SCHEME OF M.TECH (Post Graduate-CIVIL) WATER RESOURCES ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule				Credits
			L	T	P		
		SEMESTER-I					
1	CE501T	Advanced Fluid	3	-	-	3	3
2	CE503T	Mechanics Open	3	-	-	3	3
3	CE505T	Channel Hydraulics	3	-	-	3	3
4		Engineering Hydrology	3	-	-	3	3
5		Elective-I	3	-	-	3	3
6		Elective-II	-	-	4	4	2
7	CE501P	Laboratory-I Seminar-I	-	-	2	2	1
			15	-	6	21	18
		SEMESTER-II					
1	CE502T	Water Resources planning & Systems	3	-	-	3	3
2	CE504T	Engineering	3	-	-	3	3
3		Ground Water Engineering	3	-	-	3	3
4		Elective-I	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Elective-II	-	-	4	4	2
7	CE502	Laboratory-II	-	-	2	2	1
			15	-	6	21	18
1	CE601P	**SEMESTER-III** Preparatory work for Dissertation	-	-	20	20	10
1	CE602P	**SEMESTER-IV** Dissertation	-	-	32	32	16
Grand Total			-	-	-	-	62

*** applicable from Session 2012-13 onwards**

**** Syllabi of the subjects remain the same as in the previous scheme except for those given**

LIST OF ELECTIVES

CE 530T	Design of Hydraulic Structures
CE 531T	Embankment Dams
CE 532T	Hydro Power Engineering
CE 533T	Advanced Irrigation Engineering & Drainage
CE 534T	River Engineering and Sediment Transport
CE 535T	Modeling Analysis & Simulation
CE 536T	Computational Methods in fluid Mechanics
CE 537T	Watershed Management
CE 538T	Wind Engineering
CE 539T	Environmental Impact Assessment of Civil Engineering Projects
CE 540T	Remote Sensing for Water Resources Systems
CE 541T	Probabilistic Methods in Civil Engineering
CE 542T	Structural Design of Canal Structures
CE 543T	Earth Dams & Slope Stability
CE 544T	Neuro-fuzzy applications in Civil Engineering
CE 545T	Environmental Impact Assessment

SCHEME OF M.TECH (CIVIL) STRUCTURAL ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule				Credits
			L	T	P		
		SEMESTER-I					
1	CE507T	Advanced Structural Analysis	3	-	-	3	3
2	CE509T	Advanced RCC	3	-	-	3	3
3	CE511T	Design Design of	3	-	-	3	3
4		Bridges Elective-I	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Laboratory-I	-	-	4	4	2
7	CE505	Seminar-I	-	-	2	2	1
			15	-	6	21	18
		SEMESTER-II					
1	CE506T	Theory of Plates	3	-	-	3	3
2	CE508T	Advanced Design of Steel Structures	3	-	-	3	3
3		Elective-I	3	-	-	3	3
4		Elective-II	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6	CE506	Laboratory-II	-	-	4	4	2
7	P	Seminar-II	-	-	2	2	1
			15	-	6	21	18
1	CE603P	**SEMESTER-III** Preparatory work for Dissertation	-	-	20	20	10
1	CE604P	**SEMESTER-IV** Dissertation	-	-	32	32	16
Grand Total			-	-	-	-	62

*** applicable from Session 2012-13 onwards**

**** Syllabi of the subjects remain the same as in the previous scheme except for those given**

LIST OF ELECTIVES

CE-546T	Earthquake Analysis and Design of Structures
CE-547T	Structural Dynamics
CE-548T	Stability Theory in Structural Engineering
CE-549T	Pre-stressed Concrete and Composite Structures
CE-550T	Recent Advances in Construction Materials
CE-551T	Finite Element Method
CE-552T	Soil- Structure Interaction
CE-553T	Advanced Numerical Analysis
CE-554T	Programming and Computer Aided Design of Structures
CE-555T	Reliability Analysis and Design of Structures
CE-556T	Concrete Mechanics
CE-515T	Foundation Engineering

SCHEME OF M.TECH (CIVIL) ENVIRONMENTAL ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule				Credits
			L	T	P		
		SEMESTER-I					
1	CE525T	Design of Water Treatment	3	-	-	3	3
2	CE527T	Processes Advance Water Supply					
3		and Waste water Management	3	-	-	3	3
4	CE529T	Solid Waste Management	3	-	-	3	3
5		Elective-I	3	-	-	3	3
6		Elective-II	3	-	-	3	3
7		Special Lab	-	-	4	4	2
	CE517P	Assignment-I Seminar-I	-	-	2	2	1
			15	-	6	21	18
		SEMESTER-II					
1	CE518T	Air Pollution and Control	3	-	-	3	3
2	CE520T	Design of Wastewater Teatment Processes	3	-	-	3	3
3		Elective-I	3	-	-	3	3
4		Elective-II	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Special Lab	-	-	4	4	2
7	CE518	Assignment-II Seminar-	-	-	2	2	1
			15	-	6	21	18
1	CE609P	**SEMESTER-III** Preparatory work for Dissertation	-	-	20	20	10
1	CE610P	**SEMESTER-IV** Dissertation	-	-	32	32	16
		Grand Total	-	-	-	-	62

*** applicable from Session 2012-13 onwards**

**** Syllabi of the subjects remain the same as in the previous scheme except for those given**

LIST OF ELECTIVES

CE-585T	Environmental Chemistry and Microbiology
CE-586T	Water and Wastewater Treatment Processes
CE-587T	Geographic Information System (GIS) in Environmental Engineering
CE-588T	Environmental Planning and Management
CE-545T	Environmental Impact Assessment
CE-589T	Surface Water Quality Modeling and Control
CE-590T	Industrial Waste Management
CE-591T	Water Quality Management
CE-592T	Hazardous Waste Management
CE-593T	Life Cycle Analysis and Design for Environment
CE-594T	Advance Wastewater Treatment
CE-595T	Bioremediation: Principles and Application
CE-596T	Air Quality Modeling
CE-597T	Environnemental Risk Assessment
CE-598T	Advanced Computational Methods and Optimization
CE-599T	Ground Water Flow and Pollution Modeling
CE-535T	Modeling Analysis and Simulation
CE-551T	Finite Element Method
CE-567T	Flow through Porous Media
CE-544T	Neuro-Fuzzy Applications in Civil Engineering

SCHEME OF M.TECH (CIVIL) TRANSPORTATION ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule				Credits
			L	T	P		
		SEMESTER-I					
1	CE519T	Traffic	3	-	-	3	3
2	CE521T	Engineering	3	-	-	3	3
3	CE523T	Geometric Design	3	-	-	3	3
4		Pavement	3	-	-	3	3
5		Materials Elective-	3	-	-	3	3
6		I	-	-	4	4	2
7	CE513 P	Elective-II Transportation	-	-	2	2	1
			15	-	6	21	18
		SEMESTER-II					
1	CE514T	Pavement Analysis & Design	3	-	-	3	3
2	CE516T	Pavement Construction, Maintenance and	3	-	-	3	3
3		Management	3	-	-	3	3
4		Elective-I	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Elective-II	-	-	4	4	2
7	CE514	Computational	-	-	2	2	1
			15	-	6	21	18
1	CE607P	**SEMESTER-III** Preparatory work for Dissertation	-	-	20	20	10
1	CE608P	**SEMESTER-IV** Dissertation	-	-	32	32	16
Grand Total			-	-	-	-	62

*** applicable from Session 2012-13 onwards**

**** Syllabi of the subjects remain the same as in the previous scheme except for those given**

CE-557T	Statistics and Operation Research
CE-572T	GIS in Transportation
CE-573T	Concrete Technology
CE-574T	Project Management
CE-575T	Transportation Drainage Systems
CE-576T	Land Use and Transport Planning
CE-577T	Rail Transportation Systems Planning and Design
CE-578T	Airport System Planning and Design
CE-579T	Advanced geology
CE-580T	Transportation and Traffic Infrastructure Design
CE-511T	Design of Bridges
CE-559T	Ground Improvement Engineering
CE-545T	Environnemental Impact Assessment
CE-544T	Neuro-Fuzzy Applications in Civil Engineering
CE-535T	Modeling Analysis and Simulation
CE-553T	Advanced Numerical Analysis
CE-551T	Finite Element Method
CE-581T	Transportation Economics and Finance
CE-582T	Public Transportation
CE-583T	Transportation Safety and Environment
CE-584T	Transportation Planning

SCHEME OF M.TECH (CIVIL) SOIL MECHANICS AND FOUNDATION ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule				Credits
			L	T	P		
		SEMESTER-I					
1	CE513T	Engineering Properties of Soils	3	-	-	3	3
2	CE515T	Foundation	3	-	-	3	3
3	CE517T	Engineering Rock	3	-	-	3	3
4		Mechanics-I Elective-I	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Special	-	-	4	4	2
7	CE509P	Assignment-I	-	-	2	2	1
	CE511P	Seminar-I					
			15	-	6	21	18
		SEMESTER-II					
1	CE510T	Soil Dynamics & Machine Foundations	3	-	-	3	3
2	CE512T	Earth	3	-	-	3	3
3		Pressure	3	-	-	3	3
4		Elective-I	3	-	-	3	3
5		Elective-II	3	-	-	3	3
6		Elective-II	-	-	4	4	2
7	CE510P	Special Lab Assignment	-	-	2	2	1
			15	-	6	21	18
1	CE605P	**SEMESTER-III**					
		Preparatory work for Dissertation	-	-	20	20	10
1	CE606P	**SEMESTER-IV**					
		Dissertation	-	-	32	32	16
		Grand Total	-	-	-	-	62

*** applicable from Session 2012-13 onwards**

**** Syllabi of the subjects remain the same as in the previous scheme except for those given**

CE-558T	Rock Mechanics-II
CE-543T	Earth Dams & Slope Stability
CE-559T	Ground Improvement Engineering
CE-560T	Design of Foundation Systems
CE-561T	Geotechnical Exploration and Advanced Soil Testing
CE-562T	Clay Mineralogy
CE-563T	Advanced Rock Mechanics
CE-564T	Theoretical Soil Mechanics
CE-544T	Neuro-fuzzy Applications in Civil Engineering
CE-565T	Case Histories in Geotechnical Engineering
CE-566T	Computer Aided Design of Foundations
CE-567T	Flow through Porous Media
CE-568T	Engineering Geology
CE-569T	Modeling and Simulation
CE-570T	Computational and Statistical Methods
CE-545T	Environmental Impact Assessment
CE-552T	Soil-Structure Interaction
CE-571T	Pavement Analysis & design
CE-551T	Finite Element Method

Syllabus (M.Tech Civil Engineering)

M.Tech (STRUCTURAL ENGINEERING)

CE 506T	THEORY OF PLATES	CS	3 – 0 – 0	3 Credits
Internal-50	End semester-50		Total-100	

Pre-requisites: Mechanics of Solids and Theory of Elasticity.
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand behaviour of plates for UDL, hydrostatic, concentrated load cases.
CO2	Perform cylindrical bending of long rectangular plates, pure bending of rectangular and circular plates, and small deflection theories for various boundary conditions.
CO3	Understand membrane theory and structural behavior of plates.
CO4	Implement Whitney's method to analyze folded plates.

Detailed syllabus:-
Theory of thin plates with small deflection, bending of long rectangular plates to a cylindrical surface. Pure Bending of Plates -Slopes and Curvatures of slightly beni plates, relations between moments and curvatures, particular cases of pure bending of plates, strain energy in pure bending, limitations of pure bending theory.Symmetrical bending of circular plates, Differential equation for symmetrical laterally loaded circular plates, uniformly loaded circular plates, circular plates with a circular hole at the centre, circular plate concentrically loaded and circular plate loaded at the centre.Small deflections of Laterally Loaded Plates: Differential equation of the deflection surface, boundary conditions, exact theory of plates.

Simply Supported Rectangular Plates: Plates under sinusoidal loads, Navier's solution for tid1., patch load and concentrated load, Levy's solution for udl., plates under hydrostatic load, plates of infinite length.

Analysis of Plates Using Finite Difference Method: Transforming differential equation of equilibrium into finite difference equation. Transforming various types of edge conditions into finite difference equations, solving rectangular plates subjected to various types of loads and various types of edge conditions, discretizing plates of various shapes into finite different mesh form and solving for various loading and edge conditions.Bending of Anisotropic Plates: Differential equation of the bent plate, determination of rigidities in various special cases, application of the theory to the calculation of grid works and bending of rectangular circular and elliptic plates.

Elastic Buckling of thin plates: Differential equations of plate buckling, critical loads for rectangular plates, plates with all edges simply supported and under uniaxial compression, plates with two opposite edges simply supported under uniaxial compression, plates with all edges simply supported under biaxial compression.Shear Deformation Theories: First order shear deformation plate theory, higher order shear deformation plate theory, and effect of shear deformation on bending of thin plates.

Bending Analysis of Laminated Composite Plates: Strain displacement relations, governing differential equation of equilibrium, lamination configuration types, analysis of symmetric and anti -symmetric laminated plates, cylindrical bending of laminated plates.

Suggested Books:

1. Timoshenko, S.P.and Krieger, S.W., 'Theory of Plates and Shells' McGraw Hill 2" ED.
2. Florin, G., 'Theory and Design of Surface Structures and Slabs/Plates'
3. Szilard, R., 'Theory 8c Analysis of Plates'.
4. Chandrashekhara, K., 'Theory of Plates' Universities Press, Hyderabad.

CE507T	ADVANCED STRUCTURAL ANALYSIS	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of structural analysis.

Course Outcomes: At the end of course, the student will be able to:

CO1	Understand flexibility & stiffness matrix analysis of different kinds of structures.
CO2	Write computer programs for 2D and 3D structural elements.
CO3	Do analysis of practical problems.
CO4	Do Non-linear analysis of structures

Detailed Syllabus:

Basic Concepts: Static and Kinematic indeterminacy, Stiffness and flexibility, Stiffness and flexibility for prismatic members and non-prismatic members.

Direct stiffness method 2D Element: Development of stiffness matrices for Truss element, beam element, Transformation of coordinates, assembly of global matrices-stiffness matrix, load matrix, boundary conditions, and solution techniques.

Direct stiffness method 3D Element: Stiffness matrices for Truss element, beam element and grid element, transformation matrix for 3D truss elements & 3D beam element, computer programming, application to practical problems

Non-Linear Structural Analysis: Material Non-linearity, Introduction to plastic analysis, mechanism, plastic analysis, non-linear stiffness matrix analysis: Iterative methods, Incremental methods, Hysteresis loops, Assumptions, member stiffness matrix, modification of structural stiffness matrix, Incremental displacement and load vector, step by step Incremental analysis methods.

Geometric non-linearity, Geometric stiffness matrix-2D truss element, Non-linear solution algorithms: Iterative methods, Incremental methods, convergence criteria.

Suggested Books:

1. Wang, C.K., ‘Matrix Method of Structural Analysis’, International Text Book, Pasadena.
2. Martin, H.C., Introduction to Matrix Method of Structural Analysis, McGraw Hill Book Co.
3. Jain, A.K., Advanced Structural Analysis with Computer Applications, Nem Chand & Bros, Roorkee.
4. Majeed, K.I., Non Linear Structural Analysis, Butterworth Ltd. London.

CE 509T	ADVANCED R.C.C DESIGN	CS	3 – 0 – 0	3 Credits

Internal-50	End semester-50	Total-100

Pre-requisites: Basics of R.C. Elements, Structural analysis.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the background of structural concrete and behaviour of beams in flexure
CO2	Understand the behavior of beams in shear and torsion.
CO3	Design columns in uniaxial and biaxial compression and combined loading.
CO4	Design RC and PSC members as per Indian Standards and specifications.
CO5	Detail reinforcement in RC and PSC members as per Codes of Practice.

Detailed syllabus:-

Yield Line Theory: Assumptions, location of yield lines, methods of analysis, analysis of one way and two way slabs.

Strip Method of Design of slabs: Theory, application to simply supported slab, slab fixed along edges and skew slabs.

Flat slabs: Limitations of Direct Design Method, shear in flat slabs, equivalent frame method, openings in flat slabs.

Ribbed slabs: Introduction, analysis for moments and shear, deflection, arrangement of reinforcement.

Approximate Analysis of grid floors: Analysis by Timoshenko's plate theory, stiffness method and equating joint deflections.

Redistribution of Moments in Beams: Conditions for moment redistribution, single span beams, multi -span beams and design of sections.

Deep Beams: Minimum thickness, design by IS -456, design as per British and American practice, beam with holes:

Spandrel Beams: Design principles; moment, shear and torsion in beams, design of section.

Slender columns and walls: Effective • length, unbraced and braced columns, stfbility index, columns subjected to combined axial and biaxial bending, braced and unbraced walls, slenderness of walls, design of walls for vertical and in – plane horizontal forces.

Shear walls: Classification of shear walls, classification according to behavior and design of rectangular and flanged shear walls.

Cast-in-situ Beam-column Joints: Forces acting on joints, strength requirement of columns, anchorage, confinement of core, shear strength of joint, corner joint and procedure for design.

Compulation of deflection and crack width: Short term and long term deflectioli of beams and slabs, calculation of deflection as per IS 456, factors affecting crackwidth in beams, calculation of crackwidth as per. IS 456, shrinkage and thermal cracking.

Inelastic Analysis of beams and Frames: Inelastic behaviour of reinforced concrete, stress -strain characteristics of concrete and steel, concept of plastic hinges, effect of shear on rotation capacity, inelastic analysis, allowable rotation.

Suggested Books:

1. Jain, A.K. (1999), "Reinforced Concrete Limit Slate Design", Nem chand & Bros, Roorkee

2. Krishna Raju (1986), "Advanced Reinforced Concrete Design", C.B.S. Publication, New Delhi
3. Ferguson P.M., Breen J.E. and Jigsa J.O. (1988), Reinforced Concrete fundamentals",John wily & sons, New York.
4. Varghese, P.C. (2001),"Advanced Reinforced Concrete Design", prentice hall ofIndia, New Delhi.

CE 511T	DESIGN OF BRIDGES	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of structural analysis, R.C. & Steel Structures.

Course Outcomes: At the end of course, the student will be able to:

CO1	Understand types of bridges and codal provisions for loading and design standards of bridges.
CO2	Design of R.C., Steel and Pre-stressed concrete bridges.
CO3	Design and select materials suitable for bearings.
CO4	Analyze and design the bridge substructures.

Detailed Syllabus:

Introduction to different types of bridges, Temporary bridges, Military bridges, Permanent bridges, R.C.C. bridges, Steel bridges, Prestressed Concrete bridges, Movable Steel bridges. Design Loads for Bridges, Load Distribution in Multi-Beam Bridges.

Design of R.C Bridges: Slab Culvert, Box Culvert, Pipe Culvert, T-Beam Bridges. Introduction to Arch and Bow string girder bridge, Design of Prestressed Concrete Bridges: Pre-Tensioned & Post Tensioned concrete bridges, Analysis & Design Of Multilane Prestressed Concrete T-Beam Bridges, Steel bridges and its types, Economical span, Stresses and loads.

Plate girder bridges: Arrangements & floors, Plate girder railway bridges, Deck type Plate girder bridges. Truss Bridges: Arrangement & its Types, Wind forces on Lattice girder bridge, Bracings, Railway-Through Type Truss Bridges.

Different types of Bearings and their Functions, IRC Provisions for Bearings, Permissible stresses in bearings, Design of Rocker and Roller-cum-Rocker Bearings.

Piers: Types, Analysis and Design, Design of Abutments & Wing Walls.

Bridge Foundations: Types and General design criteria, Design of pile and well foundations for piers and abutments.

Suggested Books

1. Mondorf, P.E., ‘Concrete Bridges’, Taylor & Francis.
2. Rajgopalan, N., ‘Bridge Super Structures’, Narosa Publishing.
3. Victor, D.J., ‘Essentials of Bridge Engineering’, Oxford & IBH Pub. Co.
4. Krishna Raju, N., ‘Design of Bridges’, Oxford & IBH Pub. Co.
5. Krishna Raju, N., ‘Prestressed Concrete’, Tata McGraw Hill, New Delhi.

CE 515T	FOUNDATION ENGINEERING	CS	3– 0 – 0	3 Credits

Internal-50	End semester-50	Total-100

Pre-requisites: Basics and Applied soil mechanics

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze the bearing capacity of foundations on cohesive & cohesion less soil.
CO2	Perform field experiment related to calculation of settlement in foundations.
CO3	Design different kind of foundations, and cofferdams
CO4	Perform sub-soil exploration and calculate

Detailed syllabus:-

Shallow Foundation : Introduction, factors deciding depth of foundation, effect of water table on bearing capacity, points of difference between Rankine's, Terzaghi's, Meyerhof's, Skempton's bearing capacity theories, footings on slopes, footing with eccentric and inclined loads, bearing capacity of footings on layered soils, bearing capacity from SPT, SCPT, DCPT, bearing capacity of foundation with uplift forces, bearing capacity of rafts on sands and clays, distribution of contact pressure, plate load test and interpretation, settlement of footing, immediate and consolidation settlement, settlement from SPT and SCPT, settlement by Schmertann approach, computation of immediate settlement.

Pile Foundation: Uses of piles, static method of pile load capacity, negative skin friction, group action in piles, pile load test, cyclic pile load test, computation of settlement of pile group, piles subjected to lateral loads, dynamic formulae calculate the load on piles.

Caisson: Introduction, static method to find out load carrying in sands and clays, design of open caisson, types of caissons and their advantages and disadvantages, forces acting on well foundations, stability of well foundations, IS recommendations for tilts and shifts.

Foundations on Difficult Sub-soils : Collapsible soil, physical parameters for identification, procedure for calculating collapse settlement, foundation design for soils not susceptible and susceptible to wetting, expansive soils, identification, swell potential and swell pressure, methods of foundations on expansive soils, replacement of soil and CCN concept, construction on expansive soils, sanitary landfills, under-reamed piles-applications, static formulae to calculate to under-reamed pile capacity.

Cofferdams: Various types, their application, design and lateral stability of braced cofferdam, design and stability of cellular cofferdams.

Books Recommended:

1. Principles of Foundation Engineering by B.M.Das.
2. Foundation Engineering by Bowles.
3. Foundation Engineering by Leonard
4. Foundation Engineering by Peck, Hansen, Thornburn.

CE 547T	STRUCTURAL DYNAMICS	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of structural analysis.

