# University of Pune

M.E. (Civil) (Structures)

**COURSE STRUCTURE FOR M.E. (For 2008 Course)**

*(w.e.f. June – 2008)*

**SEMESTER I**

<table>
<thead>
<tr>
<th>CODE</th>
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<th>TEACHING SCHEME</th>
<th>EXAMINATION SCHEME</th>
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<td>a. Advanced Design of Concrete Structures</td>
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<td>c. Design of Composite Construction</td>
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### SEMESTER III

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Note: The Contact Hours for the calculation of load of teacher

- Seminar – 1 Hr/week/student &
- Project - 2 Hr/week/student

### SEMESTER IV

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501401: STRUCTURAL MATHEMATICS

Teaching Scheme:
Lectures : 3 Hrs/Week

Examination Scheme:
Theory Paper : 100 Marks
Duration 4 Hrs.

Section I

Unit 1: Matrices I
Review of Matrix Algebra; Matrix Methods of Structural Analysis. Flexibility & Stiffness matrices. Application of Flexibility method to beams & plane trusses, Application of Stiffness method to beams, plane trusses & space trusses, Assembly process, Applications not involving more than three unknowns.

Unit 2: Matrices II
Stiffness Matrix Method for analysis of Plane portal frames, Space portal frames & Grid structures. Transformation matrix, Assembly process, Applications not involving more than three unknowns. Eigen value problems, applications for buckling of column & vibration.

Unit 3: Differential Equations
Ordinary & Partial differential equations Taylor series, Euler’s, Range Kutta methods. Applications in structural mechanics such as critical loads of struts, beam columns. Solution of transcendental equation, Applications of bucking of simple portal frames

Section II

Unit 4: Finite Difference Method
Central, forward and backward methods. Ordinary & partial derivatives, Structural applications such as determination of deflection & indeterminate moments in beams. Buckling load of uniform & variable cross sections of columns. Laterally loaded plates, simple application of deflection and moments in plates.

Unit 5: Regression Analysis
Least square method, Polynominal function curve fitting Interpolation – Polynomial approximation, Lagranges method, spline interpolation.

Unit 6: Numerical Integration & Fourier Series

Reference Books
3. E. Balguramay - Numerical Methods - TMH Publications
4. Pallab Ghosh - - Numerical Methods with computer programmes in C++ - PHI Pvt Ltd.
11. S. Rajasekaran & G. Sankara Subramaniam – Computational Structural Mechanics – PHI
16. T.N. Ganju – Matrix Structural Analysis using spreadsheets – TMH Publication
Section I

Unit 1: Analysis of Stress and Strains
Concept of stress at a point, stress tensor, stress on inclined plane, stress components on a rectangular parallelepiped in Cartesian coordinate system, derivation of stress equilibrium equations, transformation of stresses, stress invariants. The state of strain at a point, strain displacement relations, strain compatibility condition and stress compatibility conditions.

Unit 2: Stress-Strain Relationship
Generalized Hook’s law for Isotropic, Orthotropic, Transversely Isotropic materials, plane stress, plane strain and axisymmetric problems, Problems in 2D Cartesian coordinate system, Airy’s stress function, bending of beams.

Unit 3: Polar Coordinate System
Relationship between Cartesian and Polar coordinate system, Equilibrium equations, Strain displacement relations, Stress-strain relationship, Strain-displacement relationship for plane stress and plane strain conditions, Bending of curved bar, Stress concentration problems.

Section II

Unit 4: Axisymmetric Problems
Equilibrium equations, Strain displacement relations, Stress-strain relationship, Stress-compatibility equations, Plane stress and Plane strain conditions. Cylinders subjected to internal and external pressure.

Unit 5: Torsion
Assumptions and Torsion equation for general prismatic solid bars, Warping of Non-circular sections and St. Venant’s theory. Prandtle’s stress function approach. Torsion of Circular, Elliptical and Triangular cross-section bar. Torsion of thin-walled structures by membrane analogy, Torsion of rolled sections and shear flow.

Unit 6: Beams on Elastic Foundation
Differential equation, Infinite beams with concentrated load, concentrated moment, and finite uniformly distributed load. Semi-Infinite beams with free end subjected to finite uniformly distributed load, hinged end. Finite beams with free end and hinged end.

