Department of Civil Engineering

M TECH IN STRUCTURAL ENGINEERING Teaching Scheme (2011 onwards)

1. FIRST SEMESTER

S.No.	Course No.	Course Title	L	T	P	C
1.	CE-620	Finite Element Method	3	0	0	3
	CE-621	Continuum Mechanics	3	0	0	3
3.	CE-622	Prestressed Concrete Design	3	0	0	3
4.		Programme Elective-1	3	0	0	3
5.		Programme Elective-2	3	0	0	3
6.	CE-623	Concrete Technology Laboratory	0	0	3	2
Sub Total			15	0	3	17

2. SECOND SEMESTER

S.No.	Course No.	Course Title	L	T	P	C
1.	CE-624	Structural Dynamics	3	0	0	3
2.	CE-625	Bridge Engineering	3	0	0	3
3.	CE-626	Rehabilitation and Retrofitting of concrete and Masonry	3	0	0	3
4.		Programme Elective-3	3	0	0	3
5.		Open Elective-1 (from other Dept)	3	0	0	3
6.	CE-627	Experimental Techniques	0	0	3	2
Sub Total			15	0	3	17

3. THIRD SEMESTER

S.No.	Course No.	Course Title	L	T	P	C
1.	CE-800	Seminar				2
2.	CE-801	Dissertation				12
3.	CE-799	Self Study Course				2
Sub Total						16

4. FOURTH SEMESTER

S.No.	Course No.	Course Title	L	T	P	C
1.	CE-801	Dissertation				20
Sub Total						20
Total						**70**

PROGRAMME ELECTIVE COURSES

	Course No	Course Title	L	T	P	C
Common for all stream	**CE-701**	Fuzzy logic, artificial intelligence and neural network	3	0	0	3
	CE-702	Optimization Methods	3	0	0	3
	CE-703	Construction planning and scheduling	3	0	0	3
	CE-704	GIS and its application in civil engineering	3	0	0	3
STRUCTURAL ENGINEERING	**CE-719**	Earthquake Engineering	3	0	0	3
	CE-720	Fracture Mechanics of Concrete	3	0	0	3
	CE-721	Experimental Methods in Structural Engineering	3	0	0	3
	CE-722	Numerical Method	3	0	0	3
	CE-723	Advanced Topics in Steel Structures	3	0	0	3
	CE-724	Advanced Structural Design	3	0	0	3
	CE-725	Concrete Technology	3	0	0	3
	CE-726	Matrix Methods in Structural Engineering	3	0	0	3
	CE-727	Stability of Structures	3	0	0	3
	CE-728	Advanced foundation design	3	0	0	3
	CE-729	Theory and Design of Plates & Shells	3	0	0	3
	CE-730	Advanced Theory and Design of Concrete Structures	3	0	0	3
OPEN ELECTIVES FOR OTHER DEPARTMENT			3	0	0	3
CE-750		Optimization Methods	3	0	0	3

DETAILED SYLLABUS

CE-620 Finite element Method 3+0+0

Principles of discretization, element stiffness and mass formulation based on direct, variational and weighted residual techniques and displacements approach, Shape functions and numerical integrations, convergence, Displacement formulation for rectangular, triangular and isoparametric elements for two dimensional and axisymetric stress analysis. Thin and thick plates and shells. Semi-analytical formulations, Three dimensional elements and degenerated forms. Stiffener elements and modifications such as use of different coordinate systems, use of non-conforming modes and penalty functions. FEM in incompressible and compressible fluid, applications of FEM in thermal problems.

Texts/ References

1.O.C. Zienkiewicz and R.L. Taylor, Finite element methods, Vol I & Vol II, McGraw Hill, 1989, 1992.
2.K. J. Bathe, Finite element procedures, PHI Ltd 1996.
3. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and applications of finite element analysis, Third edition, John Wiley and Sons, 1989.

CE-621 Continuum Mechanics 3+0+0

Basic concepts of the theory of continuous media, introduction to tensor algebra, theory of stresses, infinitesimal and finite strains, strain-displacement relationships, compatibility, stress-strain relationships, boundary value problem in elasticity, plane stress and plane strain case, stress function approaches, plane problems in Cartesian and polar coordinates, elements of plasticity: yield criteria, flow rule and hardening. Plastic stress-strain relationships, Variational methods, Rayleigh-Ritz and Weighted residual methods, Introduction to Hamilton's principles.

Texts/References

1. D.S. Chandrasekharaiah and L. Debnath, Continuum mechanics, Prism Books Pvt. Ltd., Bangalore 1994.
2. S. Timoshenko and J.N. Goodier, Theory of elasticity, McGraw Hill Book Company, Int. edt., 1970.
3. I. H. Shames and F. A. Cozzarellie, Elastic and Inelastic stess analysis, prentice Hall New Jersey 1992.

CE-622 Prestressed Concrete Design 3+0+ 0

Introduction to prestressed concrete: types of prestressing, systems and devices, materials, losses in prestress. Analysis of PSC flexural members: basic concepts, stresses at transfer and service loads, ultimate strength in flexure, code provisions in IS 1343. Statically determinate PSC beams: design for ultimate and serviceability limit states for flexure, and flexure combined with axial compression or tension; analysis and design for shear and torsion, code provisions. Transmission of prestress in pre-tensioned members; Anchorage zone stresses for post-tensioned members. Statically indeterminate structures Analysis and design continuous beams and frames, choice of cable profile, linear transformation and concordancy. Composite construction with precast PSC beams and cast insitu RC slab Analysis and design, creep and shrinkage effects. Partial prestressing principles, analysis and design concepts, crackwidth calculations Analysis and design of prestressed concrete pipes, tanks and spatial structures slabs, grids, folded plates and shells.

Texts/References

CE-623 Concrete Technology Laboratory **0+0+3**

i) Mix design for high strength concrete, use of admixture/plasticizer.
ii) Study of loading and response measuring systems.
iii) Testing of beams subjected to transverse (static/dynamic) loading.
iv) Testing of slab-study of flexural and punching failure
v) Photo-elastic methods of stress analysis.
vi) Different non destructive evaluation of strength of concrete/steel specimen
vii) Free and forced vibration studies using FFT analyzer.

CE-624 Structural Dynamics 3+0+0

SDOF systems: Equations of Motion, Free vibration, damping, Forced vibrations under harmonic, impulse and general loadings, Response spectrum Generalized SDOF systems: Rigid body distributed mass and stiffness systems; MDOF Systems: Dynamic properties, modal damping, classical damping, modal super-position methods; Numerical methods in dynamics: Eigen value analysis, direct integration scheme:

Continuous systems: Equations of motion, Hamilton's principle, Lagrangian formulation, Free and force vibration scheme, Wave propagation; Introduction to Random vibration: Random variables, Random process, moment and characteristic function, spectral analysis, response to random excitation; Application of structural dynamics in the design of block and frame foundation.

Text/References

1.R.W. Clough and J. Penzien, Dynamics of Structures, Second edition, McGraw Hill international edition, 1993.
2. Mario Paz, Structural dynamics, CBS Publishers 1987.
3. Anil K. Chopra, Dynamics of structures: Theory and applications to Earthquake Engg., PHI Ltd. 1997.
4. K. Rao, Vibration analysis and foundation dynamics, Wheeler, 1998.
5. E. Siniu and R. H. Scanlan, Wind effects on structures: fundamentals and applications to design, John wiley and sons, 1997.

CE-625 Bridge Engineering 3+0+0

A review of Historical Developments, Loads and stresses, choice of bridges types, IRC Loading and other bridges loads and impact factor. Types, Type selection components of Bridges, Arcs, Abutments, Pile foundations, cofferdams and other foundations suitable for bridges economical span, preliminary design of bridges.

Design of bridges: RCC Slab culvert, RCC T-Beam and Slab Bridge, Box Girder Bridge, PSC girder bridge.

Design of substructure: piers, abutments

Texts/References

1. Ponnuswamy R. "Bridge Engineering" Tata McGraw Hill Publication New Delhi.
2. Johnson Victor D. "Essentials of Bridge Engineering" Oxford and IBH publication Co. 1980.
3. Krishna Raju N. "Design of Bridges" Oxford and IBH publication Co. 1988.
4. National Building Code of India (ISI).
5. N. Rajagopalan, "Bridge Superstructure" – Narosa – 2005.
6. Jagadeesh and Jairam – A Text Book of Bridge Engineering – Prentice Hall, New Delhi.

CE-626 Rehabilitation and Retrofitting of concrete and Masonry 3+ 0+ 0

Importance of repair, rehabilitation and retrofitting as a part of construction engineering. Causes of distress, evaluation methods for condition, strength, serviceability; Repair materials, repair techniques, and quality control methods for repair of concrete. Criteria for rehabilitation; Principles of assessment of weathering and durability; Characteristics of materials; Diagnosis of construction failures; Dealing with cracks; Methods of repair in concrete, Steel and timber structural components; Corrosion damage of reinforced concrete and its repair and prevention measures; Surface deterioration, Efflorescence, causes, prevention and protection; Surface coatings and painting; Water proofing; Grouting; Retrofit techniques required in structures resulting from change in function, loading, and seismic forces.

Text Books:

1. Retrofitting Design of Building Structures by Xilin Lu
2. Earthquake-Resistant Structures: Design, Build and Retrofit by Mohiuddin Ali Khan Butterworth-Heinemann
3. Concrete Structures, Materials, Maintenance and Repair, by Denison Campbell, Allen and Harold Roper, Longman Scientific and Technical UK
4. Repairs of Concrete Structures, by Allen, R.T. and Edwards, S. C., Blakie and Sons, UK
5. Seismic design, assessment and retrofitting of concrete buildings by Michael N. Fardis Springer

PROGRAMME ELECTIVES

CE-701 Fuzzy Logic, Artificial Intelligence and Neural Network 3+ 0+ 0

Introduction- Classification of artificial intelligence-expert systems-artificial neural networks-basic concepts-uses in functional approximation and optimization-applications in the design and analysis, building construction.

Fuzzy logic-basic concepts-problem formulation using fuzzy logic-applications

Texts/References

1. D.E. Rumelhart, J.L. McClelland, Parallel distributed processing Vol 1, M I T Press England 1986.
2. Fuzzy logic implementation and applications, M.J. patyra, Mlynek, Wiley Teubner 1996.

CE-702 Optimization Methods 3+0+0

Basics of engineering analysis and design, Need for optimal design, formulation of optimal design problems, basic difficulties associated with solution of optimal problems, Classical optimization methods, Necessary and sufficient optimality criteria for unconstrained and constrained problems, Kuhn-Tucker conditions, Global optimality and convex analysis, Linear optimal problems, Simplex method, Introduction to Karmarkar's algorithm. Numerical methods for nonlinear unconstrained and constrained problems, sensitivity analysis, Linear post optimal analysis, sensitivity analysis of discrete and distributed systems. Introduction to variational methods of sensitivity analysis., shape sensitivity, Introduction to integer programming, dynamic programming, stochastic programming and geometric programming, Introduction to genetic algorithm and simulated annealing.

Text/References

1. Kalyanmov Deb, Optimization for engineering design: Algorithms and examples, PHI Pvt Ltd, 1998.
2. J.S. Arora. Introduction to optimum design, McGraw Hill International editions 1989.
3. R.T. Hafta and Z. Gurdal, Elements of structural optimization, third revised and expanded edition. Kluwer academic publishers 1996.

CE-703 Construction Planning And Scheduling 3+0+0

Construction Planning: Objectives and functions, stages in construction, work breakdown structure, pre-tender stage planning, contract stage planning, methods of scheduling, bar charts, limitations of bar charts, milestone charts, preparation of material, equipment, labour, and finance schedule.

Critical Path Method (CPM): Network techniques, element of a network, rules for developing networks, development logics, numbering events, time computations, activity floats, network updating. Resources profile, resources smoothing and resources leveling. Cost versus time, direct cost, indirect cost, total project cost, optimum duration, contracting network for cost optimization.

Programme Evaluation and Review Technique (PERT): Probability concept in network, optimistic time, pessimistic time, most likely time, variance, standard deviation, slack, central limit theorem. probability of achieving completion time.

Precedence Diagram Method (PDM): Precedence networks fundamentals, advantages, logic and precedence networks applications, PDM versus CPM.

Line of Balancing (LOB) technique in the construction scheduling: Line of balance methods of scheduling repetitive construction.

Books

- Chitkara, K.K. "Construction Project Management, Planning scheduling and controlling."
- Moder J.J. Philips, C.R. and Davis, E.W. "Project Management with CPM and PERT, and precedence diagramming"
- Pilcher, R. "Project Cost Control in Construction",
- Brien J.J. CPM in "Construction Management", Mc. Graw Hill

CE-704 GIS and Its Application In Civil Engineering 3+0+0

1. **Basics of remote sensing:** Introduction to Remote Sensing, data acquisition and processing, sensor systems, Electromagnetic Radiation (EMR) and its characteristics, Radiation principles, prosperities of solar radiant energy, atmospheric windows. Interaction in the atmosphere, nature of atmospheric interaction, atmospheric effects of visible, near infra-red thermal and microwave wavelengths, interaction at ground surface, interaction with soils and rocks, effects of soil moisture, organic matter, particles, size and texture, interaction with vegetation, spectral characteristics of individual leaf, vegetation canopies, effect of leaf pigments, radiation geometry.
2. **Introduction with GIS:** Def. of GIS, Difference between GIS and CAD worlds, utility of GIS, various GIS packages and their salient features, essential components of a GIS, scanners and digitizers.
3. **Map projection and coordinate systems:** Introduction, geographic Grid, Map projection, Coordinate systems.
4. **Vector data models and Analysis:** vector data and its representation, topological data structure, non-topological vector data structure, TIN, Region, vector data editing and analysis.
5. **Raster data models and Analysis:** acquiring and handling of raster data storage, function of raster based GIS data analysis.

6. Engineering applications of GIS: applications of GIS in civil engineering.

Books

- Remote Sensing and Image Interpretation : T.M. Lillensand and R.W. Keifer
- Principles of Remote Sensing : P.J. Curren
- Concept and Techniques of Geographical Information systems : C.P. Lo and albert K.W.Yeung
- Introduction to Geographical Information systems : Kang-tsung Chang
- Geographical Information systems- A Management Perspective : Stan Aromoff

CE-719 Earthquake Engineering 3+ 0+ 0

Earthquakes: Causes, Magnitude and Intensity, Ground Motions, Site effects, Sensors; Response spectrum: Construction, Characteristics, Design Response spectrum; Linear Earthquake analysis: Idealization of structures, Response spectrum analysis, Torsionally coupled systems, Frequency domain analysis, Time domain analysis; Nonlinear Earthquake analysis : Force-deformation relationships, Equation of motion, Controlling parameters, Ductility demand, Allowable ductility; Earthquake resistance design: philosophy ductility based design, Detailing provisions, Codal Provisions, Concepts of passive controls; Geotechnical aspects: Dynamic properties of soil, dynamic earth pressures, Liquefaction and ground improvement techniques; Retrofitting and strengthening of Buildings and Bridges.

Text/ References

1. R.W. Clough and J. Penzien, Dynamics of structures, second edition, McGraw Hill International edition, 1993.
2. M. Paz, Dynamics of structures, CBS pub. 1987.
3. A. K. Chopra, Dynamics of structures- Theory and application to earthquake engineering, PHI 1997.
4. T. Pauley and M.S. N. Priestly, Seismic design of reinforced concrete and masonry buildings. John Wiley and sons, 1992.
5. M. N. S. Priestly, F. Seible and G.M. Calvi, Seismic design and retrofit of bridges, John Wiley and sons, 1996.
6. D. J. Dowrick, Earthquake resistant design : for engineers and architects, John Wiley and sons 1987.

CE-720 Fracture Mechanics of Concrete 3+ 0+ 0

Linear Elastic fracture mechanics: Overview of fracture mechanics, fracture at atomic level, stress concentration factor, Griffith's Energy Theory, Energy release rate, SIF, Effect of finite size, Instability and R curve, crack tip plasticity, CTOD, Integral. Fracture mechanics of concrete: Why fracture mechanics of concrete? Nonlinear fracture models, RILEM fracture energy, softening of concrete, fracture process zone, size effect, interface fracture, Fracture behavior of HSC and HPC.

CE-721 Experimental Methods in Structural Engineering 3+0+0

Conventional Experimental Methods: Introduction to physical modeling in Structural Engineering; theory of structural models; elastic models- materials and techniques; inelastic models – materials and techniques; model fabrication techniques; instrumentation – principles and applications, loading systems and laboratory techniques; size effects, accuracy, and reliability in materials systems and models; model applications and case studies; structural models for dynamic loads.

Non Destructive Techniques: Rebound hammer testing, Liquid penetrant testing, Ultrasonic pulse velocity method, Acoustic emission technique, Photo-elasticity, Application of NDT for quality assessment and damage detection of structures and materials, Probability application in NDT, Statistical quality control.