Course Outcomes: At the end of course, the student will be able to:

CO1	Solve problems related to contemporary issues in structural Engineering by acquiring knowledge of mathematics, science and engineering.
CO2	To understand degree of freedom system.
CO3	Do analysis of practical problems related to earthquake phenomenon.
CO4	Do Non-linear analysis of structures

Detailed Syllabus:

Introduction: Objectives, difference between static and dynamic analysis, loading, essential characteristics of a dynamic problem, principles of dynamics, formulation of equation of motion

Single Degree of Freedom System: Analysis for free and forced vibration, Duhamels integral, Damping - types and evaluation. Response of SDOF systems to harmonic excitation, Periodic excitation, Impulsive loading, arbitrary, step, pulse excitation, Response to general dynamic loading. Numerical evaluation of dynamic response-superposition and step by step methods, generalized SDOF systems

Multi Degree of Freedom Systems: Equations of moron, evaluation of structural property matrices, problem statement and solution methods, free vibration, Forced harmonic vibration, damped motion for MDOF, generalized co-ordinates, principle of orthogonality of modes, Eigenvalue problem, modal response, approximate methods: Stodalla-Vinaello, Modified Rayleigh's method, Holzer's method, Holzer Myklested method, Matrix method, Energy method, Lagrange's equation, Modal analysis, Stochastic response of linear SDOF and MDOF system to Gaussian inputs

Continua with Infinite Degrees of Freedom: Longitudinal vibrations of prismatic bars, torsional vibrations of circular shafts, transverse vibrations of stretched wires, transverse vibrations of prismatic beams, effect of rotary inertia and shearing deformations, beams subjected to support motions, beams traversed by moving loads, coupled flexural and torsional vibrations of beams, transverse vibrations of plates.

Suggested Books:

1. Cough and Penzien, 'Dynamics of Structures' McGraw Hill Book Co.
2. Chopra, A.K., 'Dynamic of Structures- theory and Application to Earthquake Engineering'.
3. Weaver, Timoshenko & Young, "Vibration problems in Engg." John Wiley & Sons. 1990
4. Grover, G.K, 'Mechanical Vibration', Nem Chand and Bros. Roorkee

CE 549T	**Prestressed Concrete & Composite Structures**	**CS**	**3-0-0**	**3 Credits**

Internal-50	**End semester-50**	**Total-100**

Pre-Requisite: Concrete Technology

Course Outcomes: At the end of course, the student will be able to:

CO 1	To understand the prestressed concrete.
CO 2	Do analysis of practical problems related to prestressed concrete beams.
CO 3	Design the prestressed concrete members.

Detailed Syllabus:

Need for prestressing, material and there properties , pretensioning and post tensioning methods, behavior of prestress concrete beams , loss of prestress , deflections , bursting forces in anchorage zone, design methods , partial prestressing, analysis of indeterminate structures , need of composite construction , design methods for composite beam and slabs , case studies

References

1. Prestressedconcrete, N. Krishanraju, TMH Publications
2. Design of Prestressed Concrete Structures, 3rd Edition T. Y. Lin , A.P. Burns
3. Robert M Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor and Francis/BSP Books, 1998.
4. R.N. Swamy, “New Concrete Materials”, 1st Edition, Blackie, Academic and Professional, Chapman & Hall, 1983.

CE 551T	FINITE ELEMENT METHOD	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of Structural Mechanics.

Course Outcomes: At the end of course, the student will be able to:

CO1	Learn the mathematical formulation of the finite element method and how to apply it to basic (linear) ordinary and partial differential equations.
CO 2	To understand importance of finite element analysis in civil engineering
CO 3	Learn how to implement the finite element method efficiently in order to solve a particular equation.
CO 4	Application of methodologies to a wide range of engineering problems and connection with the laws of continua.

Detailed Syllabus:

Introduction: Brief history of the development, general description of the method, advantages and disadvantages of finite element method, displacement approach

Basic Principles of Structural Mechanics: Equilibrium conditions, strain-displacement relations, linear constitutive relations, Principle of virtual work, energy principle, application to finite element method

Element Properties: Displacement models, relation between the modal degrees of freedom and generalized coordinates, convergance requirements, natural coordinate systems, shape functions (interpolation functions), element strains and stresses, element stiffness matrix, equivalent nodal loads and static condensation

Isoparametric Elements: Two and three dimensional isoparametric elements, evaluation of stiffness matrix using numerical integration techniques, convergence criteria

Analysis of Framed Structures: Two and three dimensional truss elements, two and three dimensional beam elements, shear deformation in beams and beams on elastic foundation

Plane Stress, Plane Strain and Axisymmetric Stress Analysis: Triangular elements, rectangular elements, isoparametric elements Axisymmetric solid element and patch test**.**

Three Dimensional Stress Analysis: Three dimensional solid elements, eight and twenty noddedisoperimetric solid elements. element load vector and evaluation of stresses.

Analysis of Plate Bending°, C and C2 displacement functions, plate bending elements, shear deformation in plates, four and eight nodded isoparametric plate elements, selective/reduced integration and behaviour of elements.

Analysis of Folded Plates & Shells: Review of shell elements, flat shell element, bilinear degarated shell element and eight noded shell element.

Solution of Finite Element Equilibrium Equations: Direct solutions using alogrithms based on Gauss elimination, Direct solution using orthogonal matrices, Gauss-Siedel Iterative solution, frontal solution method and solution of errors

Techniques For Non Linear Analysis: Non-linear problems nonlinear solution techniques, problems involving geometric non linearity and problems involving both material and geometric nonlinearity, convergence criteria**.**

Suggested Books:

1. O.C. Zienkicwiez,'The finite Element Method, Third Ed., Tata-McGraw Hill Co. Delhi.(1988).
2. C.S. KriSltna y, 'Finite Element Analysis - Theory and Programming'. Tata McGraw Hil,cliti. (1994)

CE552T	SOIL STRUCTURE INTERACTION	CS	3-0-0	3 Credits
Internal-50	End semester-50	Total-100		

Pre-Requisite: Basics of soil-mechanics and structural analysis.

Course Outcomes: At the end of course, the student will be able to:

CO1	Understand soil-structure-interaction models.
CO2	Analyze linear and non-linear soil-structure-interaction problems on different kinds of foundations.
CO3	Analyze the soil-structure interaction of framed structures.
CO4	Analyze of soil-foundation-structure interaction and various related models.

Detailed Syllabus:

Soil-foundation-structure interaction, Soil-fluid-structure interaction, Idealization of soil by linear and non-linear modified Winkler model, Elastic continuum model (isotropic and anisotropic), Two parameter elastic models- Heteny model, Pasternak model, Reissner model.

Soil parameters: Interpretation of parameters encountered in various idealized soil models-Winkler, two parameter elastic and Elastic continuum models

Finite beams on elastic foundations: finite beams on Winkler models, finite beams on two parameter elastic model, finite beams on homogenous Elastic continuum, finite difference solution to problems of beam on linear & non-linear Winkler's model

Plates on elastic foundation: Rectangular and continuous plates on elastic foundations, plates carrying rows of equidistant columns, rectangular and circular plates on Winkler medium, Two parameter elastic medium and no elastic continuum, finite difference solution of problems of rectangular plates on linear and non-linear elastic foundation.

Soil structure interaction in framed structures: structures with isolated foundation, spring analog approach, determinations of spring parameters, structures with continuous beams and rafts as foundation, finite element modelling, sub-structure technique of analysis, concept of relative stiffness, Interactive behavior of some framed structure.

Soil pile interaction: laterally loaded single piles-Concept of coefficient of horizontal subgrade reaction, finite difference and finite element solution, soil-structure interaction of framed structures with pile foundation, Interaction of other structures with soil foundation system, Tanks with annular ring foundations, chimneys, silos, cooling towers, underground subways and tunnels.

Introduction to dynamic soil structure interaction as well as non-linear soil/concrete behavior.

Suggested Books

1. John, P. Wolf, 'Dynamic Soil-Structure-Interaction'.
2. John, P. Wolf, Soil-Structure-Interaction in Time Domain'.
3. Desai, C.S., Srivardhane, Constitutive Modelling of Soils and Rocks.

CE 553T	ADVANCED NUMERICAL ANALYSIS	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of Mathematics

Course Outcomes: At the end of course, the student will be able to:

CO 1	Implement computational methods
CO 2	Conduct computational experiments
CO3	Solve the problems of geotechnical engineering.

Detailed Syllabus:

Introduction of Programming Language 'C':

Error analysis, significant digits, inherent errors, numerical errors, absolute and relative error, error propagation, conditioning & stability.

Solution of linear simultaneous equations, direct and iterative algorithms based on Gauss elimination, Gauss Jordan method, Gauss Seidel method

Numerical solution to non-linear system of equations, bisection method, false position method, Newton-Raphson method, Secant method, fixed point method

Interpolation formulae, Polynomial forms, linear interpolation, lagrange interpolation polynomial, Newton interpolation polynomial, forward and backward differences

Numerical differentiation by forward difference quotient. Central difference quotient, Richardson extrapolation and numerical integration by Trapezoidal rule, Simpson's 1/3 rule, Romberg integration, Gaussian integration

Numerical solution of ordinary differential equations by Taylor series method, Euler's method, Runge-kutta method, Picard's method, Heun's method, polygon Method**.**

Suggested Books:

1. Terrence J.Akai , 'Numerical Methods', John Wiley & Sons lnc,Singapore,1994.
2. S.S.Shastry , 'Introductory Method of Numerical Analysis', PHI Pvt.Ltd.,1997
3. H.C.Saxena, 'Finite Differences and Numerical Analysis', S.Chand& Co.Delhi,2001.
4. Baron M.L. &Salvadori M.G., 'Numerical Methods in Engineering', PHI • Pvt.Ltd.1963

CE 554T	**Programming and Computer Aided Design of Structures**	**CS**	**3 – 0 – 0**	**3 Credits**

Internal-50	**End semester-50**	**Total-100**

Pre-requisites: Basics of Auto-Cad, Stadd Pro.

Course Outcomes: At the end of the course the student will be able to:

CO1	Designstructural elements/components, application to multistoried building,
CO2	Design water retaining structures and bridges components.
CO3	Analyze the static and dynamic analysis of structures

Detailed syllabus:-

C++ Programming basics, Loops and Decisions, Structures, Function, object and classes, operator overloading, Inheritance, pointers, files and streams, library.

Graphics hardware, Interactive input and output devices, extensive use of latest packages, static and dynamic structural analysis and finite element packages, development of design and drafting packages for structural elements/components, application to multistoried building, design of water retaining structures and bridges components.

Use of Auto CAD, STAAD Pro.

Grapher and Finite Element Packages.

Suggested Books.

I. Rajaram R., 'Object Oriented Programming and C++'.
2. Balagurusamy E. , 'Object Oriented Programming and C++'.
3. Lafore R.,' Turbo C++'.
4. Software related manuals.

CE 555T	RELIABILITY ANALYSIS & DESIGN OF STRUCTURES	CS	3-0-0	3 Credits

Internal-50	End semester-50	Total-100

Pre-Requisite: Basics of Structural Analysis

Course Outcomes: At the end of course, the student will be able to:

CO1	Solve problems related to contemporary issues in structural Engineering by acquiring knowledge of mathematics, science and engineering.
CO 2	To understand degree of freedom system.
CO 3	Do analysis of practical problems related to earthquake phenomenon.
CO 4	Do Non-linear analysis of structures

Detailed Syllabus:

Introduction-Structural safety- variations – Random variables - Probability distributions - Allowable stresses for specified reliability.

Probabilistic analysis of loads - Gravity loads - Wind loads - Wind speeds – return periods

Multi Degree of Freedom Systems:

Structural Reliability - Reliability of structural components – beams – axially loaded columns

Reliability Methods - Classification (Level 1- level 2-level 3) - First order second moment method

Reliability index - Computation of reliability index - simple problems.

Reliability based design - Determination of partial safety factors - Safety checking formats – NBC format – CEB format – LRFD format - Optimal safety factors.

Reliability of Structural systems - System reliability - Series system – Parallel redundant system- mixed system - Modeling of truss system - Modeling of frames

Suggested Books:

1. H.O. Madsen, S. Krenk, and N.C. Lind, “Methods of Structural Safety”, Dover Publications, 2006
2. R. Ranganathan, “Structural Reliability Analysis and Design”, 1st Edition, Jaico Publishing House, 1999.
3. R.E. Melchers, “Structural Reliability Analysis and Prediction”, 2nd Edition, John Wiley & Sons, 1999.
4. Thoft C.P, and Baker M.J, “Structural Reliability Theory and Its Applications”, Springer Verlag, 1982.

M.Tech Geotech
DETAILED SYLLABUS

Programme Educational Objective:

PEO1	To know the effect of clay minerals on soil properties, various methods of geotechnical investigation and its practical investigation indifferent situations.
PEO2	To understand mechanism of development of earth pressure,design and analyse various earth retaining structures.
PEO3	To determine the bearing capacity of soil, the probable settlement, stresses, settlement at any point in the semi-infinite elastic soil medium and also to design the various types of foundations for different loading conditions with the help of empirical methods and Computer Aided Design.
PEO4	To understand different techniques to improve the characteristics of weak soil and design techniques required to implement various ground improvement methods.
PEO5	To design Earthen dams, remedies or preventive measures for failure of earth dams and to understand the various theories involved in Finite Element Method.
PEO6	To understand the dynamic properties of soil and various design parameters required for the design of machine foundation.
PEO7	To study geological classification, elastic and dynamic properties of rocks, various laboratory and field tests.
PEO8	Students are able to establish the relationship between the model and the constraints, design various types of pavements, the knowledge of environment and ecology to solve problems.

Programme outcome:

PO1	Students should be able to know the effect of clay minerals on soil properties, various methods of geotechnical investigation and its practical investigation indifferent situations.
PO2	Students should be able to understand mechanism of development of earth pressure, design and analyse earth retaining structures.
PO3	Students should be able todetermine the bearing capacity of soil, the probable settlement, stresses, settlement at any point in the semi-infinite elastic soil medium and also to design the various types of foundations for different loading conditions with the help of empirical methods and Computer Aided Design.
PO4	Students should be able to understand different techniques to improve the characteristics of weak soil and design techniques required to implement various ground improvement methods.
PO5	Students should be able to design Earthen dams, remedies or preventive

	measures for failure of earth dams and assess the various theories involved in Finite Element Method.
PO6	Students should be able to understand the dynamic properties of soil and various design parameters required for the design of machine foundation.
PO7	Students should be able to assess geological classification, elastic and dynamic properties of rocks, various laboratory and field tests.
PO8	Students are able to understand the relationship between the model and the constraints, design various types of pavements, and assess the knowledge of environment and ecology to solve problems.

CE- 512 (T)	**Earth Pressure**	**CC**	**3– 0 – 0**	**3 Credits**
Internal=50		**External= 50**		**Total= 100**

Pre-requisites: None.

Course Objectives

i. To impart in-depth knowledge about the mechanism of development of earth pressure.
ii. To impart knowledge about the analysis and design of earth retaining structures.
iii. To help the students to take proper engineering decisions in practical situations.

Course Outcomes:

CO1	Capability to analyse and design earth retaining structures.
CO2	Capability to select the suitable retaining system for the different types of projects.
CO3	Capability to design excavations.

Detailed Syllabus:

1. Earth Retaining Structures: Definitions, uses of retaining walls, types of retaining walls, rockfill drains, Stability considerations for retaining walls.

2. Earth pressure due to cohesion less soil: Trial Wedge Method, Coulomb's method, Rankine's method, Culmann's graphical construction. Friction circle method.

3. Earth pressure due to cohesive soil: Trial Wedge method, friction circle method, circle of stress method.

4. Anchored Bulkheads: Sheet pile structures, cantilever sheet piles, anchored bulkheads.

5. Arching action in soils: Theory of arching, Cain's theory, braced excavation, earth pressure against bracing in cuts, heave of bottom of cut in soft clay, deep cut in sands.

6. Earth Pressure in Underground Conduits.

Book Recommended:

1 Earth Pressure & Retaining Walls by Huntington
2 Earth Pressure & Retaining Structures by Tschebatorioff
3 Analysis and Design of Foundation & Earth Retaining Structures by Shamsher Prakash, Gopal Ranjan, Swami Saran.

CE-515T	FOUNDATION ENGINEERING	CC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None

Objective

i. To study the three criteria i.e. depth and location criteria, bearing capacity criteria and settlement criteria for the design of shallow foundations.
ii. To understand action of a single pile and piles in group as deep foundation and methods of calculations of load capacity by various techniques.
iii. To design of well foundation, checking their lateral stability and procedure for construction of well foundation along with methods of rectifications of tilt and shift.
iv. To study the methods of design of foundation in expansive soils.

Course Outcomes:

CO1	Students are able to design the shallow foundations by analysing three criteria i.e. depth and location criteria, bearing capacity criteria and settlement criteria.
CO2	Students are capable to analyse action of a single pile and piles in group.
CO3	Students are able to calculate the load capacity of a Pile by various techniques.
CO4	Students are capable to design well foundation and also able to rectify the tilts and shifts.
CO5	Students are capable to design the foundations in expansive soils.

Detailed Syllabus:

1**. Shallow Foundation :** Introduction, factors deciding depth of foundation, effect of water table on bearing capacity, points of difference between Rankine's, Terzaghi's, Meyerhof's, Skempton's bearing capacity theories, footings on slopes, footing with eccentric and inclined loads, bearing capacity of footings on layered soils, bearing capacity from SPT, SCPT, DCPT, bearing capacity of foundation with uplift forces, bearing capacity of rafts on sands and clays, distribution of contact pressure, plate load test and interpretation, settlement of footing, immediate and consolidation settlement, settlement from SPT and SCPT, settlement by Schmertann approach, computation of immediate settlement.

2. Pile Foundation: Uses of piles, static method of pile load capacity, negative skin friction, group action in piles, pile load test, cyclic pile load test, computation of settlement of pile group, piles subjected to lateral loads, dynamic formulae calculate the load on piles.

3. Caisson: Introduction, static method to find out load carrying in sands and clays, design of open caisson, types of caissons and their advantages and disadvantages, forces acting on well foundations, stability of well foundations, IS recommendations for tilts and shifts.

4. Foundations on Difficult Sub-soils : Collapsible soil, physical parameters for identification, procedure for calculating collapse settlement, foundation design for soils not susceptible and susceptible to wetting, expansive soils, identification, swell potential and swell pressure, methods of foundations on expansive soils, replacement of soil and CCN concept,

construction on expansive soils, sanitary landfills, under-reamed piles-applications, static formulae to calculate to under-reamed pile capacity.

5. Cofferdams: Various types, their application, design and lateral stability of braced cofferdam, design and stability of cellular cofferdams.

Books Recommended:

1 Principles of Foundation Engineering by B.M..Das.
2 Foundation Engineering by Bowles.
3 Foundation Engineering by Leonards
4 Foundation Engineering by Peck, Hansen, Thornburn.

CE-517T	ROCK MECHANICS-I	CC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None

Course Objectives

i. To make the students understand engineering properties of rock and classification of rocks.
ii. To impart knowledge about the laboratory testing of rocks by different methods.
iii. To impart knowledge about the Institute Testing of rocks by various methods and techniques.
iv. To impart knowledge about the failure criteria, tunneling in rocks and various techniques toimprove insitu strength of rocks.

Course Outcomes:

CO1	Students are able to understand engineering properties of rock and classification of rocks.
CO2	Students are able to understand the laboratory testing of rocks by different methods.
CO3	Students are able to understand the Institute Testing of rocks by various methods and techniques.
CO4	Students are capable to analyse the failure criteria, tunnelling in rocks and various techniques to improve in-situ strength of rocks.

Detailed Syllabus:

1. Introduction: Importance of Rock Mechanics, Composition of rocks, geological classification of rocks, classification of rocks for engineering purposes, RQD method of classification of rocks.

2. Laboratory Testing of Rocks : Various methods of obtaining rock cores, method of sample preparation, effect of specimen geometry on rock strength determination, compression testing machine, uniaxial compressive strength of rock samples, factors Affecting compressive strength tests- direct and indirect methods, flexural strength tests, shear strength tests-direct shear test, torsion test, shear box test, punch test, triaxial shear test.

3. Institute Testing of Rocks : Field direct shear test on rock blocks, field triaixal strength, use of flat jacks, chamber test, plate load test, cable jacking test.

4. Stress Evaluation in Field : Stress relief technique (over coring), use of strain gauges, bore hole deformation cell, LVDT, photo-elastic stress meter, stress measurement with flat jack, typical results of evaluation, dilatometer, hydraulic fracturing techniques, uses and advantages.

5. Elastic and Dynamic Properties: Static elastic constants of rocks and their determination, stress-strain behaviour, dynamic properties of rock mass, methods of finding dynamic properties.

6. Pressure on Roof of Tunnels: Terzaghi's theory, Bieraumer's theory, Kommeral theory, Protodyakanov theory, Kastner's theory, Labasse's theory.

Book Recommended:

1. Rock Mechanics Vol. I, II, III, IV, by Lama et. Al.
2. Fundamental of Rock Mechanics by Jaegar and Cook
3. Rock Mechanics by Stagg &Zienkiewiez
4. Art of Tunnelling by Schzy

CE-513T	ENGINEERING PROPERTIES OF SOILS	CC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None

Course Objectives

i. To impart knowledge on the various factors governing the engineering behavior of soils and suitability of soils for various geotechnical engineering applications.
ii. To impart the knowledge of determination of coefficient of permeability by various methods and analyse the seepage through earth dams.
iii. To impart the knowledge about the shear strength and various methods of measurement of shear strength.
iv. To impart knowledge about the consolidation, Types of consolidation and behavior of compacted soils.

Course Outcomes:

CO1	Students are able to analyse various factors governing the engineering behaviour of soils and suitability of soils for various geotechnical engineering applications.
CO2	Students are able to determination of coefficient of permeability by various methods and analyse the seepage through earth dams.
CO3	Students are able to analyse the shear strength and various methods to measure the shear strength.
CO4	Students are able to analyse the consolidation, Types of consolidation and behaviour of compacted soils.

Detailed Syllabus:

1. General : Engineering Properties of natural soil deposit- Alluvial deposit, glacial deposit, Aeolian, Loess and Residual Soils, Soil moisture suction, suction plate method of determination, Effective stresses-Bishop's &Lambe's concepts, Sensitivity & thixotropic characteristics of clays.

2. Permeability & Seepage : Determination of Coefficient of Permeability by Parallel tube capillary model, Hydraulic radius model and other empirical relations, Seepage through Earth dam- Dupuit's solution, Schaffernak, Casagrande's and Pavlovsky's solution, seepage through dams under anisotropic conditions.

3. Shear Strength: Various types of triaxial tests- compression and extension, drainage condition, Measurement of shear strength- Measurement and application of load, cell pressure, pore water pressure, and application of back pressure in a drained test, parameter in stands, Energy correction, Skempton's Pore Pressure parameters and their determination. Shear strength of partially saturated soils, Hvorslev Parameters, stress path- Lambe's and Rendulic- Henkel unique stress path & their characteristics, relation of undrained shear strength and effective overburden pressure.

4. Consolidation: Characteristics of NC & OC clays, Reconstruction of field virgin compression curve for NC & OC clays Schmertmann correction, Secondary consolidation, three dimensional consolidation, Sand drains.

5. Behaviour of compacted soils: General, effect of compaction on structure, swelling pressure, shrinkage, shear strength, p.w.p. & permeability. Comparison of dry and wet of OMC.

Books Recommended:

1. Principal of Soil Mechanics by Scott.
2. Foundation Engineering edited by Leonards.
3. Soil Mechanics by Lambe and Whitman.

CE-510T	SOIL DYNAMICS & MACHINE FOUNDATIONS	CC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: Foundation Engineering.

Course objectives

i. To calculate the dynamic properties of soils using laboratory and field tests.
ii. Apply theory of vibrations to solve dynamic soil problems.
iii. Analyze and design behavior of a machine foundation resting on the surface, embedded foundation and foundations on piles by elastic half space concept.
iv. Analyze and design vibration isolation systems.

Course Outcomes:

CO1	To understand the basics of dynamics, dynamic behavior of soil.
CO2	Students are able to design foundations for different machines and assess the influence of vibrations and selection of remediation methods based on the nature of vibrations.
CO3	To assess the theory of liquefaction, evaluation of liquefaction potential of a soil deposit and liquefaction analysis from SPT data.

Detailed Syllabus:

1.Theory of Vibrations: Definitions, Nature of dynamic loads, Characteristic elements of a vibrating system, properties of harmonic motion, analysis of single degree freedom system with undamped free vibrations, damped free vibrations, undamped forced vibrations, damped forced vibrations, logrithmic decrement, frequency dependent excitation force, determination of viscous damping, principle of vibration measuring instruments, transmissibility, systems with two-degrees of freedom(vibration absorber),Rayleigh's method of determination of fundamental frequency of a multi-degree freedom system, systems under transient forces.

2. Wave Propagation in an Elastic Medium: Wave propagation in elastic rods, elastic infinite medium, semi-infinite elastic half space, waves generated by a surface footing.

3. Dynamic Stress Deformation and Strength Characteristics of Soils: Dynamic soil testing techniques, special requirements of apparatus for dynamic tests, Pendulum loading apparatus, oscillatory simple shear test, resonant column apparatus, field tests, stress deformation and strength characteristics of saturated sands and cohesive soils under pulsating loads.

4. Dynamic Earth Pressure Problems: Modification of Coulomb's theory and Culmann's construction for dynamic loads, analytical solutions for c -ϕ soils, point of application, displacement analysis, Indian Standard Code of Practice.

5. Dynamic Bearing Capacity: Earthquake Loads on footings, effect of horizontal load and moment, dynamic analysis of vertical and horizontal loads

6. Liquefaction of Soils: Theory of liquefaction, criteria of liquefaction, factors affecting liquefaction characteristics, laboratory studies on liquefaction, evaluation of liquefaction potential of a soil deposit, vibration table studies, liquefaction analysis from SPT data, anti-liquefaction measures.

7. Machine Foundations: Types of Machines and Machine Foundations, Criteria for satisfactory action of a machine foundation, methods of analysis, degrees of freedom of a block foundation, Barken's soil spring constants and their determination, analysis of a block foundation by Barken's theory and elastic half space theories, IS for design and construction of foundations for reciprocating machines, foundation for impact machines, IS for design and construction for impact machine, introduction to T.G. foundations, design examples.

8. Vibration Isolation: Active isolation, passive isolation, methods of active and passive isolation, wave screening, vibration absorbing materials, planning for vibration isolation.

Books Recommended:

1 Dynamics of Bases and Foundations by D.D.Barken
2 Soil Dynamics by Shamsher Prakash
3 Soil Dynamics and Machine Foundations by Swami Saran
4 Analysis and Design of Foundations for Machines by Shamsher Prakash &V.K.Puri
5 Vibration and Shock Isolation by Crede.
6 Vibration Analysis and Foundation Dynamics by Kameswara Rao
7 Handbook of Machine Foundations by Srinivasalu&Vaidyanathan
8 Principles of Soil Dynamics by B.M. Das.

CE 551T	FINITE ELEMENT METHOD	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None

Course Objectives

i. The ability to judge the situations and apply the logical aspects of the method.
ii. To study the numerical formulation for analysing geotechnical systems.
iii. To apply the concepts for solving multi task applications.

Course Outcomes:

CO1	To understand various theories involved in finite element method.
CO2	To assess various models used to simulate the soil media.
CO3	To study the numerical formulation for analysing geotechnical systems.

Detailed Syllabus:

1. Introduction: Brief history of the development, general description of the method, advantages and disadvantages of finite element method, displacement approach.

2. Basic Principles of Structural Mechanics: Equilibrium conditions, strain-displacement relations, linear constitutive relations, Principle of virtual work, energy principle, application to finite element method.

3. Element Properties: Displacement models, relation between the modal degrees of freedom and generalized coordinates, convergance requirements, natural coordinate systems, shape functions (interpolation functions), element strains and stresses, element stillness matrix, equivalent nodal loads and static condensation.

4. Isoparametric Elements: Two and three dimensional isoparametric elements, evaluation of stiffness matrix using numerical integration techniques, convergence criteria.

5. Analysis of Framed Structures: Two and three dimensional truss elements, two and three dimensional beam elements, shear deformation in beams and beams on elastic foundation.

6. Plane Stress, Plane Strain and Axisymmetric Stress Analysis: Triangular elements, rectangular elements, isoparametric elements Axisymmctric solid element and patch test.

7. Three Dimensional Stress Analysis: Three dimensional solid elements, eight and twenty noded isoparametric solid elements, element load vector and evaluation of stresses.

8. Analysis of Plate Bending: C°, C1 and C2 displacement functions, plate bending elements, shear deformation in plates, four and eight noded isoparametric plate elements, selective/reduced integration and behaviour of elements.

9. Analysis of Folded Plates & Shells: Review of shell elements, flat shell element, bilinear degarated shell element and eight noded shell element.

10. Solution of Finite Element Equilibirium Equations: Direct solutions using alogrithms based on Gauss elimination, Direct solution using orthogonal matrices, Gauss-Siedel Iterative solution, frontal solution method and solution of errors.

11. Techniques For Non Linear Analysis: Non-linear problems non-linear solution techniques, problems involving geometric non linearity and problems involving both material and geometric nonlinearity, convergence criteria.

Books Recommended:

i. O.C. Zienkiewiez,'The finite Element Method, Third Ed., Tata-McGraw Hill Co. Delhi.(1988) 2. C.S. Krishna y, Element Analysis - Theory and Programming'. Tata McGraw Hil. elm. (1994).

CE-543T	EARTH DAMS & SLOPE STABILITY	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None.

Course Objectives

i. To impart in-depth knowledge about the method of construction and causes of failures of earth dams.
ii. To impart knowledge about the analysis and design of earth dams.
iii. To impart knowledge about the various methods of seepage control and design of transition filters.
iv. To impart knowledge of various methods available for analysis of slopes and remedial techniques to protect the slope.

Course Outcomes:

CO1	Students are capable of reasoning out the causes of failure and damages of embankments and slopes.
CO2	Students are able to carry out slope stability analysis using various methods.
CO3	Students are capable to control the seepage and design of transition filters.
C04	Students are capable of carrying out remedial measures and protection of slopes.

Detailed Syllabus:

1. General: Purpose of earth dams, methods of construction, types of earth dams, materials required for earth dam construction, causes of failure of earth dams, design criteria for earth dams, suitable section for an earth dam, rockfill dams.

2**. Seepage Analysis :** General, phreatic line in earth dams and its location by various methods, problem of seepage control in earth dams-control of seepage through embankment, adverse effects of seepage, methods of seepage control, impervious core, selection of core material, core thickness, location of core in earth dam, selection, design of transition filters, rock toe, horizontal drainage, chimney drains, control of seepage through foundations-various options, upstream impervious blanket, analysis for blanket length, relief wells, related problems.

3. Stability Analysis: Shear strength of soils, pore pressure in earth dams, various conditions of stability analysis for earth dams, methods of slope stability analysis, related problems.

3. Drainage: Gravity drainage, vacuum and osmotic drainage.

4. Instrumentation: Necessity, pore Pressure measurement, vertical movement devices, horizontal movement devices, choice of instrumentation, instrumentation problems.

Book Recommended:

1 Earth and Rockfill Dams by Sherrad
2 Earth and Rockfill Dams by Bharat Singh & H. D. Sharma.

CE-564T	THEORETICAL SOIL MECHANICS	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None

Course Objectives

i. To impart knowledge required for computing stresses and settlement at any point in the semi- infinite elastic soil medium, an isotropic medium and layered deposits due to Foundation loads.

ii. To impart knowledge for evaluation of stability of foundation, slopes, cuts and retaining structures both for the conditions of undrained and drained loading.

Course Outcomes:

CO1	Students are capable to estimate the stresses in soil medium of any type due to foundation loads and settlement of foundations.
CO2	Students are capable to evaluate bound and true collapse loads of soil structures.
CO3	Students are capable to evaluate the stability of foundation, slopes, cuts and retaining structures both for the conditions of undrained and drained loading.

Detailed Syllabus:

1. Fundamental Relations: Concept of stress, concept of strain, rotation of axes, principal stresses and strains, invariants, Octahedral stresses and strains, equations of equilibrium, equations of equilibrium in polar coordinates, stress-strain relations, generalised Hooke's law, two-dimensional analysis, plane stress case, plane strain case, equation of compatibility in terms of stress components and Airy's stress functions, Mohr's diagram, problems.

2. Stresses and Displacements in Soil Mass as an Elastic Body: Line load(two dimensional case), vertical, horizontal and inclined line loads on semi-infinite systems, distributed line loads(two dimensional), uniform normal load over a strip, normal load over a circular and rectangular area, triangular and other loadings.

3. Settlement and Consolidation: Finite Difference Method, Relaxation Method, Numerical Solution of one dimensional consolidation equation, problems.

4. Stability of Soil Structures: Soil strength, conventional methods, effect of wall movement on lateral earth pressure(Dubrova's method), various cases, effect of surcharge on lateral earth pressure.

5. Limiting Equilibrium of Soil Structures: Dimensional similitude, fundamental concepts and relations, Sokolovsky's equation for characteristic lines, solution procedures, bearing capacity, stability of slopes.

Book Recommended:

1. Fundamentals of Theoretical Soil Mechanics by Harr

CE-562T	CLAY MINEROLOGY	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None.

Course objectives

i. The students are expected to understand the origin, occurance, classification and structure of clay minerals.
ii. To understand the clay- water ions exchange theories.
iii. To study the different clay minerals by various analysis methods.

Course outcomes:

CO1	Students should know the origin, occurrence, classification and structure of clay minerals.
CO2	Students are able to identify clay minerals by using different methods and techniques.
CO3	To impart knowledge of clay – water ions exchange theories.

Detailed Syllabus:

1. Introduction: Definitions, factors affecting properties of clay materials, inter-atomic bonding, secondary bonds.

2. Classification and Structure of Clay Minerals : Basic Iattice structure, structural units of clay minerals, basic structure of silica, classification of clay minerals, Isomorphous substitution, inter sheet and inter layer bonding in clay minerals, the 1:1 minerals, montmorillonite minerals, mica-like clay minerals, chlorite minerals, chain structure clay minerals, mixed layer minerals, non-crystalline clay minerals.

3. Origin and Occurrence of Clay Minerals: Process and agents of weathering, formation of clay minerals, origin and occurrence of various clay minerals.

4. Identification of Clay Minerals: Differential thermal analysis, X-ray diffraction analysis, optical microscope studies of soils, electron microscope studies, shape and size of clay minerals.

5. Clay-Water: Influence of dissolved ions, possible mechanism of clay-water interaction, evidence on the structure and properties of adsorbed water.

6. Clay-Water Electrolyte Systems: Ion distribution in clay-water systems, cation exchange, cation exchange capacity, theories of ion exchange, anion exchange, engineering significance of base exchange.

7. Effect of Clay Minerals on Soil Properties: Effect on Atterberg Limits, shrinkage and swelling characteristic, compressibility, soil structure, permeability, strength and deformation behaviour.

Book Recommended:

1 Fundamentals of Soil Behaviour by J.K.Mitchell
2 Applied Clay Mineralogy by Grim
3 Clay Mineralogy by Grim

CE- 571 (T)	PAVEMENT ANALYSIS & DESIGN	EC	3– 0 – 0	3 Credits
Internal= 50		External= 50		Total= 100

Pre-requisites: None.

Course Objectives:

i. The students are expected to understand the properties and use of various materials and construction, analysis of stress distribution, evaluation and maintenance of flexible and rigid pavements
ii. Understand the basic modelling concepts used to analyze flexible and rigid pavements.
iii. Appreciate pavement management concepts to better manage road pavement.
iv. Apply the various types of highway appurtenance to enhance the safety of motorists.
v. Learn to estimate traffic noise and the effect of noise attenuation measures.
vi. To develop an ability to structural design of Airport pavements using different methods.

Course Outcomes:

CO1	The students would have gained knowledge on the Material properties, Design, Evaluation and Management of Pavement Systems.
CO2	Design flexible and rigid pavements.
CO3	Propose a pavement management system framework.
CO4	Design highway appurtenance and highway drainage.
CO5	Design mitigation measures to attenuate traffic noise.

Detailed Syllabus:

1. Introduction: Types Of pavements, components of a flexible and a rigid pavement, Design strategies, comparison of Highway and airport pavements, Design approaches, Factors affecting design.

2. Stresses in Flexible Pavements: Layered system concept, Multilayer system, one layer systems, two layer systems, deflections, Influence of type pressure, total load and c/c spacing, ESWL by equal stress and equal deflection, three layer systems.

3. Design of flexible Pavements: Various design methods, CBR method, Current Indian practice, triaxial Method, Burmistser's method, AASHO method, Haveem or California Resistance Value method, National Crushed Stone Association (USA) method.

4. Stresses in Rigid Pavements: Stresses due to load, Westergaard's theory, stresses due to temperature change, combined loading and temperature stresses, effect of type pressure, total load and wheel configuration, joints & their various types.

5. Design of Rigid Pavements: Current Indian Practice, spacing of expansion and contraction joints, design of temperature Reinforcement, Dowel Bars and Tie bars.

6. Pavement evaluation and Strengthening: Structural evaluation by Bankelman Beam Method, Present Serviceability rating and present Serviceability Index, Types of overlays Design of overlays. Current Indian Practice in the design of overlays.

7. Structural Design of Airport Pavements: Design factors, various methods of design, CBR method, Mcleod Method, LCN Method.

Book Recommended:

Principles of Pavement Design by Yoder and Witczak

CE-565T	CASE HISTORIES IN GEOTECHNICAL ENGINEERING	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: Earth Dams and Slope Stability.

Course objectives

i. To impart knowledge of shear failure and settlement failure of foundations by different case studies.
ii. To impart knowledge of foundation failure and seepage failure of earth dams by different case studies.
iii. To impart knowledge of failure due to liquefaction of soils during earthquake by different case studies.
iv. To impart knowledge of slope failure, landslides, landslips and Retaining wall failures.

Course Outcome:

CO1	Students are able to assess the shear failure and settlement failure of foundations
CO2	Students are able to assess the foundation failure and seepage failure of earth dams.
CO3	Students are able to assess the failure due to liquefaction of soils during earthquake.
CO4	Students are able to assess the slope failure, landslides, landslips and Retaining wall failures.

Detailed Syllabus:

Case studies of shear failure and settlement failure of foundations e.g. foundation distress of Leaning Tower of Pisa, Transcona Grain Elevator, Settlement of Mexico City etc..

Case studies of foundation failure and seepage failure of earth dams e.g. Panchet Dam (Maharashtra), Nanak Sagar Dam, Sampna Dam, Ahroura Dam, Vaiont Reservoir Disaster, Fort Peck Dam Slide etc.

Case studies of failures due to liquefaction of soils during earthquake e.g. failures during Kobe Earthquake in Japan etc.

Case studies of landslides, landslips and other slope failures.

Case studies of retaining wall failures.

Books Recommended:

1 Earth and Rockfill Dams by Bharat Singh &H.D.Sharma
2 Soil Mechanics by Perloff& Baron
3 Soil Mechanics & Foundation Engineering by Oza

CE-566T	**COMPUTER AIDED DESIGN OF FOUNDATIONS**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course objectives:

i. To impart knowledge of various soil parameters and laboratory tests relevant to foundation design.
ii. To impart knowledge to design of shallow foundation, pile foundation and retaining walls by using components of CAD packages for respective structures.

Course outcome:

CO1	Students are able to assess various soil parameters and laboratory tests relevant to foundation design.
CO2	Students are able to design of shallow foundation, pile foundation and retaining walls by using components of CAD packages for respective structures.

Detailed Syllabus:

1. **Soil Parameters for Foundation Design:** Major soil types, physical and engineering properties of soils, processing of field and laboratory test data to obtain parameters relevant to foundation design.

2. **Shallow Foundations:** Footings and rafts, proportioning of foundations based on SPT, SCPT, PLT & consolidation test data. Structural analysis and design - conventional, beams on elastic foundation, finite differences method of analysis of footing and rafts, structural design details, components of CAD package on shallow foundations.

3. **Pile Foundations:** Design steps, proportioning a pile foundation - analytical estimation of load - settlement behaviour of piles, lateral analysis of piles, and analysis of pile group subjected to vertical and lateral load, components of CAD package on pile foundations.

4. **Retaining Walls:** Design steps, types of walls and their selection, tentative dimensions, forces acting on the wall and their estimation, stability checks, structural design of components, drainage details, components of CAD package for retaining walls.

Books Recommended:

1. Course Package on "Computer Aided Analysis and Proportioning of Foundations" by G. Ramaswamy (Dept. of Continuing Education, Roorkee).
2. Foundation Analysis and Design by Bowles
3. Design of Foundation systems by Kurian

CE 597T	**Environmental Impact Assessment**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course Objectives

i. To create ability to identify, formulates, and solve environment related problems.
ii. To develop an understanding of ethical and professional responsibility.
iii. To understand the impact of engineering solutions in economic and environmental context.

Course Outcomes:

CO1	Students are able to develop an ability to apply knowledge of environment and ecology to solve engineering problems.
CO2	Students are able to design a process for economic and safe aspects for the society.

Detailed Syllabus:

Introduction: Basic concepts of environmental risk and definitions; hazard identification procedures; environmental risk zonation.

Consequence analysis and modelling (discharge models, dispersions models, fire and explosion models effect models etc.)

Estimation of incident frequencies: Estimations of incident frequencies from historical date, frequency modelling techniques e.g., Fault Tree Analysis (FTA) and Event Tree Analysis (ETA).

Human factors in risk analysis; Calculation and presentation of risk (individual risk, societal risk); Risk management, rules, regulations and conventions, case studies.

BooksRecommended:

1.Masters, G.M. (1998) Introduction to Environmental Engineering and Science, Prentice Hall, USA

2. Schwarzenbach, Gschwend, and Imboden (1993) Environmental Organic Chemistry, John Wiley and Sons, Inc. NY.

CE-558T	**ROCK MECHANICS-II**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: Rock Mechanics-I.

Course objectives

i. To impart knowledge of Rock Joint properties.
ii. To impart knowledge of Rock mass classification for underground excavations.
iii. To impart knowledge of various structural defects in rocks.
iv. To impart knowledge of various types of folds and joints their effects and their civil engineering importance.

Course outcome:

CO1	Students are able to assess various Rock Joint properties.
CO2	Students are able to classify the rock mass for underground excavations.
CO3	Students are able to assess various structural defects in rocks.
CO4	Students are able to assess various types of folds and joint their effects and their civil engineering importance.

Detailed Syllabus:

1. Significant Rock Joint Properties: Intensity of joints, roughness, scale effects, single joint orientation.

2. Rock Mass Classification for Underground Excavation: South African Geomechanics classification (RMR), rock structure rating (RSR), rock mass quality (Q)

3. Structural Defects: Folds Parts, nomenclature, plunge, refolding, fold system. Faults-General characteristics, nature of Movement along fault, classification. Joints- effects, parts, classification, types of joints in common rocks

4. Empirical Strength Criteria: Intact rocks, anisotropic rocks, rock mass.

5. Importance of Geological Structures: Simple type of folds, slip folds, flexural slip folds, parasitic folds and folds and flow folds. Effect of the folding and their civil engineering importance, effect of joints and their civil engineering importance.

Book Recommended:

1 Rock Mechanic, Vol., I, II, III, IV by Lama et.al.
2 Fundamentals of Rock Mechanics by Jaeger and Cook
3 Rock Mechanics and Design of Structures in Rock by Obert and Duvell

CE-560T	**DESIGN OF FOUNDATION SYSTEAMS**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course Objectives

i. To determine the bearing capacity of soil and the probable settlement and also to select the type of depth of foundation for a project.
ii. To impart empirical knowledge of soil behaviour required by the geotechnical engineer for the design of foundation and other soil related structures.
iii. To impart knowledge of structural design and various construction techniques of pile foundation and pile cap.
iv. To impart knowledge of design of Retaining walls, piers, abutments and retaining wall for seismic forces.
v. To impart knowledge of design and construction methods of Marine Sub – structures.

Course outcomes:

CO1	A comprehensive and well defined knowledge on bearing capacity theories is expected.
CO2	Students are trained how to design the foundations of a particular project depending upon the properties of soil and type of projects.
CO3	Students are capable to design the Retaining walls, piers, abutments and retaining wall for seismic forces.
CO4	Students are able to assess the design and construction methods of Marine Sub – structures.

Detailed Syllabus:

1. Shallow Foundations: Types and their suitability, bearing capacity and settlement, conventional method of design, soil line method, beams on elastic foundation analysis, finite difference method of design, footings and raft foundation subjected to eccentric-inclined loads, footing on slopes, footings in seismic zones, IS code.

2. Pile Foundations: Types, structural design, design of pile cap, design of pile foundation for a multi-storeyed building and other important structures, construction techniques.

3. Bridge Sub-structures: Forces on a bridge foundation (IRC & IRS specifications), well foundation components, stability analysis, design of various parts, material for construction, sinking of well, placing of curb, dredging, jetting, design of well foundation for piers and abutments.

