations – Secant, fixed point iteration, Newton-Raphson, differential equations – initial and boundary value problems - Euler's methods, Runge-Kutta methods, predictor-corrector methods, Wilson theta, HHT-α methods, finite difference, numerical integration - trapezoidal rule, Simpson's rule, quadrature.

Matrix algebra

Matrix operations, Gaussian elimination, Gauss-Jordan elimination, matrix inversion, singular value decomposition, LU decomposition, Eigenvalues, Eigenvectors, introduction to parallel computing.

Stochastic modeling and simulation

Probability preliminaries, random variables and random processes, Monte Carlo simulations - random number generation, Gaussian and non-Gaussian random process simulation, variance reduction, statistics - sampling distributions, point estimation, hypothesis testing, maximum likelihood estimation.

Machine learning

Supervised machine learning - regression and classification, machine learning algorithms - linear and logistic regression, decision trees, support vector machines, random forest, gradient boosting techniques, neural networks - multilayer perceptron, backpropagation, convolutional neural networks, introduction to deep learning.

References:

1. Chopra, S.C., and Raymond, P.C., Numerical methods for engineers, Eighth edition, McGraw-Hill, New Delhi, 2021.

2. Strang, G., Introduction to linear algebra, Sixth edition, Wellesley-Cambridge Press, Wellesley 2023.

3. Rubinstein, R.Y., and Kroese, D.P., Simulation and the Monte Carlo method, Third edition, John Wiley & Sons, Inc., New Jersey, 2017.

4. Bishop, C.M., Pattern recognition and machine learning, Springer, New York, 2006.

CE6123E EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

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.

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.

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 – guidelines for earthquake resistant design – ductile detailing for seismic design - improving seismic behaviour of masonry, timber and steel buildings.

Seismic design of water tanks – elevated tower supported tanks- hydrodynamic pressure in tanks – examples - seismic design of towers – stack like structures – chimneys.

Seismic design principles of retaining walls – concept of seismic design 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 PublishersPvt .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).

CE6128E ANALYTICAL DYNAMICS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate problems of dynamics using differential equation approach and variational approach.
CO2: Solve engineering problems that can act as benchmark solutions for testing computational methods and software.
CO3: Appreciate energy theorems and variational principles of mechanics in theory and in dealing with real-life problems.
CO4: Formulate numerical solutions to mechanics problems based on variational formulations

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.

Motion relative to rotating reference frames: Transformation of coordinates, rotating coordinate systems, moving references.

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.

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, Dover Publications, New York, 2003.
2. Goldstein, H., Poole, C.P., and Safko, J., Classical mechanics, Third edition, Pearson Education Limited, Noida, 2011.
3. Torok, J.S., Analytical mechanics with an introduction to dynamical systems, John Wiley & Sons, Inc., New York, 2000.
4. Baruh, H., Analytical dynamics, McGraw-Hill, New York, 1999.
5. Greenwood, D.T., Classical dynamics, Dover Publications, Inc., New York, 1997.

CE6127E FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To understand the design and environmental factors leads to the failure of structures.
CO2: To assess the distress in structural members and identify the causes for the failures
CO3: To familiarize the modern techniques to repair and strengthen the structural members

Defects and failure of structures

Causes of distress in concrete structures – Design and construction errors – Durability of RCC structures – Effects due to climate, fire, chemicals, wear and erosion – Corrosion of rebars – Damage due to earthquake – Provisions in IS 1893 and IS 4326 – Types of cracks – Learning from failures – Case studies

Condition assessment and NDT methods

Diagnosis and Assessment of Distress: Preliminary inspection, planning stage, visual inspection, field and laboratory testing stage – Load test for Stability – non-destructive tests: ultrasonic pulse velocity method, rebound hammer technique, penetration resistance, pull out tests, core sampling and testing – Crack detection techniques – Chemical tests: carbonation and chloride tests – Corrosion potential assessment, cover meter survey, resistivity measurement – Identification and estimation of damage, structural integrity and soundness assessment, interpretation and evaluation of results – consideration for repair strategy – Case studies of RCC buildings subjected to distress

Repair materials and methods

Essential parameters for repair materials: Premixed cement concrete and mortars, polymer modified mortars and concrete, epoxy and epoxy systems, Rust eliminators, polymer concrete system – Repair to active and dormant cracks: grouting, routing and sealing, stitching, slurry injection, gunite, shortcrete, vacuum concrete – Repair and strengthening of various damaged structural elements (slab, beam, and columns): reinforcement replacement, plate bonding technique, ferrocement jacketing, RCC jacketing, internal and external pre-stressing, fiber wrap technique – Underwater repair – Chemical and electrochemical method of repair– Cathodic protection – Case studies