Reference Books
4. Irving Shames, Mechanics of deformable solids, Prentice Hall
501403: STRUCTURAL DYNAMICS

Teaching Scheme:
Lectures : 3 Hrs/Week

Examination Scheme:
Theory Paper : 100 Marks
Duration 4 Hrs.

Section I

Unit 1:
Nature of exciting forces, degrees of freedom and mathematical modelling of dynamic systems. Single degree freedom system (SDOF): An undamped and damped free vibrations, Viscous and Coulomb’s damping.

Unit 2:
SDOF system: Undamped and damped Forced Vibrations to harmonic excitations, Fourier analysis of periodic forces. Response to unit impulse and arbitrary loading by Duhamel’s integral.

Unit 3:

Section II

Unit 4:
Multiple degrees of freedom (MDOF) system: Free vibrations of a shear building, fundamental frequencies and mode shapes, Orthogonality of mode shapes, Power and Stodola methods. Concept of Tuned Mass Dampers.

Unit 5:

Unit 6:
Continuous system: Free transverse vibrations of beams for various boundary conditions. Free vibration analysis of a cantilever beam by Rayleigh Ritz and Finite Element Method.

Reference Books
4. R.C. Roy - Structural Dynamics an Introduction to Computer Methods, John Wiley & Sons Publications
5. Madhujit Mukhopadhyay – Structural Dynamics Vibrations and Systems, Ane Books India Publishers
(a) ADVANCED DESIGN OF CONCRETE STRUCTURES

Section I

I - REINFORCED CONCRETE

Unit 1:
Yield Line Theory for analysis of Slabs: Equilibrium and virtual work methods of analysis, Rectangular slabs and triangular slabs with various edge conditions – yield line patterns, Circular slabs, Design for limit state of strength and serviceability, Orthotropically reinforced slabs.

Unit 2:
Grid or Cofferd Floors: General features, Rigorous and approximate methods of analysis, Design of grid floors. Design of aqueduct.

Unit 3:
Elevated Service Reservoirs: Rectangular, Circular and Intze type. Design of staging for wind and earthquake forces, container with flat base and domed bottom. Membrane analysis, Effect of Joint reactions due to continuity.

Section II

II - PRESTRESSED CONCRETE

Unit 4:

Unit 5:

Unit 6:
Prestressed Concrete Pipes and Tanks: Circular prestressing, types of Prestressed concrete pipes. Prestressed Concrete tanks: General features, Analysis and design of circular tanks.

Reference Books
2. N. Krishna Raju – Prestressed Concrete, Tata Mc Graw Hill Publication Co
(b) STRUCTURAL DESIGN OF CONCRETE BRIDGES

Section I

Unit 1:
Introduction to bridge engineering, classification and components of bridges, layout, planning. Structural forms of bridge decks, beam and slab decks, cellular decks. Standard specification for bridges, IRC loadings for road bridges, loading standards for railway bridges.

Unit 2:
Design of slab culvert, box culvert and skew bridge.

Unit 3:

Section II

Unit 4:
Structural classification of Rigid Frame bridge, analysis and design of Rigid Frame bridge.

Unit 5:
Classification and design of bearings. Expansion joints. Forces acting on abutments and piers, analysis and design, types and design of wing walls.

Unit 6:
Bridge foundations, design of open well, pile and caisson foundation.

Reference Books
2. T.R. Jagadeesh, M.A. Jayaram - Design of Bridge Structures, Prentice-Hall of India
4. David Lee – Bridge Bearings and Expansion Joints, E & FN Spon
5. V.K. Raina – Concrete Bridge Practice Analysis, design and Economics, Tata McGraw Hill
(c) DESIGN OF COMPOSITE CONSTRUCTION

Section I

Unit 1:

Unit 2:
Composite floors, Structural elements, Profiled sheet decking, Bending resistance, Serviceability criterion, Analysis for internal forces and moments

Unit 3:
Composite Columns, Materials, Concrete filled circular tubular sections, Non-dimensional slenderness, local buckling of steel sections, Effective elastic flexible stiffness, resistance of members to axial compressions, Composite Column design, Fire Resistance.

Section II

Unit 4:
Composite trusses, Design of truss, Configuration, Application range, Analysis and Design aspects and connection details.

Unit 5:
Design of Multi-storeyed commercial and residential composite building, Design basis, load calculations, Design of composite slabs with profile decks, composite beam design, design for compression members, vertical cross bracings, design of foundation.

Unit 6:

Reference Books
2. INSDAG teaching resources for structural steel design Vol – 2, Institute for Steel Development and Growth Publishers, Calcutta
4. INSDAG Design of Composite Truss for Building, Institute for Steel Development and Growth Publishers, Calcutta
5. INSDAG Handbook on Composite Construction – Bridges and Flyovers, Institute for Steel Development and Growth Publishers, Calcutta
6. INSDAG Design Guide for Composite Highway Bridges (Steel Bridges), Institute for Steel Development and Growth Publishers, Calcutta
(d) DESIGN OF FOUNDATIONS

Section I

Unit 1:
Foundation objectives and their importance, Classification of foundations, Soil classification. Geotechnical design parameters, bearing capacity, settlements and factors affecting settlement. Loads for design, depth of foundation and depth of soil exploration. Parameters for design of foundation on various types of soil, soil structure interaction.

Unit 2:
Types of rafts, Design of Flat slab raft, and beam and slab raft foundation.

Unit 3:
Machine Foundation: Introduction, machine vibrations, design of foundations for rotary machines and impact machine, vibration characteristics, design consideration for foundations.

Section II

Unit 4:
Pile foundations: Function and Classification of piles, Concrete piles, Precast and cast-in-situ piles. Static point and skin resistance capacity of a Pile, Pile settlements, Laterally loaded Piles. Various pile group patterns, Efficiency of Pile in group, Negative skin friction.

Unit 5:
IS code recommendations for structural design for various piles. Design of RC cast-in-situ and precast pile by IS code method. Pile group analysis by rigid and flexible methods, Design of pile cap.

Unit 6:
Shell Foundations: Types and applications, Soil structure interaction, Membrane analysis for Hyper and Conical RC shells with and without edge beams, detailing of critical sections.

References Books
11. IS 1904: 1986 Code of practice for design and construction of foundations in soils: general requirements (Third Revision)
17. IS 9456: 1980 Code of practice for design and construction of conical and hyperboloidal types of shell foundations
(a) ADVANCED DESIGN OF METAL STRUCTURES

Section I

Unit 1:
Hoarding Structures – Analysis and design of hoarding structures under dead, live and wind load conditions.

Unit 2:
Castellated beams – Fabrication of the castellated beam from rolled beam. Design of castellated beam for bending and shear.

Unit 3:
Design of Aluminum Structures: Introduction, Stress-Strain Relationship, Permissible Stresses, Tension and Compression Members, Laced and Battened Columns, Beams, Riveted and Bolted Connections.

Section II

Unit 4:
Microwave Towers – Introduction, structural configuration, function, analysis and design. Transmission Towers – Introduction, structural configuration, bracing systems, analysis and design, codal provision for design of tower and foundation.

Unit 5:
Tubular Structures - Tubular Trusses, joint details, tubular scaffoldings, codal provisions

Unit 6:
Cold Form light gauge section- Type of cross section, Stiffened, multiple stiffened and unstiffened element, flat- width ratio, effective design width, Design of light gauge compression, tension and flexural members.

References Books
1. Ram Chandra - Design of steel Structures Vol II, Standard Book House, Delhi
2. Punmia and Jain- Comprehensive Design of steel structure.
3. Teaching resource materials by INSDAG, Kolkatta
4. IS: 800 – 1984 Code of Practice for General Construction in Steel 22/29
5. IS: 875 – 1964 Code of Practice for Structural Safety of Building: Loading Standards (Revised)
6. IS: 801- 1975 Code of practice for use of cold formed light gauge steel structural members in
10. SP: 6 (2)- 1962 Steel beams and plate girders.
12. IS codes for Aluminum Structures, IS:3908, 3909, 3921, 5384, 6445, 6476, 6475, 6449, 8147, Bureau of Indian Standards
(b) STRUCTURAL DESIGN OF STEEL BRIDGES

Section I

Unit 1:
Introduction to steel bridges, classification, selection of bridges, erection methods, historical development of bridges and loading standards for highway and railways.

Unit 2:
Plate Girder Bridges - Types of floor systems, design of deck type plate Girder bridges for broad gauge railway, horizontal truss bracings and end cross frames.

Unit 3:
Truss Girder Bridges - Types, component part, economic proportion, design of through truss girder bridges for highway and broad gauge railway. Various bracing systems for through type truss girder bridges.

Section II

Unit 4:
Plate Girder Bridges - Types of floor systems, design of deck type plate Girder bridges for highway, horizontal truss bracings and end cross frames.

Unit 5:
Truss Girder Bridges - Types, component part, economic proportion, design of through truss girder bridges for highway. Various bracing systems for through type truss girder bridges.

Unit 6:
Bearings – Types, function, selection and design of various types of end bearings

References Books
1. Ram Chandra - Design of steel Structures Vol II, Standard Book House, Delhi
3. T.R. Jagadeesh, M.A. Jayaram - Design of Bridge Structures, Prentice-Hall of India
5. IS: 800 – 1984 Code of Practice for General Construction in Steel
7. IS: 1915 – 1961 Code of Practice for Steel Bridges
(c) PLASTIC METHOD FOR ANALYSIS AND DESIGN OF STEEL STRUCTURES

Section I

Unit 1:
Plasticity in ductile materials, actual and idealized stress-strain graph for mild steel, elasto-plastic behavior of beam in flexure, shape factor for different cross sections, yield zones, concept of plastic hinge.

Unit 2:
Plastic collapse loads of determinate and indeterminate structures such as beams and rectangular portal frames, statical and kinematical methods, basic and combined mechanisms. Determination of plastic collapse loads, bending moment diagram at collapse.

Unit 3:
Plastic collapse loads of frames with inclined members such as gable portal frames, various mechanisms.

Section II

Unit 4:
Philosophy of Limit State design, requirement of steel for design, Limit State of Strength and Serviceability, partial safety factors, design of laterally supported beams, shear resistance

Unit 5:
Secondary design considerations, design of beams with high shear, interaction of bending and shear, interaction of bending and axial force.

Unit 6:
Design of rectangular and gable portal frames, design of corner connection with and without haunches.

References Books
2. SP: 6 (6) – 1972 Handbook for Structural Engineers: Application of plastic Theory in Design of Steel Structures
3. Draft Code for Revision of IS: 800 Code of Practice for General Construction in Steel
4. A.S. Arya and J.L. Ajmani – Design of Steel Structures, Nemchand & Bros., Roorkee
5. Teaching Resource for Structural Steel Design – INSDAG Kolkatta
8. L.S. Beedle – Plastic Design of Steel Frames, John Willey & Sons
(d) DESIGN OF INDUSTRIAL STEEL STRUCTURES

Section I

Unit 1:
Analysis and design of knee braced trussed bent with hinged, fixed and partially fixed bases without gantry. Design of knee brace, roof column and its base.

Unit 2:
Various types of column configurations in case of knee braced trussed bent with gantry loads. Design of stepped columns and bases under various load combinations.

Unit 3:
Analysis and design of gable portal frame with and without gantry loads. Design of bracket supporting gantry loads.

Section II

Unit 4:
Open web frames for industrial shed, trussed purlins.

Unit 5:
Mobile gantry structure, machine foundations

Unit 6:
Analysis and design of various bracing systems in industrial shed structure, industrial flooring.

References Books
2. A.S. Arya and J.L. Ajmani – Design of Steel Structures, Nemchand & Bros., Roorkee
3. Teaching Resource for Structural Steel Design – INSDAG Kolkata
4. IS: 800 – 1984 Code of Practice for General Construction in Steel
5. IS: 875 – 1964 Code of Practice for Structural Safety of Building: Loading Standards (Revised)
7. Steel Designers Manual – ELBS
This will be based on syllabi of theory subjects of Semester I. It shall consist of one assignment on each unit of each subject of Semester I. Besides this, following are subject wise additional requirements for term work.

1. Structural Mathematics –
   a. Computer programming for **any four** methods of the following.
      i. Matrix multiplication
      ii. Matrix inversions
      iii. Solution of simultaneous equations
      iv. Runge – Kutta method
      v. Regression analysis
      vi. Gauss Quadrature rule
   b. Software applications for analysis of structures for **any two** of the following
      i. Space truss
      ii. Space frame
      iii. Portal with inclined leg, Gable portal frames
      iv. Vierendeel girder

2. Structural Dynamics – Experimental work to be carried out for Dynamic Analysis of beams and multi storied shear frames under harmonic/non-harmonic excitations.

3. At least one site visit and preparation of study reports of various case studies for actual field/practice oriented problems for each Elective I and II.

4. At least one project comprising Analysis, Design and Drawing using professional software for a structure in practice for Elective I or II.
501407: SEMINAR I

Teaching Scheme: Practical: 4 Hrs/Week
Examination Scheme: Term Work: 50 Marks

1. Seminar I topic should be based on latest developments in the Structural Engineering.
2. Format of the report should be as per the standards of International Journals in Engineering.
3. Student should submit the report on the Seminar I and present in the presence of panel of examiners appointed by the Principal.

501408: THEORY OF PLATES AND SHELLS

Teaching Scheme: Lectures: 3Hrs/Week
Examination Scheme: Theory Paper:100 Marks

Duration: 4Hrs.

Section I

Unit-1:


Unit-2:

Analysis of Rectangular Plates: Navier solution for plates with all edges simply supported. Distributed loads, point loads and rectangular patch load.

Levy’s Method: Distributed load and line load. Plates under distributed edge moments.

Raleigh- Ritz approach for simple cases in rectangular plates.

Introduction to shear deformation theories.
Unit-3:


Simply supported and fixed edges. Distributed load, ring load, a plate with a central hole.

Section II

Unit-4:

Introduction: Classification of shells on geometry, thin shell theory, equations to shell surfaces, stress resultants, stress-displacement relations, compatibility and equilibrium equations.

Shells of Revolution: Membrane theory, equilibrium equations, strain displacement relations, boundary conditions, cylindrical, conical and spherical shells.

Unit-5:

Circular cylindrical shells: Membrane theory: Equilibrium equations, strain displacement relations, boundary conditions.

Bending Theory: Equilibrium equation, strain displacement relations, governing differential equation, solution for a simply supported cylindrical shell, various boundary conditions. Application to pipes and pressure vessels.

Unit-6:
Beam theory of cylindrical shells: Principles of Lundgren’s beam theory, beam analysis, arch analysis, application to cylindrical roof shells.

Reference Books

2. Ansel C. Ugural, Stresses in Plates and Shells, Mc Graw Hill
3. G. S Ramaswamy, Design and Construction of Concrete Shell Roofs, CBS Publications
501409: FINITE ELEMENT METHOD

Teaching Scheme:

Lectures: 3Hrs/Week

Examination Scheme:

Theory Paper: 100 Marks

Duration: 4Hrs.

Section I

Unit 1:


Unit 2:

Two dimensional elements in plane stress / strain problems. CST, LST & Rectangular elements, Standard formulation procedure using variational principle. Use of polynomial displacement functions, Pascal triangle. Requirements for convergence

Unit 3:

Shape functions in Cartesian & natural coordinate systems, shape functions for one dimensional element such as truss & beam. Shape function for two dimensioned elements. Concept of isoparametric elements, Jacobian Matrix, Formulation procedure for 2 D quadrilateral isoparametric element in plane elasticity problem.
Section II

Unit 4:

Three dimensional elements such as Tetrahydron, Hexahydron, shape functions, stress strain relations, isoparametric elements.

Axisymmetric elements in axisymmetric problems, stress strain relations, triangular and Quadrilateral elements.

Unit 5:

Thin Plate bending elements, various Triangular and Rectangular elements, ACM (Adini, Clough, Melosh) and BFS (Bogner, Fox, Schimdt) elements, Conforming & nonconforming elements, Concept of four noded & eight noded isoparametric elements, Mindlin’s hypothesis for plate bending element.

Unit 6:

Flat & curved shell element, elements for cylindred shells, curved solid element, Ahmad’s degenerated solid element, Pawsey’s eight noded shell element.

Reference Books


2. C.S. Krishnamoorthy – Finite Element Analysis – Theory & Programming - Tata
McGraw Hill Publishing Co. Ltd


5. S.S. Bhavikatti - Finite Element Analysis – New Age International Publishers, Delhi


501410: MANAGEMENT IN STRUCTURAL ENGINEERING
Section I

Unit 1: Resource Management


Unit 3: Structural Audit, Assessment of health of structure, study of structural drawings, nature of distress, visual observations,

Collapse and investigation, limitations on investigator, tools for investigation, Various NDT Methods for assessing strength of distressed materials, investigation management, review of assimilated information, interviews and statements, evaluation and reporting, presentation of report, communication gap among client, architect, consulting engineer & contractor.

Section II

Unit 4: Retrofitting of Structures, parameters for assessment for restoration strategies,
selection of construction chemicals during restoration, Specification for important items of work in restoration, Structural detailing for restoration, Various techniques of retrofitting.

Unit 5: Safety during construction, formwork and staging, material handling, Existing methods of formwork, Modular formwork, Structural aspects for formwork in buildings & bridges.

Unit 6: Demolition of Structure, study of structural system and structural drawings, need and importance for demolition, outline of various demolition methods and their evaluation, partial and controlled demolition, role of safety measures, temporary support structures in demolition. Recycling of demolished materials, contracts

References

1. Handbook of material management by Deananmmmer, McGrawHills
4. Properties of Concrete by A M Neville, Longman

8. Formwork Construction and Practice by Richardson J.G, VP


10. Formwork To Concrete by Austin C.K, Chapman and Hall

11. Design & Construction Of Formwork For Concrete Structures by Wynn A.E., Concrete Publishing Limited

12. Demolition and reuse of concrete by Y Kasai, Chapman and Hall


15. Demolition of Structures, Report by Mr. Girish Kulkarni, Mumbai

16. Structural Audit, Report by Mr. Umesh Dhargalkar, Mumbai


27. Websites for Formwork
   a) http://www.dir.gld.gov.au/workplace/law/codes/formwork design
   b) www.peri-usa.com/, www.specialformwork.com/

28. Websites for Demolition of Structures
   a) www.Howstuffworks.com
   b) www.Findarticles.com
   c) www.historylinks.org
   d) www.implosionworld.com
   e) www.home.earthlik.com
   f) www.seattlepi.com
   g) www.seattletimes.com
   h) www.phillyblast.com
i) www.usgs.gov
501411: ELECTIVE III

Teaching Scheme:          Examination Scheme:
Lectures : 3 Hrs/Week     Theory Paper : 100 Marks

Duration 4 Hrs.

501411 (a) EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

Section I

Unit 1:


Unit 2:


Unit 3:

Capacity based design of soft story RC building, design of Shear Walls. Ductile detailing as per latest IS:13920.

Section II

Unit 4:

Seismic design of multi-storeyed steel structures with various bracing systems.

Lateral load analysis and design of two-storied masonry buildings. P-delta analysis.

Unit 5:

Seismic design of Elevated RC Circular Water Tanks.

Ductility requirements, types of ductility, factors affecting ductility. IS code provisions

Unit 6:

Seismic retrofitting, Sources of weakness in RC framed buildings, Classification of retrofitting techniques, Conventional and non-conventional methods, Comparative study of various methods and case studies. Introduction to Base Isolation systems. IS code provisions for retrofitting of masonry structures, failure modes of masonry structures and repairing techniques.

Note: For this subject add in Lab Practice II the following assignment.

Modelling of multi-storeyed structures including shear walls and diaphragms using standard software for all load combinations.
Reference Books


5. IS:13828 – Improving Earthquake Resistance of Low Strength Masonry Buildings, 1993


7. IS:13920 – Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Force, 1993


11. Joshi P S et al. - Design of Reinforced Concrete Structures for Earthquake Resistance Published by Indian Society of Structural Engineers, 2001
501411 (b) STRUCTURAL STABILITY

Unit 1:

Fundamental concepts, elastic structural stability, structural instability, analytical methods for the stability analysis, equilibrium, imperfections and energy methods.

Unit 2:

Elastic buckling of columns, assumptions, critical load for various boundary conditions, columns with geometric imperfection, large deflection theory of columns, Southwell plot, Orthogonality of buckling modes, eccentrically loaded columns, numerical techniques – Finite difference and Finite element approach.

Unit 3:

Elastic buckling of beam-column, differential equations of beam-column, beam-column with concentrated point load, several point loads, continuous lateral load, single couple, uniformly distributed load, end couples.

Unit 4:

Elastic buckling of frames, triangular, partial, multistory portal and box frames with symmetric & anti symmetric buckling, stiffness method approach, approximate method, buckling of open sections, torsional buckling.

Unit 5:

Elastic buckling of thin plates, equilibrium approach, rectangular plate with axial load in one and two directions, various boundary conditions, Energy methods – Rayleigh Ritz and Gelerkin, large deformation theory of plates and effective width concept, post buckling behavior of plates.

Unit 6:
Dynamic stability of structures, objectives, Hamilton and Lagrange’s equation for discrete and continuous systems, pulsating load on a column.

Reference books

3. Iyenger N.G.R., Elastic Stability of Structural elements, Mc Millan, India

501411 (c) STRUCTURAL RELIABILITY

Section I

Unit-1:

Concepts of structural safety: Design methods, statistics and probability: Data reductions, Histograms, Sample correlation. Random variable, Discrete and continuous variables and common probability distribution.

Unit-2:

Resistance distribution and parameters: Statistical analysis of materials: steel, concrete bricks and mortar, Dimensional variations, characterization of variables and allowable stresses based on specified reliability.

Probabilistic Analysis for live load, gravity load and wind load.
Unit-3:

Computation of basic structural reliability, Reliability analysis of simple element such as beam and column. Reliability methods, basic variables, first order second moment methods (FOSM) and concept of reliability index. Reliability of structural systems: Redundant and non-redundant systems, series, parallel and mixed systems.

Section II

Unit-4:

Monte Carlo Methods of Analysis: Study of structural safety-generation of random numbers-continuous, discrete and jointly distributed variables-Application to reliability analysis of concrete structures.

Unit-5:

Reliability based design: Load and resistance factors of design, safety checking formats and code calibrations, I.S. code provision, Introduction to stochastic process.

Unit-6:

Decision Analysis: Introduction, simple risk decision problems, decision problems, decision model, decision tree, decision criteria, decision based on existing information, Prior analysis
Reference Books

Section I

Unit 1:

Types of Nonlinearities - Geometric Nonlinearity, Material Nonlinearity, Nonlinear Governing Equation for Beams: Moment-curvature Nonlinearity, Geometric Nonlinearity Due to Stretching, Material Nonlinearity,

Geometrically Nonlinear Beam Problems - Moment-Curvature Nonlinearity-Cantilever Beam, Centrally Loaded beam with two supports, Cantilever Beam subjected to Tip Load

Unit 2:


Unit 3: Nonlinear Static Analysis of Plates - Boundary Conditions and method of solution, Large Deflection of Rectangular Plates.
Section II

Unit 4:
Nonlinear Analysis of Columns- Post buckling of cantilever column, Large deflection of column with both ends hinged

Unit 5:

Unit 6:

Reference Books

501412 : ELECTIVE IV (Open)

Teaching Scheme:
Lectures : 3 Hrs/Week

Examination Scheme:
Theory Paper : 100 Marks
Duration 4 Hrs.

501412 (a) MECHANICS OF MODERN MATERIALS

Section I

Unit 1:
Introduction to Modern Materials: Fiber-Reinforced Polymer Composite (FRPC) Materials:
Definition, Historical development, applications. Fibers and Matrix, types and their properties.

Unit 2:


Unit 3:


Section II

Unit 4:

**Unit 5:**

Hygrothermal Expansion and Design of Composite Structure: Coefficients of thermal and moisture expansion of various unidirectional lamina, load deformation relationship, residual stresses for cross ply symmetric laminates. Design methodology, design of pressure vessel for various laminate configurations.

**Unit 6:**


*Reference Books*


Section I

Unit 1:
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.

Unit 2:
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.

Unit 3:
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.

Section II

Unit 4:
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.
Unit 5:

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.

Theorems of Limit Analysis - Alternative statement of the limit theorems, the specific dissipation function, cold bending of bar beyond elastic limit, spring back, plastic bending with strain hardening material, plastic bending of wide plate.

Unit 6:

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.

Reference Books


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

Unit 1:

Structure of biomaterials, classification of bio materials, mechanical properties, iscoelasticity, elasticity of non-Hookean materials. Hard tissue replacements, internal fracture fixation devices, joint replacements, dental implants.

Unit 2:

Metallic Biomaterials and ceramic biomaterials steps involved in the fabrication of metallic implants, stainless steel Co-Cr-alloys Ti & its alloys, medical applications, corrosion of metallic implants.

Non-absorbable or relatively Bioinert bioceramics Bio-degradable or resorbable ceramics. Bio active or surface reactive ceramics, deterioration of ceramics.

Unit 3:

Polymeric Biomaterials and composite biomaterials, 80

Polymerization, polyolefins, Polyamides, acrylic polymers, rubbers, high strength thermoplastics, medical applications, deterioration of polymers. Structure, bounds on properties, anisotropy of composites, particulate composite fibrous composites, porous materials.

Section-II

Unit 4:
Mechanical properties of cartilage. Diffusias properties of articular cartilage mechanical properties of bone.

Unit 5:

Kinetics and kinematics of joints elbow, Hip, Knee joint; Evaluation of joint forces and moments. Equilibrium of joint fundamental concepts of Gait analysis

Unit 6:


Reference books

501412 (d) OPTIMIZATION TECHNIQUES

Teaching Scheme

Lectures : 3 Hrs / Week

Examination Scheme

Theory Paper : 100 Marks

Duration : 4 Hours

Section I
Unit 1: Introduction:

Engineering application of optimization, statement of an optimization problem with example for minimum weight and optimum cost consideration, classification of optimization problems and techniques, Single variable optimisation, multivariable optimization with equality and inequality constraints and without constraints.

Unit 2: Linear Programming

Introduction, standard form of the problem, Geometry, basic terminology

Techniques of linear programming: Simplex method, Revised simplex method: Duality in linear programming, decomposition principle, post-optimality analysis, applications to engineering design

Unit 3: Non Linear Programming

Introduction, elimination methods: various search methods-Fibonacci method and golden section method

Interpolation method-Quadratic and cubic interpolation methods, Direct root method.

Section II

Unit 4: Unconstrained optimization Techniques:

Introduction; Standard form of the problem and basic terminology; Direct search method- Simplex method, Random search method, Univariate and pattern search method

Indirect search method-Steepest Descent (Cauchy) method, Conjugate gradient method, Newton’s method, Application to engineering problems

Unit 5: Constrained Optimization

Introduction; Standard form of the problem and basic terminology; Direct method: Sequential Linear Programming; Generalised Reduced gradient method, Methods of feasible direction

Indirect method: Penalty function method Interior and exterior penalty function method, Convex programming problem, Check for convergence

Application to engineering problems

Unit 6: Introduction to non-traditional methods:
Genetic Algorithm: Introduction, Representation of design variables, objective function and constraints,
Genetic operators and numerical results.

Introduction to Neural network based optimisation

References

   and Sons, London
501413: LAB PRACTICE II

Teaching Scheme: Examination Scheme:
Lectures : 6 Hrs/Week Term work: 50 marks

This will be based on syllabi of theory subjects of Semester II.

It shall consist of one assignment on each unit of each subject of Semester II.

Besides this, following are subject wise additional requirements for term work.

A) Finite Element Method – Software applications of following cases
   i. Plane stress / plane strain problem
   ii. Axisymmetric problem
   iii. Three dimensional problem
   iv. Plate and shell structures

501414: SEMINAR II

Teaching Scheme: Examination Scheme:
Practical: 4 Hrs/Week Term Work: 50 Marks
1. Seminar II consists of case study and report of any one topic from the subject ‘Management in Structural Engineering’.
2. Format of the report should be as per the standards of International Journals in Engineering.
3. Student should submit the report on the Seminar II and present in the presence of panel of internal examiners appointed by the Principal.

501415: SEMINAR III

Teaching Scheme: 
Practical: 4 Hrs/Week

Examination Scheme: 
Term Work: 50 Marks

1. Seminar III consist of literature review and report based on the topic of project.
2. Format of the report should be as per the standards of International Journals in Engineering.
3. Student should submit the report on the Seminar III and present in the presence of panel of examiners appointed by the University of Pune.

501416: PROJECT STAGE I

Teaching Scheme:
Practical: 18 Hrs/Week

The project work commences from Semester III, and it should preferably be a live problem in the construction industry or scientific research for determining solution by making individuals’ contribution.

Project Stage I consists of report containing literature review, identification of problem, methodology and synopsis of the project.
501417: PROJECT STAGE II

Teaching Scheme:                                      Examination Scheme:

Practical: 18 Hrs/Week                                Term work: 150 Marks

                          Oral: 100 Marks

Student should submit the final report in a standard format based on project and present in the presence of panel of examiners appointed by the University of Pune.