4. Design of retaining walls for hydraulic structures on curves and with surcharge on backfill, design of piers, abutments and retaining walls for seismic forces.

5.Marine Sub-structures: Types of structures, breakwaters, wharves, sea well, design and construction methods.

Book Recommended:

1. Design of Sub-structures by Swami Saran.
2. Design of Foundation Systems by Kurian.
3. Foundation Analysis and Design by Bowles
4. Foundation Design by Teng.

CE-563T	**ADVANCED ROCK MECHANICS**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: Rock Mechanics-I, Rock Mechanics- II.

Course Objectives

i. To impart knowledge of various theories of failures and cracks.
ii. To impart knowledge of uses, properties and qualities of various types of explosives.
iii. To impart knowledge of blasting theory and various factors associated with blasting.
iv. To study the criteria of rock stability and design of slopes.
v. To study the stresses around tunnels and underground openings under different loading conditions.

Course outcomes:

CO1	Students are able to assess various theories of failures and cracks of rocks.
CO2	Students are able to understand the uses, properties and qualities of various types of explosives.
CO3	Students are able to assess blasting theory and various factors associated with blasting.
CO4	Students are able to understand the criteria of rock stability and design of slopes.
CO5	Students are able to assess the stresses around tunnels and underground openings under different loading conditions.

Detailed Syllabus:

1. Strength and Failure of Rocks: Types of failure, theories of failure-Coulomb-Navier theory, Mohr's theory, fracture of jointed rocks in uniaxial compression, crack phenomenon and mechanism of failure, Griffith's two dimensional theory of cracks, elementary theory of crack propagation strain energy associated with cracks, dynamics of crack propagation, modified Griffith's brittle fracture criterion.

2. Rock Blasting and Explosives : Explosives, uses, types, properties, composition of high explosives, choice and quality of explosives, mechanism of detonation, breaking ground with explosives, blasting theory, calculation of burden distance, factors involved in blasting, blast hole diameter, quarry blasting practice.

3. Rocks Slope Stability: Rock slope, mechanism of failure, shape of failure zone, criteria of rock stability, geological considerations, block sliding, principles of design of slopes.

4. Stabilization of Rocks: Rock bolting, principal of rock bolting, types and applications of rock bolt, rock grouting, grouting, operations, and methods of grouting, guniting.

5. Stress around Tunnels and under Ground Openings: under various loading condition, effect of number of tunnels and shape of tunnels, design of pressure tunnels in rocks.

6. Creep of Rocks: time dependents properties of rock.

Book Recommended:

1. Rock Mechanics Vol. I, II, III, IV by Lama et. Al.
2. Fundamentals of Rock Mechanics by Jaegar and Cook
3. Rock Mechanics by Stagg &Zienkiewiez
4. Art of Tunnelling by Schzy

CE-544T	NEURO-FUZZY APPLICATION IN CIVIL ENGINEERING	EC	3– 0 – 0	3 Credits
Internals=50		Externals=50		Total=100

Pre-requisites: None.

Course Objectives

i. To impart knowledge of basic concepts of Neural Networks and fuzzy Logic and Characteristics of Neuro- Fuzzy computing.
ii. To impart knowledge of formulation, parameters and basic operations of fuzzy sets.
iii. To impart knowledge of Fuzzy reasoning, fuzzy modeling and its applications in civil engineering problems.
iv. To impart knowledge of fundamental concepts of Artificial Neural Networks.
v. To impart knowledge of applications of Neuro-fuzzy computing.

Course outcomes:

CO1	Students are able to assess the basic concepts of Neural Networks and fuzzy Logic and Characteristics of Neuro- Fuzzy computing.
CO2	Students are able to assess the formulation, parameters and basic operations of fuzzy sets.
CO3	Students are able to assess the Fuzzy reasoning, fuzzy modelling and its applications in civil engineering problems.
CO4	Students are able to assess the fundamental concepts of Artificial Neural Networks.
CO5	Students are able to assess the various applications of Neuro-fuzzy computing.

Detailed Syllabus:

1. Introduction: Basic concepts of Neural Networks and fuzzy Logic, Differences between conventional computing and Neuro-fuzzy computing, Characteristics of Neuro- Fuzzy computing.

2. Fuzzy Set Theory: Basic definitions and terminology and membership functions – formulation and parameters, basic operations of fuzzy sets- complement, intersection, vision, T-norm and T- conorm.

3. Fuzzy Reasoning and Fuzzy Inference: Fuzzy relations, Fuzzy rules, Fuzzy reasoning, Fuzzy Inference systems, fuzzy modelling, Applications of Fuzzy reasoning and modelling in Civil Engineering Problems.

4. Fundamental Concepts of Artificial Neural Networks: Model of a neuron, activation functions, neural processing. Network architectures, learning methods.

5. Neural Network Models: Feed forward Neural Networks, Back propagation algorithm, application of Feed forward networks, Recurrent networks, Hopfield networks, Hebbian learning, Self organizing networks, unsupervised learning, competitive learning.

6. Neuro –fuzzy Modelling: Neuro-fuzzy inference systems, Neuro-fuzzy control.

7. Applications of Neuro-fuzzy Computing: Hydrologic Modelling, Time series Analysis and Modelling, Remote sensing, Environmental Modelling, Construction Management, Fault detection and rehabilitation of structures, Water Management, Design of Foundations, Transportation planning.

Book Recommended:

1. Jang, JSR, C.T. Sun and E. Mizutan (1997), “Neuro-Fuzzy and Soft Computing”, Prentice Hall, N.J.
2. Simon Haykin, (1994), “Neural Networks. A Comprehensive Foundation”, McMillan College Publishing Company.
3. Kosko, B. (1997), “Neural Networks and Fuzzy Systems”, Prentice Hall of India Pvt. Ltd., New Delhi.
4. Klir, George J., T.A. Forger, (1995), “Fuzzy Sets, Uncertainty and Information”, Prentice Hall of India, Pvt. Ltd., New Delhi.
5. Rao V and H. Rao, (1996), “C++ Neural Networks and Fuzzy Logic, BPB Publications, New Delhi.

CE-567T	**FLOW THROUGH POROUS MEDIA**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course outcomes

i. To study the basic principles of flow.
ii. To study the different mapping techniques.
iii. To control the seepage and to analyse the seepage with various theories and techniques.
iv. To impart the knowledge of various de-watering methods and drainage methods for stability of slope.

Course Outcomes:

CO1	Students should be able to analyse the seepage with various theories and techniques.
CO2	Students should be able to utilize basic principles of flow.
CO3	Students should be able to use different mapping techniques.
CO4	Students should be able to perform analysis of the seepage by application of seepage theories.

Detailed Syllabus:

1. Basic Principles: Darcy's Law, Permeability and its field determination, equation of continuity, velocity potential, stream function Laplace's equation. Solution of Laplace's Equation: Solution by graphical method, flow nets in homogeneous soils, anisotropic soils and layered soils, computation of seepage quantity, seepage pressure, uplift pressure on structures, exit gradient, piping due to subsurface erosion and heave. Two and three dimensioned electrical analogy method, relaxation method.

2. Seepage through Earth Dams: Determination of phreatic line, Dupuit's solution, Casagrande's solution, Kozeney parabola, entrance and exit corrections, flow nets for zoned earth dams and earth dams on pervious foundations under steady seepage conditions, flow nets for homogeneous sections under sudden drawn down, introduction to control of seepage, filters -type, selection and design.

3. Solution by Mapping Techniques: Conformal mapping of elementary function, Kozeney's basic parabola, Schwarez-Christoffel transformation, Khosla's solution, Velocity hydrograph, flow characteristics at singular points, examples of velocity hydrograph, solution by complex velocity, solution of triangular dam.

4. Seepage in Foundations: Construction dewatering-Methods of dewatering, Design of dewatering for foundation excavations, foundation improvement by drainage, drainage in retaining structures, influence of seepage on stability of slopes, drainage methods for stability of slopes.

Book Recommended:

1. Harr, M.E. " Ground Water & Seepage"
2. Cedergren "Seepage, Drainage & Flownets"

CE-570T	**COMPUTATIONAL AND STATISTICAL METHODS**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course objectives

i. To study linear and non-linear equations using numerical techniques.
ii. Apply finite difference and finite element method for analysing behaviour of geotechnical structures.
iii. Apply correlation and regression analysis for the geotechnical data.

Course Outcomes:

CO1	Students would be able to apply finite difference and finite element method for analyzing behavior of geotechnical structures.
CO2	Students would be able to solve linear and non-linear equations using numerical techniques.

Detailed Syllabus:

1. Numerical Solution of Ordinary Differential Equations: Solution by Taylor's Series- Euler's Method – RungeKutta Methods – Simultaneous and Higher Order Equations- Boundary Value Problems – Applications.

2. Finite Difference Method: Finite Difference Representation of Differential Equations – Stability – Consistency and Convergence of Partial Differential Equations – Time integration – Finite Difference Methods in Solution of Steady and Unsteady Problem- Jacobi's Method, Gauss Seidel Method, Successive Over Relaxation Method and Method of Characteristics – Application and Examples.

3. Finite Element Method: Basic Concepts – Solution of Discrete Problems – Steady State and Time Dependent Continuous Problems – Application of Finite Method through Illustrative Examples.

4. Classification and Presentation of Data: Basic Concepts of Probability – Probability Axioms – Analysis and treatment of Data – Population and Samples – Measures of Central Tendency – Measures of Dispersion – Measures of Symmetry – Measures of Peakedness.

5. Probability Distribution: Discrete and Continuous probability Distribution Functions – Binomial, Poisson, Normal, Lognormal, Exponential, Gamma Distribution, Extreme Value Distribution - Transformations to Normal Distributions, Selecting a Probability Distribution, Parameter Estimation – Method of Moments, Method of Maximum Likelihood, Probability Weighted Moments and Least Square Method, Joint Probability Distributions.

6. Regression Analysis: Simple Linear Regression, Evaluation of Regression – Confidence Intervals and Tests of Hypotheses – Multiple Linear Regression – Correlation and Regression Analysis.

Books Recommended:

1. Applied Numerical Methods for Engineers by Akai
2. Statistical Methods in Hydrology by Haan
3. Computational Methods in Subsurface Flow by Huyorkon, Pinder
4. Numerical Recipes – The Art of Scientific Computing by Press, Flannery, Tenklsky, Vetterling.

CE-559T	**GROUND IMPROVEMENT ENGINEERING**	**EC**	**3– 0 – 0**	**3 Credits**
Internals=50		**Externals=50**		**Total=100**

Pre-requisites: None.

Course Objectives

i. To impart knowledge of various problems associated with soil deposits and various methods to evaluate them.
ii. To impart knowledge of different techniques to improve the characteristics of soil.
iii. To impart knowledge of design techniques required to implement various ground improvement methods.

Course Outcomes:

CO1	Students are able to identify and evaluate the deficiencies in the soil deposits.
CO2	Students are able to improve the characteristics of the soil by using different techniques.

Detailed Syllabus:

1. Introduction: Need for ground improvement, historical review of methods adopted in practice, current status and scope in the profession.

2. Methods of Ground Improvement: Mechanical stabilization, dynamic compaction, impact loading, vibro-floatation, preloading, sand drains, stone columns, sand compaction piles, lime column, granular piles, dynamic consolidation, compaction by blasting, use of admixtures, injection of grouts- design guidelines and quality control, electrical and thermal methods, stabilization of black cotton soils.

3. Geosynthetics: Raw materials, durability and aging, manufacturing methods, geotextiles-testing and evaluation, geotextile as separators and as reinforcement, geotextile in filtration, drainage and erosion control, bearing capacity improvement by geotextiles.

4. Reinforced Earth: Basic mechanism, choice of soil and reinforcement, strength characteristics of reinforced earth, principles of design of reinforced earth wall.

Books Recommended:

1 Modern Geotechnical Engineering by Alam Singh
2 Indian Geotechnical Conference(1986), Indian Geotechnical Society,Vol.I
3 Soil Mechanics & Foundation Engineering, Vol.II,(Foundation Engineering) by V.N.S.Murthy
4 Designing with Geosynthetics by Koerner
5 Engineering with Geosynthetics by Rao & Raju.

CE 552T	SOIL STRUCTURE INTERACTION	EC	3– 0 – 0	3 Credits
Internal=50		External=50		Total=100

Pre-requisites: None.

Course Objectives

i. The ability to identify the situations where the topic is relevant
ii. Should be able to apply the effects of interaction between soil and foundation
iii. The ability to apply the concepts for solving multi task applications

Course Outcomes:

CO1	Understand various theories involved in soil structure interaction.
CO2	Understand capabilities of various models used to simulate the interaction.

Detailed Syllabus:

1. Definition of soil-foundation interaction soil-foundation-structure interaction, soil-fluid- structure interaction, idealization of soil by linear and non-linear winkler model, elastic continuum model (isotropic and anistropic), two parameter elastic models - heteny model, pasternak model, Reissner model.

2. Soil Parameters: Interpretation of parameters encountered in various idealised soil models- winkler, two parameter elastic and elastic continuum models.

3. Finite Beams on Elastic Foundation: Finite beams on winkler model, finite beams on two parameter elastic medium, finite beams on homogeneous, isotropic elastic continuum, finite difference solution to problems of beams on linear and non-linear winkler models.

4. Plates on Elastic Foundation: Rectangular and continuous plates on elastic foundation, plates carrying rows of equidistant columns, rectangular and circular plates on winkler medium, two parameter elastic medium and no elastic continuum, finite difference solution of problems of rectangular plates on linear and non-linear elastic foundation.

5. Soil- Structure Interaction in Framed Structures: Structures with isolated foundations- spring analog approach, determination of spring parameters, structures with continuous beams and rafts as foundation-finite element modelling, sub-structure technique of analysis, concept of relative stiffness, Interactive behaviour of some framed structures.

6. Soil-pile Interaction: Laterally loaded single piles- concept of coefficient of horizontal sub grade reaction, finite difference and finite element solution, soil-structure interaction of framed structures with pile foundations.

7. Interaction of other Structures with Soil-foundation System: Tanks with annular ring foundations, chimneys, silos, cooling towers, underground subways and tunnels.

8. Introduction to dynamic soil-structure interaction as well as non-linear soil/ concrete behavior.

Books Recommended :

1. John, P. Wolf, " Dynamic Soil-Structure Interaction". 2. John, P.wol f, "Soil-Structure Interaction in Time Domain". 3. Desai, C.S. , Srivardhane, " Constitutive Modelling of Soils and Rocks". 4. S. Timoshenko, Woimowski and Krigger, "Theory of Plates and Shells".

CE-568T	ENGINEERING GEOLOGY	EC	3– 0 – 0	3 Credits
Internals=50		External=50		Total=100

Pre-requisites: None.

Course Objectives

i. To impart knowledge and skills in assessing the quality of foundation rocks, their aggregates and building material derived from rocks and assess the geological suitability of sites.
ii. To impart knowledge of weathering, development of soil and various hydrogeological properties of rocks.
iii. To impart knowledge of Plate tectonics, Hill slope stability and Landslides etc.
iv. To impart knowledge of surface and subsurface investigations for various civil engineering projects.

Course Outcomes:

CO1	Students are able to assess the quality of foundation rocks, their aggregates and building material derived from rocks and assess the geological suitability of sites.
CO2	Students are able to assess weathering, development of soil and various hydrogeological properties of rocks.
CO3	Students are able to assess Plate tectonics, Hill slope stability and Landslides etc.
CO4	Students are able to assess the surface and subsurface investigations for various civil engineering projects.

Detailed Syllabus:

1. Geomorphology: Endogenous and Exogenous process of development of landforms, Development of slopes.

2. Weathering: Rock types and influence of weathering on different types of rocks. Depth of weathering. Development of soil. Hydro-geological properties of rocks.

3. Earth Movements: Crust of earth, Elementary ideas about plate tectonics, Hill slope stability, Landslide, subsidence.

Geological investigations of selections of sites for various Civil Engg. Projects:

(a) Surface Investigations: Study of Satellite Imageries, Aerial Photos and geological maps, geological field work (Field visits for under-construction Civil Engg. Projects).

(b) Subsurface Investigation: Resistivity survey and Lithologs date correlation.

Books Recommended:

1. A Text Book of Geology by E.S. Dana
2. The Dynamic Earth by B.Skinner and S.C. Parter
3. The Morphology of Earth by L.C. King
4. Principle of Geomorphology by W.D. Thornbury

5. Principle of Physical Geology by Holmes
6. Ground Water Hydrology by D.K. Todd
7. Aerial Photographic Interpretation by D.R. Lueder
8. Geophysical Methods in geology by P.V. Sharma
9. Elements of Engg. Geology by J.E. Richey.

CE-569T	MODELLING AND SIMULATION	EC	3– 0 – 0	3 Credits
Internals=50		External=50		Total=100

Pre-requisites: None.

Course objectives:

i. To able the students to model the domain.
ii. To impart the knowledge of establishing the relationship between the model and the constraints.
iii. To impart the knowledge to model the dynamic structures.

Course outcome:

CO1	Students are able to model the domain.
CO2	Students are able to establish the relationship between the model and the constraints.
CO3	Students are able to model the dynamic structures.

Detailed Syllabus:

1. **Modelling Process:** Taxonomy of model types; Steps in model building; simulation; algorithms and Heuristics; Simulation languages.
2. **Primitive Models:** Establishing relationships via physical laws; Establishing relationships via curve fitting; Parameter estimation problems; Elementary state transition models.
3. **Forecasting:** Nature of data; Statistical attributes of data; Probability distribution and their mechanisms; Generation of random numbers; Time series.
4. **Pattern Recognition:** Neighborhood and distances; Cluster analysis; Individual and group preference patterns.
5. **Static Equllibrium Models:** graphical models and matrix models; Input-output type models; decomposition of large systems; Routing problems.
6. **Linear Dynamical Structure:** Block diagram representation of model structure; Transfer function representation; State space models; Stability; system control.
7. **Growth and Decay Processes:** Discrete and continuous growths; Limits to growth: Competition among species; Growth process and integral equations; Discrete event approach; Population planning.

Simulation of Discrete and Continuous Processes: Monte Carlo methods; Stochastic simulation; System identification; Inverse problems; Virtual reality; typical example and case studies related to Civil Engineering.

Books Recommended:

1. R. Haberman, Mathematical Models.
2. D.P. Maki and M. Thompson, Mathematical Models and Applications.
3. R.E. Shannon, System Simulation: Art and Science.

M.Tech Environment

CE518T	AIR POLLUTION AND CONTROL	CS	3– 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify sampling techniques and analyze air quality.
CO2	Understand plume behaviour for different atmospheric stability conditions.
CO3	Assess concentration of pollutant at different receptor locations using plume dispersion modelling
CO4	Design air pollution control systems and evaluate their efficiency

Detailed Syllabus:

Introduction: Definition, Various Sources, Classification of Pollutants, Effects on environment including living and non-living matter.

Ambient and Stack Monitoring: Monitoring Techniques, High Volume sampling, Handy Sampler, Bio aerosol sampler, Indoor air sampler, Stack sampling, Analysis of various air pollutants.

Ambient Air Quality and Emissions: Air pollution indices, Standards, norms, rules and regulations.

Air Pollution Control: Preventive measures, Controls at source methods for gaseous and particulates, Automobile emissions control using catalytic converters.

Air pollution Meteorology and Modelling: Adiabatic lapse rate, ELR, Atmospheric stability conditions, Wind Velocity Profile, Maximum Mixing Depth (MMD), Temperature inversions, Wind rose diagram, Plume behavior, Effect of terrain on plume behaviors, introduction to air quality modelling.

Readings:

1. Colls, J., Air Pollution: Measurement, Modeling and Mitigation, CRC Press, 2009
2. Noel, D. N., Air Pollution Control Engineering, Tata McGraw Hill Publishers, 1999
3. Stern, A.C., Fundamentals of Air Pollution, Academic Press, 1984

CE520T	DESIGN OF WASTEWATERT TREATMENT PROCESSES	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify and assess the characteristics of wastewater and their impacts
CO2	Plan and design the components of wastewater treatment systems
CO3	Understand underlying principles of processes involved in secondary wastewater treatment systems.
CO4	Design sludge treatment and disposal methods.

Detailed Syllabus:

Introduction: Wastewater characteristics and variations, design and analysis of wastewater conveyance system, selection of treatment chain, Plant silting, Treatability studies.

Design of physiochemical unit operation: screening, flow measurement and pumping, grit removal, equalization, sedimentation, floatation.

Design of secondary treatment process: Activated sludge process, Trickling filters, Rotating Biological contractors, Upflow anaerobic sludge blankets (UASB), Anaerobic filters.

Sludge Disposal: Sludge Thickening, Sludge drying, aerobic and anaerobic digestion of sludge.

Design of low cost systems: Oxidation ponds, aerated lagoons.

Hydraulic treatment plants; flow measurements and hydraulic control points, hydraulic profiles through the treatment plants.

Readings:

1. Benefield L.D. and Randall C.D., Biological Process Designs for Wastewater Treatment, Prentice Hall Pub. Co., 1980
2. Metcalf and Eddy, Wastewater Engineering – Collection, Treatment, Disposal and Reuse, 4th Ed., McGraw Hill Pub. Co., 2003
3. UdoWiesmann, In Su Choi and Eva-Maria Dombrowski, Fundamentals of Biological Wastewater Treatment, 1st Ed., Wiley, 2007

CE527T	ADVANCED WATER SUPPLY AND WASTE WATER MANAGEMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Perform sizing calculations for conventional water treatment process units.
CO2	Physical chemical unit processes for advanced water treatment.
CO3	Plan and design water and wastewater control and disposal systems
CO4	Develop integrated water management system

Detailed syllabus:

Planning of Water supply projects, components of water supply scheme, water demands and estimation of design capacity, surface sources and design intake works, selection of pumps and design of pumping station, hydraulics of pumping mains, hydraulics analysis of distribution network and its optimization, design of distributed systems, leakage analysis and control. Planning of wastewater management projects; urban hydrology and estimation of municipal sewage and storm runoff, design of sewerage systems, selection of pumps and design of pumping stations, sewer appurtenances, construction and maintenance of sewerage systems.

Readings:

1. Metcalf and Eddy (2003) Wastewater Engineering, Treatment Reuse. Fourth edition, Tata McGraw Hill publishing Company Limited, New Delhi.
2. Peavy, Rowe and Tchobanoglous (1987) Environmental Engineering, McGraw Hill Book Company, Singapore.
3. CPHEEO (1993) Manual on Sewerage and Sewage Treatment, G.O.I., New delhi.
4. CPHEEO (1999) Manual on water supply and Treatment, G.O.I., New delhi.
5. Fair, Geyer and Okun (1971) Elements of Water Supply Wastewater Disposal, John Wiley and Sons, New York.
6. Steel and McGhee (1979) Water Supply and Sewerage, McGraw Hill Inc. USA.

CE529T	SOLID WASTE MANAGEMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Examine physical and chemical composition of solid wastes
CO2	Analyze activities associated with the management of solid waste.
CO3	Understand method to recover materials, conserve products, and to generate energy from solid wastes.
CO4	Design and locate waste containment systems as per regulatory standards.

Detailed Syllabus:

Introduction: Necessity and importance of solid waste and hazardous waste disposal, definitions, sources, classifications and characteristics, data collection, collection and reduction at source.

Transport: Collecting equipments, Systems of collection, garbage, chutes, transfer stations, bailing and compacting.

Disposal Options: Recovery of materials, selection of site, land disposal, ocean disposal, feeding to hogs.

Sanitary land filling: definitions, methodology, trench, area, ramp, pit method, site selection, basic steps involved, cell design and prevention of pollution, Leachate treatment, gas collection and recirculation.

Composting: Aerobic and anaerobic composting, factors affecting composting Indore and Bangalore process of composting, vermicomposting.

Incineration: Processes 3Ts to control high temperature incinerators, design approach prevention of air pollution.

Prolysis: Process, basic steps involved, end product, pyrolysis of specific solid waste.

Recycle and Reuse: Material and energy recovery operation.

Readings:

1. Tchobanoglous G, Theisen H and Vigil SA , Integrated Solid Waste Management, Engineering Principles and Management Issues' McGraw-Hill, 1993
2. Vesilind PA, Worrell W and Reinhart D, Solid Waste Engineering' Brooks/Cole Thomson Learning Inc., 2002
3. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, Environmental Engineering, McGraw Hill Inc., N.York, 1985
4. G. Tchobanoglous., Frank Kreith ,Hand Book of Solid Waste Management, McGrawHill, Inc., N.York., 2002
5. Qian X, Koerner RM and Gray DH, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002

CE545T	ENVIRONMENTAL IMPACT ASSESSMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify environmental attributes for the EIA study.
CO2	Identify methodology and prepare EIA reports.
CO3	Specify methods for prediction of the impacts.
CO4	Formulate environmental management plans.

Detailed syllabus:

Introduction to environmental impact analysis, assessment and statement, evolution of EIA, national environmental policy. EIA process: Screening and scoping criteria; Rapid and comprehensive EIA Impact Assessment Methodologies – Matrices, overlays, network analysis. Specialized areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; cost-benefit analysis; Expert system and GIS applications. Legislative and environmental clearances procedures in India: Siting criteria; public participations; resettlement and rehabilitation. Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case Studies of EIA of river valley projects and thermal power projects.

Readings:

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill Pub. Co., 1997
2. David P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, 2003
3. Hosetti, B. B., Kumar A, Eds, Environmental Impact Assessment & Management, Daya Publishing House, 1998
4. UNESCO, Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development, UNESCO/UNEP, Paris, 1987
5. Anjaneyulu.Y., and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007
6. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004

CE585T	ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the fundamentals principles of environmental chemistry.
CO2	Understand water chemistry required in the treatment processes of water and wastewater
CO3	Analyze the growth kinetics of microorganisms.
CO4	Understand the processes in biological treatment systems.

Detailed Syllabus:

Chemical Equilibrium and Kinetics Fundamentals Colorimetry: Light adsorption, Beer's and Lambert's law; Electro chemistry: Electrodes and pH measurement, Basic concepts from colloidal chemistry; Acids and Bases; Titrations; Acidity; Alkalinity; buffers and Buffer Intensity; Chemical equilibrium calculations; pC-pH diagram, Langelierindex, Solubility diagram, Oxidation and Reduction reactions. Laboratory procedures for determining the physical, chemical and microbial parameters of water and wastewater. Gas chromatography and mass spectroscopy, Light scattering and molecular luminescence methods, Flame emission and Atomic Adsorption spectroscopy continuous monitoring methods.

Structure of Cell; Types of microorganisms found in the environment; metabolic classification of organisms, enzymes, cofactors, biochemistry of carbohydrates, proteins, fats, etc. Bacteria: Morphology spore formation, bacterial growth curve-phases, specific growth rate and generation time; Algae: Occurrence, biological economic importance, morphology, classification and metabolism with special reference to those from that influence the environment; Fungi:Morphology, characteristics, classification, detection, metabolism, Species of importance in biodegradation of organic matter; Bacteria: Structure, composition, reproduction, metabolism, nutritional types, growth kinetics, detoxifying bacteria withspecial reference to phenols and heavy metals; Role of bacteria in bio-concentration of trace contamination in food chain.

Readings:

1. BenefieldD. L., Judkins F. J., WeandL. B., Process Chemistry for Water and Wastewater Treatment, 1st Edition, Prentice Hall, 1982
2. Bitton, G., Wastewater Microbiology, 3rd Ed., Wiley, 2005
3. Mitchell, R., and Gu, J.D., Environmental Microbiology, 2nd Ed., Wiley-Blackwell, 2010
4. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5th edition McGraw-Hill Inc.

CE586T	WATER AND WASTEWATER TREATMENT PROCESSES	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze water quality
CO2	Epidemiological and toxic aspects
CO3	Design conventional water treatment systems
CO4	Design treatment systems for removal of dissolved solids
CO5	Analyze and design water distribution systems

Detailed Syllabus:

Structure and basic properties of water and their significance in environmental engineering. Source of water impurities; Water quality parameters; Epidemiological and toxic aspects; physical and chemical interactions due to various forces; Suspension and dispersions; Surface and colloidal chemistry; Settling of particles in water, Coagulation and flocculation, floatation, filtration mechanisms and interpretations, ion exchange and adsorption, Chemical Oxidation/reduction processes; Disinfection using chlorine, UV, ozonation. Water stabilization, aeration and gas transfer. Reverse osmosis, electrodialysis and desalination; treatment and sludge management.

Readings:

1. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, Environmental Engineering, McGraw Hill., 1984
2. Viessman Jr, Hammer J. M, Perez, E.M, and Chadik, P. A, Water Supply and Pollution Control, PHI Learning, New Delhi, 2009
3. M. Hanif Chaudhary, Applied Hydraulic Transients, 3rd Ed., Springer., 2014

CE590T	INDUSTRIAL WASTE MANAGEMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE
Course Outcomes: At the end of the course the student will be able to:

CO1	Sample and analyze the characteristics of industrial wastewaters.
CO2	Analyze the effects of disposal of industrial wastes
CO3	Identify and design treatment options for handling industrial wastewater.
CO4	Identify and design treatment options for handling industrial wastewater.

Detailed Syllabus:
Nature of characteristics of industrial wastes: Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications.
Flow sheet analysis; Energy and resources (material and water) audits for efficient usage and conservation; waste audits, emission inventories and waste management hierarchy for process industries; Thermodynamics constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicator; Concept of industrial ecology and symbiosis of eco-parks.
Water and energy use and industry, industrial water quality requirements, deteriorations in water quality. Control and removal of specific pollutants in industrial wastewaters i.e., oil and grease, cyanide, fluoride, toxic organics, heavy metals, radioactivity. Recent trends in industrial waste management.
Case studies of various industries, e.g., dairy, fertilizer, distillery, sugar, pulp and paper, iron and steel, metal plating, refining, thermal power plants.

Readings:

1. Industrial Wastewater Management, Treatment and Disposal, WEF Manual of practice No. FD-3, 3rd Ed., WEF Press and McGrawHill, 2008
2. Numersorn, N.L., Liquid Waste from Industry – Theories, Practice and Treatment, Addison-Wesley, 1971
3. Patwardhan, A.D., Industrial Waste Water Treatment, PHI Learning, 2009 Rao, M.N., and Dutta, A.K., Wastewater Treatment, IBH Publ., 1995

CE591T		**WATER QUALITY MANAGEMENT**	**CS**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Meaning of important parameters for measuring water quality, water quality criteria and standards, and their relation to public health, environment and urban water cycle.
CO2	Water quality tests and to determine how the parameters relate to each other.
CO3	Principles and the practical approaches and techniques required to effectively monitor the chemical, hydrological, microbiological and aquatic elements of water quality.
CO4	Water quality tests and to determine how the parameters relate to each other.

Detailed syllabus:

Introduction: Quality parameter and classification of natural water, Physico-Chemical and biological water quality classification of aquatic systems. Sources of pollution: characteristics of point and non-point sources of pollution. Eutrophication in natural water bodies: causes processes and control Toxic wastes: Sources, transportation and management strategies.
Thermal pollution: causes, model and control.
Acid rains: Occurrences, impacts and strategies for control
Water quality monitoring: Objectives, requirements, planning and various techniques.
Case studies related to water quality monitoring under various river actions plans including Ganga and Yamuna Action plans.

Readings:

1. Reckhow and Chapra (1983) Engineering Approaches for Lake Management, Vol. 1, Butterworth, Boston.
2. Thomson and Mueller (1987) Principles of Surface Water Quality Modelling and Control, Harper and Row, NY.
3. Tchobanoglous and Schroeder (1987) Water Quality: characteristics, Modelling and modification, Addition – Wesley Pub. Co., USA
4. APHA (1998) Standard Methods for Examination of Water and Wastewater, 20th Edition, Washington, D.C.
5. Velz, C.J.(1970) Applied Stream Sanitation, Wiley Interscience, NY.

CE592T	HAZARDOUS WASTE MANAGEMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Examine physical and chemical composition of hazardous wastes
CO2	Analyze activities associated with the management of hazardous waste.
CO3	Understand method to recover materials, conserve products, and to generate energy from hazardous wastes.
CO4	Design and locate waste containment systems as per regulatory standards.

Detailed Syllabus:

Introduction: Definition, Sources and classification, Lake mark episodes, regulation for Hazardous Waste Management.

Hazardous Waste Characteristics and Site Assessment: Ignitability, corrosivity, reactivity, toxicity, EPA-designated hazardous wastes, assessment of hazardous sites.

Waste Minimization and Resource Recovery: Approaches to waste reduction, Benefits of hazardous waste reduction, Properties in hazardous waste management, development of tracking system, Selection of the waste minimization process, case studies on by product recovery from incineration.

Chemical, Physical and Biological Treatment: Description of unit operation and process, Case study on oil field waste treatment with mobile system.

Thermal process: Advantages and disadvantages of incineration, chemistry of incineration, thermodynamics of incineration, design of an incineration system. Incineration standards, Types of incinerators: Liquid injection, rotary Kiln and fluid bed, multiple hearth furnaces, fluidized and catalytic incinerator.

Transportation of hazardous wastes: Regulation, Containers for hazardous materials, bulk and non-bulk transport, hazardous substances emergency response.

Land-fill Disposal: Landfill at disposal sites, developing a new facility, operating a landfill.

Site Remediation: Site assessment and inspection, the hazardous system and the national priority list, remedial action, monitoring of disposal sites.

Readings:

1. Wentz, C.A. (1989) Hazardous waste management, McGraw Hill
2. LaGerga and Mercer (2001) Hazardous Waste Management, McGraw Hill Inc., USA.
3. Cornwell, D. (1998) Introduction to Environmental Engineering, McGraw Hill Inc. USA

CE593T	LIFE CYCLE ANALYSIS AND DESIGN FOR ENVIROMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Perform life cycle inventory analysis of products.
CO2	Develop strategies to bring energy efficiency in all stages of the product development cycle.
CO3	Formulate plans for comprehensive environmental protection, in order to comply with environmental laws.

Detailed Syllabus:

Engineering Products and Processes: Environmental health and safety, Product life cycle stages, material toxicity, pollution and degradation, environmentally conscious design and manufacturing approaches, Sustainable development and industrial ecology, System life cycle from cradle to reincarnation, Product life extension, Organizational issues. Pollution prevention practices, Manufacturing process selection and trade-offs. Design for environment: Motivation, concerns, definitions, examples, guidelines, methods and tools.

Recyclability assessments, design for recycling practices. Re-manufacturability assessments, design for remanufacture / Reuse practices.

Industrial ecology and eco-industrial parks, eco-labels and life cycle analysis (LCA): LCA methodology, steps, tools and problems, Life cycle accounting and costing.

ISO 14000 Environmental Management Standards, New Business paradigms and associated design practices.

Readings:

1. Ciambrone , D.F., Environmental Life Cycle Analysis, CRC Press, 1997
2. Handbook on Life Cycle Assessment : Operational guide to the ISO standards, Kluwer Academic Publishers, 2004

CE594T	ADVANCE WASTEWATER TREATMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Design processes for advanced wastewater treatment
CO2	Design approaches for biological nitrogen and phosphorus removal processes.
CO3	Kinetics and Modelling of Reactors
CO4	Physico-chemical treatment processes

Detailed syllabus:

Microbiological Concepts: Cells, classification and characteristics of living organisms, characterisation techniques, reproduction metabolism, microbial growth kinetics.

Kinetics and Modelling of Reactors: types of reactors, kinetics of biochemical operations, modelling of suspended growth systems, techniques for evaluation of kinetic and stoichiometric parameters.

Concepts and principles: Carbon oxidation, nitrification, denitrification, methanogenesis, sulphate reduction.

Engineered systems: Waste and water treatment chains, low cost options, decentralized and combined treatment systems.

Physico-chemical treatment: Membrane process: Reverse osmosis, nanofiltration, ultrafiltration, microfiltration adsorption, advance oxidation processes, chemical precipitation.

Biological nutrient removal: Tertiary treatment, Aerobic and Anaerobic treatment processes; overflow land disposal and constructed wetlands.

Readings:

1. Metcalf and Eddy (2003) Wastewater Engineering, Treatment Reuse. Fourth edition, Tata McGraw Hill publishing Company Limited, New Delhi.
2. Weber, W.J. (1972) Physicochemical Process for Water Quality Control, Wiley Interscience, New York.
3. Eckenfelder, W.W. (2000) Industrial Pollution Control, McGraw Hill Book Company, Singapore.
4. Peavy, Rowe and Tchobanoglous (1987) Environmental Engineering, McGraw Hill Book Company, Singapore.

CE595T	BIO-REMEDIATION: PRINCIPLES AND APPLICATION	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fundamental principles of bioremediation processes
CO2	Identify bioremediation processes different pollutants.
CO3	Design process for enhancing biodegradation.
CO4	Identify ethical, environmental, societal and safety issues related to bioremediation using genetically engineered bacteria

Detailed syllabus:

Introduction: Bioremediation, current bioremediation practice and application.
Microbial systems of bioremediations; factors influencing bioremediation (environmental factors, physical factors and chemical factors); Genetic responses of microorganisms to the presence of pollutants (plasmid coded inducible degradative enzymes)
Application of genetically engineered microorganisms for hazardous waste management; Microbial transformation reactions (aerobic and anaerobic biotranformations); Microbial detoxification of speciality chemicals (insecticide, herbicide, fungicides, polychlorinated biphenyls, heavy metals)
Bioremediations systems and processes (Solid, liquid and slurry phase bioremediations); Microbial cleaning of gases (biofiltration and bioscrubbing);
In Situ bioremediation, laboratory scale biotreatability studies for bioremediations, Management of bioremediation project.

Readings:

1. Ergas, S.J., Chang, D.P.Y., Schreoder, E.D., and Eweis J.B., Bioremediation Principles , WCB/McGraw-Hill, 1998
2. Rittmann, B.E., and McCarty, P.L., Environmental Biotechnology : Principles and Applications, McGraw Hill, 2001

CE596T	AIR QUALITY MODELLING	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Modelling atmospheric pollution and air quality.
CO2	Mathematical modelling of air quality, including hands on development of these models.
CO3	Specify methods for prediction of the impacts.
CO4	Exposure to various scientific and regulatory-grade regional air quality models and their applications.

Detailed syllabus:

Introduction to Air Quality Modelling: Approaches to model formulation. Model classification, criteria for model selection. Air pollution meteorology – meteorological parameters, stability classification; plume rise, plume behaviour, dispersion parameters. Basic diffusion equation, deterministic, numerical and statistical modelling approach. Introduction to boundary layer turbulence – physical modelling approach. Stochastic modelling approach to air pollution dispersion. Theory of Gaussian plume model and its application. Introduction to indoor air quality model. ISCST3; CALINE4; ROADAIR. Case studies.

Readings:

1. Seinfeld, J.H. (1986) Atmospheric Chemistry and Physics of Air Pollution, John Wiley and Sons Inc., USA
2. Seinfeld, J.H. (1975) Air Pollution: physical and Chemical Fundamentals, McGraw Hill Inc. USA
3. Peavy, Rowe and Tchobanoglous (1987) Environmental Engineering, McGraw Hill Book Company, Singapore.

CE597T	ENVIRONMENTAL RISK ASSESMENT	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the complex environmental issues and their impact on business and industry.
CO2	Specify strategies and polices used to promote cleaner production in industry.
CO3	Identify mitigation methods for minimising the environmental risk due to anthropogenic activities.
CO4	Describe criteria and process for implementing Environmental Management systems.

Detailed syllabus:

Introduction: Basic concepts of environmental risk and definitions; hazard identification procedures; environmental risk zonation.
Consequence analysis and modelling (discharge models, dispersions models, fire and explosion models effect models etc.)
Estimation of incident frequencies: Estimations of incident frequencies from historical date, frequency modelling techniques e.g., Fault Tree Analysis (FTA) and Event Tree Analysis (ETA).
Human factors in risk analysis; Calculation and presentation of risk (individual risk, societal risk); Risk management, rules, regulations and conventions, case studies.

Readings:

1. Masters, G.M. (1998) Introduction to Environmental Engineering and Science, Prentice Hall, USA
2. Schwarzenbach, Gschwend, and Imboden (1993) Environmental Organic Chemistry, John Wiley and Sons, Inc. NY.

CE598T	ADVANCED COMPUTATIONAL METHODS AND OPTIMIZATIONS	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply numerical schemes for solution of differential equations in Water Resources and Environmental Engineering
CO2	Apply finite difference schemes for solution of hydraulic and hydrologic models
CO3	Formulate finite element model for solution of flow through porous media
CO4	Perform statistical analysis of water resources and environmental engineering systems

Detailed syllabus:

Numerical Methods: Newton Raphson Method for solution of simultaneous equations. Numerical solutions of partial differential equations: Finite difference methods, finite element method and method of characteristics. Explicit and Implicit methods to solve simple parabolic differential equations, convergence, boundary value problems and successive over relaxations methods. Numerical dispersions errors and their preventions, Comparisons of solutions by analytical and finite difference techniques for one dimensional instantaneous discharge simple computer program based examples.

Optimization: Definition and classification of optimizations problems, importance in Environmental studies, Single and multivariable optimization without and with constraints.

Linear Programming: Standard form of problems, Pivotal reduction of equations, Single and two phase simplex methods, Piece wise linear approximation of non-linear optimization.

Numerical search methods for 1-D Nonlinear problems: Dichotomous, Fibonacci and Golden section methods, Quadraticand cubic interpolation methods, solution of linear programming problems using computer programming.

Statistics and probability: Frequency distribution – characteristics of distributions: central tendencies and dispersions, concept of probability – Binomial , Poisson and Normal distribution – applications – method of least square and regression – multiple regression – the Chi-Squared test – F Test , Analysis problems using Computer Programming.

Readings:

1. Hoffman, J.D., Numerical Methods for Engineers and Scientists, CRC Press, Special Indian Edition., 2011
2. Kotteguda, N.T. and Renzo Resso, Statistics, Probability and Reliability for Civil and Environmental Engineers, McGraw Hill Companies Inc., New York., 1998
3. Schilling, R.J., and S.L. Harris, Applied Numerical Methods for Engineering, CENGAGE Learning, India Edition., 2007
4. Abbot, M.A. and Vervey, Computational Hydraulics, Elsevier Publications., 1996

CE599T	GROUND WATER FLOW AND POLLUTION MODELLING	CS	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Methodology and basic tools of water quality modelling.
CO2	Different modelling approaches their scope and limitations.
CO3	Fate and transport of pollutants in different water bodies.
CO4	Techniques of analysis to assess population dynamics.
CO5	Numerical modelling and finite difference methods..

Detailed syllabus:

Subsurface processes and concepts for groundwater resources evaluation.

Unsaturated zone properties: Soil moisture levels, Retention curves, Flow through unsaturated porous media, infiltration and wetting front.

Groundwater contamination, sources and causes of groundwater pollution.

Pollution Dynamics, Hydrodynamics dispersions, Biodegradations, Radioactivity decay, Reactive processes, Multiphase contamination, NAPLs, VOCs, Site specific groundwater quality problems in Indian context.

Numerical models, Finite difference methods, Numerical modelling of steady and transient flows in saturated and unsaturated domains, Contamination transport modelling, Application of FEM and BIEM in groundwater modelling, Regional aquifer simulation.

Contaminated groundwater systems and their rehabilitation, Development and optimization based management of aquifer systems, stochastic models, Random field concepts in groundwater models; Application emerging techniques to groundwater management.

Readings:

1. Rich L.G. (1972) Environmental Systems Engineering, McGraw Hill Inc. USA.
2. Thoman R.V.(1980)Systems Approach to Water Quality Management, McGraw Hill Inc. USA
3. Canter and Knox (1985) Ground Water Pollution Control, Lewis Publication, Michigan, USA.
4. Sun, N. (1995) Mathematical Modelling, John Wiley and Sons, USA.
5. Schnoor, J.L. (1996) Environmental Modelling, John Wiley and Sons, USA

M.TECH IN CIVIL ENGINEERING

WATER RESOURCES ENGINEERING

CE 501T	**ADVANCED FLUID MECHANICS**	**CC**	**3– 0 – 0**	**3 Credits**
Internal: 50 marks	**End Term: 50 marks**		**Total: 100 marks**	

Pre-requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	**Formulate momentum, energy and mass transport models**
CO2	**Analyze Potential Flows**
CO3	**Develop approximate solutions for small and large Reynolds number flows**
CO4	**Apply turbulent flow models**
CO5	**Boundary layer formation and stress acts at the boundary**

Detailed syllabus:
KINEMATICS OF FLUIDS:
Methods of describing fluid motion-Lagrangian and Eulerian methods, Translation, Rotation and rate of deformation. Streamline, Path lines and streak lines, Material Derivative-local and Convective Acceleration, Fluid rotation-Vorticity Vector.
STRESSES IN FLUIDS AND RATE OF STRAIN:
Stresses at a point fluids. Stress Tensior-Normal and shear stresses, Nature of strains. Relations between stresses and rates of strains-Stokes law of viscosity. Viscous contribution to normal stresses.
FUNDAMENTAL EQUATIONS OF FLOW OF VISCOUS COMPRESSIBLE FLUIDS: Reynold's transport theorem, Equations of Continuity and Momentum in integral form and applications, Differential form of continuity equation and Euler's equation of motion, Navier-Stoke's equations of viscous compressible fluids.
TWO AND THREE DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW OF FLUIDS:
Circulation concept-Stoke's theorem, Kelvin's theorem, Stream function, Irrotational flow and velocity potential function, Integration of Euler's equation-along a stream line for irrotational flows, Momentum theorem and moment of momentum theorem. Laplace equation and Flow nets, Two dimensional flow examples-Rectilinear flow, Source/Sink, Vortex, Doublet, Dipole. Three dimensional axis - Symmetric flow examples-Uniform flow. Source / Sink, Doublet, Rankine's method of constructing flow net.
Motion of solids in a fluid superposition of source and rectilinear flow(two and three dimensional cases). Superposition of source and sink with rectilinear flow (Rankine body). Superposition of rectilinear and doublet. Cylinder and sphere in uniform

flow: Superposition of vortex and doublet on uniform rectilinear flow, Presence of force of lift on the cylinder/sphere in motion with circulation, lifting vanes.