References:

1. ACI 546R-14, Guide to Concrete Repair, American Concrete Institute, 2014
2. ACI PRC-364.4-21: Determining the Load Capacity of a Structure when Structural Drawings are Unavailable – TechNote, American Concrete Institute, 2021
3. Concrete Repair and Maintenance Illustrated: Problem Analysis; Repair Strategy; Techniques by Peter. H. Emmons, Galgotia publications Pvt. Ltd., 2002.
4. Concrete Structures: Protection, Repair and Rehabilitation, R.Dodge Woodson, Elsevier, 2009.
5. Construction Failures, Jacob Feld and Kenneth L Carper, Wiley Europe, 1997
6. CPWD Handbook on Repair and Rehabilitation of RCC buildings, Jain Book Agency, 2011.
7. Design and Construction Failures, Dov Kaminetzky, Galgotia Publication, New Delhi,2001
8. Diagnosis and treatment of structures in distress by R. N. Raikar, Published by R&D Centre of Structural Designers & Consultants Pvt. Ltd., Mumbai, 1994.
9. Handbook on seismic retrofit of buildings, A. Chakrabarti et.al., Narosa Publishing House, 2008.

CE6130E STRUCTURAL HEALTH MONITORING

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Understand systems and sensors for health monitoring of structures
CO2: Gain knowledge of the static and dynamic measurement techniques
CO3: Carry out different damage detection techniques for health monitoring of structures
CO4: Use the IoT and machine learning concepts for health monitoring of structures

Introduction to structural health monitoring (SHM)

Need for Structural Health Monitoring, Structural Health Monitoring versus Non-Destructive Evaluation, Methods of SHM, Local & Global Techniques for SHM, Short & Long-Term Monitoring, Active & Passive Monitoring, - Challenges in SHM - Remote Structural Health Monitoring – Importance and Advantages – Methodology – IoT applications in SHM – Application Machine leaning Techniques in SHM.

Sensors and instrumentation for SHM

Sensors for measurements: Electrical Resistance Strain Gages, Vibrating Wire Strain Gauges, Fiber Optic Sensors, Temperature Sensors, Accelerometers, Displacement Transducers, Load Cells, Humidity Sensors, Crack Propagation Measuring Sensors, Corrosion Monitoring Sensors, Pressure Sensors, Acoustic emission sensors, ultrasonic sensors, piezoceramic sensors and actuators, fiber optic sensors and laser shearography techniques, imaging techniques – Data Acquisition Systems – Data Transmission – Data Processing – Storage of processed data – Knowledgeable information processing

Measurement and damage detection techniques

Static measurement: Load test, concrete core trepanning, flat jack techniques, static response measurement – Dynamic measurement: vibration-based testing – ambient excitation methods, measured forced vibration – impact excitation, step relaxation test, shaker excitation method – Damage diagnostic methods based on vibrational response and wave propagation – Neural network-based classification techniques- Extraction of features from measurements, training and simulation techniques, connectionist algorithms for anomaly detection, multiple damage detection

Data processing and case studies

Review of Signals – Advanced signal processing methods – Wavelet, Hilbert-Huang transform, Practical aspects of testing large bridges for structural assessment – Optimal placement of sensors – Structural integrity and condition monitoring of aging multistorey buildings.

References:

1. Daniel Balageas, Peter Fritzen, Alfredo Guemes, Structural Health Monitoring, John Wiley & Sons, 2006.
2. Douglas E Adams, Health Monitoring of Structural Materials and Components Methods with Applications, Wiley Publishers, 2007
3. Hua-Peng Chen, Structural Health Monitoring of Large Civil Engineering Structures, Wiley Publishers, 2018
4. Ansari, F Karbhari, Structural health monitoring of civil infrastructure systems, V.M. Woodhead Publishing, 2009
5. J. P. Ou, H. Li and Z. D, “Duan Structural Health Monitoring and Intelligent Infrastructure”, Vol1, Taylor and Francis Group, London, UK, 2006.
6. Victor Giurglutiu, “Structural Health Monitoring with Wafer Active Sensors”, Academic Press Inc, 2007.

CE6131E STRUCTURAL RELIABILITY

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify deterministic and random variables associated with structures and quantify the degree of randomness
CO2: Perform reliability analysis for 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

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.

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

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

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, 2014

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.

CE6133E RANDOM VIBRATIONS

Pre-requisites: Nil

L	T	P	O	C
3	0	0	0	3

Total Lecture Sessions: 39

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.

Basic Theory of Stochastic Processes (A review)

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.

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.

Linear systems with multiple inputs and outputs

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.

Response of non-linear systems to random excitation

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

References:

1. Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.
2. Loren D Lutes & Shahram Sarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, NJ, 1997.
3. J Solnes, Stochastic Processes & Random Vibration, Theory and Practice, John Wiley,1997
4. Lin, Y. K., Probabilistic Theory in Structural Dynamics, McGraw Hill, 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.

CE6134E ENGINEERING FRACTURE MECHANICS

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	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.

Introduction

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.

Energy balance approach and Elastic Plastic fracture mechanism

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 JICtest and COD test.

Fatigue crack growth mechanism

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.

CE6135E PRESTRESSED CONCRETE DESIGN

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Analyse prestressed 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.

Introduction

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.

Design of shear and torsion

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.

Flexural members and Indeterminate structure

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. Kumar, P. Elements of Fracture Mechanics, Tata McGraw Hill, 2009.
4. Nagarajan, P.,Prestressed concrete Design, Pearson,2013
5. Dayaratnam, P., Prestressed Concrete, Oxford and IBH, 1982.
6. Rajagopalan, N., Prestressed Concrete, Narosa publishers, New Delhi, 2004.
7. Relevant BIS codes

CE6136E MECHANICS OF COMPOSITE STRUCTURES

Pre-requisite: Nil

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

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.

Introduction

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

Composite floors

Structural elements, Profiled sheet decking, Bending resistance, Serviceability criteria, Analysis for internal forces and moments.

Composite columns

Materials: Structural steel, Concrete, Reinforcing Steel, Composite column design, Fire resistance, Combined compression and uniaxial bending.

Continuous beams and slab Hogging moment regions of composite beams, Vertical shear and moment, Shear interaction, Global analysis of continuous beams, Design strategies.

References:

1. Johnson, R.P, Composite Structures of Steel and Concrete, Vol.1Beams, Slabs, Columns and Frames in Buildings, Oxford Blackwell Scientific Publications, London, 1986.

2. INSDAG teaching resource for structural steel design, Vol 2, INSDAG, Ispat Niketan, Calcutta, 2003.

CE6137E ADVANCED FINITE ELEMENT ANALYSIS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Perform finite element analysis of structures using plate and shell elements.
CO2: Perform error analysis and convergence studies within the realm of the finite element method.
CO3: Apply the finite element method to structural dynamics and vibration problems.
CO4: Develop finite element models capable of simulating the real behavior of structures with reasonable accuracy.
CO5: Solve nonlinear problems using the finite element method.

Plate Elements and Shell Elements

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

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

Error Analysis and Imposition of Constraints

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.

Dynamic Analysis and Structural Modeling

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.

Nonlinear Finite Element Analysis

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 $[k_\sigma]$ and its use for buckling analysis.

References:

1. Cook, R.D., Concepts and Applications of Finite Element Analysis, Fourth Edition, John Wiley & Sons Inc., Singapore, 2003.
2. Asghar Bhatti, M., Advanced Topics in Finite Element Analysis of Structures, Wiley, 2006.
3. Reddy, J.N., An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, 2021.
4. Desai, C.S., and Kundu, T., Introductory Finite Element Method, CRC Press, London, 2001
5. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1996.
6. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, Mc Graw Hill, 2000.

CE6138E THEORY OF PLASTICITY

Pre-requisite: Theory of Elasticity

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

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

Fundamentals of Plasticity

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.

Yield Surfaces

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.

Plastic Behaviour and Limit Analysis

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.

Limit Analysis in Plane Stress and Plane Strain

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, 1974.
3. Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York, 1987.
4. Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1998.
5. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1988.

CE6226E GEOGRAPHIC INFORMATION SYSTEM AND ITS APPLICATIONS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the components of a GIS and the reference systems for mapping and data acquisition
CO2: Select suitable data representation tools and methods for analysis
CO3: Process the data to derive meaningful inferences for decision making
CO4: Apply the tools and techniques available in GIS for the selected practical applications

Introduction: Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo-referencing – data acquisition

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.

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.

GIS Applications: Applications of GIS in Environment monitoring – Natural hazard management – Natural resources management urban planning – utility management – Land information – Business development

References

1. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S. Publications, Hyderabad, 2001.
2. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
3. Chang, K-T., Introduction to Geographic Information Systems, McGraw Hill Education, 2016.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersey, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.
6. Heywood, I., Cornelius S. and Carver S., An Introduction to Geographical Information Systems, Pearson Education Ltd, Delhi, 2006.
7. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990.
8. Jensen J R and Jensen R R, Introductory Geographic Information Systems, Pearson Education Ltd, Delhi, 2013.
9. Lo, C.P. and Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.

CE6403E ADVANCED DESIGN OF FOUNDATIONS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze and interpret soil properties for foundation design.
CO2: Utilize advanced geotechnical analysis methods for complex foundation systems.
CO3: Evaluate and analyze bearing capacity and immediate settlement of foundations.
CO4: Understand design considerations for retaining walls and earth retaining structures.

Ground Exploration and Shallow Foundation

Introduction, soil exploration (SPT, CPT, PLT) − analysis and interpretation of soil exploration data − estimation of soil parameters for foundation design. Bearing capacity theories − Methods for bearing capacity estimation − total and differential settlements of footing and raft, code provisions − Design of individual footings, strip footing, combined footing, rigid and flexible mat, buoyancy raft, basement raft, underpinning.

Pile and Well Foundations

Estimation load carrying capacity of single and pile group under various loading conditions − Pile load testing (static, dynamic methods and data interpretation) − settlement of pile foundation, code provisions, design of single pile and pile groups, and pile caps. Well or Caisson foundation types, components, construction methods, design methods (Terzaghi, IS and IRC approaches), check for stability, base pressure, side pressure and deflection.

Retaining Walls and Reinforced Earth

Types (types of flexible and rigid earth retention systems: counter fort, gravity, diaphragm walls, sheet pile walls, soldier piles and lagging) − Support systems for flexible retaining walls (struts, anchoring), construction methods, stability calculations − design of flexible and rigid retaining walls, design of cantilever and anchored sheet pile walls. Geotechnical properties of reinforced soil − shallow foundation on soil with reinforcement, retaining walls with reinforcements, design considerations.

Soil Foundation Interaction
Idealized soil, foundation and interface behavior − Elastic models of soil behavior; Elastic-plastic and time dependent behavior of soil − Beams and plates on elastic foundation; numerical analysis of beams and plates resting on elastic foundation.

References:

1. A.P.S. Selvadurai, Elastic Analysis of Soil-Foundation Interaction, Elsevier Scientific Publishing Company, 2013

2. B. M. Das, Principles of Foundation Engineering, PWS Publishing Company, 2015

3. J. Bowles, Foundation Analysis and Design, McGraw-Hill Book Company, 1982

4. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers and Distributors, 2017

5. S. Saran, Analysis and Design of Substructures, Oxford & IBH Publishing Company Pvt. Ltd., 2009.

IE6001E ENTREPRENEURSHIP DEVELOPMENT

Pre-requisites: NIL

L	T	P	O	C
2	0	0	4	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Describe the various strategies and techniques used in business planning and scaling ventures.
CO2: Apply critical thinking and analytical skills to assess the feasibility and viability of business ideas.
CO3: Evaluate and select appropriate business models, financial strategies, marketing approaches, and operational plans for startup ventures.
CO4: Assess the performance and effectiveness of entrepreneurial strategies and actions through the use of relevant metrics and indicators.

Entrepreneurial Mindset and Opportunity Identification

Introduction to Entrepreneurship Development - Evolution of entrepreneurship, Entrepreneurial mindset, Economic development, Opportunity Recognition and Evaluation - Market gaps - Market potential, Feasibility analysis - Innovation and Creativity in Entrepreneurship - Innovation and entrepreneurship, Creativity techniques, Intellectual property management.

Business Planning and Execution

Business Model Development and Validation - Effective business models, Value proposition testing, Lean startup methodologies - Financial Management and Funding Strategies - Marketing and Sales Strategies - Market analysis, Marketing strategies, Sales techniques - Operations and Resource Management - Operational planning and management, Supply chain and logistics, Stream wise Case studies.

Growth and Scaling Strategies

Growth Strategies and Expansion - Sustainable growth strategies, Market expansion, Franchising and partnerships - Managing Entrepreneurial Risks and Challenges - Risk identification and mitigation, Crisis management, Ethical considerations - Leadership and Team Development - Stream wise Case studies.

References:

1. Kaplan, J. M., Warren, A. C., & Murthy V. (Indian Adoption) (2022). Patterns of entrepreneurship management. John Wiley & Sons.
2. Kuratko, D. F. (2016). Entrepreneurship: Theory, process, and practice. Cengage learning.
3. Barringer, B. R. (2015). Entrepreneurship: Successfully launching new ventures. Pearson Education India
4. Rajiv Shah, Zhijie Gao, Harini Mittal, Innovation, Entrepreneurship, and the Economy in the US, China, and India, 2014, Academic Press
5. Sundar,K.(2022). Entrepreneurship Development, 2nd Ed , Vijaya Nichkol Imprints, Chennai
6. E. Gordon,Dr. K. Natarajan., (2017).Entrepreneurship Development, 6th Ed, Himalya Publishers, Delhi
7. Debasish Biswas, Chanchal Dey,Entrepreneurship Development in India, 2021, Taylor & Francis.

MS6174E TECHNICAL COMMUNICATION AND WRITING

Pre-requisites: NIL

L	T	P	O	C
2	1	0	3	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Apply effective communication strategies for different professional and industry needs.
CO2: Collaborate on various writing projects for academic and technical purposes.
CO3: Combine attributes of critical thinking for improving technical documentation.
CO4: Adapt technical writing styles to different platforms.

Technical Communication
Process(es) and Types of Speaking and Writing for Professional Purposes - Technical Writing: Introduction, Definition, Scope and Characteristics - Audience Analysis - Conciseness and Coherences - Critical Thinking - Accuracy and Reliability - Ethical Consideration in Writing - Presentation Skills - Professional Grooming - Poster Presentations

Grammar, Punctuation and Stylistics
Constituent Structure of Sentences - Functional Roles of Elements in a Sentence - Thematic Structures and Interpretations - Clarity - Verb Tense and Mood - Active and Passive Structures - Reporting Verbs and Reported Tense - Formatting of Technical Documents - Incorporating Visuals Elements – Proofreading

Technical Documentation
Types of Technical Documents: Reports, Proposals, Cover Letters - Manuals and Instructions - Online Documentation - Product Documentation - Collaborative Writing: Tools and Software - Version Control Document Management - Self Editing, Peer Review and Feedback Processes

References:

1. Foley, M., & Hall, D. (2018). Longman advanced learner’s grammar, a self-study reference & practice bookwith answers. Pearson Education Limited.

2. Gerson, S. J., & Gerson, S. M. (2009). Technical writing: Process and product. Pearson.

3. Kirkwood, H. M. A., & M., M. C. M. I. (2013). Hallidays introduction to functional grammar (4th ed.). HodderEducation.

4. Markel, M. (2012). Technical Communication (10th ed.). Palgrave Macmillan.

5. Tuhovsky, I. (2019). Communication skills training: A practical guide to improving your social intelligence, presentation, Persuasion and public speaking skills. Rupa Publications India.

6. Williams, R. (2014). The Non-designer’s Design Book. Peachpit Press.

ZZ6002E RESEARCH METHODOLOGY

Pre-requisites: NIL

L	T	P	O	C
2	0	0	4	2

Total Lecture sessions: 26

Course Outcomes

CO1: Explain the basic concepts and types of research.

CO2: Develop research design and techniques of data analysis

CO3: Present research to the scientific community

CO4: Develop an understanding of the ethical dimensions of conducting research.

Exploring Research Inquisitiveness

Philosophy of Scientific Research, Role of Research Guide, Planning the Research Project, Research Process, Research Problem Identification and Formulation, Variables, Framework development, Research Design, Types of Research, Sampling, Measurement, Validity and Reliability, Survey, Designing Experiments, Research Proposal, Research Communication, Research Publication, Structuring a research paper, structuring thesis/ dissertation.

Data Analysis

Literature review :Tools and Techniques, Collection and presentation of data, processing and analysis of data, Descriptive statistics and inferential statistics, Measures of central tendency, dispersion, skewness, asymmetry, Probability distributions, Single population and two population hypothesis testing, Parametric and non-parametric tests, Design and analysis of experiments: Analysis of Variance (ANOVA), completely randomized design, Measures of relationship: Correlation and regression, simple regression analysis, multiple regression, interpretation of results, Heuristics and simulation.

Research writing and Ethics

Reporting and presenting research, Paper title and keywords, writing an abstract, writing the different sections of a paper, revising a paper, responding to peer reviews.

The codes of ethics, copyright, patents, intellectual property rights, plagiarism, citation, acknowledgement, avoiding the problems of biased survey.

References:

1. Krishnaswamy, K.N., Sivakumar, A.I., and Mathirajan, M., *Management Research Methodology, Pearson* Education, 2006

2. Leedy, P, D., *Practical Research: Planning and Design* (12 e) Pearson., 2018

3. Kothari, C.R., Research Methodology – Methods and Techniques, New Age International Publishers, 2004

4. Mike Martin, Roland Schinzinger., *Ethics in Engineering*, Mc Graw Hill Education, 2004

5. Vinod V Sople, *Managing Intellectual Property-The Strategic Imperative*, EDA Prentice of Hall Pvt. Ltd., 2014