References:

1. H.G. Harris and G.M. Sabnis, (1999) Structural Modeling and Experimental Techniques, second edition, CRC Press.
2. E. Bray and R. K. Stanley, Non destructive evaluation, CRC Press.
3. J. Szilord, Ultrasonic testing, Wiley Interscience.
4. A.W. Hendry, Photoelastic analysis, Pergamon Press, The Macmillan Co., New York.

CE-722 Numerical methods 3+0+0

Linear equations and eigen value problems, Accuracy of approximate calculations, Nonlinear equations, interpolation, differentiation and evaluation of single and multiple integrals, initial and boundary value problems by finite difference method, Newton's method, variation and weighted residual methods, introduction to finite element methods, fundamental of statistical distribution.

Texts/References

1. J.B. Scarborough, Numerical mathematical analysis, Oxford & IBH Publishing CO Pvt.
2. K. K. Jain, S. R.K lyengar and R.K. Jain Numerical methods-problem and solutions, Wiley eastern limited.
3. R.W. Hamming, Numerical methods for scientist and engineers, McGraw Hill.

CE-723 Advanced Topics in Steel Structures 3+ 0+ 0

Connections: Behavior and modelling of semirigid connections under static and cyclic loads, Behavior under earthquake and fatigue. Buckling: Effective length of compression members, beam columns, Lateral buckling of beams, Interaction buckling behavior of cold formed steel members, buckling of plates and shells. Composite structures: Structural steel concrete composite beams, columns and connections. Space structures: Tensile structures, cable roofs, cable supported bridges, Tensegrity structures Tubular structures.

Nonlinearity: Advanced analysis methods

Reliability: Robustness of steel structures, reliability of steel structures, Limit states design.

Other Metals: Structures in aluminium and stainless steel.

CE-724 Advanced Structural Design 3+0+0

General introduction, Selection of structural systems, Modeling of load, : general introduction to Probability Distribution Function, Modeling of D.L., L.L, W. L. and earthquake effects, Modeling of material properties: Introduction to material strength from solid state physics, uniaxial, biaxial and triaxial stresses, failure criteria and size effects. Modeling of structures, Beams, 2-D, 3-D, elements, transitional elements Design formats: reliability approach, LRFD, determination of safety factors, Design of R.C. members and Prestress concrete members, Design of building frames, Tall wind induced structures, chimney transmission line towers and safety related structures.

Text/References:

1. R. Ranganathan, Reliability analysis, Jaico Publishing house, 1999.
2. S.U. Pillai and Devdas Menon, Reinforced concrete design, Tata McGraw-Hill publishing company Limited, New Delhi 1998.
3. R. Park and T. Pauley, Reinforced concrete structures
4. N. Krishna Raju, Prestresses concrete, Third edition, Tata McGraw Hill Publishing Ltd New Delhi 1995.
5. S.N. Manohar, Tall Chimneys, Tata McGraw Hill Publishing company limited, New Delhi 1985.
6. Wai-Fah Chen and A.F. Saleeb, Constitutive equations for engineering materials Vol.1: Elasticity and modeling, Revised edition, Elsevier 1994.

CE-725 Concrete Technology 3+ 0+ 0

Concrete materials: Cement Production, Types, Tests, Standards, Hydration chemistry; Aggregates Geology of concrete aggregates, Tests and standards; Admixtures for concrete; Concrete mixture proportioning. Concrete behaviour: Properties of fresh concrete; Mechanical behaviour of concrete; Durability of concrete. Special topics: Special cement and concrete; Advances in concrete construction; Nondestructive evaluation of concrete structures; Cement based composites; Fracture mechanics of concrete.

CE-726 Matrix in Structural Engineering 3+0+0

Basic approaches of structural analysis, stiffness and flexibility method, stiffness and flexibility coefficients, derivation of stiffness matrix of skeletal member under axial, bending and torsion. Assembly of stiffness matrix, storage scheme, Band width minimization, skyline storage. Solution of algebraic equations, truss, plane frame, grid, space frame, treatment of boundary conditions: penalty function and Lagrange multiplier techniques, condensation and sub-structuring, flexible connection and finite size joints, symmetry and anti-symmetry, concepts of re-analysis, derivation of stiffness matrix for axial members of variable cross section. Rayleigh-Ritz principle, Introduction to FDM and FEM. Advantages of FEM, Comparison between FEM and FDM, concept of discretization of structures and shape function, plane stress, plane strain problems, lagrangian and serendipity elements, Isoparametric formulation, Numerical integration and order of integration, Criteria for convergence, computer implementations of algorithms.

Texts/references

1. M.B. Kanchi, Matrix method of structural analysis, 2nd and enlarged edition, Wiley Eastern Ltd 1993.
2. W. McGuire, R.H. Gallagher and R.D. Ziemian, Matrix structural analysis, John Wiley & sons Inc, 2000.

3. C.S. Krishnamoorthy, Finite elements analysis: Theory and programming, Second edition, Tata McGraw Hill Publishing company limited 1994.
4. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and applications of finite element analysis, Third edition, John Wiley & sons 1989.

CE-727 Stability of Structures 3+ 0+ 0

Concepts of stability Axially Compressed Members Euler buckling Energy, Rayleigh Ritz, and Galerkin methods Numerical methods Effects of imperfections, residual stresses and inelasticity Effect of shear deformation Nonprismatic members. Instability of beams, beam columns, frames Finite Element Method, P Delta effects, Bracing Requirements. Introduction to instability of plates and shells Critical discussion of design specifications.

CE-728 Advanced Foundation Design 3+0+0

General principles, Bearing capacity, settlement and lateral pressure, Design of Shallow foundations, spread, strip and combined footings (Conventional and elastic line methods), Raft footings (conventional, finite difference and elastic half space methods), Design of deep foundations: piles and pile groups, pile caps, Design of retaining walls and sheet piles, principles of design of coffer-dams and diaphragm walls, design of machine foundation.

Texts/ References

1. Foundation analysis and Design, J.E. Bowles McGraw Hill New York
2. Design of foundation Systems: Principles and practice, P.N. Kurien New Delhi, Narosa.
3. Foundation design and construction, M.J. Tomlinson, Addison Wesley.

CE-729 Theory and Design of Plates and Shells 3+ 0+ 0

Plate equation in cartesian and polar coordinates for isotropic plates Analysis of rectangular and circular plates with different boundary conditions and loadings Energy methods in analysis of plates Orthotropic plates Plates on elastic foundation. Classification of shells Membrane and bending theory for singly curved and doubly curved shells Various approximations Design of cylindrical shells, HP shells, conoids Analysis of folded plates Design of diaphragms Detailing of reinforcements for shells Framework for shells and folded plates.

CE-730 Advanced Theory & Design of Concrete Structures 3+ 0+ 0

Review of Basic Concepts, Background to Code Formulations, and Advanced Theory in the following topics: Behaviour of concrete under uniaxial and multiaxial states of stress; effect of creep, shrinkage and temperature; Durability of concrete: deterioration due to chemical attack and corrosion of steel; methods to check loss of durability in concrete; Basic design philosophies: limit sates method; comparison with working stress and ultimate load methods; Behaviour and design of reinforced concrete skeletal members considering flexure; flexural shear; torsion, combined with flexure and flexural shear; axial compression, combined with flexure: behaviour of short and slender columns, including biaxial bending; eccentric tension; bond Serviceability limit states: estimation of deflections and crackwidths in RC members Behaviour and design of special RC members deep beams; walls, including shear walls; ribbed slabs; corbels; pile caps. Limit analysis of RC members: moment redistribution in continuous beams; yield line analysis of slabs.

OPEN ELECTIVE FOR OTHER DEPARTMENT

CE-702 Optimization Methods 3+0+0

Basics of engineering analysis and design, Need for optimal design, formulation of optimal design problems, basic difficulties associated with solution of optimal problems, Classical optimization methods, Necessary and sufficient optimality criteria for unconstrained and constrained problems, Kuhn-Tucker conditions, Global optimality and convex analysis, Linear optimal problems, Simplex method, Introduction to Karmarkar's algorithm. Numerical methods for nonlinear unconstrained and constrained problems, sensitivity analysis, Linear post optimal analysis, sensitivity analysis of discrete and distributed systems. Introduction to variational methods of sensitivity analysis., shape sensitivity, Introduction to integer programming, dynamic programming, stochastic programming and geometric programming, Introduction to genetic algorithm and simulated annealing.

Text/References

1. Kalyanmov Deb, Optimization for engineering design: Algorithms and examples, PHI Pvt Ltd, 1998.
2. J.S. Arora. Introduction to optimum design, McGraw Hill International editions 1989.
3. R.T. Hafta and Z. Gurdal, Elements of structural optimization, third revised and expanded edition. Kluwer academic publishers 1996.