LAMINAR FLOW OF VISCOUS INCOMPRESSIBLE FLUIDS:

Similarity of flows, Reynolds Number and its significance, Flow between parallel flat plates, Couette flow, Plane Poiseville flow, Flow through pipes, Hagen-Poisseille flow, Axial flow, Flow between two coaxial cylinders, Flow between two concentric rotating cylinders, Measurement of viscosity, Unsteady motion of a flat plate (plane wall).

LAMINAR BOUNDARY LAYER:

Properties of Navier-Stoke's equations-Boundary layer concept, Prandtl's boundary layer equations in two dimensional flow. Boundary layer along a flat plate-Blasius solution for shearing stress & boundary layer thickness; Boundary layer on a surface with pressure gradient, Momentum integral theorems for boundary layer, Von Karman integral relation from boundary layer equation and using moment law, Applications of momentum integral relation to the boundary layers-Von Karman Pohlhausen method, Separation of boundary layer flow-mathematical criterion and prediction of separation. Methods of boundary layer, Control including boundary layer suction.

BOOKS RECOMMENDED:

- Fox, R.W., Pitchard, P.J., and Mcdonald, A.T., Fluid Mechanics, Wiley India Pvt. Ltd., 2009.
- Schlichting, H., and Gresten, K., Boundary Layer Theory, Springer Publications, 2004.
- White, F.M., Viscous Fluid Flow, McGraw Hill Pub. Co, New York, 2011.
- Yalin, M.S., Theory of Hydraulic Models, McMillan Co., 1971

CE 503T	OPEN CHANNEL HYDRAULICS	CC	3– 0 – 0	3 Credits
Internal: 50 marks	End Term: 50 marks		Total: 100 marks	

Pre-requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze components of hydrologic cycle
CO2	Predict hydrologic extreme events for hydraulic and hydrologic design
CO3	Develop forecasting models for operation of hydrologic systems
CO4	Assess surface water resources

Detailed syllabus:

BASIC FLUID FLOW CONCEPTS:
Classification of open channels, Classification of flow, Basic equations, Energy & Momentum coefficients, Pressure variation in a vertical.

UNIFORM FLOW IN RIGID-BOUNDARY CHANNELS: Shear stresses on the boundary, Velocity distribution, Flow over scattered roughness elements, Chezy's equation, Manning's equation, Effect of channel shape on resistance equation, Conveyance of a channel, Section factor curves. Flow in a circular channel, Relation between conveyance & depth.

UNIFORM FLOW IN MOBILE-BOUNDARY CHANNELS: Incipient motion condition. Regimes of flow, Resistance to Flow in alluvial streams, Non-scouring erodible boundary Channels.

SPECIFIC ENERGY SPECIFIC FORCE AND CRITICAL DEPTH: Specific energy, Specific force, Critical depth computations, Control section, Applications of specific energy and critical depth concepts.

GRADUALLY VARIED FLOW: Types of non-uniform flow and governing equation, Characteristics of surface curves, Classification of surface curves, Computations of GVF in prismatic and non-prismatic channels, Division of flow at islands, Delivery of canals.

RAPIDLY VARIED FLOW: Types of jump, Hydraulic jump in horizontal and sloping rectangular channels, Location of jump on horizontal floor, Forced hydraulic jump, Jump in expanding and non rectangular channels, Critical depth flume. End depth in a free overfall, Sluice gate flow.

UNSTEADY FLOW: Waves & their classification, Celerity of a wave, Surges, equation of motion. Method of characteristics, Dam break problems, Flood routing in channel.

SPATIALLY VARIED FLOW AND TRANSITION: SVF with increasing and decreasing discharge, Side weir, Bottom racks, Subcritical and supercritical transitions.

BOOKS RECOMMENDED:

- Open Channel Hydraulics by V.T.Chow, McGraw Hill. New York.
- Flow Through Open Channels by Ranga Raju K.G., Tata McGraw Hill.
- Flow in Open Channes by K. Subramanya, Tata McGraw Hill, Delhi.
- Open Channel Hydraulics by French R.FI.

CE 505T	ENGINEERING HYDROLOGY	CC	3 – 0 – 0	3 Credits
Internal: 50 marks	End Term: 50 marks	Total: 100 marks		

Pre-requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze components of hydrologic cycle
CO2	Predict hydrologic extreme events for hydraulic and hydrologic design
CO3	Develop forecasting models for operation of hydrologic systems
CO4	Assess surface water resources

Detailed syllabus:

INTRODUCTION:

Systems concept, Hydrologic system model, Hydrological model classification.

HYDROLOGIC PROCESSES:

Reynolds transport theorem, Continuity equations-integral equation of continuity, Discrete time continuity, Momentum equations, Porous medium flow, Energy balance, Transport processes.

ATMOSPHERIC WATER:

Atmospheric circulation, Water vapor, Precipitation, Thunder-storm cell model, Evaporation-energy balance method, Aerodynamic method, Combined aerodynamic and energy balance method, Evapotranspiration.

SUB-SURFACE WATER:

Unsaturated (low-continuity equation, Momentum equation, Infiltration, Horton's equation. Philip's equation, Green Ampt method, Green-Ampt parameters, Two layer Green Ampt Model, Ponding time.

SURFACE WATER:

Sources of stream flow, Horotonian overland flow, Sub surface flow, Saturation overland flow. Stream flow hydrograph, Storm hydrograph, Base flow separation, Excess rainfall and direct runoff, Runoff coefficients, Abstractions using infiltration equations, SCS method for abstractions, Urbanization effect, Time distribution of SCS abstractions, Catchment characteristics, Number of streams, Length of streams, Stream density, Drainage density, Order of streams, Mean and median elevation. Hypsometric curves.

HYDROLOGIC MEASUREMENT:

Hydrologic measurement sequence, Measurement of atmospheric water-atmospheric moisture, Rainfall. Snowfall, Interception, evaporation,evapotranspiration, Measurement of surface water-water surface elevation, Flow velocity, Stream flow rate, Discharge computation, Rating curve, Measurement of sub-surface, Water-soil moisture. Infiltration, Ground water.

UNIT HYDROGRAPH:

General hydrologic system model, Linear system in continuous time, Response functions of linear systems, Impulse response function, Step response function. Pulse response function, Linear system in discrete time, Discrete pulse response function, The unit hydrograph, Unit hydrograph derivation, Unit hydrograph application, Unit hydrograph by matrix calculation. Solution by linear regression, Solution by linear programming, Synthetic unit hydrograph, Snyder's synthetic unit hydrograph, SCS dimensionless hydrograph, Unit hydrograph for different rainfall duration, Instantaneous unit hydrograph.

LUMPED FLOW ROUTING:
Lumped system routing, Level pool routing, Runge-Kutta method, Hydrologic river routing, Linear reservoir model, Composite models.

HYDROLOGIC STATISTICS:
Variables, Mean, Mode, Median, Standard deviation, Coefficient of variation, Moments, Skewness, Probalistic treatment of hydrologic data, Frequency and probability functions quality criteria, Groundwater samples, Changes in chemical composition, Dissolved gases and Temperature of groundwater: Occurrence of saline groundwater.

POLLUTION OF GROUNDWATER:
Pollution of groundwater in relation to water use-municipal, industrial and miscellaneous sources and causes, Attenuation of pollution, Distribution of pollution in the groundwater, evaluation of pollution potential, monitoring of groundwater quality.

MANAGEMENT OF GROUNDWATER:
Concepts of basin management, Equation of hydrologic equilibrium, Groundwater basin investigations, Data collection and field work, Alternative basin yield, Evaluation of perennial yield, Salt balance, Basin management by conjunctive use.

GROUNDWATER MODELLING TECHNIQUES:
Porous media models, Analog models, Electric analog models, Digital computer models.

BOOKS RECOMMENDED:

- Groundwater Hydrology by D.R. Todd-John Wiley & Sons.
- Ground Water by H.M. Raglumath- Wiley Eastern.
- Theory of Groundwater Flow by A. Verruijit- Macmillan & Co.
- Groundwater and Tubewells by S.P. Garg- Oxford Pub. Co.
- Groundwater hydrology by II. Bouwer-McGraw Book Co.

CE 504T	GROUND WATER ENGINEERING	CC	3 – 0 – 0	3 Credits
Internal: 50 marks	End Term: 50 marks			Total: 100 marks

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	**Model regional groundwater flow and design water wells**
CO2	**Formulate and solve conjunctive use of surface water and groundwater resource utilization problems**
CO3	**Identify sites for artificial recharge of groundwater and determine the consequences of artificial recharge**
CO4	**Conduct Geophysical exploration studies for groundwater source identification**

Detailed syllabus:-

OCCURRENCE OF GROUND WATER:

Groundwater in hydrological cycle, Properties of rocks and water bearing formations affecting ground water flow, Ground water basins, Vertical distribution of ground water, Ground water potential and its exploitation in India.

GROUNDWATER MOVEMENT:

Darcy's law, Permeability and its determination, Flow rates and directions of flow of ground water, Dispersion of tracers in ground water, Unsaturated flows, General equations governing steady/unsteady flow through confined and unconfined aquifers.

HYDRAULICS OF WATER WELLS:

Flow in confined aquifers towards wells in steady and unsteady state. Flow through leaky or semiconfined acquifers into wells, Dupuits assumption for unconfined aquifers, Steady and unsteady flows into wells, Theis, Jacob's and Chow's methods of solution of unsteady flows, Method of superposition in groundwater flow-method of images, Solutions of flow towards wells near a recharge boundary or impermeable boundary, Use of observation wells, Multiple well systems, Partially penetrating wells.

DESIGN AND CONSTRUCTION OF WELLS:

Selection of Aquifer, well depth and well diameter, selection of screen-type and design of well screen, Provision of artificial gravel pack and shrouded wells, Test holes and well logs, Method of construction of shallow and deep wells including drilling, Completion and development of wells, Pumping equipment, resting the wells for yield, Maintenance and protection of wells, Rehabilitation of old and abandoned wells.

SURFACE INVENSTIGATIONS OF GROUNDWATER:

Geological methods, Remote sensing, Geophysical exploration, electrical Resistivity method, Seismic Refraction method, Gravity and magnetic methods, Water Witching.

SUBSURFACE INVESTIGATION OF GROUNDWATER:

Test drilling measurement of water levels, Geophysical logging, Resistivity logging, Spontaneous potential logging, Radiation logging, Temperature logging, Caliper logging, Fluid conductivity logging, Fluid Velocity logging, miscellaneous logging and other subsurface techniques.

ARTIFICIAL RECHARGE OF GROUNDWATER:

Concept of artificial recharge: Methods of artificial recharge-water spreading, Waste water recharge for reuse, Recharge mounds , Induced recharge, Artificial recharge for energy purposes.

SALINE WATER INTRUSION IN AQUIFERS:

Occurrence of saline water intrusion, Ghyben-Herzberg Relation between fresh and saline water shape and structure of fresh water and salt water interface, upcoming saline water, fresh water and salt water relations on oceanic islands, Control of salt water intrusion, Recognition of sea water in the ground water.

QUALITY OF GROUND WATER:

Sources of salinity, Measures of water quality, Chemical analysis-graphical representation, physical and Biological analysis, water

BOOKS RECOMMENDED:

- Karamouz, M, Ahmadi, A, and Akhbari, M, Groundwater Hydrology: Engineering, Planning and Management, CRC Press, 2011.
- Todd, D.K., and Mays, L. W., Groundwater Hydrology, John Wiley & Sons, Singapore, 2011.
- Davis, S.N., and De Weist, R.J.M., Hydrogeology, John Wiley & Sons, New York, 1966.
- Domenico, Concepts and Models in Groundwater Hydrology, McGraw Hill Inc. New York, 1972

CE 537T	WATERSHED MANAGEMENT	DE	3 – 0 – 0	3 Credits
Internal: 50 marks	End Term: 50 marks		Total: 100 marks	

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	**Identify causes of soil erosion**
CO2	**Plan and design soil conservation measures in a watershed**
CO3	**Plan and design water harvesting and groundwater recharge structures**
CO4	**Plan measures for reclamation of saline soils**

Detailed syllabus:-

INTRODUCTION

Water and life, Management and conservation of water, Climate data, Soil erosion and sedimentation, Conservation of soil, System and conceptual models of runoff hydrograph, System models. Conceptual models of unit hydrograph, Conceptual models, Dynamic models.

TIME SERIES ANALYSIS:

Determination of trend and periodic components, Analysis of stochastic components Stationary and non-stationary series, Synthetic data generation and short term forecasting.

SOIL EROSION AND ITS CONTROL:

Types of soil erosion wind erosion, Water erosion. Estimation of soil erosion, Soil loss models, Sediment yield models. Sediment graph, Bed-load models, Controlling soil erosion due to wind and water soil conservation practices, Vegetative and mechanical practices, Erosion control in torrents and gullies.

WATER HARVESTING:

Storage structures. Yield from catchment, Diversion of runoff, Ponds and reservoirs, Earth embankments.

WATERSHED:

Watershed programs. Mass soil movement, Afforestation, Streams. Management of saline and alkaline soils, Grassland management, Watershed water sources, Conservation of water, Augmentation of water resource, Methods of artificial recharge.

Project Proposal and Report Writing

BOOKS RECOMMENDED:

- Chow. V.T. Handbook of Applied Hydrology. Mc Graw-Hill, New York
- Rattan Lal. Soil Erossion in the Tropics. Mc Graw-Hill New York.
- Dutta. SK. Soil Conservation and Land Management, International Book Distributors, Dehradun. Blaisdell, F.W. and A.F. Moratz.
- Soil and Water Conservation- Erosion Control Structures. Agricultural Engg. Handbook. Mc Craw Hill. New York.
- Whiny, V.V. N. Land and Water Management Engineering Kalyani Publishers, New Delhi.
- Glianshyant -Das. Hydrology and Soil Conservation Engineering. Prentice Hall of India. New Delhi.

CE 533T	ADVANCED IRRIGATION ENGINEERING & DRAINAGE	DE	3 – 0 – 0	3 Credits
Internal: 50 marks	End Term: 50 marks	Total: 100 marks		

Pre-requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Plan irrigation systems and command area development programs
CO2	We can Evaluate performance of an irrigation system
CO3	Evaluate performance of an irrigation system
CO4	Plan measures for reclamation of water logged lands
CO5	Develop strategies for conflict management in irrigation projects

Detailed syllabus:-

CONSUMPTIVE USE:

Definition, Direct measurement of consumptive use, Methods of estimating consumptive use, Penman method, Blaney Criddle method, Thornthwaite method, Lowery Johnsen method, Consumptive use of typical crops.

WATER APPLICATION METHODS:

Border irrigation-details, straight & contour borders, border specifications, stream size, hydraulics of border irrigation, design of border irrigation systems, Check basin irrigation-types & design considerations, hydraulics of check basin irrigation, design of check basin irrigation system. Furrrow irrigation-characteristics & types, its hydraulics & design considerations. Sprinkler irrigation system-adaptability, limitations & types, components of sprinkler system & design, moisture distribution, uniformity, testing water distribution pattern of rotating head sprinklers, operation & maintenance of sprinkler system. Drip irrigation-components, details, nozzles, drip irrigation system design, basic hydraulics, design of laterals for uniform and non-uniform slopes, design charts for the submain and main line design, evaluation of drip irrigation system. Introduction to sub irrigation and surge flow irrigation methods and reuse of waste water for irrigation.

WATER CONVEYANCE AND CONTROL:

Design of lined & unlined channels, Maintenance of irrigation canal, Weed and plant growth, Canal breach, closure of breach, Field channels, Water control and diversion structures. Check gates. Seals and on farm water distribution, Portable check dams, Turnouts, Types, Water conveyance through prefabricated canals. Underground pipe line, Irrigation distribution systems. Pipes used, Testing of pipes, Installation of concrete pipe lines. Gate stands, air vents end plugs, Outlets in pipes, Riser valve, Design of underground pipe line, Irrigation system. Common problems of underground pipe lines.

LAND GRADING SURVEY AND DESIGN:

Criteria for land levelling, Land clearing, Layout of fields and irrigation and drainage system, Land grading survey, Land levelling design methods, Plane and profile methods, Plan inspection& contour adjustment methods, Construction & maintenance, Job planning, Contour bench leveling, Bench location, Planning of bench location, contour bench construction, Equipment used for land grading & field layouts.

SALT PROBLEMS IN IRRIGATED LAND:

Definitions, determination of the properties of saline & alkaline soils, Origin & Causes of salt built up in irrigated soils. Origin of salt in irrigated water, Causes of salt accumulation. Effect of irrigation soil management, and crop management in soil salinity, Nature and extent of salt problem in irrigated areas of India. Water logging and soil salinity & alkalinity. Influence of salts on physical properties of soils, Salt balance, leaching requirements, Leaching methods, Drainage of irrigated lands in relation to salinity control. Quality of irrigation water, its chemical analysis, water quality criteria. Classification of irrigation water, Quality of Statistical parameters, Fining a probability distribution, Method of moments, Method of maximum likelihood, Testing the goodness of fit, Probability distributions for hydrologic variables. Normal, lognormal, exponential, Gamma, Pearson type III, Log-Pearson type III and extreme value distributions.

FREQUENCY ANALYSIS:

Return period, Hydrologic data series, Extreme value distributions, Frequency analysis using frequency factors probability plotting, Probability paper, plotting positions, Water resources council method, Determination of the coefficient of skewness, Testing for outliers, Reliability of analysis, Confidence limits, Standard error, Expected probability. Time series models in hydrology, Trends of annual series, Moving average and exponential smoothing, ARMA model, Generation of synthetic flow data.

BOOKS RECOMMENDED:

- Applied Hydrology by Chow, Maidment & Mays McGraw Hill Inter Editions.
- Applied Hydrology by K.N.Mutreja, Tata McGraw Hill.
- Hydrology H.M.Raghunath, Wiley Eastern Ltd.

CE 502T	WATER RESOURCES PLANNING AND SYSTEMS ENGINEERING	CC	3-0-0	3 Credits
Internal: 50 marks	End Term: 50 marks	Total: 100 marks		

Pre-requisites: Knowledge of basic water resources engineering.

Course Outcomes:

CO1	Students should be able to apply concepts of systems analysis for planning of water resources systems and minor levels
CO2	Students can perform basic economic analysis between alternate water resources projects and to evaluate the economic feasibility of water resources engineering projects
CO3	Students must in position to formulate and solve deterministic optimization models for design and operation of water resources systems
CO4	To develop analytical skills to formulate and solve stochastic problems for decision making under uncertainty

Detailed Syllabus:

INTRODUCTION:

Planning, Meaning and Significance. Need for water resources systems planning, Issues in planning. Planning process.

PLANNING FOR WATER RESOUCES DEVELOPMENT:

Statement of objectives. Data requirements. Project formulation. Environmental considerations in planning, Systems analysis. Pitfalls in project planning. Conservation and augmentation of water resources. Multipurpose projects. Functional requirements in multi-purpose project. Compatibility of multipurpose uses.

ECONOMIC ANALYSIS:

Equivalence of kind. Equivalence of time, Value. Cost. Benefit. Discounting factors, Discounting techniques. Measurement of cost and benefit. Benefit-cost analysis. Project evaluation, Benefit-cost variation. Limitations of benefit-cost analysis. Dynamic of project analysis.

FINANACIAL ANALYSIS:

Role of financial analysis. Distinctions from economic analysis. Financial feasibility, Separable and non-separable costs. Cost allocation, allocation consequences. Water resources pricing.

WATER RESOURCES SYSTEMS:

Concepts of systems engineering in water resources. Objective function, Production function and optimality conditions. Linear, non-linear and dynamic programming, Sensitivity analysis, Stochastic models, Statistical decision theory. Application of water resources systems engineering to practical problems.

BOOKS RECOMMENDED:

1. Water Resources Engineering by R.K. Liniley and Franzini, McGraw-Hill Book Co.
2. Water Resources Systems Engineering by Hall and Dracup ,McGraw Hill Book Co.
3. Economics of Water Resources Engineering by L. Douglas James. and Robert R. Lee McGraw Hill BookCo.
4. Design of Water Resources Systems by Arther Mass et. Al, Harward Univ. Press Cambridge. 1967
5. Optimization Theory and Applications by S.S.Rao, Willy East. Ltd.

CE 531T	EMBANKMENT DAMS	DE	3-0-0	3 Credits
Internal: 50 marks	End Term: 50 marks		Total: 100 marks	

Pre-requisites: Knowledge of basic Soil mechanics and foundation engineering.

Course Outcomes:

CO1	An understanding of the importance of slope stability in dam safety, and the basic theoretical principles supporting slope stability analysis methods
CO2	An understanding of the significance of adequate subsurface characterization and shear strength property selection
CO3	An understanding of soil stress-strain behavior and its relationship to shear strength
CO4	An understanding of how to select shear strength parameters from field and laboratory data
CO5	An understanding of slope stability rehabilitation measures
CO6	Awareness about the quality control and instrumentations required in it

INTRODUCTION:

Classification of earth dams, Earth dam foundations, Causes of failure and criteria for safe design, Preliminary section.

SEEPAGE & ITS CONTROL:

Fundamentals of seepage flow, Kozeny's solution, Cassagrande's method, Top flow line for inclined discharge faces, Transverse isotropy, Non homogeneous sections. Flowet for seepage through an earth darn, Methods of seepage control, Provision of impervious core in the embankment, Design of transition filters, Drainage of embankments, Drainage of the upstream face, Control of seepage coming out on the downstream lace, Control of seepage through rock, Clayey & pervious foundations, Cutoffs. Alluvial grouting, upstream impervious blanket, counter berm, Relief wells, Treatment of liquefying sands.

STABILITY OF SLOPES:

General concepts, Stress relationship and shear parameters, Mohr strength theory, Mom-Coulomb's envelope, Shearing strength of cohesive &cohesionless soils, Critical 'stages for design, Construction pore pressure, Hill's method, factor affecting construction pore pressure, Steady seepage and drawdown pore pressures, Unsteady analysis, Control -of drawdown pore pressures, Location of critical slip surface, Total and effective stress methods of analysis, Stability analysis by method of slices, Accuracy of simplified !methods, Choice between Fellenus and Bishop's methods, Morgenstern- Price method, Wedge method, Three dimensional effects, Earthquakes, Application of dynamic response analysis, Deformation analysis, Suggested design procedure.

QUALITY CONTROL AND INSTRUMENTATION:

Compaction of cohesive and cohesionless soils, Field compaction methods, Placement Control of embankment, Compaction control of embankment, Compaction control of gravelly material, Frequency oftesting, Statistical evaluation of tests,Borrow area control adjustment of moisture, Foundation preparation, Contact. treatment, Pore pressure measurements-open stand

pipe piezometers,Closedhydraulictype,Pneumatictypepiezometers,Electricaltypepiezometers,Vertical movement devices Tube settlement gauges,Find level devices, devices for measuring settlement gauges, Fluid level devices, Horizontal movementdevices, Extensimeter sinclinometers, surfacemeasurements. Stressmeasurements, Seismicmeasurements,Choiceof instrumentation, Instrumentation problems.

BOOKS RECOMMUNDED:

1. Engineering for Embankment Damsby B. Singh and R. S. Varshney ; A. A. Balkema Publishers
2. Geotechnical Engineering of Dams by Robin Fell and Patrick MacGregor., David Stapledon, Graeme Bell., CRC Press
3. IS 7894 (1975): Code of practice for stability analysis of Earth dams.

CE 530T	DESIGN OF HYDRAULIC STRUCTURES	DE	3-0-0	3 Credits
Internal: 50 marks	End Semester: 50 marks		Total: 100 marks	

Pre-requisites: Knowledge of hydraulic structures, foundation engineering and concrete technology.

Course Outcomes:

CO1	To analyze and design gravity dams
CO2	To analyze and design Arch and Buttress dams
CO3	To design spillways and energy dissipation structures
CO4	To estimate hydropower potential
CO5	To design of Weir and Barrages

GRAVITY DAMS:

Darn parameters, Criteria for selection of dam sites, Joints & keys, Cooling arrangement, Water stops at joints, Closing gaps, forces acting on darns, Types of loads, Elementary profile of a gravity dam, Step by step method, Stability analysis methods, Safety criteria, Gravity analysis, Internal stress calculations, Graphical determination of shear stress, Effect of foundation elasticity on stresses, Galleries, Behavior of concrete gravity darn subjected to earthquakes, 'thermal stresses.

ARCH DAMS:

Development of arch dam, Valleys suited for arch darns, Arch darns layout, Types of arch dams, Appurtenant works, Thin cylinder theory and most economical central angle, Design of arch dam, Suitability at abutments, Effects of foundation elasticity on the behaviors of an arch dam.

BUTTRESS DAMS:

Types of buttress darn, Selection of type of buttress dam, Most economical profile having no tension, Design principles, Buttress design by Unit column theory, Basic shape of buttress, Design of multiple arch darn, Provision of spillways and outlet works. –

SPILLWAYS AND ENERGY DISSIPATORS:

Factors affecting design, Components of spillways, Types of spillways, Design principles, Hydraulic design ogee spillway, Side channel spillway, Chute spillway, Syphon spillway, Shaft-spillway, Energy dissipation below spillways, Bucket type energy dissipaters, Design of various types of stilling basins.

WEIRS AND BARRAGES:

Design of weirs & barrages on permeable foundation, Khosla theory of independent variable, Schwarz Christoffel transformation, Upstream and downstream protection, Flownets, Design of sloping glacis weir, Calculation for hydraulic jump and uplift pressure.

HYDRAULIC MODELS:

Theory of similarity, dimensional analysis, Basic concepts, Froude law, Reynolds law, Mach law, Cavitation number, Modeling technique, Models of weirs, Darns, Spillways and energy dissipaters.

BOOKS RECOMMENDED:

1. Engineering for Dams by Creager, Justin & Hinds, Willey Eastern Pvt. Ltd., Delhi
2. Concrete Dams by R.S. Varshney, Oxford & IBH Pub. Co. Delhi.
3. Dams-Part I Gravity Dams by K.B. Khushalani, Oxford & MN, Delhi.
4. Design of Weirs on Permeable Foundations, CBIP Pub. No 20, Delhi
5. Hydraulic Design of Spillways, ASCE Technical Engg. No. 12, Design guides as adapted from the US Army Corps.
6. Hydraulic Structures; P. Novak, AIB Moffat, C. Nalluri, and R.Narayanan: Taylor & Francis, New York

CE-545T	ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT	DE	3 0 0	3
Internal:50 Marks	**End Term: 50 Marks**	**Total:100 Marks**		

Pre-requisites: None

Course Outcomes: After the completion of the course, students are able:

CO1	To develop an understanding of current EIA methods and the techniques and tools used.
CO2	To develop an understanding of current assessment methods and legislation.
CO3	To apply knowledge acquired to the process of environmental impact modeling and prediction as a design tool with application to a number of case studies
CO4	To adapt skills in GIS to environmental management systems

Detailed syllabus:

Introduction to environmental impact analysis, assessment and statement, evolution of EIA, national environmental policy. EIA process: Screening and scoping criteria; Rapid and comprehensive EIA

Impact Assessment Methodologies – Matrices, overlays, network analysis.

Specialized areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; cost-benefit analysis; Expert system and GIS applications.

Legislative and environmental clearances procedures in India: Siting criteria; public participations; resettlement and rehabilitation. Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case Studies of EIA of river valley projects and thermal power projects.

Books:

1. Canter, L.W. (1996) Environmental Impact Assessment, McGraw Hill, Inc., NY.
2. Rau and Wooten (1980) Environmental Impact Analysis Handbook, McGraw Hill, Inc., NY.
3. Jain, Urban and Stacey (1977) Environmental Impact Analysis, Van Nostrand and Reinhold Company, NY

CE-535T	MODELING ANALYSIS AND SIMULATION	DE	3 0 0	3
Internal:50 Marks	End Term: 50 Marks	Total:100 Marks		

Pre-requisites: None

Course Outcomes: After the completion of the course, students are able:

CO1	To provide a strong foundation on concept of simulation, and modeling.
CO2	To understand the techniques of random number generations.
CO3	To design simulation models for various case studies like time series,input-output, etc.
CO4	To practice on simulation tools and impart knowledge on building simulation systems.

Detailed syllabus:

MODELLING PROCESS:

Taxonomy of model types, Steps in model building; Simulation, Algorithms and Heuristics, Simulation languages.

PRIMITIVE MODELS:

Establishing relationships via physical laws, Establishing relationships via curve fitting, Parameter estimation problems, Elementary state transition models.

FORECASTING:

Nature of data, Statistical attributes of data, Probability distributions and their mechanisms, Generation of random numbers, Time series.

PATTERN RECOGNITION:

Neighbourhood and distances, Cluster analysis, Individual and group preference patterns.

STATIC EQULLIBRIUM MODELS:

Graphical models and matrix models, Input-output type models, Decomposition of large systems, Routing problems.

LINEAR DYNAMICAL STRUCTURE:

Block diagram, Representation of model structure, Transfer function representation, State space models, Stability, System control.

GROWTH AND DECAY PROCESSES:

Discrete and continuous growths, Limits to growth, Competition among species, Growth process and integral equations, Discrete event approach, Population planning.

SIMULATION OF DISCRETE AND CONTIUOUS PROCESSES:

Monte Carlo methods, Stochastic simulation, System identification, Inverse problems, Virtual reality, Typical example and case studies related to Civil Engineering.

BOOKS RECOMMUNDED:

I. R. Haberman, Ma.thematical Models. Prentice Hall.
2. D.P. Maki and M. Thompson, Mathematical Models and Applications. Prentice Hall.
3. R.E. Shannon, System Simulation: Art and Science Prentice Hall.

CE-536T	COMPUTATIONAL METHODS IN FLUID MECHANICS	DE	3 0 0	3
Internal:50 Marks	End Term: 50 Marks	Total:100 Marks		

Pre-requisites: None

Course Outcomes:

After the completion of the course, students are able:

CO1	To identify, formulate, and solve engineering problems by numerical techniques like Method of characteristics, Finite difference Method, Finite Element Method.
CO2	To learn various types of modelings like as steady state flow, hydraulic transients in pipes, non-uniform, spatially varied flows in open channels
CO3	To analyze and interpret data obtained from the numerical solution of fluid flow problems.
CO4	To use the techniques, skills, & engineering tools necessary for engineering practice by applying numerical methods to a "real-world" fluid-flow problem, integrating various numerical techniques in formulating a numerical solution method for that problem.

Detailed syllabus:

Review of numerical techniques like Method of characteristics, Finite difference Method, Finite Element Method, Modelling of steady state flow and hydraulic transients in pipes, Modelling of non-uniform, Transient, Spatially varied flows in open channels, Numerical solutions for Navier- Stokes equation, Boundary layer and Reyonlds equations, Modelling of groundwater flow and contaminated transport in groundwater.

BOOKS RECOMMENDED:

1. Computational Hydraulic, by M.B. Abbot, Pitman 2. Computational Hydraulics, by C.A. Brebbia and A.J. Ferrante, Butterworths 3. Introduction to Groundwater Modelling, by H.A. Want and M.P. Anderson

CE-538T	WIND ENGINEERING	DE	3	0	0	3
Internal:50 Marks	**End Term: 50 Marks**	**Total:100 Marks**				

Pre-requisites: None

Course Outcomes:

After the completion of the course, students are able:

CO1	To wind energy conversion technology and power generation.
CO2	To wind resources assessment and techniques.
CO3	To Planning, including design of wind farms.
CO4	To possesses the competencies necessary for the design and implementation of complex wind energy systems.

Detailed syllabus:

Atmospheric pressure and gradient wind, Wind climate and structure, Peak 3-sec, 10 min and hourly mean wind speeds. Low cycle energy and large scale pressure systems, Wind energy and turbulence, Spectral distribution and boundary layer (ABL) & its characterstics. Aerodynamilcs of bluff bodies, Vortex shedding and associated unsteady along and across wind forces. Peak factor and gust factor estimation. Buffeting and ovalling, Gallaping and flutter. Extreme winds, Correlation and spectral function. Random vibration theory, Autocorrelation function, Power spectral density, Narrow and wide bar random processes. Response of SDF in the frequency domain to random excitation. Application to MDF systems. Experimental procedures for response studies. Wind tunnel and its salient features, ABL simulation. Basic wind tunnel instrumentation for the measurement of flow parameters, Forces, Displacements and strains. Use of statistical methods for analysis of measured data and its interpretation. Analytical procedures for along wind and across wind forces. Wind effects on buildings, Chimneys, towers and bridges, Pressure coefficients and internal pressures. Case studies. Codal provisions, Design wind velocities, Wind resistant design- Indian Codes and other International codes of Practice.

BOOKS RECOMMENDED:

1. Wind Effects on Structures-An Introduction to Wind Engineering, Emil Simiu Rbtert H.Scanian, John Wiley & Sons, 3rd Ed.1996.
2. Wind Effects on Civil Engineering Structures V.Kciousek, M.Pimer, O.Fiscer and J.Naprstek, Elsevier Pub. Amsterdum, 1984.
3. Wind Forces in Engineering by Peter Sachs, Pergamon Press, 2" Ed.1978.
4. Cook, N.J. The Designer's Guide to Wind Loading of Building Structures Part-1 Background, Damage Survey, Wind Data and Structural Classification and Part,-2, Static Structures, Butterworths, 1985.

M.Tech Transportation

DETAILED SYLLABUS

M.Tech. (Civil) First Semester

CE-513T	**Transportation Lab**	**Core**	**3-0-0**	**4.5 credits**
Internal=40		**External=60**		**Total=100**

1. Traffic volume and speed study using videography technique.
2. Speed study by Radar Gun.
3. Determination of Reaction time of Driver.
4. Traffic study by automatic counter and classifier.
5. Overlay design by Benkelman Beam.
6. Unevenness Index of road.
7. Bitumen content determination.
8. Bituminous Mix Design.
9. Mix Design for Cement Concrete Pavement.
10. Non-destructive testing of CC pavements.
11. MORTH Specifications for Road and Bridge Works, IRC Publication.

M.Tech. (Transportation) Second Semester

CE-514T	Pavement Analysis and Design	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Traffic Engineering.

Course Outcomes

CO1	Design flexible and rigid pavements.
CO2	Propose a pavement management system framework.
CO3	Design highway appurtenance and highway drainage.
CO4	Design mitigation measures to pavement distress.

Syllabus

Pavement Types: Definition, Highway and Airport Pavement comparison, Wheel Loads, Tyre Pressure, Contact Pressure, Design Factors, Type of distresses: structural and functional, Serviceability.

Stresses in Flexible Pavements: Layered system concept, multi-layered solutions, Burmister's method, Fundamental Design concepts.

Stresses in Rigid Pavements: Relative stiffness of slabs, Modulus of subgrade reaction, Stresses due to warping, stresses due to friction, effect of warping, contraction and expansion, Plain versus reinforced pavements, stresses in dowel bar, and tie bar, combined stresses.

Design of Flexible Pavements: Design factors, Design wheel load, Equivalent single wheel load, Difference between Airport and Highway Design concept, Different design methods, Examples of comprehensive design process.

Design of Rigid Pavement: General design considerations, Design of joints in cement concrete pavements, spacing of expansion joint, Spacing of contraction joints, Design of dowel bars and tie bars, IRC recommendations for design of Concrete pavements.

Pavement Evaluation and Rehabilitation: Pavement distresses in flexible and rigid pavements, condition and evaluation survey, Present serviceability index, Methods of measuring condition, skid resistance, Principles of maintenance, Methods of structural evaluation and overlay design.

Books Recommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles of Pavement Design, by Yoder E.J. and Witczak M.W. 2nd, John Wiley & Sons, INC.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw-Hill Publishing Co. Ltd. N.Delhi.

M.Tech. (Transportation) Third Semester

CE-514P	**Computational Laboratory**	**Core**	**3-0-0**	**4.5 credits**
Internal=40		**External=60**		**Total=100**

Exposure to various Transportation Related Software like

Rate Analysis by MORTH software.

MX Road.

IRC software for Pavement Design.

IRC software for Decision modelling.

M.Tech. (Civil) Second Semester

CE-516T	Pavement Construction, Maintenance and Management	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Pavement Material.

Course Outcomes

CO1	Student should be able to select appropriate earth moving and compaction equipment depending upon the requirement.
CO2	Student should be able to prepare quality assurance and quality control plans in an attempt to construct better performing pavements.
CO3	Student should be able to evaluate the pavements based on the functional and structural characteristics.
CO4	Student should be able to evaluate the safety aspects of the pavements specifically in terms of friction and other related distresses.
CO5	Student should be able to select maintenance technique depending upon the intensity of the distresses.

Syllabus

Introduction: History of road construction, stages of construction, seasonal limitations of pavement construction.

Stabilization of soil: Mechanical stabilization, cementing additives and chemicals, thermal stabilization.

Construction of non-bituminous pavements: Brief introduction to earthwork machinery: shovel, hoe, clamshell, dragline, bulldozers, cleaning and grubbing, excavation for mad and drain, principles of field compaction of embankment / subgrade. Compacting equipment. Granular roads. Construction steps of GSB, WBM 'and WMM.

Construction of bituminous pavements: Various types of bituminous constructions. Prime coat, tack coat, seal coat and surface dressing. Construction of BUSG, premix carpet, BM, DBM and AC. Brief coverage of machinery for construction of bituminous roads: bitumen boiler, sprayer, pressure distributer, hot-mix plant, cold-mix plant, tipper trucks, mechanical paver or finisher, rollers. Mastic asphalt. Introduction to various IRC and MORTH specifications.

Construction of cement concrete roads: Construction of cement concrete pavements, machinery involved in construction, slip-form pavers, joints in cc pavements, IRC and MORTH specifications.

Construction of other types of pavements: Basic concepts of the following: soil stabilized roads, use of geo-synthetics, reinforced cement concrete pavements, pre-stress concrete pavements, roller compacted concrete pavements and fibre reinforced concrete pavements.

Use of fly ash in cement concrete road construction.

Highway maintenance: Pavement distresses. Maintenance operations. Maintenance of WBM, bituminous surfaces and cement concrete pavements.

Functional and structural evaluation of pavements, pavement maintenance, maintenance management.

Related topics: Emulsified bituminous mix, precoating of aggregates, recycling of bituminous pavements, shoulder construction.

Books Recommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw Hill Publishing Co. Ltd. N.Delhi.

M-TECH (Transportation) First Semester

CE-519T	Traffic Engg.	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Apply the Concept for determine the different Trip Generation Models and various model in Urban Transport Planning.
CO2	Apply the concept of Mean, Mode and variance for determining the speed, flow and density.
CO3	Identify model computed are good or not applicable for existing Urban planning condition.

Syllabus

Traffic Characteristics: Importance of traffic characteristics. Road user characteristics. Vehicular characteristics. Max dimensions and weights of vehicles allowed in India. Effects of traffic characteristics on various design elements of the road.

Traffic Studies: Traffic volume study, speed study and origin and destination study. Speed and delay study. Use of photographic techniques in traffic surveys.

Traffic Accidents: Accident surveys. Causes of road accidents and preventive measures. **Capacity and Level of Service:** Fundamental diagram of traffic flow. Relationship between speed, volume and density. Level of service. PCU. Design service volume. Capacity of non-urban roads. 1RC recommendations. Brief review of capacity of urban roads.

Traffic Regulation and control Devices: Traffic control devices: signs, signals, markings and islands. Types of signs, Types of signals. Design of signals. Intersections at grade and grade separated intersections. Design of a rotary. Types of grade separated intersections.

Design of Parking Lighting and Terminal Facilities: Parking surveys. On street parking, off street parking.

Traffic Regulation: Need and scope of traffic regulations. Regulation of speed, vehicles and drivers. General traffic regulations. Motor vehicle act. Scope of traffic management.

Books Recommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Traffic Engg and Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw-Hill Publishing Co. Ltd. N.Delhi.
(v) Traffic Engg. by Matson, T.M., Smith, W.S. and Hurd, F.W, McGraw- Hill Book Co., New York.
(vi) Traffic Flow Theory. By Drew, D.R., McGraw- Hill Book Co., New York.
(vii) Basic Statistics - Simpson and Kafks; Oxford and IBH Calcutta, 1969.
(viii) Fundamentals of Mathematical Statistics – Gupta, S.C and Kapoor, K.V.Sultanchand.

M.Tech. (Transportation) First Semester

CE-521T	Geometric Design	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Understand the factor influencing road vehicle performance characteristics and design.
CO2	Apply basic science principles in estimating stopping and passing sight distance requirements.
CO3	Design transportation related project in a team.
CO4	Design basic horizontal and vertical alignment of the highway.

Syllabus

Highway Alignment: Requirements, factors controlling alignment, Obligatory points, Engineering surveys for Highway location, Route selection, steps in new project, Highway Classifications.

Cross Sectional Element: Pavement Surface Characteristics, Factors affecting skid resistance, Pavement Unevenness, Camber, Providing camber in the field, Width of carriageway, Design Vehicle, Medians, Kerbs, Road Margins, Right of Way, Typical Cross Sections of Roads.

Sight Distances: Introduction, Stopping Sight Distance, Reaction Time, Analysis of Stopping distance, Overtaking Sight distance, Analysis of Overtaking Sight distance, Effect of grade on sight distances, Overtaking zone, Intermediate sight distance, Sight distance at intersections.

Super elevation: Requirement of super elevation, Limits and attainment of super elevation in the field.

Horizontal Alignment: General, Design speed, Horizontal curves, super elevation, Analysis of super elevation, Super elevation design, Attainment of super elevation, Widening of pavement on horizontal curves, Methods of introducing extra widening, Horizontal Transition curves, Different types of Transition curves, length of transition curve, Setting out of transition curve, Set-back distance on horizontal curves, Curve Resistance.

Vertical Alignment: General, Gradients, Compensation in gradient on horizontal curves, Vertical curves, Summit curve, Length of summit curve, Valley Curve, Length of valley curve.

Relevant IRC standards for Urban and Rural roads.

Books Recommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw Hill Publishing Co. Ltd. N.Delhi.
(v) Principles of Highway Engineering and Traffic Analysis, by Mannering, F., W. Kilareski, and S. Washburn 3rd Edition, John Wiley and Sons, 2005.

M.Tech. (Transportation) First Semester

CE-523T	Pavement Materials	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	The students would have gained knowledge on the Material properties.
CO2	Students would be able to Design, Evaluation and Management of Pavement Systems.

Syllabus

Sub grade: Significance of subgrade soil, Characteristics of soil, Desirable properties, Index Properties of Soil, Soil Classification based on Grain size, Soil Classification System, Evaluation of soil Strength.

Aggregates: Introduction, Desirable properties of Road Aggregates, Tests for Road Aggregates.

Bituminous Materials: Introduction, Types of Bituminous materials, Tests on Bitumen, Cutback and Emulsions.

Paving Mixes: Granular mix design, Design of Bituminous Mix, Marshal Method of bituminous mix design.

Polymer and Rubber Modified binders: Physical and chemical properties. Fly ash and its characterization. Performance based mix design Approaches. Visco elastic properties of bitumen and bituminous mixture.

Materials for joints in Cement Concrete Pavements.

Books Recommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw-Hill Publishing Co. Ltd. N.Delhi.
(v) MORTH Specifications for Road and Bridge Works, IRC Publication.

M.Tech. (Transportation) Elective

CE-572T	GIS in Transportation	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Surveying.

Course Outcomes

CO1	The students would have knowledge on the basics of Remote Sensing and GIS techniques and their application in the Transport sectors.
CO2	The students should be able to read and analyse map projection and Coordinate system.
CO3	Students would be able to perform urban transportation planning based on GIS application.

Syllabus

Introduction: GIS Operations, GIS for Transportation.

Map Projection and Coordinate System: Map Projection, Coordinate Systems.

Data Modelling& Data Base Design: Vector Data Model, Spatial Data Model, and Data modelling in GIS-T.

Shortest Path & Routing: Fundamental Network properties, Shortest Path analysis.

Network flows & facility Location: Flow through Network, Closed Facility.

GIS Based Spatial Analysis and Modelling: GIS and Spatial analysis, function, Customizing GIS, Geographic Visualization.

Books Recommended

(i) Miller, H.J. and Shaw S.L. "GIS for TransportationPrinciples and Applications" Oxford University Press.
(ii) Chang K.T. "Introduction to GIS" TMH, New Delhi.
(iii) Anji Reddy, "Remote Sensing and Image Interpretation", John Wiley and Sons Inc. New York, 1987.
(iv) M.G.Srinivas, "Remote Sensing Applications",Narosa Publishing House, 2001.
(v) Burrough P.A, "Principles of GIS for Land Resources Assessment", Oxford Publication, 1994.
(vi) Jeffrey Star and John Ester, Geographical Information System – An Introduction, Prentice Hall Inc., Englewood Cliffe, 1990.
(vii) Marble, D.F, Calkins, H.W and Penquest, Basic Readings in GIS, Speed System Ltd., New York, 1984.

M.Tech. (Transportation) Elective

CE-573T	Concrete Technology	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Construction Material.

Course Outcomes

CO1	Determine the properties of concrete ingredients i.e. cement, sand, coarse aggregate by conducting different tests.
CO2	Recognize the effects of the rheology and early age properties of concrete on its long-term behaviour.
CO3	Develop an advanced knowledge of the mechanical performance of cement based materials and how it can be controlled.
CO4	Use various chemical admixtures and mineral additives to design cement based materials with tailor-made properties.
CO5	Use advanced laboratory techniques to characterize cement-based materials.
CO6	Understand the mix design and engineering properties of special concretes such as high-performance concrete, self-consolidating concrete, fibre reinforced concrete, sprayed concrete, etc.

Syllabus

Concrete as Pavement Material: Introduction, Preparation and Grade of Concrete.

Concrete Ingredients: Types of Cement, Aggregates, Classification of Aggregate, Properties of Aggregate, Quality of Mixing Water, Admixtures.

Properties of Concrete: Introduction, Workability, Stress Strain Characterizes of Concrete, Young's Modulus of concrete, Creep and shrinkage of Concrete, Permeability, Durability of Concrete, Joints.

Production of Concrete: Hatching, mixing, Transportation, compaction, vibration, curing, formwork removing, ready mixed concrete.

Non-Destructive Testing of Concrete: Significance, Rebound Hammer, Ultrasonic Pulse Velocity Technique, Penetration Technique, Pullout test, Cover meter, Core tests.

Deterioration: Causes, Deterioration by Water, surface weir, Frost action, chemical Reaction, corrosion of reinforcement etc. Preventive Measures.

Advances in Concrete: Introduction to Light Weight concrete, high strength Concrete, Prestressed concrete. Fibre reinforced concrete, Polymer concrete composites, Fly ash concrete.

Books Recommended

(i) Gambhir,M.L., "Concrete Technology" TMI-1 Pub. N Delhi.
(ii) Shetty M.S."Concrete Technology" S. Chand& Co. N Delhi.
(iii) Special Structural concretes by Rafat Siddique, Galgotia Publications 2000.
(iv) Design of Concrete Mixes by N.KrishnaRaju, CBS Publications, 2000.
(v) Concrete: Micro Structure by P.K.Mehta, ICI, Chennai.
(vi) Properties of Concrete by A.M.Neville, ELBS publications Oct 1996.
(vii) Concrete Technology by A.R. Santhakumar, Oxford University Press.

M.Tech. (Transportation) Elective

CE-574T	Project Management	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Life cycle techniques.
CO2	Construction equipment, equipment economics.
CO3	Need of PPP, types of PPP, BOT, BOOT, and DFBOOT.
CO4	Arbitration and settlement of disputes, arbitration and conciliation Act.

Syllabus

Time Estimates: Earliest Expected Time, Latest allowable occurrence time, slack time, earliest start time, earliest finish time, Latest start time, and latest finish time.

Network Scheduling: Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Precedence diagram technique (PDM).

Cost Optimization: cost slope, crashing critical path, Optimum duration.

Updating: Introduction, examples, when to update.

Resource allocation: Introduction, resource smoothing, resource levelling, Line of Balancing technique (LOB). Resource Based Network.

Linear Programming and critical path scheduling: Introduction, standard form, formulation by linear programming, transportation model, method of solution, fictitious cost method, linear programming and critical path.

Books Recommended

(i) PERT and CPM by L.S.Sirinath.
(ii) Application of PERT and CPM by B.C. Punmia
(iii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iv) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.

M.Tech. (Civil) Elective

CE-575T	Transportation Drainage Systems	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Transportation Planning.

Course Outcomes

CO1	Student should be able to minimize the impact on any area, waterways from changes to natural flow regimes, including flood frequency, runoff volume, runoff frequency and flow velocity resulting from urban development.
CO2	Student should be able to protect an area waterways from pollution including nutrients, toxicants, sediment, litter and changes to water chemistry.
CO3	Student should be able to encourage integration of drainage systems into the urban landscape to maximize the visual and recreational amenity of developments.
CO4	Student should be able to ensure that flood waters don't present an unacceptable risk to the community.

Syllabus

Introduction: Importance of drainage, Types of Road Drainage, General Criterion for Road Drainage.

Systems of Drainage: Surface and sub-surface drainage systems, Internal drainage of pavement structure, components of surface drainage system, surface drains, road side drains, catch water drains, geometric design of road, hydraulic design of drains, shoulder drainage, drainage layer, subsurface drainage with transverse drains, horizontal drains, sub surface drain in heavy clayey soil, sub surface drain at valley curve / change of grade, capillary cut-off.

Design of surface drainage and subsurface drainage system: Hydrologic analysis, hydraulic analysis, data for drainage design, design steps, Cross Drainage, Sub surface drainage, lowering of water table, control of seepage flow, control of capillary rise, design of filter material, drainage of slopes and erosion control, road construction in water logged areas. Drainage in hill roads. Drainage systems for Airports and Railways.

Books Recommended

(i) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(ii) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.
(iii) Rural Roads Manual, IRC SP-20.

M.Tech. (Civil) Elective

CE-577T	Land Use and Transport Planning	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Design and conduct surveys to provide the data required for transportation planning.
CO2	Learn and understand zonal demand generation and attraction regression models.
CO3	Learn and understand demand distribution models (gravity models) and modal split models for mode choice analysis.
CO4	Develop and calibrate trip generation rates for specific types of land use developments.
CO5	Make final decisions among planning alternatives that best integrate multiple objectives such as technical feasibility and cost minimization.

Syllabus

Land use and transport planning, Selection of land use transport models, Lowry Derivative models, Garin-Lowry model, Matrix operations for simplifying computations, applications in India, Transport planning for small and medium sized cities, quick response techniques. Traffic simulation.

Books Recommended

(i) Traffic Engg. And Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chant! Bros., Roorkee.
(iii) Introduction to Transport Planning by Bruton, M.J., Hutchinson Technical Education, London.
(iv) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.

M.Tech. (Civil) Elective

CE-579T	Advanced Geology	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Geology.

Course Outcomes

CO1	Students are able to assess the quality of foundation rocks, their aggregates and building material derived from rocks and assess the geological suitability of sites.
CO2	Students are able to assess weathering, development of soil and various hydrogeological properties of rocks.
CO3	Students are able to assess Plate tectonics, Hill slope stability and Landslides etc.
CO4	Students are able to assess the surface and subsurface investigations for various civil engineering projects.

Syllabus

Introduction, object and scope, Importance of Geology in Transportation Engg Projects, external and internal geological forces causing changes, weathering and erosion of surface of earth, soil profile and its importance. Rocks of earth surface, texture, structure and origin of rocks, their engineering uses.

Forms of structures of rocks, bedding plane and outcrops, dip and strike, folds, faults, joints and unconformity and recognition on outcrops, importance of geological structures in transportation engineering projects.

Hydrogeology, water table, ground water considerations in transportation projects, geological investigations, remote sensing techniques for geological and hydrological investigations. Uses of geological maps, interpretation of data.

Geological conditions and their influence on the selection, location, type and design of tunnels, highways, bridges. Landslides, hill slope stability.
Precautions and treatment against faults, joints and ground water.

Books Recommended

(i) Introduction to Physical Geology by A. Holmes.
(ii) A Text Book of Geology by P.K. Mukherjee.
(iii) Physical and General Geology by S.K. Garg.
(iv) Engineering and General Geology by Prabin Singh.

M.Tech. (Civil) Elective

CE-580T	Transportation and Traffic Infrastructure Design	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Geometric Design.

Course Outcomes

CO1	Have the basic knowledge of the design principles of transport infrastructure including roads, railways and airport runways as well as the skills to plan and design transport elements such as road, railway and airport layout and structures.
CO2	Able to formulate and design cost-effective transport infrastructure.
CO3	Able to understand the current transport infrastructure development issues and contribute to discussion on these contemporary issues.

Syllabus

Design and drawing of grade intersections, rotaries, mini round about, interchanges, multi-level intersection, on-street parking facilities, off-street parking facilities, layout for buses and trucks, guard rails, retaining sides, pedestrian sideways, foot bridges, underpasses.

Books Recommended

(i) Traffic Engg. And Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.

M.Tech. (Transportation) Third Semester

CE-581T	Transportation Economics and Finance	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Should have learnt the underpinnings of transportation economics using microeconomic principles and tools.
CO2	Should have learnt selected issues and contemporary problems in transport from a welfare economics approach.
CO3	Should be able to hone one's economic intuition and reasoning by having given an in-class group presentation on a transportation issue.

Syllabus

Economic Evaluation of Transport Plans: Need for economic evaluation, Cost and benefits of Transport Projects, Time horizon in Economic Assessment, Basic Principles of Economic evaluation, Interest rate, Method of economic evaluation, Benefit cost ratio method, First year rate of return, Net Present value method, Internal rate of return method, Comparison of various methods of economic evaluation.

Vehicle Operating Costs: Introduction, Road user cost study in India, Components of VOC, Factors affecting VOC, Fuel consumption Relationship, Spare parts consumption, Maintenance and Repairs, labour cost, Tyre life, Lubricants, Utilization and fixed costs.

Value of travel time savings: Introduction, Classes of transport users enjoying travel time savings, Methodology for monetary evaluation of passengers' travel time, Review of work in India on passengers' travel time.

Accidents Costs: Introduction, Relevance of accident costing for a developing country, Review of alternative methodologies for accident costing, Indian studies.

Traffic Congestion, Traffic Restraints and Road Pricing: Congestion as a factor in road traffic, Traffic Restraint, Road Pricing.

Highway Finance: Basic principles, Distribution of highway cost, Sources of Revenue, Highway Financing in India.

BooksRecommended

(i) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Principles and Practice of Highway Engg. by L.R.Kadiyali, Khanna Publishers, Delhi.
(iv) Principles of Transportation and Highway Engineering by G.V.Rao, Tata McGraw-Hill Publishing Co. Ltd. N.Delhi.

M.Tech. (Civil) Third Semester

CE-582T	Public Transportation	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Traffic Engineering.

Course Outcomes

CO1	Student should be able to select and plan Transit corridor.
CO2	Student should be able to design and implement various LRT and BRT types in various scenario.
CO3	Student should be able to design accessible transport for people regardless of demographics such as income or age.
CO4	Student should be able to prepare estimate of transit demand and route development, properties of a good route set.

Syllabus

Modes of public transportation and application of each to urban travel needs.

Transit system operations, para-transit systems, street transit systems, rapid transit systems, Estimation of transit demand, route development, properties of a good route set, determination of a good route set, stop location and stopping policy, schedule development, properties of a good schedule, determination of a good schedule.

Capacity of rapid transit systems, line capacity of RTS, capacity of street transit systems.

Transit corridor, identification and planning, mass transport management measures, integration of public transportation modes. Public transport infrastructure, case studies, multi-mode transportation system.

Planning for public transport, fares and subsidies.

Intermediate Public Transport in Indian Cities, types of IPT vehicles, Characteristics of IPT modes.

BooksRecommended

(i) Traffic Engg. And Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(ii) Introduction to Transport Planning by Bruton, M.J., Hutchinson Technical Education, London.
(iii) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.

M.Tech. (Civil) Third Semester

CE-583T	Transportation Safety and Environment	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Outcomes

CO1	Student should be able to analyse trends in Roads and Highways Development.
CO2	Student should be able to perform road Safety Audit.
CO3	Student should be able to Investigate accidents and Identify Potential Sites for Treatment.

Syllabus

Trends in Roads and Highways Development, Problem of Road Accidents In India, Characteristics of Road Accidents, Causes of Accidents, Global and Indian Road Safety Scenario, Factors Responsible for Success Stories in Road Safety, Role of Highway Professionals in Highway Safety.

Planning of Roads for Safety, Land Use Planning and Zoning, Development Control and Encroachment, Network Hierarchy, Route Planning Through Communities, Access Control, Traffic Segregation, Traffic CalmingDesigning for Safety: Road Link Design, Alignment Design, Cross-Sectional Elements, Traffic Control Devices, Roadside Safety, Roadside Facilities, Some Critical Elements, Junction Design Basic Principles, Selection of Junction Type, Factors Affecting Safety at Various Junction Types, Elements to Improve Road Safety, Provisions for Vulnerable Road Users.

Road Safety Audit, Concepts of Road Safety Audit, Road Safety Auditors & Key Personnel in RSA, Organizing and Conducting a Road Safety Audit, Example and Commonly Identified, Issues During RSA, Road Safety Audit Report, Development of Cost-effective of Road Safety AuditAccident Investigation and Prevention, Basic Strategies for Accident Reduction, Significance of Accident Data, Accident Investigation and Identification of Potential Sites for Treatment, Problem Diagnosis, Selection of Countermeasures, Example of Selection of Countermeasures, Detailed Design and Implementation of Countermeasures, Monitoring and Evaluation Non-Engineering Measures for Road Safety, Behavioural Countermeasures, Education, Training and Publicity, The Goal of Police Traffic Control Activities, Strategy for Road Safety Management by Police, Role of NGOs in Road Safety, Legal Framework for Road Safety Transport related pollution, noise pollution, air pollution, effects of weather conditions, vehicular emission parameters, pollution standards, ETA requirements of highway projects, world bank guidelines, EIA practices in India.

Fuel crisis and transportation, factors affecting fuel consumption, fuel economy in various modes of transportation, various types of alternative fuels.

Books Recommended

(i) Traffic Engg and Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) Trainers Road Safety Manual, NHA and Ministry of Shipping, Road Transport and Highways, Govt. of India.

M.Tech. (Civil) Second Semester

CE-584T	Transportation Planning	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Traffic Engineering.

Course Outcomes

CO1	Students would be aware of the Principles and Planning of Transportation Infrastructure.
CO2	Student should be able to perform complete traffic analysis.
CO3	Student should be able to evaluate problems in transit systems.

Syllabus

Transport Planning Process: Status of transportation in India. Objectives and scope of transport planning.Urban, regional and national transport planning. Transport planning process, various stages. Land use and traffic.

Transportation Survey: Definition of study area. Zoning. Types of surveys. 0-D surveys. Inventories of existing transport facilities, land use and economic activities.

Trip Generation: Trip purpose. Factors affecting trip generation. Trip generation estimation by multiple linear regression analysis, brief review of category analysis, advantages and limitations of these methods.

Trip Distribution: Methods of trip distribution. Basic concepts of uniform factor method, average factor method and opportunity model. Trip distribution by gravity model.

Traffic Assignment: Principles of assignment. Assignment techniques. All or nothing assignment. Brief review of multipath assignment, capacity restraint assignment and diversion curves.

Modal Split: General considerations for modal split. Factors affecting modal split. Brief introduction to various methods of modal split.

Evaluation: Need for evaluation. Several plans to be formulated. Testing. Considerations in evaluation. Economic evaluation, basic principles, brief introduction to various methods of economic evaluation, comparison.

Mass Rapid Transit Systems: Problems of Urban Transport. Introduction to MRTS. Requirements of MRTS. Types of MRTS. MRTS in India.

BooksRecommended

(i) Traffic Engg and Transport Planning by L.R.Kadiyali, Khanna Publishers, Delhi.
(ii) Highway Engg by S.K.Khanna & C.E.G. Justo, Nem Chand Bros., Roorkee.
(iii) (iii) Introduction to Transport Planning by Bruton, M.J., Hutchinson Technical Education, London.
(iv) Principles of Transportation Engineering by Chakroborty & Das, Prentice Hall, India.

M.Tech. (Transportation) Second Semester

CE-514T	Pavement Analysis and Design	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Traffic Engineering.

Course Objectives

COE1	Understand the basic modelling concepts used to analyses flexible and rigid pavements.
COE2	Appreciate pavement management concepts to better manage road pavement.
COE3	Apply the various types of highway appurtenance to enhance the safety of motorists.
COE4	Learn to estimate traffic noise and the effect of noise attenuation measures.

M.Tech. (Civil) Second Semester

CE-516T	Pavement Construction, Maintenance and Management	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Pavement Material.

Course Objectives

COE1	Select appropriate earth moving and compaction equipment depending upon the requirement.
COE2	Prepare quality assurance and quality control plans in an attempt to construct better performing pavements.
COE3	Evaluate the pavements based on the functional and structural characteristics.
COE4	Evaluate the safety aspects of the pavements specifically in terms of friction and other related distresses.
COE5	Select maintenance technique depending upon the intensity of the distresses.

M-TECH (Transportation) First Semester

CE-519T	Traffic Engg.	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	Provides knowledge on Statistical and Analytical Techniques and its application in traffic and transportation engineering.
COE2	Student will be able to learn Sampling Techniques and Statistical distributions.
COE3	Student will be able to learn and understand law of probability and conditional probability.

M.Tech. (Transportation) First Semester

CE-521T	Geometric Design	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	Identify the factors governing design of highway infrastructures.
COE2	Apply design principles, components and design criteria.
COE3	Design and analyze the highway system and signal system with the available methods.
COE4	Maintain the roads geometric design and apply remedial measures.
COE5	Execute the minor and major projects related to highway infrastructure.

M.Tech. (Transportation) First Semester

CE-523T	Pavement Materials	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Course Objectives

COE1	The students are expected to understand the properties of materials.
COE2	The students would be able to use of various materials and construction.
COE3	The students will be able to analyse of stress distribution, evaluation and maintenance of flexible and rigid pavements.

M.Tech. (Transportation) Elective

CE-572T	GIS in Transportation	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Surveying.

Course Objectives

COE1	Introduce the students, the recent techniques of Remote Sensing and GIS and Its application in Traffic and Transportation Engineering.

M.Tech. (Transportation) Elective

CE-573T	Concrete Technology	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Construction Material.

Course Objectives

COE1	Use different types of cement as per their properties for different field applications.
COE2	Design economic concrete mix proportion for different exposure conditions and intended purposes.
COE3	Supervise various concreting operations.
COE4	Carry out field and laboratory tests on concrete in plastic and hardened stage.

M.Tech. (Transportation) Elective

CE-574T	Project Management	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	Student will role of project management.
COE2	Student will learn on estimation and approvals of project.
COE3	Student will learn on critical construction management.
COE4	Student will learn on BOT, BOOT & PP projects.

M.Tech. (Civil) Elective

CE-575T	Transportation Drainage Systems	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Transportation Planning.

Course Objectives

COE1	To minimize the impact on any area, waterways from changes to natural flow regimes, including flood frequency, runoff volume, runoff frequency and flow velocity resulting from urban development.
COE2	To protect an area waterways from pollution including nutrients, toxicants, sediment, litter and changes to water chemistry.
COE3	To encourage integration of drainage systems into the urban landscape to maximize the visual and recreational amenity of developments.
COE4	To ensure that flood waters don't present an unacceptable risk to the community.

M.Tech. (Civil) Elective

CE-577T	Land Use and Transport Planning	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	Student will understand and apply basic concepts and methods of urban transportation planning in the India.
COE2	Student will learn methods of designing, conducting and administering surveys to provide the data required for transportation planning.
COE3	Students will understand and be able to apply travel demand modelling, Mode Choice Modelling and Traffic Assignment Modelling.

M.Tech. (Civil) Elective

CE-579T	Advanced Geology	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Geology.

Course Objectives

COE1	To impart knowledge and skills in assessing the quality of foundation rocks, their aggregates and building material derived from rocks and assess the geological suitability of sites.
COE2	To impart knowledge of weathering, development of soil and various hydrogeological properties of rocks.
COE3	To impart knowledge of Plate tectonics, Hill slope stability and Landslides etc.
COE4	To impart knowledge of surface and subsurface investigations for various civil engineering projects.

M.Tech. (Civil) Elective

CE-580T	Transportation and Traffic Infrastructure Design	Elective	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Geometric Design.

Course Objectives

COE1	To enable students to acquire basic knowledge of design principles for transport infrastructure development.
COE2	To enable students to design major transport infrastructures including road drainage, road pavement, road junction, railways and airport runway.
COE3	To enable students to assess engineering judgment on alternative transport infrastructure designs.

M.Tech. (Transportation) Third Semester

CE-581T	Transportation Economics and Finance	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	To learn the underpinnings of transportation economics using microeconomic principles and tools.
COE2	To study selected issues and contemporary problems in transport from a welfare economics approach.

M.Tech. (Civil) Third Semester

CE-582T	Public Transportation	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- Traffic Engineering.

Course Objectives

COE1	Reduce traffic growth and congestion by achieving a mode shift from private motorized vehicle trips to a more efficient and sustainable mode of transport.
COE2	Create an efficient multimodal public transport network that will facilitate the interconnection and interoperability of associated transport networks.
COE3	Improved mobility for non-drivers.
COE4	Improved safety.
COE5	Energy conservation, Air, noise and water pollution reductions.

M.Tech. (Civil) Third Semester

CE-583T	Transportation Safety and Environment	Core	3-0-0	4.5 credits
Internal=50		External=50		Total=100

Pre-requisite:- None.

Course Objectives

COE1	Improving the road traffic environment.
COE2	Comprehensively implementing traffic safety awareness initiatives.
COE3	Securing safe driving.
COE4	Ensuring vehicle safety.
COE5	Maintaining road traffic order.

M.Tech. (Civil) Second Semester

CE-584T	**Transportation Planning**	**Core**	**3-0-0**	**4.5 credits**
Internal=50		**External=50**		**Total=100**

Pre-requisite:- Traffic Engineering.

Course Objectives

COE1	To impart knowledge in the rudiments and advancements in Transportation planning and Travel Demand Forecasting.