

Department: Civil Engineering
Programme: B.Tech. in Civil Engineering

Year I

Semester I

			L	T	P	C
CY	5102	Applied Chemistry I-B	3	0	0	3
MA	5101	Engineering Mathematics III-A	3	1	0	4
CE	5101	Structural Analysis - II	3	1	0	4
CE	5102	Design of RC Structures - II	3	1	0	4
CE	5103	Fluid Mechanics - II	3	0	2	4
CE	5104	Transportation Engineering – II	3	0	2	4
						23

Semester II

CE	5201	Water Resources Engineering - II	3	1	0	4
CE	5202	Geotechnical Engineering - II	3	0	2	4
CE	5203	Introduction to Finite Element Method	2	1	0	3
CE	5204	Design of Steel Structures - II	3	1	0	4
CE	5205	Environmental Engineering - II	3	1	2	5
MA	5201	Numerical Methods	3	1	0	4
						24

Year II

Semester I

HS	60**	Open Elective	3	0	0	3
CE	6101	Engineering Geology	3	0	2	4
CE	6102	Structural Dynamics	3	1	0	4
CE	6103	Computational Methods in Civil Engineering	2	0	4	4
CE	60**	Elective - I	3	1	0	4
CE	60**	Elective - II	3	1	0	4
CE	6179	Industrial Training (AUDIT)	--	--	--	2
CE	6199	Project Part – I (AUDIT)	0	0	4	2
						23+4

Semester II

HS	6201	Human Resource Management	3	0	2	4
CE	6201	Planning, Estimation and Valuation	3	0	0	3
CE	6202	Advanced Mechanics of Solids	3	1	0	4
CE	60**	Elective - III	3	1	0	4
CE	60**	Elective – IV	3	1	0	4
CE	6299	Project	0	0	8	4
ED	6200	Extra Curricular Activities and Discipline	0	0	0	2
						23+2

Bridge Courses for lateral Entrants (10+3 Diploma) to Degree Module

Semester I

HS	4301	Elements of Economics	3	0	0	3
CY	4301	Comprehensive Chemistry	4	0	2	5
MA	4301	Comprehensive Mathematics-I	3	1	0	4
PH	4301	Comprehensive Physics	4	0	2	5
ES	4377	Programming in C/C++ (Audit)	2	0	4	4
CE	4301	Geotechnical & Transportation Engineering	4	0	2	5

22+4						

Semester II

HS	4401	Comprehensive Communication Skill	2	0	2	3
MA	4401	Comprehensive Mathematics-II	3	1	0	4
CE	4401	Hydraulics & Water Resources Engineering	3	1	2	5
CE	4402	Concrete Technology & RCC Structures	3	1	2	5
CE	4403	Structural Analysis & Steel Structures	4	0	2	5
CE	4404	Building Planning & Environmental Engg.	4	0	2	5

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List of Electives for Degree Module

- CE 6001 Ground Water Hydrology
- CE 6002 Flood Control and River Training works
- CE 6003 Bridge Engineering
- CE 6004 Matrix Methods of Structural Analysis
- CE 6005 Earthquake Resistant Structures
- CE 6006 Advanced Soil Mechanics and Foundations
- CE 6007 Machine Foundations
- CE 6008 Hydro-Power Development
- CE 6009 Design of Pre-Stressed Concrete Structures
- CE 6010 Pavement Design
- CE 6011 Earth and Earth Retaining Structures
- CE 6012 Mathematical Modeling in Environmental Engineering
- CE 6013 Advanced Wastewater Treatment Techniques
- CE 6014 Environmental Impact Assessment and Audit
- CE 6015 Solid Waste Management
- CE 6016 Industrial Pollution and Control
- CE 6017 Principles and Practices in Geotechnical Engineering
- CE 6018 Open Channel Hydraulics
- CE 6019 Water Resources Systems
- CE 6020 Elements of Earthquake Engineering
- CE 6021 Ground Improvement Technique
- CE 6022 Systems Approach in Civil Engineering
- CE 6023 Water Pollution Engineering
- CE 6024 Advanced Concrete Technology
- CE 6025 Urban Planning and Design
- CE 6026 Theory of Elasticity
- CE 6027 Finite Element Methods
- CE 6028 Urban Transportation Systems Planning
- CE 6029 Traffic Engineering
- CE 6030 Geodetic Surveying

Courses offered by the Civil Engineering Department to other Departments

Module	Course Code	Course Title	Contact Hours (L-T-P:Cr)	Offered to the Students of
Base	ES 1151	Engineering Drawing	0 0 6 3	AE, CE, EE, EC, and ME
Diploma	CE 3103	Surveying - I	2 0 2 3	CE(L) and FO (To be run simultaneously with CE 2103 for Base(CE) Students)
	CE 3151	Engineering Graphics	0 0 4 2	CE(L), CS(L), EC(L), and EE(L)
	ES 3200	Environment and Ecology	3 0 0 3	AE, CE, CS, EC, EE, ME, & FO (Environment part is to be taught by faculty from CE, and Ecology part by faculty from FO. CC may be either from CE or FO on rotation/convenience basis)
	CE 4226	Basics of Civil Engineering	3 0 2 4	ME
Degree	CE 3221	Surveying for Forestry	3 0 2 4	FO
	CE 5221	Forest Engineering	3 0 2 4	FO

COURSE CONTENTS

CE 4301 Geotechnical and Transportation Engineering : 5 Credits (4-0-2)

Unit I	Introduction, definitions and relationships; Index properties of soils; Soil classification; Soil structure; Soil compaction; Permeability and Seepage.	14 lectures
Unit II	Effective stress; Stress distribution in soil mass; One dimensional consolidation; Shear strength of soils and shear tests.	14 lectures
Unit III	Roads; Introduction, Classification of road pattern; Geometric design – factors, considerations; Traffic control devices.	14 lectures
Unit IV	Railways – Rails, sleepers, ballast; Geometrics for broad gauge, cent deficiency; points and crossing, station yard.	14 lectures

Books:

1. Principles of Soil Mechanics and Foundation Engineering, V.N.S. Murthy, UBSPD, New Delhi, 2001
2. Soil Engineering, Part I: Fundamentals & General Principles, Allam Singh & G.R. Chowdhary, C.B.S, New Delhi, 1994.
3. Fundamentals of Geotechnical Engineering, B.M. Das, Brookes & Cole Publications, London, 1998.
4. Highway Engineering, S K Khanna and C E G Justo, Nem Chand & Brothers, Roorkee, India, 1990.
5. A Text Book of Railway Engineering, Arora & Saxena, Dhanpat Rai & Sons, Delhi, 1981.

CE 4401 Hydraulics and Water Resources Engineering: 5 Credits (3-1-2)

Unit I	Properties of liquid; Hydraulic pressure and its measurement; Flow of liquids.	6 lectures
Unit II	Steady, unsteady, laminar and turbulent flows; Continuity equation, momentum equation, and energy equation.	6 lectures
Unit III	Orifices, mouthpieces, nozzles, and venturi meters; Flow through pipes.	6 lectures
Unit IV	Hydrological cycle- precipitation, mass curve, point rainfall, depth area relationship; Evapotranspiration and infiltration.	6 lectures
Unit V	Stream Flow measurements, rainfall-run off characteristics, flow duration and flow mass curve; Hydrographs; influencing factors, base flow separation, effective rainfall, unit hydrograph, use and limitations.	8 lectures
Unit VI	Ground water; aquifers and their properties, specific yield and specific retention, Darcy's law, hydraulic conductivity; Soil-water relationship, field capacity consumptive use, requirement and frequency of irrigation; Water logging and canal lining; River training works.	10 lectures

Books :

1. Hydraulics and Fluid Mechanics including Hydraulic Machines, Modi and Seth, Standard Book House, Delhi, 1998.
2. Fluid Mechanics, Hydraulics and Hydraulic Machines, Arora, K.R., Standard Book House, New Delhi, 1999.
3. Engineering Hydrology, Subramanya, K., Tata McGraw Hill, New Delhi, 2006.
4. Hydrology, Principles, Analysis and Design by Raghunath, H.M. New Age International, New Delhi, 1985.
5. Irrigation Engineering & Hydraulic Structures., Garg, S.K., Khanna Publishers, Delhi., 1993.

CE 4402 Concrete Technology and RCC Structures: 5 Credits (3-1-2)

Unit I	Concrete: Importance, grades, Ingredients, Cement: Objective, Composition, Varieties and respective advantages; Aggregates: Objectives, Classification, Characteristics and properties of aggregates; Water: Quality, Mixing and Curing. Admixtures: Objective, Types of admixture, compounds and functioning.	8 lectures
Unit II	Quality Control - Influencing Parameters, advantages, measure of variability and Statistical Quality Control, Yield of concrete, Concrete mix proportioning using BIS and IRC methods; Production of concrete: Batching, mixing, transporting, placing, compacting, finishing, curing; operations involved in pavement concreting.	6 lectures

Unit III	Rheology of fresh concrete, Properties of fresh and hardened concrete. Special Concrete - Ferro-Cement, Polymer Concrete Composites, Lightweight, Heavy weight concrete, Fibre reinforced concrete, Dry lean concrete, Pavement quality concrete, Roller compacted concrete, Mass concrete, Guniting.	6 lectures
Unit IV	Working stress method of RC design; Design of rectangular and flanged beam for flexure, bond, shear and torsion. One way, two way and continuous slabs.	10 lectures
Unit V	Introduction to limit state method of design; Design for flexure, shear, torsion, and compression; beams; one way, two way, and continuous slabs; Axially and eccentrically loaded columns.	12 lectures

Books :

1. Concrete Technology, A. M. Neville and J. J. Brooks, Pearson Education Asia, 1999.
2. Concrete Technology, M L Gambhir, Tata McGraw Hill, New Delhi, 1995.
3. Concrete Technology, P. D. Kulkarni, R. K. Ghosh and Y. R. Phull, New Age International, New Delhi, 1998.
4. Concrete Technology, M S Shetty, S. Chand & Company, New Delhi, 2005(e).
5. Concrete for Construction, V K Raina, Tata McGraw Hill, New Delhi, 1988.
6. Concrete Technology, A. R. Santhakumar, Oxford University Press, New Delhi, 2007.
7. IS 16415: 2015, Composite Cement – Specification, BIS.
8. IS 456 : 2000, Plain and Reinforced Concrete - Code of Practice, (4th Revision), BIS.
9. IS 10262 : 2009, Concrete Mix Proportioning – Guidelines BIS.
10. IS 383, 1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, BIS.
11. Concrete Manual: Laboratory Testing for Quality Control of Concrete, M L Gambhir, Dhanpat Rai & Sons, New Delhi, 1987.
12. Concrete Structure, Mallick & Gupta, Oxford & IBH, New Delhi, 1993.
13. Design of RCC Structure, M.L. Gambhir, Macmillan India Ltd., Delhi, 1993.
14. Reinforced Concrete Structural Elements: Behaviour, Analysis and Design, P. Purushothaman, Tata McGraw Hill, New Delhi, 1984.
15. IS 456:2000, BIS

CE 4403 Structural Analysis and Steel Structure: 5 Credits (4-0-2)

Unit I	Three hinged arches, cables and suspension bridges; Influence line diagram for reaction, shear and bending moment for determinate beams, arches and trusses.	9 lectures
Unit II	Deflection by moment-area, conjugate beam, and energy methods.	9 lectures
Unit III	Degree of indeterminacy and stability; Principle of superposition, Betti's Law, Castigliano's theorem; Analysis of indeterminate beams by strain-energy and virtual work methods.	10 lectures
Unit IV	Design of riveted, welded and bolted connections.	9 lectures
Unit V	Design of tension and compression members; design of columns with splicing, lacing and battening.	10 lectures
Unit VI	Design of beam-column connections; Column bases, foundation; Roof trusses.	9 lectures

Books:

1. Theory and Analysis of Structure Vol. II, O.P. Jain and A S Arya, Nem Chand & Brothers, Roorkee, India, 1976.
2. Basic Structural Analysis, C.S. Reddy, Tata McGraw Hill, New Delhi, 1996.
3. Theory of Structures, Timoshenko & Young, McGraw Hill International, Singapore, 1965.
4. Steel Structures, A S Arya and J L Ajmani, Nem Chand & Brothers, Roorkee, India, 1996.
5. Design of Steel Structure, P. Dayaratnam, Wheelers Publishing, Allahabad, 1990.
6. Design of Steel Structure, Kazmi and Jindal, Prentice Hall of India, New Delhi, 1987.

CE 4404 Building Planning and Environmental Engineering: 5 Credits (4-0-2)

Unit I	Model Building Byelaws for urban centres in plain and hilly region, Growing Environmental concerns, Increased Safety and Security measures, Technological Developments, Swachh Bharat Mission, Development permission; site planning	10 lectures
Unit II	Planning for utility - Principles of building planning for utility, aspects, prospect, grouping, circulation, privacy, furniture layout, sanitation, elegance, economy	10 lectures

flexibility. Planning for Aesthetic - Principles of architecture, Quality of architecture, factors in architecture etc.

Unit III	Introduction to water and wastewater engineering; Water demand, quality characteristics of water and wastewaters.	12 lectures
Unit IV	Treatment of water: intake, screening, plain sedimentation, aeration, coagulation cum flocculation, filtration, disinfection, distribution system.	12 lectures
Unit V	Estimation of dry weather and wet weather flows; Treatment of wastewater: a brief introduction of aerobic and anaerobic treatments, sludge digestion and its disposal; Self-purification of streams	12 lectures

Books:

1. Planning & Designing Buildings, Y.S. Sane, Engineering Book Publishing Co., Pune, 1959.
2. Building Byelaws of Class-A Town, Respective Municipal Corporations, NBC, Latest Publication.
3. National Building Code, BIS
4. Time Saver Standards– Building and Site Planning, De Chiera, McGraw Hill International, Singapore, 1984.
5. Environmental Engineering Vol. I, Water Supply Engineering, S.K. Garg, Khanna Publishers, Delhi, 2005.
6. Environmental Engineering Vol. II, Sewage Disposal & Air Pollution Engineering, S.K. Garg, Khanna Publishers, Delhi, 2006.
7. Wastewater Engineering: Treatment, Disposal & Reuse, MetCalf & Eddy, Tata McGraw Hill, New Delhi, 2003.
8. Environmental Engineering, Peavy, Rowe and Tachobanglous, McGraw Hill, International, Singapore, 1985.

CE 5101 Structural Analysis II: 4 Credits (3-1-0)

Unit I	Method of Consistent Deformations, Least Work and Three Moment Equations: Static and Kinematic indeterminacies, Stiffness and Flexibility Methods, Analysis of single-degree and multi-degree indeterminate beams by Method of Consistent Deformations, Least Work and Three Moment Equations, Settlement of supports.	12 lectures
Unit II	Slope Deflection Method: Slope deflection equations, Fixed end moments, Equations of equilibrium, Member end moments and shears, Analysis of continuous beams with or without settlement of supports, Frames without and with side-sways, Frames with inclined legs.	8 lectures
Unit III	Moment Distribution Method: Member stiffness, Carryover moments, Carryover factor, Distribution factors, Basic concepts and operations in the Moment Distribution Method, Analysis of continuous beams, Frames without and with side-sways, Frames with inclined legs. Kani's Method: Rotation factors, Rotation moments, Basic operations in Kani's Method, Analysis of continuous beams with varied support conditions, Settlement of supports, Analysis of symmetric frames with line of symmetry passing through the beam or column.	12 lectures
Unit IV	Two Hinged Arches and Indeterminate Trusses: Two hinged arches, Horizontal thrust, Analysis of two hinged semi-circular and segmental arches by method of least work, Parabolic arches with secant variation of Moment of inertia, Shear force, Normal thrust, and Radial shear at any point in the arch. Indeterminate Trusses: Internal and external indeterminacies, Analysis of trusses up to total two degrees of indeterminacy by method of least work. Influence Lines for Statically Indeterminate Structures: Muller Breaslau's principle and its application in drawing ILD for indeterminate structures.	10 lectures

Books :

1. Basic Structural Analysis, C S Reddy, Tata McGraw Hill, New Delhi, 1996.
2. Structural Analysis, Aslam Kassimali, PWS Publications, 1999
3. Elementary Structural Analysis, S Utku, C H Norris and J B Wilbur, McGraw Hill Inc., Singapore, 1991.
4. Intermediate Structural Analysis, C K Wang, McGraw Hill International, Singapore, 1983.
5. Structural Analysis, R C Hibbeler, Pearson Education, New Delhi, 2008.
6. Structural Analysis, A Ghali and A M Neville, Chapman and Hall, London, 1989.
7. Structural Analysis, Coates, Cutie and Kong, ELBS, London, 1987.
8. Theory of Structures, Timoshenko and Young, McGraw Hill NY, 1965.
9. Elementary Theory of Structures, Yuan-Yu Hsieh and S T Mau, Prentice Hall Inc, NJ, 1995.

10. Fundamentals of Structural Analysis, 4th Edition, Kenneth M Leet, Chia-Ming Uang and Anee M Gulbert, McGraw-Hill International Edition, New York, 2011.

CE 5102 Design of RCC Structures II: 4 Credits (3-1-0)

Unit I	Design of combined footings, rafts, and piles	10 lectures
Unit II	Design of cantilever and counter fort retaining walls	8 lectures
Unit III	Design of Water Retaining Structures	6 lectures
Unit IV	Design of staircases; Design of columns under biaxial bending.	6 lectures
Unit V	Analysis and design of frames under gravity and lateral loads by approximate and exact methods, Substitute Frame method	6 lectures
Unit VI	Introduction to pre-stressed concrete structures: methods, losses	6 lectures

Books:

1. Advanced Reinforced Concrete Design, P C Varghese, PHI, New Delhi, 2006
2. Advanced Reinforced Concrete Design, N. Krishna Raju, CBS, New Delhi, 1988.
3. Design of Reinforced Concrete Structures, N Subramanian, Oxford University Press, New Delhi, 2013.
4. Comprehensive RCC Designs, B C Punamia, Ashok K Jain, and Arun K. Jain, Laxmi Publications, New Delhi, 1998.
5. Reinforced Concrete: Limit State Design, A K Jain, Nem Chand & Broders, Roorkee, India, 1997.
6. Plain and Reinforced Concrete, Vol. I & II, Jai Krishna & O P Jain, Nem Chand & Broders, Roorkee, India, 1981.
7. Reinforced Concrete Structural Elements: Behaviour, Analysis & Design, P. Purushothaman, Tata McGraw-Hill, New Delhi, 1984.
8. Reinforced Concrete Design, S.N. Sinha, , Tata McGraw-Hill, New Delhi, 1988.
9. Limit State Design of Concrete Structures, Ramachandra, Standard Book House, Delhi, 1990.
10. IS: 456-2000, BIS Publication
11. IRC: 112-2011, Code of Practice for Concrete Road Bridges, IRC, New Delhi

CE 5103 Fluid Mechanics II: 4 Credits (3-0-2)

Unit I	Dimensional analysis and Similitude: Nature of dimensional analysis, Rayleigh method, Buckingham's π - theorem, determination of π -groups, dimensionless groups of significance, flow similarity and model studies.	8 lectures
Unit II	Basic control volume: approach, control volume equation, continuity equation, momentum equation, Application of all basic equations: forces on bends, flow through nozzles, moment of momentum equation.	8 lectures
Unit III	Drag and lifts: flow around submerged objects, effect of viscosity on development of drag, effect of streamlining, drag for two dimensional body, terminal velocity, lift on circular cylinder, concept of boundary layer, thickness of boundary layer along a thin plate, laminar boundary layer	9 lectures
Unit IV	Open channel hydraulics: one dimensional method of flow analysis, velocity distribution, kinetic energy, specific energy, critical depth, sub-critical, critical and super-critical flows, uniform flows, Manning's formula, normal depth, hydraulically efficient channel section, hydraulic jump.	9 lectures
Unit V	Introduction to Turbomachinery: Types of turbines, impulse and reaction turbines, axial and radial flow pumps, coefficients of pumps, specific speed of pumps and turbines, similitude of pumps and turbines.	8 lectures

Books:

1. Engineering Fluid Mechanics, C. T. Crowe, D. F. Elger, J. A. Roberson, John Wiley & Sons, Inc. 2001.
2. Theory and Problems of Fluid Mechanics, Subramanya, K., Tata McGraw Hill, New Delhi, 1993.
3. Hydraulics and Fluid Mechanics including Hydraulics Machines, Modi, P.N. and S.M. Seth, Standard Book House, Delhi 1998.
4. Fluid Mechanics through Problems, Garde R.J. , New Age International, New Delhi, 1989.
5. Fluid Mechanics Fundamentals and Applications, Cengel, Y. A. and Cimbala, J. M., Tata McGraw Hill Company Limited, New Delhi, 2006..
6. Fluid Mechanics, White, F. M. McGraw.Hill Book Co. International Student Edition, Singapore, 1986.

CE 5104 Transportation Engineering II: 4 Credits (3-0-2)

Unit I	Introduction: transportation demand, urban transportation systems & planning, Travel Demands Forecasting; four-stage sequential modeling approach;	10 lectures
Unit II	Highway capacity and Level of Service concepts, characteristics of uninterrupted traffic, capacity and LOS of Uninterrupted facilities, PCU.	6 lectures
Unit III	Characteristics of interrupted traffic, design of signalized intersections- operation, regulation, conflict area, capacity and LOS of signalized intersections, signal coordination. Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection.	12 lectures
Unit IV	Airport Engineering: terminal area concept; Runway cross-section details, orientation, length fixation, practical difficulties and corrections; Runway geometric design, taxiway and apron arrangement, basic runway patterns and runway numbering.	8 lectures
Unit V	Highway Pavements: types, components, structural action, design considerations.	6 lectures

Books:

1. Transportation Engineering and Planning, C.S. Papacostas, Prentice-Hall India, 2001.
2. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.
3. Traffic Engineering: Transport Planning, L. R. Kadiyali, Khanna Publishers, Delhi 2011.
4. Highway Engineering, S K Khanna , C E G Justo and A.Veeraraghavan, Nem Chand & Brothers, Roorkee, India, 2015.
5. Highway Engineering.: R Srinivasa Kumar, Universities Press, Hyderabad India, 2011.
6. Dock & Harbour Engineering, H P. Oza, Charotar Publishing House, Anand, India, 2016.
7. Airport: Planning & Design, Khanna & Arora, Nem Chand & Brothers, Roorkee, India, 1990.

CE 5201 Water Resources Engineering II: 4 Credits (3-1-0)

Unit I	Canal headworks: location of headworks on rivers, different units of head works, afflux, waterway and different levels for weir construction, undersluices, design of weir.	6 lectures
Unit II	Sub-Surface flow: seepage forces, theory of seepage, seepage equation, method of determination of seepage pressure, sheet pile at the upstream end, sheet pile at the downstream end, intermediate sheet pile, depressed floor, determination of exit gradient, uplift force on the floor of canal.	8 lectures
Unit III	Cross-drainage structure: need of cross-drainage structure, types of cross-drainage structures, selection of the type of cross-drainage structures, design of cross-drainage structures, waterway and head way of the stream, head loss through cross-drainage structure, design of transitions for the canal waterway.	6 lectures
Unit IV	Classification of Embankment dams: Gravity Dam, Embankment dam, Butress Dam; Gravity dams: forces on a gravity dam, causes of failure of a gravity dam, stress analysis in gravity dams, design of gravity dams. Embankment dams: classification of embankment dams, factors influencing the design of an embankment dam, general design criteria for embankment dams.	12 lectures
Unit V	Channel design: Kennedy and Lacey's regime theory, sediment transport, incipient motion of sediment transport, critical tractive force approach, bed load, suspended load, bed-material load, wash load; Design of rigid-boundary channels carrying clear water, design of alluvial channels	10 lectures

Books:

1. Irrigation and Water Power Engineering. Punmia, B.C. and Pandey, B.B. Lal, Laxmi Publication, Delhi, 1986.

2. Irrigation Engineering, Asawa, G.L., New Age International, New Delhi, 1993.
3. Irrigation Water Resources and Water Power Engineering, Modi, P.N., Standard Book House, Delhi, 1995.
4. Fundamentals of Irrigation Engineering, Singh, Bharat, Nem Chand & Bros, Roorkee, 1997.
5. Hydraulic Structures, 4 th edition, Novak, P. , Moffat, A. I. B., Nalluri, C. and Narayanan, R. Taylor & Francis London, UK. (2007)

CE 5202 Geotechnical Engineering II: 4 Credits (3-0-2)

Unit I	Soil exploration: purpose and planning, boring methods, soil sampling, observation of ground water tables, standard penetration tests, cone penetration tests, coring of rocks, geophysical exploration.	8 lectures
Unit II	Slope stability analysis: infinite and finite slopes, earth and rockfill dams, filter criteria.	8 lectures
Unit III	Lateral earth pressure: introduction, earth pressure at rest, active and passive earth pressures, Rankine's and Coulomb's theories, graphic solution for Coulomb's active earth pressure, cantilever and anchored sheet pile walls, braced cuts.	8 lectures
Unit IV	Shallow-foundations: bearing capacity: general concepts, Terzaghi's theory, effect of groundwater table, the general bearing capacity equation, eccentrically loaded foundations, plate load tests, foundation settlements.	8 lectures
Unit V	Deep foundations: Piles, types, bearing capacity of single pile and pile groups, pile load tests, settlement of piles, negative skin friction; Shaft and caisson foundations. Foundations on expansive soils; Elements of machine foundations; Laterally loaded piles- Cantilever method.	10 lectures

Books:

1. Geotechnical and Foundation Engineering: Design and Construction, Day, Robert W., McGraw Hill, NY, 1999.
2. Principles of Soil Mechanics and Foundation Engineering, Murthy, V.N.S., UBSPD, New Delhi, 2001.
3. Soil Engineering Part-I: Fundamentals and General Principles, Singh, Alam and Chowdhary, G.R., CBS, New Delhi, 1994.
4. Geotechnical Engineering: Principles and Practices, Coduto, Donald P., Prentice Hall. Inc., NJ, 1998.
5. Principles of Foundation Engineering, Das, B. M., PWS & ITP Pub. Company, London, 1999.
6. Geotechnical Engineering: Soil Mechanics and Foundation Design, Cernica, John N., John Wiley & Sons, NY, 1996.
7. Solving Problems in Soil Mechanics, Sutton, B. H. C., Addison – Wesley Pub. Co., NY, 1993.
8. Manual of Soil Laboratory Testing, Vol. I, II, & III, Head, K. H., John Wiley & Sons, NY, 1996.
9. Analysis and Design of Sub-Structures: Limit state Method, CRC Press, New Delhi

CE 5203 Introduction to Finite Element Method: 3 Credits (2-1-0)

Unit I	Basic concepts of FEM; Direct Stiffness Method (DSM); Concept of an Element and node; Natural and Essential Boundary Conditions; Steps in FEM; Derivation of element stiffness equations for 1D bar element, truss element and beam element using the concept of mechanics; Treatment of Nonhomogeneous displacement boundary condition.	8 lectures
Unit II	Multi-Freedom Constraints (MFC), Treatment of MFC using Master Slave Elimination Method and Penalty Factor Augmentation Method. Solving simple problems of bars and truss subjected to MFCs.	4 lectures
Unit III	Concept of vibrational formulation of FEM, Minimization of potential energy, Galerkin and Rayleigh-Ritz Methods, Analysis of bars and beams using Galerkin's and Rayleigh-Ritz methods.	4 lectures
Unit IV	Types of elements, coordinate systems and shape functions, Serendipity and Lagrange Shape Functions; Strain-displacement matrix; Vibrational approach for assembling stiffness matrix, Consistent load vectors; Analysis of Beam and Plane Frames.	8 lectures
Unit V	Introduction to Two Dimensional Problems, Iso-parametric formulation, CST.	4 lectures

Books :

1. An Introduction to the Finite Element Method; J. N. Reddy, Tata McGraw Hills, 2009
2. Introduction to Finite Elements in Engineering; T.R. Chandrapatla and Ashok D. Belegundu, Prentice Hall of India, New Delhi, 2013

3. Finite Element Procedures in Engineering Analysis; Klaus-Jurgen Bathe, Prentice Hall of India, New Delhi, 2002.
4. Finite Element Analysis; S.S. Bhavikati, New Age International Publishers, 2005
5. Introduction to the Finite Element Method, A Numerical Method for Engineering Analysis; Desai and Abel, CBS Publishers & Distributors Pvt Ltd., 2005
6. Class Notes of Prof. Carlos Felippa, Univ of Boulder, Colorado, (<http://www.colorado.edu/engineering/cas/courses.d/IFEM.d/>)

CE 5204 Design of Steel Structures II: 4 Credits (3-1-0)

Unit I	Plastic Analysis of Steel Structures: plastic bending, plastic modulus, shape factor, moment curvature relationship, plastic moment capacity, lower and upper bound theorems, analysis of beams and frames.	10 lectures
Unit II	Introduction to Limit State Method of Design and IS-800: 2007: Limit States for Steel design, Limit States of Strength, Limit States for Serviceability, Actions (Loads), Probabilistic basis of design, Characteristic loads and strengths, Partial safety factors, Design loads and strengths, Classification of cross-sections, Types of elements, Combination of loads, Criteria for failure/Collapse of steel.	6 lectures
Unit III	Design of Connections: Bolted and welded connections; Types of bolts and bolted joints, Load transfer mechanism, Failure of Bolted joints, Strength and Efficiency of bolted joint; Types of welds, Assumptions in the analysis of welded joints, Design of groove, fillet, intermittent fillet, butt, and plug and slot welds, Applications..	6 lectures
Unit IV	Design of Tension and Compression Members, and Column Bases: Types of tension members, Net sectional area, Effective net area, Types of failure, Design strength of tension members; Effective lengths of columns, Slenderness ratio, Types of sections, Types of buckling, Classification of cross-sections, Design of axially loaded compression members; Types of column bases, Design of Slab and Gusseted bases.	10 lectures
Unit V	Design of Beams, Plate Girders, and Roof Trusses: Behaviour of beams in flexure under ultimate loads, Classification of Cross-sections, Bending and shear strengths of beams, Design procedures for Rolled and Built-up sections; Elements of Plate Girders, Proportioning of web and flanges, Design of vertical, horizontal and load bearing stiffeners, Curtailment of flange plates; Selection of type of truss, Loads on roof truss, Analysis of roof truss, Selection of sections for the members, Connections.	10 lectures

Books :

1. Limit State Design of Steel Structures, S.K Duggal, Tata McGraw Hill Education Pvt Ltd, New Delhi, 2011.
2. Limit State Design of Steel Structures, Rama Chandra and Virendra Gehlot, Scientific Publishers (India), Jodhpur, 2010.
3. Limit State Design of Steel Structures, I C Syal and Satinder Singh, Standard Publishers Distributors, New Delhi, 2015.
4. Design of Steel Structures, N Subramanian, Oxford University Press, New Delhi, 2008
5. Plastic Methods of Structural Analysis, B.G. Neal, Chapman & Hall, London, 1965.
6. Ductile Design of Steel Structures, M. Bruneau, China-Ming Uang, and Andrew Whittaker, Mc Graw Hill, NY, 1998.
7. IS-800: 2007: General Construction in Steel-Code of Practice, BIS, New Delhi, 2007.

CE 5205 Environmental Engineering II: 5 Credits (3-1-2)

Unit I	Biological & physico-chemical principles in environmental Engineering, reaction kinetics - elementary reactions, rates of reactions, stoichiometry of reactions, homogeneous and heterogeneous reactions, biochemical reactions. Mass balance relationships - point form of continuity equation, mass balance equation, classification of reactor types, reactor dynamics, development of mathematical model for ideal reactors, field reactors.	12 lectures
Unit II	Design of water treatment facilities: principles & design of primary settling tanks, tube settlers, rapid mixing unit, flocculates, rapid sand filter and disinfection unit, design of distribution system.	8 lectures
Unit III	Design of wastewater treatment facilities: aerobic – principle & design of activated sludge process, trickling filter, aerated lagoons, oxidation ditches, oxidation ponds, fish ponds & maturation ponds, rotating biological contactors; Anaerobic - Anaerobic digesters, anaerobic filters, UASB reactors & hybrid reactors.	10 lectures

Unit IV	Solid wastes – classification and characteristics, principle of solid waste management, collection, handling and disposal of solid wastes.	6 lectures
Unit V	Air pollution and its control: air pollutants, their standards, methods & equipment for control of air pollutants; Environmental impact assessment: introduction, principles & methods of EIA, environmental legislation.	6 lectures

Books:

1. Environmental Engineering, H.S. Peavy, D.R. Rowe & G. Tchobanoglous, McGraw Hill International, New York, 1985.
2. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
3. Chemistry for Environmental Engineering, Sawyer, C.N., McCarty, P.L., Parkin, G.F., Tata McGraw-Hill, 2003.
4. Wastewater Treatment Concept and Design Approach: G. L. Karia & R. A. Christian, PHI, N. Delhi.
5. Wastewater Treatment for Pollution Control and Reuse, S. J. Arceivala, Asolekar, Tata McGraw Hill, New Delhi.
6. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 2003.
7. Wastewater Treatment Plants: Planning, Design & Operation, S.R. Qasim, CRC Press, Book World Enterprises, Mumbai, 2010.
8. Integrated Solid Waste Management, Engineering Principles and Management Issues, George Tchobanoglous, Hilary Theisen and Samuel Vigil. McGraw-Hill Edition (India) Private Limited, New York. 2015.
9. Management of Organic Waste: S. Kumar & A. Bharti, INTECH.
10. Air Pollution & its Control, Perkins, McGraw-Hill, New York, 1986.
11. Methods of Environmental Impact Assessment, Peter Moris and Riki Therivel, UCL Press, London, 1995.
12. Environmental Impact Assessment: Canter, McGraw Hill Education Private Limited, New Delhi, 2014

CE 5221 Forest Engineering: 3 Credits (3-0-0)

Unit I	Construction materials: stones, bricks, tiles, lime, cement, sand, timber, steel, concrete, paints, bituminous materials, etc.	12 lectures
Unit II	Building construction: foundation, masonry work, DPC, lintels, doors and windows, roofs, flooring, plastering etc.	10 lectures
Unit III	Water supply and sanitary services construction details, septic tank, soak pit.	10 lectures
Unit IV	Construction of roads, railways, and bridges.	10 lectures

Books:

1. Civil Engineering Materials, TTTI, Chandigarh, Tata McGraw Hill, New Delhi, 1992.
2. Engineering Materials, Sushil Kumar, Metropolitan Publishers, New Delhi, 1983.
3. Building Construction, B.C. Punmia, Laxmi Publication, Delhi, 1998.
4. Building Construction Vol. I to IV, W.B. Mackey, Orient Longman, Mumbai, 1993.
5. Highway Engineering, S K Khanna and C E G Justo, Nem Chand and Borthers, Roorkee, India, 1990.
6. A Text Book of Railway Engineering., Arora & Saxena, Dhanpat Rai and Sons, New Delhi, 1981.

CE 6101 Engineering Geology: 4 Credits (3-0-2)

Unit I	Basic principles of geology, origin of earth – various theories, structure of earth crust, evidences, age of earth.	7 lectures
Unit II	Rocks: Primary classification, texture and structure of igneous, sedimentary and metamorphic rocks; Rock forming minerals – physical properties, their engineering significance.	7 lectures
Unit III	Weathering and erosion, soil formation conservation and erosion control, geological works by wind, water and glaciers and their resulting features;	7 lectures
Unit IV	Structural geology-bed, dip, strike, folds, faults, joints and unconformity; Rocks as a construction material;	7 lectures
Unit V	Geophysical investigations – principles and methods, Earthquakes and landslides.	7 lectures
Unit VI	Aquifers and underground water; Selection of site for dams, reservoir, tunnels and highways, Geological mapping; related practices, Introduction to remote sensing.	7 lectures

Books:

1. A Geology for Engineers, Blyth, FGH and de Freitas, M.H., ELBS, 8/e
2. Engineering Geology, F. G. Bell, Butterworth-Heinemann (Elsevier) 2/e, 2007
3. A Text Book of Engineering & General Geology, Praveen Singh, S.K. Kataria & Sons, Ludhiana, 1990.
4. A Text Book of Geology, P. K. Mukherjee, The World Press Private Limited, Kolkata, 1990.
5. Engineering Geology for Civil Engineers, D. Venkat Reddy, Oxford & IBH, New Delhi, 1995.
6. Structural Geology, M P Billings, Prentice Hall of India, New Delhi, 1972.

CE 6102 Structural Dynamics: 4 Credits (3-1-0)

Unit I	Single degree of freedom systems - free vibration: introduction to dynamics of structures and their modelling, springs in series and parallel; Equation of motion and response, free vibration , damping, amplitude, natural frequency and logarithmic decrement.	7 lectures
Unit II	Single degree of freedom system - forced vibration under harmonic loading; Undamped and damped harmonic excitation; resonance; Half power method for damping; transmissibility, vibration isolation, seismic instruments; Intoduction to Duhamel Integral, response to unit impulse, infinite duration step force, rectangular pulse force, linearly increasing force concept of response spectrum.	10 lectures
Unit III	Multi degree of freedom system: Equation of motion, two degrees of freedom system, natural vibration, frequency and modes, orthogonality and normalisation of modes.	7 lectures
Unit IV	Solution of equation of motion: eigen vlalue problem, estimating fundamental frequency by Rayleigh's method; Holzer's and stodola method and other matrix method.	6 lectures
Unit V	Modal analysis: modal equation, modal expansion of displacement, modal displacement super position, response, element forces.	6 lectures
Unit VI	Continuous systems: un-damped equation of motion, natural vibration frequencies and modes of uniform simply supported and cantilever beams, modal orthogonality.	6 lectures

Books:

1. Structural Dynamics: Theory & Computations, Mario Paz, CBS, New Delhi, 1985.
2. Dynamics of Structures, Anil K. Chopra, Prentice Hall of India, New Delhi, 2000.
3. Dynamics of Structures, Clough and Penzien, McGraw Hill International, New York, 1993.
4. Structural Dynamics, Craig Jr., John Wiley and Sons, New York, 1981.
5. Theory of Vibrations with Applications, W. T.Thomson, CBS, New Delhi, 1988.
6. Vibrations, Dynamics & Structural Systems, M. Mukhopadhyay, Oxford and IBH, New Delhi, 1989.

CE 6103 Computational Methods in Civil Engineering: 4 Credits (2-0-4)

Unit I	Introduction to Direct Stiffness Method and FEM. Introduction to MATLAB/SCILAB programming environment	14 lectures
Unit II	Examples from RCC structures (eg. Design charts for singly and doubly reinforced beams, design of slabs).	3 lectures
Unit III	Examples from Geotechnical Engineering. (eg. Design of footings, settlement analysis, flow nets)	3 lectures
Unit IV	Examples from Fluid Mechanics (eg. Critical depth calculations in trapezoidal, circular and rectangular channels, pipe network analysis)	4 lectures
Unit V	Examples from Environmental Engineering (eg. Application to treatment systems and their modelling).	2 lectures
Unit VI	Examples from Highway Engineering.(eg. Design of super elevation , transition curves etc.)	2 lectures

Books:

1. Finite Element Methods for Engineers, Chandraputula and Belegundu, Pearson, 2006
2. Numerical Methods for Engineers, S.K. Gupta, New Age International, New Delhi, 1995.
3. Computer Programming in FORTRAN 77, V Rajaraman, Prentice Hall of India, New Delhi, 2001.
4. Numerical Recipes in C++ or FORTRAN, Press et.al., Cambridge University Press, 2002
5. MATLAB Programing for Engineers, Stephen J. Chapman, 2001
6. Numerical and Statistical Methods with SCILAB for Science and Engineering, Urroz, G.E., Infoclearing House.com, 2006
7. Documentations from <http://www.scilab.org>

CE 6201 Planning, Estimation and Valuation: 3 Credits (3-0-0)

Unit I	Building bye-laws for high rise building specially for fire & infrastructure, site climate, integrated approach to building planning, built environment..	7 lectures
Unit II	Energy management in buildings, Concept of green buildings, Rating systems of buildings, Energy audit and life cycle cost of buildings.	7 lectures
Unit III	Units of measurements, taking out quantities, abstracts of quantities for mass concrete, RCC, steel work, deep foundations, dams, irrigation structures, water supply and sanitary services	10 lectures
Unit IV	Preparation of bills – specifications, tendering procedures and contracts..	6 lectures
Unit V	Valuation of properties – methods of valuation, income approach, cost approach, related practice.	12 lectures

Books :

1. Fire Safety in Buildings(2e), V. K. Jain, New Age Publishers, New Delhi, 2010.
2. Housing, Climate and Comfort, Evans Martin, The Architectural Press - London, 1980.
3. National Building Code of India, Part IV, BIS New Delhi– 2005.
4. Commentary on National Building Code (Part 4) – Fire and Life Safety.
5. Energy Audits: A Workbook for Energy Management in Buildings, Tarik Al-Shemmeri, John Wiley & Sons, 2011.
6. Green Buildings : Project Planning and Cost Estimation, [R S Means](#), John Wiley & Sons, 2011.
7. Time Saver Standard – Site Planning, De Chiara and Koppelman, McGraw Hill International, Singapore, 1984
8. Singapore, 1984
9. Time Saver Standard- Interior Design & Space Planning, De Chiara, McGraw Hill International, Singapore,1991.
10. Estimation, Costing and valuation in Civil Engineering, B.N. Dutta, USB Publishers Distributors Limited, New Delhi, 1998(ed).
11. Estimating Costing Specification and Valuation in Civil Engineering (18e), M. Chakraborty, Published by author, 21B Bhabananda road, Kolkata,2005.
12. Building Technology and Valuation, TTTI, Madras, Tata McGraw Hill, New Delhi, 1989.
13. Valuation of Real Properties, Rangwala S. C., Charotar Publishing House, Anand, India, 2000.

CE 6202 Advanced Mechanics of Solids: 4 Credits (3-1-0)

Unit I	State of stress in 3D; Equations of equilibrium in Cartesian and polar co-ordinates; Analysis of strains.	10 lectures
Unit II	Theories of failures and their significance, Unsymmetrical bending of beams,	8 lectures
Unit III	Curved beams of small and large curvatures, crane hooks, rings and chain links; Shear center.	8 lectures
Unit IV	Thin and thick cylinders, Introduction to shells, Membrane analysis of cylindrical shells.	10 lectures
Unit V	Stress concentration; Introduction to experimental stress analysis - mechanical and electrical strain gauges and strain rosettes, analysis,	6 lectures

Books:

1. Advanced Mechanics of Solids, 3rd Edition, L.S. Srinath, Tata McGraw Hill, New Delhi, 2009.
2. Advanced Mechanics of Materials, 6th Edition, Aurther P Boresi and Richard J Schmidt, John Wiley and Sons, Inc, New York, 2003.
3. Advanced Strength and Applied Stress Analysis, 2nd Edition, Richard G Budynas, McGraw Hill International, New York, 1999.
4. Engineering Solid Mechanics Fundamentals and Applications, Abdel-Rahman Ragab and Saleh Eldain Bayoumi, CRC Press, Boca Raton, Florida, 1999.

5. Strength of Material, G.H. Ryder, MacMillan India Ltd, New Delhi, 2001 reprint.
6. Engineering Mechanics of Solids, Egor P Popov, Prentice Hall of India, New Delhi, 1990.
7. Introduction to Solid Mechanics, 2nd Edition, Irving H Shames, Prentice Hall of India, New Delhi, 1990.
8. Fundamentals of Structural Mechanics, 2nd Edition, Keith D Hjelmstad, Springer (India) Private Ltd, New Delhi, 2005.
9. Mechanics of Materials, Vol I & II, E J Hearn, Butterworth-Hrinemann(Elsevier), Reed Elsevier (India) Private Ltd, New Delhi, 2008.
10. Advanced Mechanics of Solids, Otto T Bruhns, Springer-Verlog, Springer (India) Private Ltd, New Delhi, 2008.
11. Design and Construction of Concrete Shell Roofs, G.S. Ramaswamy, Tata McGraw Hill, New Delhi, 1971.
12. Theory of Elasticity, Timoshenko and Goodier, McGraw Hill, New York, 1982.
13. Experimental Stress Analysis, L.S Srinath et. al, Tata McGraw Hill, New Delhi, 1984.

CE 6001 Ground Water Hydrology: 4 Credits (3-1-0)

Unit I	Occurance of ground water , ground water movement, saturated and unsaturated flow. ground water geophysics : electrical resistivity and seismic refraction method.	10 lectures
Unit II	Groundwater flow: differential equations governing groundwater flow, radial flow to wells.	8 lectures
Unit III	Evaluation of aquifer properties: Theis method, Jacob method, Chow's method.	8 lectures
Unit IV	Groundwater modelling techniques Analog models, Mathematical models.	8 lectures
Unit V	Groundwater recharge, discharge and balance; management of groundwater: concept of basin management, conjunctive use.	8 lectures

Books:

1. Groundwater Hydrology, Todd, D.K., John Wiley & Sons, Singapore, 1995.
2. Groundwater, Freeze, R.A. and J.A. Cherry, Prentice Hall. Inc., NJ, 1979.
3. Groundwater, Raghunath, H.M, New Age International, New Delhi.,1982.
4. Groundwater Assessment Development & Management, Karanath, Tata McGraw Hill , New Delhi, 1987.
5. Hydraulics of Groundwater, Bear, J., McGraw Hill, New York, 1979.

CE 6002 Flood Control & River Training Works : 4 Credits (3-1-0)

Unit I	Concept of probability and probability distribution: basic concepts, properties of random variables, discrete probability distribution, normal distribution, continuous probability distributions, confidence intervals.	15 lectures
Unit II	Flood frequency analysis: Log normal distribution, Log Pearson type III distribution, Gumbel's method.	9 lectures
Unit III	Flood control measures: structural & non-structural measures.	9 lectures
Unit IV	River training works: rivers, their behavior, control and training.	9 lectures

Books:

1. Irrigation and Water Power Engineering, B.C. Punmia & B.B. Lal, Laxmi Publications, New Delhi, 1986.
2. Flood Control Engineering, S.N. Ghosh, Oxford and IBH, New Delhi, 1986.
3. Statistical Methods in Hydrology, R.T. Clarke, Jonh Wiley & Sons, New York, 1994.

CE 6003 Bridge Engineering: 4 Credits (3-1-0)

Unit I	Site selection; Economic spans, bridge components; Types of bridges and selection of suitable type, IRC specifications and standard loading.	7 lectures
Unit II	Foundations: water way scour depths, types of bridge foundations and considerations in their design.	7 lectures
Unit III	Pier, pier caps, abutments; Approaches and bearings and considerations in their design.	7 lectures
Unit IV	Analysis and Behaviour of T-beams with diaphragm, culverts, Box girder bridges, cable stayed and suspension bridges.	7 lectures

Unit V	Courbon's method for assessment of load distribution, Pigeud's method of slab design.	7 lectures
Unit VI	Design of RC culvert, T-beams and cantilever type bridges; Construction procedures of foundation and super structures.	7 lectures

Books:

1. Bridge Engineering, S. Ponnuswami, Tata McGraw Hill, New Delhi, 1986.
2. Essentials of Bridge Engineering, J Victor, Oxford and IBH, New Delhi, 1991.
3. Comprehensive RCC design, B C Punamia, Ashok K Jain and Arun K Jain, Laxmi Publications, New Delhi, 1999.
4. Design of Concrete Bridges, M G Ashwani, V N Vazrani and MM Ratwani, Khanna Publications, New Delhi, 1981.
5. Design of Bridges, N K Raju, Oxford & IBH, New Delhi, 1998.
6. Principles and Practice of Bridge Engineering, S P Bindra, Dhanpat Rai & Sons, Delhi, 1987.

CE 6004 Matrix Methods of Structural Analysis: 4 Credits (3-1-0)

Unit I	Types of framed structures and their deformations.	8 lectures
Unit II	Static and kinematic indeterminacy; Force and displacement equations.	10 lectures
Unit III	Formulation of member and global stiffness and flexibility matrices for 2D framed structures; Equivalent joint loads.	12 lectures
Unit IV	Formulation of member and global stiffness and flexibility matrices for 3D framed structures equivalent joint loads.	12 lectures

Books:

1. Introduction to Matrix Analysis of Structures, S K Mallick and K S Rangaswami, Khanna Publishers, Delhi, 1971.
2. Structural Analysis- a Matrix Approach, G. S. Pandit & S P Gupta, Tata McGraw Hill, New Delhi, 1981.
3. Elementary Structural Analysis, S Utku, C H Norris and J B Wilbur, McGraw Hill Inc., Singapore, 1991.
4. Matrix Method of Analysis of Structures, M B Kanchi, New Age International, New Delhi, 1993.
5. Matrix Analysis of Structures, H I Laursen, McGraw Hill, New York, 1966.
6. Basic Structural Analysis, C S Reddy, Tata McGraw Hill, New Delhi, 1996.
7. Structural Analysis, A. Ghali & A M Neville, Chapman and Hall, London, 1989.

CE 6005 Earthquake Resistant Structures: 4 Credits (3-1-0)

Unit I	Philosophy of Earthquake Resistant Design, General effects of Earthquake Loading on Structures, Architectural Planning for Earthquake Resistance, Strong Column-Weak Beam philosophy, Soft Storey phenomenon, Short Column problem	6 lectures
Unit II	Response of Structures to Earthquakes: Elastic Response Spectra and Elastic Design Spectra, Introduction to Performance Based Design	5 lectures
Unit III	Modal Analysis of MDF systems: Modal expansion of displacement and exciting force, Modal mass, Modal height, Mode participation factor	8 lectures
Unit IV	IS Codal recommendations: Detailed study of IS-1893-2002 (part-I), IS 1893-1984 (Excluding buildings), IS 13920-1993, Reinforcement detailing for imparting ductility; Salient features of IS 4326-1993.	8 lectures
Unit V	Seismic coefficient and Response Spectrum loading of shear buildings, Analysis of Torsional shear, Example design of Multistoreyed buildings; Ductile detailing of beams and columns.	10 lectures
Unit VI	Introduction to non linear analysis of buildings, Introduction to useful/Free codes viz. OpenSees, Seismostruct etc.	5 lectures

Books:

1. IS 1893 (Part-I)-2002, IS Criteria for Earthquake Resistant Design, BIS, New Delhi
2. IS 4326-1993, IS COP for Earthquake Resistant Design and Construction of Buildings, BIS, New Delhi
3. IS-13920-1993, IS COP- Ductile Detailing of RC structures Subjected to Seismic Forces, BIS, New Delhi
4. Dynamics of Structures, Chopra, A. K. (2001), PHI, EEE, New Delhi
5. Seismic Analysis of Structures, Dytta , T. K. (2010) John Wiley & Sons (Asia) Pvt Ltd, Singapore
6. Proposed Draft Provisions and Commentary on Indian Seismic Code IS 1893 (Part-I), Jain, S. K. and Murty, C. V. R. (2005), Document No. IITK-GSDMA-EQ05-V-5.0; and IITK-GSDMA-EQ-15-V-1.0; <http://www.nicee.org>
7. Design Example of a Six Storey Building, Shah, H. J. and Jain, S. K. (2005), Document No. IITK-GSDMA-EQ26-V-1.0; <http://www.nicee.org>
8. Selective resources from <http://opensees.berkeley.edu>

CE 6006 Advanced Soil Mechanics & Foundations: 4 Credits (3-1-0)

Unit I	3D Consolidation, Skempton's pore pressure parameters, stress paths and invariants, constitutive relations.	7 lectures
Unit II	Earth pressures.	7 lectures
Unit III	Methods of stability analysis of earth and rock-fill dams.	7 lectures
Unit IV	Ultimate bearing capacity of shallow foundation by limit equilibrium method, limit analysis and method of characteristics.	7 lectures
Unit V	Settlement response of pile foundations.	7 lectures
Unit VI	Critical state soil mechanics, soil-structure interaction; Reinforced earth.	7 lectures

Books:

1. Elementary Mechanics of Soil Behavior: Saturated Remolded Soils, Biarez, Jean, and Hicher, Pierre-Yves, Balkema Publishers, 1994.
2. Limit Analysis in Soil Mechanics (Developments in Geotechnical Engineering, Vol. 52), Liu, X. L. and Chen, Wal-Fah, Elsevier Science Ltd, 1991.
3. Limit Equilibrium, Plasticity and Generalized Stress-Strain in Geotechnical Engineering, American Society of Safety Engineers Staff, American Society of Civil Engineers, NY 1981.
4. Soils and Foundations, Evett, Jack, and Liu, Cheng, Prentice Hall Inc, NJ, 1997.
5. Soil Mechanics: Concepts and Applications, Powrie, William, E & F N Spon, London, 1997.

CE 6007 Machine Foundations: 4 Credits (3-1-0)

Unit I	Theory of vibration: free and forced vibration, damping.	8 lectures
Unit II	Natural frequency of foundation- soil systems, amplitude and settlement, damping characteristics, dynamic soil properties, in-situ measurements.	8 lectures
Unit III	Design of machine foundations.	10 lectures
Unit IV	Wave propagation through soil, effects of pile driving and blasting on adjacent structures, vibration isolation.	8 lectures
Unit V	Seismic design of foundations, beneficiary aspects of vibrations in soil engineering practice.	8 lectures

Books:

1. Dynamics of Bases and Foundations, D.D. Barken, Mc Graw Hill, NY, 1962.
2. Vibrations of Soils and Foundations, Richart F.E. et al, Prentice Hall Inc, NJ, 1970.
3. Theory of Vibration with Applications, W.T. Thomson, CBS, New Delhi, 1988.
4. Soil Dynamics, Shamsheer Prakash, McGraw Hill International, New York, 1961.
5. Soil Dynamics and Machine Foundations, Swami Saran, Galgotia Publications, New Delhi, 1999.

CE 6008 Hydropower Development: 4 Credits (3-1-0)

Unit I	Hydro vs. thermal power, run-off river plant, storage, pumped storage, tidal and diversion plant.	10 lectures
Unit II	Water power potential, mass curve, load duration curve, peak percentage curve, types of power supply, reservoir operation.	10 lectures
Unit III	Power conduits, unsteady flow in power canal and power tunnel; Penstock-economic diameter, supports such and anchor blocks and saddles, expansion joints; Surge tank, water hammer in penstock.	12 lectures
Unit IV	Design of intake structures; Type of hydroelectric turbine; Selection of turbines; Power house details.	10 lectures

Books:

1. Irrigation, Water Resource and Water Power Engineering, P.N. Modi, Standard Book House, New Delhi, 1995.
2. Handbook of Hydroelectric Engineering, P.S. Nigam, Nem Chand & Bros, Roorkee, India, 1985.
3. Water Power Engineering, M.M. Dandekar & K.N. Sharma, Vani Educational Book, