Academic Program: PG

Academic Year 2023-24

Syllabus

I & II Semester M.Tech.

COMPUTER AIDED DESIGN OF STRUCTURES

Department of Civil Engineering

ACADEMIC AUTONOMY

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,

DHARWAD – 580 002

(An Autonomous Institution Approved by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465Fax: 0838-2464638 Web: www.sdmcet.ac.in**

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for I & II semester M.Tech. Computer Aided Design of Structures is recommended by the Board of Studies of Civil Engineering and approved by the Academic Council, SDM College of Engineering &Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2023-24 till further revision.

Principal Chairman BoS & HoD

SDM College of Engineering & Technology, Dharwad

VISION AND MISSION

VISION:

To develop competent professionals with human values

MISSION:

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft-skills leading to overall personality development.

SDM College of Engineering & Technology, Dharwad

Civil Engineering Department

DEPARTMENT VISION AND MISSION

VISION:

To be a Centre of excellence, practice state-of-art civil engineering education and developing high quality engineers to serve society.

MISSION:

The stated vision can be achieved through

- Development of robust curriculum to meet the expectations of industry.
- Interactive teaching-learning process with modern educational tools.
- Establishing synergy between teaching and research.
- Networking with industry.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To provide proficiency in the basic principles and advanced courses of technology in Computer Aided Design of Structures so that students are able to formulate, analyze and solve the societal problems for sustainable development related to Structural Engineering.

2. To expose students to the latest innovations and trends with a view to inculcate strong research orientation in Computer Aided Design of Structures as well as in multidisciplinary streams.

3. To create a congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations.

4. To produce Structural Engineers who integrate and build on the program's core curricular concepts in the pursuit of professional leadership, teamwork, life-long learning, and successful career advancement.

PROGRAMME OUTCOMES (PO):

PO1: An ability to independently carry out design /research/investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over design of structures using software tools as per the specialization of the program.

Scheme of Teaching and Examinations – 2023-24
M.Tech., Computer Aided Design of Structures (CADS)
I SemesterMTech.

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
22PRIC100	Research Methodology and IPR	3-0-0	3	50	100	3	-	-
22PCDC100	Mathematics	4-0-0	4	50	100	3	-	-
22PCDC101	Finite element analysis of structural systems	4-0-0	4	50	100	3	-	-
22PCDC102	Solid Mechanics	4-0-0	4	50	100	3	-	-
22PCDEXXX	Elective 1	4-0-0	4	50	100	3	-	-
22PCDL103	CAD lab – Structural Analysis	0-0-3	2	50	-	-	50	3
22PCDL104	Seminar	0-0-2	1	50	-	-	-	-
Total		**19-0-5**	**22**	**350**	**500**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

***SEE** for theory courses is conducted for 100 marks and reduced to 50 marks.

** Classes and evaluation procedures are as per the policy prescribed for online courses by the respective organizations.

Seminar is to be conducted every week and 2-3 students/week will present a topic from emerging areas in respective PG program preferably the contents notstudied in their regular courses. The seminar shall be evaluated by 3 faculty members having specialization in respective program and allied areas.

List of Electives

Course Code	Elective Courses
22PCDE125	Structural Dynamics -Theory & Computations
22PCDE126	AI and Expert Systems in Structural Engineering
22PCDE127	Geotechnical Aspects of Foundations and Earth Retaining Structures

Scheme of Teaching and Examinations – 2023 -24
M.Tech., Computer Aided Design of Structures (CADS)
II Semester M. Tech.

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
22PCDC201	Advanced Design of reinforced concrete structural elements	4-0-0	4	50	100	3	-	-
22PCDC202	Structural Stability Analysis	4-0-0	4	50	100	3	-	-
22PCDEXXX	Elective 2	3-0-0	3	50	100	3	-	-
22PCDEXXX	Elective 3	3-0-0	3	50	100	3	-	-
22PCDEXXX	Elective 4	3-0-0	3	50	100	3	-	-
22PCDL203	CAD lab – FE analysis	0-0-3	2	50	-	-	50	3
22PCDL204	Seminar	0-0-2	1	50	-	-	-	-
Total		**17-0-5**	**20**	**350**	**500**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

***SEE** for theory courses is conducted for **100 marks** and reduced to **50 marks**.

** Classes and evaluation procedures are as per the policy prescribed for online courses by the respective organizations.

Seminar is to be conducted every week and 2-3 students/week will present a topic from emerging areas in respective PG program preferably the contents not studied in their regular courses. The seminar shall be evaluated by 3 faculty members having specialization in respective program and allied areas.

List of Electives

Course Code	Elective Courses
22PCDE225	Structural Optimization - Theory & Computations
22PCDE226	Reliability Analysis and Design of Structural Elements
22PCDE227	Advanced Design of Steel Structures
22PCDE228	Design of Stack, Tower and Water Storage Structural Systems
22PCDE229	Seismic Resistant Design of Structural Systems
22PCDE230	Advanced Structural Dynamics
22PCDE231	Design of Tall Structures
22PCDE232	Action and Response of Structural Systems

I Semester

22PRIC100	Research Methodology and IPR	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

The students are expected to learn about the need and types of research, problem formulation, literature review, measurement, scaling, data collection, testing of hypothesis, result interpretation and report writing. Further, the students shall know about the intellectual property rights, copy rights, trademarks, patents, patents filing procedure, infringement & remedies, and information technology act etc.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	Formulate their search problem, carryout literature survey and decide the methodology.		**1**	
CO2	Use measurement and scaling and carryout data collection.		**1**	
CO3	Test the hypothesis, interpret & analyze the results, and write the report.	**2**	**3**	
CO4	Explain the need of IPR, copy right, patents, trademarks, & the filing procedure and know about infringement, remedies, and regulatory framework.		**2**	

PO's	**PO-1**	**PO-2**	**PO-3**
Mapping Level	2.0	2.5	2.0

Contents:

1) **Research Methodology:** Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, importance of knowing how research is done, research process, criteria of good research and problems encountered by researchers in India.

03 Hours

Defining the Research Problem: Research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem, an illustration.

02 Hours

2) **Reviewing the literature:** Importance of the literature review in research, how to review the literature, searching the existing literature, reviewing the selected literature, and writing about the literature reviewed. **03 Hours**

Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs, basic principles of experimental designs, important experimental designs.

04 Hours

3) **Measurement and Scaling:** Measurement in research, measurement scales, sources of error in measurement, scaling, meaning of scaling and important scaling techniques.

03 Hours

Data Collection: Collection of primary data, observation method, interview method, collection of data through questionnaires, collection of data through schedules, difference between questionnaires and schedules, collection of secondary data.

03 Hours

4) **Testing of Hypotheses:** What is a Hypothesis? Basic concepts concerning testing of hypotheses, procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, tests of hypotheses.

03 Hours

5) **Interpretation and Report Writing:** Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing, different steps in writing report, layout of the research report, types of reports, oral presentation, and mechanics of writing a research report, precautions for writing research reports, plagiarism and its significance. **04 Hours**

6) **Introduction to Intellectual Property Rights:** Meaning and conception of IPR, competing, rationale for protection, international conventions, world court.

02 Hours

Copy right: Historical evolution of the law on copy right, meaning, content, substance, ownership, primary, special rights, obligations, period, assignment, and relinquishment of copy rights. License and application for registration of copy right.

Patents: Meaning of Patent, purpose and policy object of patent law, gains to inventor, application of patents, joint application, discovery and invention, patentable and non-patentable inventions, publications and public use, priority date and its purpose, procedure for obtaining patent. Stages of procedure, refusal to grant patent

- consequence, protection period, drafting if claims, grant of patent and significance of date of patent and date of ceiling. Services available with patent office, jurisdiction, appellate authorities, powers and obligations of central government, patent agent and controller – not a civil court.**05 Hours**

Industrial design: Concepts & Significance **02 Hours**

Trademarks: Definitions and conceptions of Trademark, advantages of registration, marks which are not registrable, known, and well-known trademarks, application for registration and procedure for registration, procedure, and certification of Trademarks.

02 Hours

Infringement and Remedies: Meaning of infringement, acts of infringements, suit against infringement and defense against infringement, reliefs, and certificate of validity. **02 Hours**

The information Technology Act: Definitions, certifying authority, meaning of compromise of digital signature, offences and penalties, applicability of IPRs, cybercrimes, adjudicating officer, violation, damages and penalties, Cyber regulation appellate tribunal, World Wide Web and domain names and cyber flying.**01Hour**

Reference Books:

1) C.R. Kothari, Gaurav Garg, Research Methodology: Methods and Techniques, New Age International, 4th Edition, 2018.
2) Ranjit Kumar, Research Methodology a step-by-step guide for beginners, SAGE Publications, 3rd Edition, 2011.
3) Fink A, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
4) N. K. Acharya, Textbook on Intellectual Property Rights, 4th Edition, Asia Law House, Hyderabad.

22PCDC100	Applied Mathematics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of, Formulation of mathematical models to simple physical systems, establishing numerical solutions based on extensive computational mathematics for the mathematical models developed and forming the basic algorithms for framing the basis for computer-based solutions in modern systems.

Course Outcomes (COs):

Description of the Course Outcome:	Mapping to POs (1 to 3)

At the end of the course the student will be able to:		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Apply** the idea of random variables (discrete/continuous) and probability distributions in analyzing the probability modelsarising in random processes.	3	1	--
CO-2	**Understand** each technique and use appropriate method to analyse multivariate data.	3	1	--
CO-3	**Apply** the concepts of optimization for constrained and un-constrained engineering problems.	3	1	--
CO-4	**Understand** each technique and use appropriate numerical method to solve differential equations	3	1	--
CO-5	**Establish** the numerical solutions for simultaneous linear algebraic equations.	3	1	--

PO's	1	2	3
Mapping Level	2		3

Course content:

Module 1:Probability Theory. Definitions of random variables and probability distributions, probability mass and density functions, expectation, moments, central moments, characteristic functions, probability generating and moment generating functions-illustrations. Binomial, Poisson, Exponential, Gaussian distributions example.**10Hours**

Module 2: Statistics Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis. The problem of over fitting model assessment.

Sampling Random samples, sampling distributions of estimators,Methods of Moments and Maximum Likelihood. **11Hours**

Module 3: Optimization: One dimensional unconstrained optimization –Constrained Optimization-Linear programming, and non-linear constrained optimization.

10Hours

Module 4: Numerical Differentiation & Integration: Newton's forward and back ward difference formula. Newton –Cotes and Gauss Quadrature Integration formulae, Romberg's integration.
Numerical solutions for differential equations: Numerical solution of Ordinary Differential Equations – Euler's Method andfourth order Runge-Kutta methods. **11Hours**

Module 5: Numerical Methods in Linear Algebra: Gauss elimination, Gauss-Jordon, LU Decomposition, QR Method, Jacobi and Gauss-Seidel Method, Eigenvalues and Eigenvectors – Power method, householder transformation, physical interpretation of Eigenvalues and Eigenvectors.**10Hours**

Reference Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engineering Computation, New Age International, 2003.
4. Taha H A, "Operations research- An Introduction", Mc Milan Publishing Co,1982.
5. Applied statistics and probability for engineers by Douglas C.Montgomery and Geaorge C Runger,Wiley India, 4th edition.

22PCDC101 Finite Element Analysis of Structural Systems (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): Toprovidethe fundamentalconceptsoftheoryofthefiniteelementmethod.
Todevelopproficiencyintheapplicationofthefiniteelementmethod(modeling,analysis,and interpretationofresults)to practicalengineeringproblems.

Course Outcomes (COs):

Description of the Course Outcome:At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explainthebasictheorybehindth e finiteelementmethod.			**1**
CO-2	Formulateandanalyseshapefun ctionsfordifferenttypesofelemen tsusedin FEA.	**1**	**3**	
CO-3	Usethemappingtechniquesfordif ferentelementshapes.	**1**	**3**	

CO-4	Solvenumericalexamplesusing finiteelementmethodforrealstructures.	**1**	**3**	
CO-5	Implementcomputer-orientedproceduresforFEbasedstructuralanalysis.	**1**	**3**	

POs	PO-1	PO-2	PO-3
MappingLevel	2.6		3

Contents:

Module 1: ApproximateSolutionsofdifferentialequationsMathematicalbackground,Needfor and importance ofdifferentialequations,Initialandboundaryvalue problems, Differential equationforaxialdeformationof bars,exactsolutionforaxialdeformationofa uniformbar,taperedbarwithlinearlyvaryingcrosssection(illustration aboutthe difficulty).AxialDeformation ofBarswithuniform crosssection usingGalerkinand Raleigh-RitzMethod.

Finiteelementmethod:Conceptandbasicprocedure, Idealization ofcontinuum using different types ofelements(Bar, Beam, Membrane,Plate andShell), Choiceofdisplacementfunction, Generalizedand Natural coordinates.Interpolation (shape) functions.Formulationusingprincipleofvirtual work.

10Hours

Module 2: Interpolation(shape)functionsofBar,BeamandTriangularelements,Barelements:Generalizedcoordinateapproach,Lagrange interpolation forLinear,quadraticand cubicvariation inGeneralized andnaturalcoordinates.Beam elementsTwonoded (Hermitian interpolation ingeneralizedandnaturalcoordinates). Triangularelements: Threenodes(Generalizedandarea coordinates),six nodesandtransitionelements with fourandfive nodesinareacoordinates. **11 Hours**

Module 3: Interpolation (shape) functionsofRectangular and Solid elements rectangular elements:Fournodes(Cartesian,naturalcoordinates, andLagrangeformula),eight nodes(serendipity element)innaturalcoordinates,ninenodes(Lagrangeelement) using Lagrange formula and transition elements with seven nodes in natural coordinates.Tetrahedral element:Fournodes,tennodes(volumecoordinates), Hexahedron(Brickelement):Lagrangeformulainnaturalcoordinates. **11 Hours**

Module 4: Mappingtechniquesusinginterpolationfunctions.MappingaStraightLine,Curve, andquadrilateralareaswith straightandcurvededges,Requirementforvalidmapping GuidelinesforMappedElementShapes.Numericalexamples **10 Hours**

Module 5: Numericalintegration-Gaussquadrature.Lineor one-DimensionalIntegrals:One point,TwopointandThree-pointformula.ProcedureandNumericalexamples.Area ortwo-dimensional Integrals:procedureandNumericalexamples.Volumeorthree-dimensionalIntegrals:procedureandNumericalexamples. **10 Hours**

Reference Books:

[1]Zeinkiewicz,O.C.andTaylorR.L.,Thefiniteelementmethodforsolidandstructuralmechanics, Butterworh–Heinemann,2013.

[2] Krishnamoorthy C.S., FiniteElementAnalysis: Theory and programming, Tata McGrawHillPublishingCo. Ltd.,2017.

[3] M.AsgharBhatti,Fundamentalfiniteelementanalysisandapplications,JohnWiley&Sons,2005.

[4] RobertDCook,Malkas,D.S.andPlesha.,M.E.,ConceptsandApplicationsofFiniteElement Analysis,3rdEdition,JohnWileyandSons,NewYork.2007.

[5] Bathe.K.J.,FiniteelementproceduresinEngineeringAnalysis.PHI.NewDelhi,2002.

[6] DavidV Hutton,Fundamentalsoffiniteelementanalysis,McGrawHill,2003.

[7] ReddyJ.,AnIntroductionto FiniteElementMethods,McGrawHillCo.,2013

22PCDC102 Solid Mechanics (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): To introduce students to the fundamental concepts of the mechanics of deformable bodies along with state-of-the-art computational methods in civil engineering. The range of material behavior considered includes Finite Deformation Elasticity The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Apply knowledge of mathematics, science, and engineeringby developing the		1,2,3	

	Equilibrium equations			
CO-2	Formulate, analyze and solve two-dimensional elasticity rectangular and polar coordinate problems using classical approach.		1,2,3	
CO-3	Formulate, analyze and solve three-dimensional stress-strain problems using classical approach.		1,2,3	
CO-4	Formulationand implementation of Isoparametric finite element models for two and three-dimensional deforming bodies	1,2,3		
CO-5	Use FEM for solving continuum mechanics problems.	1,2,3		

POs	PO-1	PO-2	PO-3
MappingLevel	2.4	2.4	2.4

Contents:

Module 1: Basic Concepts: Definition of stress and strain at a point, components of stress and strain at a point, strain displacement relations in cartesian coordinates, constitutive relations, equilibrium equations, compatibility equations.Principal stresses — Determination of the principal stresses and principal planes. — Stress invariants — Determination of the maximum shearing stress- Octahedral stress components, Principal strains — strain invariants. boundary condition plane stress, plane strain — Definition.

10 Hours

Module 2: Two-dimensional problems in Rectangular Coordinates: Airy's stress function approach to 2-D problems of elasticity. Solution by Polynomials— End Effects, Saint — Venant's Principle — solution of some simple beam problems, including working out of displacement components. **11 Hours**

Module 3: Two - dimensional problems in Polar coordinates: General equation in Polar coordinates —Strain and displacement relations, equilibrium equations - Stress distribution symmetrical about an axis — Pure bending of curved bars — Displacements

for symmetrical stress distributions —Bending of a curved bar by a force at the end — The effect of a small circular hole on stress distribution in a large plate subjected to uniaxial tension and pure shear.

11 Hours

Module 4: Analysis of Stress and Strain in Three Dimensions: Introduction — Principal stresses —Determination of the principal stresses and principal planes. — Stress invariants — Determination of the maximum shearing stress- Octahedral stress components, Principal strains — strain invariants. **10 Hours**

Module 5: Yield Criteria and Introduction to ideally plastic solid: Maximum principal stress and shearing stress theory, Significance of theories of failure, Mohrs theory of failure, ideally plastic solid, stress space and strain space. **10 Hours**

Reference Books:

[1]TimoshenkoandGoodier," Theory Of Elasticity" McGrawHill BookCompany,IIIEdition,1983.

[2] Valliappan.S, "ContinuumMechanicsfundamentals ", Oxford and IBH, 2nd edition, 2009.

[3] Srinath.L.S.," Advanced Mechanics of Solids",Tata McGraw-Hill Publishing Co. Ltd., NewDelhi, 2009.

[4] H. Jane Helena, "Theory of Elasticity & Plasticity", PHI Learning, 2017.

22PCDL103 Cad lab —Structural Analysis (0-0-3) 2

Contact Hours: 35

Course Learning Objectives (CLOs): In a professional design scenario, it is very important to use industry standard software in a Proficient manner besides knowing the theoretical concepts of structural analysis. The programming exercises help in understanding the implementation of algorithms into a program.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Use industry standard software in a professional set up.	**2**	**3**	
CO-2	Apply finite element modeling, specification of loads and boundary condition, performing analysis and	**2**	**3**	

	interpretation of results for final design			
CO-3	Develop customized design automation tools	**2**	**3**	

POs	PO-1	PO-2	PO-3
MappingLevel		3	2

Contents:

1. Structural Analysis of 2D and 3D Trusses

2. Structural Analysis of Continuous Beams using for different types of loadings and support conditions

3. Structural Analysis of 2D and 3D Rigid and Braced Frames for different types of loadings, support conditions, section orientations and stiffness variation between columns and beams, Member offsets, End release, Tension only members, Active and Inactive member specifications, Soil-Structure Interaction Problems using Winkler Springs

4. Program Development for Matrix operations- Multiplication, Transpose, Inverse, Gauss elimination and Gauss-Seidel, Cholesky methods for solution of linear system of equations using VBA / MATLAB / C++
5. Program Development for Analysis of Trusses, Beams and Frames using VBA / MATLAB / C++

* *Exercises 1to 3 onStructural Analysis using Industry Standard Software's*

22PCDL104Seminar (0-0-2) 1

Course Learning Objectives (CLOs): Develop skills in searching technical literature, analyzing and evaluating it to compare the various approaches and prepare a written report and also presenting it orally.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Prepare reports and compile data.		**2**	

CO-2	Prepare presentations and communicate findings to the audience.		**2**	

POs	PO-1	PO-2	PO-3
MappingLevel		2	

The student must prepare, submit a seminar report and make a presentation on the Seminar topic allotted. The seminar shall be evaluated as internal assessment by a committee constituted by the HOD.

22PCDE125 Structural Dynamics -Theory & Computations (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course focuses on how to model single degree, multi degree of freedom systems and continuous vibratory systems for un-damped, damped forced and free vibrations. Quantification of responses of these systems is also discussed.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain D-Alembert's principle, SDOFS for un-damped, damped free case of structure.		**1,3**	
CO-2	Explain SDOFS for Harmonic loading case and Vibration isolation system of SDOFS.	**1,3**		
CO-3	Analyze the Multi-storey shear building (Two and three DOF) under free and forced vibration for damped and un-damped condition.		**3**	
CO-4	To study the effect of impulse load using Duhamel's Integral. Apply the knowledge of Fourier series in structural dynamics.	**3**		

CO-5	To study discretization of Continuous Systems	**3**		

POs	PO-1	PO-2	PO-3
MappingLevel	2.5		2.6

Contents:

Module1:Single Degree of Freedom System: Degrees of freedom, undamped system, springs in parallel, in series. Newton's laws of motion, free body diagrams. D'Alembert's principle, solution of the differential equation of motion, frequency and period, amplitude of motion. Damped Single degree of freedom system – viscous damping, equation of motion, critically damped system, over damped system, under damped system, and logarithmic decrement. **11 Hours**

Module 2; Response of single degree of freedom system to harmonic loading: Undamped harmonic excitation, damped harmonic excitation, evaluation of damping at resonance, bandwidth method (Half power) to evaluate damping, response to support motion, force transmitted to the foundation, seismic instruments, generalized single degree of freedom system (rigid body and distributed elasticity). **11 Hours**

Module 3: Generalized Co-ordinates and Rayleigh's method: Multistory Shear Building. Free vibration – natural frequencies and normal modes, Zero modes of vibration. Forced motion – modal superposition method – response of a shear building to base motion. Damped motion of shear building – equations of motions – uncoupled damped equation – conditions for uncoupling. Hamilton's principle. **10 Hours**

Module 4 : Response to General Dynamic Loading: Impulsive loading and Duhamel's integral, numerical evaluation of Duhamel's integral, un-damped system, numerical evaluation of Duhamel's integral, damped system. Fourier analysis and response in frequency domain – Fourier analysis, Fourier co-efficient for piece-wise liner functions, exponential form of Fourier series, discrete Fourier analysis, fast Fourier transform **10 Hours**

Module 5: Analysis of Continuous Systems: Longitudinal Vibration of auniform rod. Free transverse vibration of uniform beams Orthogonality of normal modes. Undamped forced vibration of beams by mode superposition. **10 Hours**

Reference Books:

1. MarioPaz,"Structural Dynamics,Theory And Computation",3rdEdition,CBSPublisher, June, 2006
2. Mukhopadhyaya, "Vibration, Dynamicsand Structural Problems, "Oxford IBH Publishers, April 2021.

3. Clough,Ray W and Penzien J, “Dynamics of Structures”,3rd Edition,McGraw-Hill,2003.
4. Roy R.Craig, Andrew J. Kurdila,“Fundamentals of Structural Dynamics”,John Wiley & Sons, 2006.

22PCDE126 AI and Expert Systems in Structural Engineering (4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs): Expert systems are the most mature and widely used commercial application coming out of artificial intelligence. In an expert system, the computer applies heuristics and rules in a knowledge-specific domain to render advice or make recommendations, much like a human expert would.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Use expert systems to achieve fairly high levels of performance in task areas which require a good deal of specialized knowledge and training.	**3**	**1**	
CO-2	Develop expert systems to perform tasks which are physically difficult, tedious, or expensive to have a human perform	**3**	**1**	

POs	PO-1	PO-2	PO-3
MappingLevel	2		3

Contents:

Module 1: Artificial Intelligence:

Introduction: AI - Applications fields, defining the problems - state space representation - problem characteristics - production system - production system characteristics. Knowledge Representation: Formal logic - predicate logic - logic programming - forward v/s backward reasoning - matching control knowledge. **10 Hours**

Module 2: Search and Control:
Concepts - uninformed / blind search: depth first search - breadth first search - bi-directional search - informed search - heuristic graph search - generate and test - hill climbing – best-first search - AND OR graph search. Non-formal Knowledge Representation - semantic networks - frames— scripts— production systems, Programming in LISP.**11 Hours**

Module 3: Expert Systems:
Their superiority over conventional software — components of an expert system — expert system life cycle-expert system development process- nature of expert knowledge — techniques of soliciting and encoding expert knowledge. Inference: Forward chaining - backward chaining - rule value approach.
11 Hours

Module 4: Uncertainty
Symbolic reasoning under uncertainty: logic for non-monotonic reasoning. Statistical reasoning:Probability and Bayes' theorem - certainty factor and rule-based systems - Bayesian network –Dempster - Shafer theory. **10 Hours**

Module 5; Fuzzy reasoning and Neural Networks:
Features of rule-based, network- based and frame -based expert systems — examples of expert systems in Construction Management and Structural Engineering. Expert system shells. Neural Networks: An introduction — their possible applications in Civil Engineering.

10 Hours

Reference Books:

[1] Adeli,H., "Expert Systems in Construction and Structural Engg",Chapman & Hall,NewYork,1988.
[2] PattersonD W,"Artificial Intelligence and Expert Systems",Prentice-Hall,NewJersey, 1st edition, January 2015.
[3] Rich,E., Knight K., Shivshankar B Nair, "Artificial Intelligence",TMH, NewDelhi, 3rd edition, 2017.
[4] Rolston, D.W.,"Artificial Intelligence and Expert Systems"McGrawHill,NewYork, January 1997.
[5] Nilsson,N.J.,"Principles of Artificial Intelligence", Narosa., New Delhi, January 1993.

22PCDE127Geotechnical Aspects of Foundations and Earth Retaining Structures (4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs): This course focuses on how to Plan a site investigation, classify and characterize soils for foundation design to estimate the

capacity of foundations, and the settlement of the soil under the foundation load as well as computation of earth pressure and stability of different types of retaining structures.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Plan a subsurface exploration	**3**	**1**	
CO-2	Evaluate appropriate bearing capacity correction factors to use in design	**3**	**1**	
CO-3	Identify strategies to mitigate the effects of expansive soils on foundations	**3**	**1**	
CO-4	Select the appropriate deep foundation type for different soil profiles	**3**	**1**	
CO-5	Compute earth pressure and implement the design procedure for block foundation	**3**	**1**	

POs	PO-1	PO-3
MappingLevel	2	3

Contents:

Module 1: Bearing Capacity of Soils: Generalized Bearing Capacity Equation; Field tests for Bearing Capacity and settlement estimation; Settlement of shallow foundations-Elastic and consolidation settlements; Settlement estimates from penetration tests; Settlement tolerance; Allowable bearing pressure.**10 Hours**

Module 2: Design Parameters for Substructures: Factors influencing selection of depth of Foundation, Subgrade Reaction, Winkler hypothesis and Beams on Elastic Foundation Approach; Soil Line Method;Foundations on expansive soils.Geotechnical failure of foundations during earthquake — Earthquake Resistant design of Shallow foundation —Liquefaction and Remedial measures.**10 Hours**

Module 3: Pile Foundations; Classification of pile foundations and general considerations of design; Ultimate load capacity of piles; Pile settlement; Analysis of single pile and pile group; laterally loaded piles and ultimate lateral resistance. Uplift resistance of piles and anchored foundations; under reamed Pile; Pile load tests; Design examples. **11 Hours**

Module 4: Retaining structures: Earth pressure theories, Fill Walls, Concrete/Gravity walls, Mechanically Stabilized Earth (MSE) walls- Analysis and Design; Sheet pile walls, internally braced excavations (struts), externally braced excavations (tieback excavations), Soil Nailing. **11 Hours**

Module 5: Elements of Soil Dynamics and Design of Machine Foundations: IS 2974 Parts I to IV Machine- Foundation System, Block Foundations, Frame Foundations, Design Criteria, Tuning of Foundation, DOF of a Rigid Block Foundation, Linear Elastic Spring, Elastic Half Space Analog, Parameters influencing Dynamic Soil Parameters, Soil Mass Participation, Effect of Embedment, Soil Damping, Machine Parameters, Vibration Isolation System.**10 Hours**

Reference Books:

[1] Bowles J.E “Foundation Analysis and Design”, McGraw Hill.
[2] Swami, S. (1999). “Soil Dynamics and Machine Foundation”, Galgotia Publications Pvt Ltd, New Delhi
[3] Dr. B C Punmia, Soil Mechanics and Foundation Engineering
[4] Leonards. G.A, “Foundation Engineering”, McGraw Hill.
[5] Varghese P C, “Foundation Engineering”, PHI Learning Pvt. Ltd
[6] Srinivasulu. P. and Vaidyanathan, V. (1980). “Handbook of Machine Foundations”, Tata McGraw- Hill Publishing Company, New Delhi

II Semester

22PCDE201Advanced Design of Reinforced Concrete Structural Elements **(4-0-0)4**

Contact Hours: 52

Course Learning Objectives (CLOs): To provide a detailed treatment of fundamental concepts for the design of RC structural elements, and to present different methods for the design of RC beams subjected to shear and torsion, Deep beams, flat slab systems including integration with finite element procedures. The course also aims at explaining the underlying theory for the provisions in IS standards.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss the behavior of Reinforced Concrete Beams in Shear and Torsion.		**1,3**	
CO-2	Apply redistribution of moments in design of Reinforced Concrete beam.	**1,3**		
CO-3	Design of Reinforced Concrete Deep Beams	**1,3**		
CO-4	Analysis and design of compression members	**1,3**		
CO-5	Design of flat slabs		**1,3**	

POs	PO-1	PO-2	PO-3
MappingLevel	2.6		2.6

Contents:

Module 1: Behavior of RCBeams inShear and Torsion: Modes of Cracking , Shear Transfer Mechanisms , Shear Failure Modes, Critical Sections for Shear Design , Influence of Axial Force on Design Shear Strength, Shear Resistance of Web Reinforcement, Compression Field Theory, Strut-and- Tie Model. Equilibrium Torsion and Compatibility Torsion, Design Strength in Torsion, Design Torsional Strength with Torsional Reinforcement. **10 Hours**

Module 2: Redistribution of Moments in RC Beams: Conditions for Moment Redistribution — Final shape of redistributed bending moment diagram — Moment redistribution for a two-span continuous beam— Advantages and disadvantages of Moment redistribution — Modification of clear distance between bars in beams (for limiting crack width) with redistribution — Moment — curvature Relations of Reinforced Concrete sections . Curtailment of tension Reinforcement - code procedure — Numerical Example. **10 Hours**

Module 3: Design of Reinforced Concrete Deep Beams: Introduction — Minimum thickness -Steps of Designing Deep beams — design by IS 456 - Detailing of Deep beams. **10 Hours**

Module 4: Behavior and Analysis of Compression Members: Effective Length Ratios of Columns in Frames, Code Charts — Numerical Examples, Short Columns - Modes of Failure in Eccentric Compression, Axial Load - Moment Interaction equation, Interaction Surface for a Biaxial Loaded Column, Concept of Equilibrium approach and application to Non rectangular columns. Slender Column: Braced and Unbraced, Design Methods as per IS 456 — Strength Reduction and Additional Moment Method. **11 Hours**

Module 5: Flat Slab Design: Behavior of Slab supported on Stiff, Flexible and no beams, Equivalent Frame Concept, Proportioning of Slab Thickness, Drop Panel and Column Head, Transfer of Shear from Slab to column, Direct Design Method, Equivalent Frame Method — Design Examples. FE analysis and design of Slab Panels based on Wood-Armer equations.**11 Hours**

Reference Books:

[1] S. Pillai, DevdasMenon- Reinforced concrete design, 4th Edition, October 2021.

[2] Varghese. P.C., Advanced Reinforced Concrete design, Prentice, Hall of India,

[3] Krishna Raju — “Advanced R.C. Design”, CBSRD, 1986,

[4] Park R. and Paulay, T., Reinforced Concrete Structures, John Wiley and sons.

[5]Karve.S.R. and Shah V.L., Limit State theory and design of Reinforced Concrete, Pune Vidyarthi Griha Prakashan, Pune.

22PCDC202Structural Stability Analysis (4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to learn buckling characteristics of various structural elements and plates by energy and FE approach. Solution to practical problems will be emphasized including integration with finite element analysis. The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Illustrate detailed treatment of buckling characteristics of various structural elements	**1**	**3**	
CO-2	Calculate critical load by elastic energy method	**1**	**3**	
CO-3	To assess different methods to solve stability problems including integration with finite element procedures	**1**	**3**	
CO-4	Calculate and analyze buckling of simply supported rectangular plate	**1**	**3**	
CO-5	Calculate and analyze buckling of simply supported rectangular plate under combined bending and compression	**1**	**3**	

POs	PO-1	PO-2	PO-3
MappingLevel	3		2

Contents:

Module 1: Beam column: Differential equation. Beam column subjected to (i) lateral concentrated load, (ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series.Euler's formulation using fourth order differential equation for pinned-pinned, fixed-fixed, fixed-free and fixed- pinned columns.

10 Hours

Module 2: Buckling of frames and continuous beams: Elastic Energy method: Approximate calculation of critical loads for a cantilever. Exact critical load for hinged-hinged column using energy approach. Buckling of bar on elastic foundation. Buckling of cantilever columns under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section.Effect of shear force on

critical load. Columns subjected to non-conservative follower and pulsating forces. **11 Hours**

Module 3: Stability analysis by finite element approach: Derivation of shape functions for a two noded Bernoulli-Euler beam element (lateral and translational DOF) —element stiffness and Element geometric stiffness matrices — Assembled stiffness and geometric stiffness matrices for a discretized column with different boundary conditions — Evaluation of critical loads for a discretized (two elements) column (both ends built-in). Algorithm to generate geometric stiffness matrix for four noded and eight noded isoparametric plate elements. Buckling of pin jointed frames (maximum of two active DOF)-symmetrical single bay Portal frame. **11 Hours**

Module 4: Buckling of simply supported rectangular plate: Buckling of uniformly compressed rectangular plate simply supported along two opposite sides perpendicular to the direction of compression and having various edge condition along the other two sides- Buckling of a Rectangular Plate Simply Supported Along Two opposite sides and uniformly compressed in the Direction Parallel to Those sides. **10 Hours**

Module 5: Buckling of simply supported rectangular plate —combined effects: Buckling of a Simply Supported Rectangular Plate under Combined Bending and Compression — Buckling of Rectangular Plates under the Action of Shearing Stresses — Other Cases of Buckling of Rectangular Plates. **10 Hours**

Reference Books:

[1] Stephen P. Timoshenko, James M. Gere, “Theory of Elastic Stability”, 2nd Edition, McGraw-Hill, New Delhi.

[2]Zeiglar.H,” Principles of Structural Stability”, Blasdell Publication

[3] Robert D Cook et al, “Concepts and Applications of Finite Element Analysis”, 3rd Edition, John Wiley and Sons, New York

[4]Rajashekaran. S, “Computational Structural Mechanics”, Prentice-Hall, India.

[5] Ray W Clough and J Penzien,“Dynamics of Structures”, 2nd Edition, McGraw-Hill, New Delhi.

22PCDL203Cad Lab—FE Analysis (0-0-3)2

Contact Hours: 35

Course Learning Objectives (CLOs): In a professional design scenario, it is very important to use industry standard software in a Proficient manner besides knowing the theoretical concepts of structural analysis. The programming exercises help in understanding the implementation of algorithms into a program.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:	Mapping to POs (1 to 3)		
	Substantial Level (3)	Moderate Level (2)	Slight Level (1)

CO-1	Use industry standard software in a professional set up.	**2**	**1,3**	
CO-2	Apply finite element modeling, specification of loads and boundary condition, performing analysis and interpretation of results for final design	**2**	**1,3**	
CO-3	Develop customized design automation tools	**2**	**1,3**	

POs	PO-1	PO-2	PO-3
MappingLevel	2	3	2

Contents:

1. FEAnalysis of Framed structures due to Seismic forces using modal dynamics
2. FE Analysis of Plane Stress and Plane Strain Problems
3. Flexural Behavior of Slab Panels with different aspect ratio and boundary conditions
4. FE Analysis of Slab panel resting on column supports- DropPanels,Capitals
5. FE Analysis of Slab on Grade(Raft), Underpass, Bridge Structures
6. Programming exercises usingC/VBA/VB/MATLABfor CST, LST and Rectangular Elements

**Exercises 1to 5 on FE Analysis are aimed at using Industry Standard Software*

References:

[1] Timoshenko and Krieger, “Theory of Plates and Shells”, McGraw-Hill International Book Company

[2] Chopra, A.K.-“Dynamics of structures”, Prentice-Hall of India Pvt. Ltd. New Delhi.

[3] Clough, R.W. and Penzien J. - “Dynamics of Structures”, McGraw Hill Book Co. New York

[4] Bathe.K.J, “Finite element procedures in Engineering Analysis” .PHINew Delhi

22PCDL204Seminar (0-0-2) 1

Course Learning Objectives (CLOs): Develop skills in searching technical literature, analyzing and evaluating it to compare the various approaches and prepare a written report and also presenting it orally.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Prepare reports and compile data.		**2**	
CO-2	Prepare presentations and communicate findings to the audience.		**2**	

POs	PO-1	PO-2	PO-3
MappingLevel		2	

The student must prepare, submit a seminar reportand make a presentation on the Seminar topic allotted. The seminar shall be evaluated as internal assessment by a committee constituted by the HOD.

22PCDE225Structural Optimization - Theory & Computations (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): In this course, topics on Classical Optimization Techniques, Linear Programming, Nonlinear Programming, Stochastic Programming and Genetic Algorithms are dealt.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Classify the Optimization problems and techniques.	**3**	**1**	
CO-2	Solve the Optimization problems by Linear programming method and sketch them graphically.	**3**	**1**	
CO-3	Solve the Optimization problems by Non - Linear programming method.	**3**	**1**	
CO-4	Solve the Optimization problems by Stochastic programming method.	**3**	**1**	

POs	PO-1	PO-2	PO-3
MappingLevel	2		3

Contents:

Module1: Classical Optimization Techniques: Engineering applications, Statement of optimization problem,Classification of optimization problems, Optimization techniques.Single variable optimization, Multivariable optimization with no constrains, with equality constraints-Lagrange multiplier-method, constrained variation method-and with inequality constraints Kuhn-Tucker conditions. **08 Hours**

Module2:LinearProgramming: Standard form of Linear programming problem, simplex method, revised simplex Method. **08 Hours**

Module 3: Nonlinear Programming: One dimensional minimization methods, Elimination and Interpolation methods, unconstrained Optimization Techniques, Direct Search methods, Descent Methods, ConstrainedOptimizationTechniques,Direct methods, indirect methods.**08 Hours**

Module4:StochasticProgramming:For optimization of design of structural elements with random variables. Application Problems:Optimum DesignRC, PSC, Steel structural elements. Algorithms for optimum designs. **08 Hours**

Module5: Genetic Algorithms: Introduction fitness functions including the effect of constraints crossover,mutation.**07 Hours**

Reference Books:

[1] Rao.S.S- OptimizationTheoryandApplications,WileyEasternLimited,1978.
[2]Fox.R.L. - Optimization Methods for Engineering Design", Addison Wesley,
[3] Stark.R.M.Nicholls.R.L.,Mathematical Foundations for Design", McGraw Hill Book Company.
[4] Narsing k Deo— System simulation with digital computer", Prentice- Hall of India Pvt ,Ltd. New DelhI.

22PCDE226 Reliability Analysis and Design of Structural Elements (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): Assessment of safety of structures is a very important task of structural engineers. The action and response are subjected to statistical variations and are probabilistic. The primary objective of this course is to learn different methods of evaluation of safety taking into account the variation of design parameters.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Summarize concepts and techniques of reliability and probability distributions	**1,3**		
CO-2	Define safety format or failure surface for a given action and response along with their statistics.	**1,3**		
CO-3	Compute reliability index, for the given design details	**1,3**		
CO-4	Arrive at mean value of a dominant design parameter for the target reliability index	**1,3**		
CO-5	Use simulation techniques to arrive at the statistics of design variables	**1,3**		

POs	PO-1	PO-2	PO-3
MappingLevel	3		3

Contents:

Module 1: Concept of variability: Applications of Statistical principles to deal with randomness in basic variables, statistical parameters and their significance, curve fitting, correlation, and regression. **08 Hours**

Module 2: Description of various probability distribution: Probability theory, binomial, Poisson, Normal, Log-normal, External distributions, Testing of Goodness of fit of distribution to the actual data using Chi-square method. **08 Hours**

Module 3: Basic structural reliability: Random variables, continuous variables, discrete variable and computation of structural reliability.
08 Hours

Module 4: Reliability methods: Introduction, Basic variables and Failure surface, FOSM, Hasofer and Lind Method (AFOSM), determination of ‘β’ for present designs.**08 Hours**

Module 5: Simulation techniques and reliability-based design: Monte Carlo method, Applications, Reliability based design. Determination of partial safety factors, Safety checking formats. **07 Hours**

Reference Books:

[1] Ang A.H.S and W.H. Tang, Probability concepts in Engineering planning and Design, John Wiley and sons, New York, Vol.I and II.

[2] Ranganthan R, Reliability Analysis and Design of Structures, Tata McGraw Hillpublishing Co. Ltd., New Delhi.

[3] John B. Kennedy and Adam Neville, Basic Statistical Methods for Engineers and Scientists,

22PCDE227 Advanced Design of Steel Structures (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): This course covers the advanced principles of the design of hot-rolled and cold-formed steel structural members. Reference is made to the IS 800 and 811 standards, explaining the underlying theory for the provisions in these standards. The objectives are to provide students with advanced knowledge of steel structural design and confidence to apply the underlying principles to solve a wide range of structural steel problems. The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Analyze and Design of Laterally unrestrained beams	**1,3**		
CO-2	Analyze and Design of beams subjected to torsion and bending	**1,3**		
CO-3	Analyze and Design of Beam-column in frames	**1,3**		
CO-4	Analyze and Design of Beams with web opening	**1,3**		
CO-5	Analyze and Design of cold formed steel sections	**1,3**		
CO-6	Discuss, Analyze and Design of fire resistance steel structures	**1,3**		

POs	PO-1	PO-2	PO-3
MappingLevel	3		3

Contents:

Module 1: LaterallyUnrestrainedBeams: LateralBucklingofBeams,Factorsaffectinglateral stability,IS800codeprovisions, DesignApproach.Lateralbucklingstrengthof Cantileverbeams,continuousbeams,beams with continuous anddiscrete lateral restraints,Mono-symmetricandnon-uniformbeams–DesignExamples.Conceptsof -Shear Center,Warping,UniformandNon-Uniformtorsion. **08 Hours**

Module 2: Beam-Columnsin Frames: BehaviorofShortandLongBeam-Columns,Effectsof Slenderness RatioandAxialForceonModesofFailure,Biaxialbending,Strengthof BeamColumns,SwayandNon-Sway Frames,StrengthandStabilityofrigidjointed frames,EffectiveLengthofColumns-,MethodsinIS800–Examples.**08 Hours**

Module 3: SteelBeamswithWebOpenings: Shapeofthewebopenings, practicalguidelines, andForcedistributionandfailurepatterns,Analysisofbeamswithperforatedthin andthickwebs,Designoflaterally restrainedcastellatedbeamsforgivensectional properties,Vierendeelgirders(designfor givenanalysisresults) **08 Hours**

Module 4: Coldformedsteelsections: Techniquesandproperties, Advantages,Typicalprofiles, Stiffenedandunstiffenedelements,Local buckling effects, effectivesection properties, IS801&811codeprovisions,numericalexamples-beamdesign,column design.
08 Hours

Module 5: Fireresistance: Fireresistancelevel,PeriodofStructuralAdequacy,Propertiesof steelwithtemperature,Limiting Steeltemperature, Protectedandunprotected members,Methodsof fireprotection,Fireresistanceratings-NumericalExamples.
07 Hours

Reference Books:

[1] N. Subramanian,Design of Steel Structures, Oxford,IBH.
[2]Duggal.S.K.,Limit State Design of Steel structures. Tata McGraw-Hill.
[3]S.S.BhavikattiDesign of Steel Structures, by limit state method as per IS 800-2007, IK publication.

22PCDE228 Design of Stack, Tower and Water Storage Structural Systems (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): To illustrate the quintessential differences in the design of stack, tower and water storage structural systems with reference to other structural systems the delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Analyze and Design of Steel Chimneys	3	1	
CO-2	Analyze and Design of Transmission line towers	3	1	
CO-3	Analyze and Design of Trestles	3	1	
CO-4	Analyze and Design of water storage structures	3	1	
CO-5	Analyze and Design of over-head tanks	3	1	
CO-6	Analyze and Design of Steel Chimneys	3	1	

POs	PO-1	PO-2	PO-3
MappingLevel	2		3

Contents:

Module 1: Steel Chimneys: Lining for chimneys — breach opening — Forces acting on steel chimneys including seismic forces — Analysis Design and Detailing of RC chimneys for different load combinations. Design of thickness of steel plate — Design of base plate — Design of anchor bolts — Design of foundation. **08 Hours**

Module 2: Transmission line towers of various shapes and member types: Loads on towers — Analysis and Design of Steel transmission line towers. Design of Foundations

08 Hours

Module 3: Trestles: Analysis and design of Steel Trestles for vertical and horizontal loads

08 Hours

Module 4: Water Storage structures: Properties of un-cracked section —Calculation of thickness and reinforcement for Liquid retaining structure, Design and Detailing of underground, Ground Level. **08 Hours**

Module 5: Overhead water tanks: Circular, Rectangular on framed and Shaft type of Staging systems as per IS 3370 Parts 1 to 4. **07 Hours**

Reference Books:

[1] Ramachandra, Design of Steel structures Vol.1 and Vol. 2. Standard Publication
[2] S.K. Duggal, Design of Steel structures. Tata McGraw-Hill
[3]Vazirani & Ratwani, Steel structures, Vo1.III
[4]IS: 6533. Code of Practice for Design and Construction of steel chimneys.
[5] IS 802: Use of Structural Steel in Overhead Transmission Line Towers — Code of Practice - Part 1 Material, Loads and Permissible Stresses

22PCDE229 Seismic Resistant Design of Structural System (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): In this course, topics covered on Seismic hazard assessment, Earthquake effects on structures, Concepts of earthquake resistant design of earthen, masonry and RCC buildings are dealt with.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Interpret engineering seismology and Seismic hazard assessment.	**3**	**1**	
CO-2	Evaluate earthquake forces and effect of earthquake on different types of structures.	**3**	**1**	
CO-3	Differentiate the philosophy and principles of earthquake resistance design of structures.	**3**	**1**	
CO-4	Illustrate Earthquake Resistance design of masonry and RCC buildings	**3**	**1**	

POs	PO-1	PO-2	PO-3
MappingLevel	2		3

Contents:

Module 1: Seismic Hazard Assessment- Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seismic tectonics and seismic zoning of India, Earthquake monitoring and seismic instrumentation, Characteristics of strong Earthquake motion, Estimation of Earthquake parameters,Micro zonation.
08 Hours

Module 2: Earthquake effects on structures: Response to ground acceleration, response analysis by mode superposition, torsional response of buildings, response spectrum analysis, selection of design earthquake, earthquake response of base isolated buildings, earthquake response of inelastic structures, allowable ductility demand Response Spectra / Average response Spectra, Design Response Spectra, Evaluation of earthquake forces (IS 1893 – 2002). Effect of earthquake on different types of structures – Lesson learnt from past earthquakes. **08 Hours**

Module 3: Concepts of earthquake resistant design- Structural Systems / Types of buildings, causes of damage, Planning consideration/Architectural Concept (IS 4326–1993) (Do's and Don'ts for protection of life and property), Philosophy and principle of earthquake resistance design, Guidelines for Earthquake Resistant design.**08 Hours**

Module4: Earthquake Resistant Masonry Buildings Earthquake Resistant low strength masonry buildings, Strength and Structural properties of masonry–Lateral load Design considerations. **08 Hours**

Module5: Earthquake Resistant Design of RCCBuildings–Material properties–lateral load analysis design and detailing. Basic concepts of seismic base isolation and Seismic Isolation systems. **07 Hours**.

Reference Books:

1. Chopra, A.K.- "Dynamics of structures", Prentice-Hall of India Pvt. Ltd. New Delhi.
2. Clough, R.W. and Penzien J. - "Dynamics of Structures", McGraw Hill Book Co. New York.
3. S.K.Duggal -"Earthquake Resistant Design of Structures" Oxford publications New Delhi.

22PCDE230 Advanced Structural Dynamics (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The primary objective of this course is to learn advanced methods for solving problems in vibrations. Focus will be given to the use of general relationships in the solution of linear and non-linear problems. The course also

addresses other sources of vibrations such as blast and water waves.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Analyze and solve dynamic response of MDOF system	**1,3**		
CO-2	Formulate, analyze and solve nonlinear structural dynamic	**1,3**		
CO-3	Define and describe random vibration	**1,3**		
CO-4	Formulate, analyze and solve blast loads on structures	**1,3**		
CO-5	Define and describe water waves and analyze response of structures to water waves	**1,3**		

POs	PO-1	PO-2	PO-3
MappingLevel	3		3

Prerequisites:

1. Structural dynamics

Contents:

Module 1: Analysis of Dynamic Response of MDOF Systems by Direct Integration: Basic concept of direct integration methods — central difference methods - Wilson - D Method - Newmark Method — Stability and accuracy of direct integration method.

08 Hours

Module 2: Nonlinear Structural Response — Classification of nonlinear analysis — Systems with nonlinear characteristics — formulation of incremental equations of equilibrium — numerical solution of nonlinear equilibrium equations for single degree freedom systems - linear acceleration step by step method, elastoplastic behavior, algorithm for the step-by-step solution for elastoplastic SDOF system. Newmark Method — Wilson-D - Method Response spectra — construction of a response spectrum, response spectrum for support disturbance, tripartite response spectra, response spectra for inelastic design. Non-liner Response of MDOF Systems — incremental equation of motion, Wilson-D method.

08 Hours

Module 3: Introduction to Random Vibration — Random functions, normal and Rayleigh's distribution, correlation, Fourier transform, spectral analysis, spectral density function, response to random excitation. **08 Hours**

Module 4: Blast Loads on Structure: Sources of Blast Loads — shock waves — sound speed and Mach numbers. Shock pressure. Determination of blast loads — defining blast loads — structure loading. Strain rate effects — approximate solution technique for SDOF systems. **08 Hours**

Module 5: Basic Concepts of Water Waves — Linear wave theory — dispersion equations — wave particle velocities- wave energies. Nonlinear waves- Stokes wave theory — Conidial Wave theory — stream function wave theory. Waves transformations — Shoaling - refraction — diffraction — dissipation —breaking. Wave statistics — significant wave — short term statistics — wave spectra — long term statistics. Wave information — wave measurements — Hind casts. **Response of Structures to Water Waves:** Morrison equation, force coefficient, linearized Morrison equation, inclined cylinders — transfer lift forces. Diffraction theory- scattering problem — wave forces on vertical walls — wave forces on a low vertical wall - wave forces on a rectangular structure.

07 Hours

Reference Books:

1. MarioPaz, "Structural Dynamics, Theory and Computation", 3rd Edition,CBSPublisher, June 2006.
2. Mukhopadhyaya, "Vibration, Dynamics and Structural Problems, "Oxford IBH Publishers, April 2021.
3. Clough,Ray W and Penzien J, "Dynamics of Structures",3rd Edition,McGraw-Hill,2003.
4. Joseph W Tedesco, William G McDougal, D.Allen Ross, "Structural Dynamics Theory and Applications" Publishers Addison Wesley Longman, Inc, 1998.

22PCDE231 Design of Tall Structures (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): To summarize fundamental concepts for the design of tall structure and to present the influence of different loads on the tall structure. The course also aims at explaining the underlying theory for the provisions in IS standards.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Describe tall structures and the types of loads acting on		1	

	tall structures.			
CO-2	Explain dispersion of Lateral Forces, flooring system, wall panel system, and multi-story box system.	**3**	**1**	
CO-3	Discuss different framing system and their comparison – drift and dynamic response of building	**3**	**1**	
CO-4	Design of tall structure by approximate method	**3**	**1**	
CO-5	Describe other latest tall structure framing system	**3**	**1**	

POs	PO-1	PO-2	PO-3
MappingLevel	2		3

Course Contents:

Module1: Introduction to Tall Building in the Urban Context - The Tall Building and its Support Structure - Development of High-Rise Building Structures - General Planning Considerations. Dead Loads – Live Loads-Construction Loads -Snow, Rain, and Ice Loads - Wind Loads-Seismic Loading – Water and Earth Pressure Loads - Loads - Loads Due to Restrained Volume Changes of Material - Impact and Dynamic Loads - Blast Loads -Combination of Loads. **08 Hours**

Module2: The vertical structure plane Dispersion of Vertical Forces- Dispersion of Lateral Forces – Optimum Ground Level Space - Shear Wall Arrangement - Behavior of Shear Walls under Lateral Loading. The Floor Structure or Horizontal Building Plane Floor Framing Systems-Horizontal Bracing- Composite Floor Systems the High - Rise Building as related to assemblage Kits Skeleton Frame Systems – Load Bearing Wall Panel Systems - Panel – Frame Systems –Multi-storey Box Systems. **08 Hours**

Module3: Common high-rise building structures and their behavior under load The Bearing Wall Structure- The Shear Core Structure - Rigid Frame Systems- The Wall - Beam Structure: Interspatial and Staggered Truss Systems - Frame - Shear Wall Building Systems - Flat Slab Building Structures - Shear Truss – Frame Interaction System with Rigid - Belt Trusses - Tubular Systems-Composite Buildings - Comparison of High - Rise Structural Systems Other Design Approaches Controlling Building Drift Efficient Building Forms – The Counteracting Force or Dynamic Response. **08 Hours**

Module4: Approximate structural analysis and design of buildings Approximate Analysis of Bearing Wall Buildings the Cross Wall Structure - The Long Wall Structure The Rigid

Frame Structure Approximate Analysis for Vertical Loading – Approximate Analysis for Lateral Loading - Approximate Design of Rigid Frame Buildings-Lateral Deformation of Rigid Frame Buildings The Rigid Frame - Shear Wall Structure – The Vierendeel Structure-The Hollow Tube Structure. **08 Hours**

Module 5: Other high-rise building structure Deep - Beam Systems -High-Rise Suspension Systems – Pneumatic High -Rise Buildings - Space Frame Applied to High - Rise Buildings - Capsule Architecture.

07 Hours

Reference Books:

[1] Wolfgang Schuller - “High - rise building Structures", John Wiley and Sons, New York.
[2] Bryan Stafford Smith and Alex Coull, “Tall Building Structures ", Analysis and Design, John Wiley and Sons, Inc., 1991.
[3]Coull, A. and Smith, Stafford, B. " Tall Buildings ", Pergamon Press, London, 1997.
[4]LinT.Y. and Burry D.Stotes, " Structural Concepts and Systems for Architects and Engineers ", JohnWiley, 1994.
[5] Lynn S.Beedle, “Advances in Tall Buildings”, CBS Publishers and Distributors, Delhi, 1996.
[6]Taranath.B.S.,“Structural Analysis and Design of Tall Buildings”, McGraw Hill,1998.

22PCDE232 Action and Response of Structural Systems (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):A structural system may be subjected to several combinations of actions when deployed into service. Certain important decisions such as, proper identification of structural systems, design actions on them and the recourse to the type of analysis must be made during the design process. The focus of this course is on how to calculate the various design loads, known as actions, which are required to determine the design forces, known as ‘Response” or effects of actions.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Understand the importance of appropriate code provisions	**1**	**3**	

CO-2	Familiarize with procedures for calculating action effects for different types of structures frequently encountered in practice	**1**	**3**	
CO-3	Assess the basic need, concepts and procedures of different types of analysis		**3**	
CO-4	Characterize the response of different types of structural systems for Tall buildings		**3**	

POs	PO-1	PO-2	PO-3
MappingLevel	3		2

Contents:

Module 1: IS 875 PART 1, 2, 4, 5: Sources, Nature and Magnitude, Probabilistic assessment, CharacteristicandDesignvalues.IS875PART1 and 2 code provisions. Load combination rules for design.Estimation of DL and LL on structural elements such as Slab,Beams,Columns,indifferent types of structural systems, Joint Loads on Trusses, Distributed load on Purlins- Numerical examples.Accidental loads Impact and collisions,ExplosionsandFire – Numerical examples. **08 Hours**

Module2: Wind Load- IS875 PART 3: Buildings: NatureandMagnitude,Factors influencing wind loads, Internal and External pressure distribution, Design Wind Speeds and Pressure, Numerical Examples to calculate external and internal pressure for different types of buildings and regions— Flat roof, Pitched Roof, mono slope roof, Hipped roof,Signboard,Water tank on braced and shaft staging,Multistory Frames. **08 Hours**

Module3: Seismic Loads IS1893 Buildings-Nature and Magnitude, Centre of mass and rigidity,Calculation of Design Seismic Force by Static Analysis Method, Dynamic Analysis Method Location of Centre of Mass, Location of Centre of Stiffness, and Lateral Force Distributions as per code provisions. **08 Hours**

Module4: Vehicles Loads as per IRC 6-2010 on Road Bridges— Class70R, ClassAA, ClassA, Class B, Tracked Vehicle, Wheeled Vehicle, Load Combinations, Impact, Wind, Water Currents, Longitudinal Forces: acceleration, breaking and frictional resistance, Centrifugal forces, temperature, Seismic forces, Snow Load, Collision Loads. Load Combinations- Simple Numerical examples. **08 Hours**

Module5: Types of Analysis and Behavior of Tall Buildings: Linear,Nonlinear behavior,Material nonlinearity,Geometric nonlinearity,Rigid and ElasticSupports,First Order Elastic Analysis, Second Order Elastic Analysis, First order Inelastic Analysis, Second order InelasticAnalysis— Concepts and Brief descriptions Behavior of Structural forms in Tall buildings— Rigid frame, Braced Frames, Shear Walls,Core walls,Tubular, Belt Truss, Outrigger. **07 Hours**

Reference Books:

[1]IS Codes IS875 Parts (1to5), IS1893,IRC6,
[2] An explanatory Handbook on IS875 (PART3);Wind Load on Building and Structures,
[3] Document No:IITK-GSDMAWind07V1.0-IITK-GSDMAProject on Building Codes
[4] Explanatory Examples on Indian Seismic Code IS1893 (Part I): Document No: IITK-GSDMA-EQ21-V2.0-IITK-GSDMAProject onBuilding Codes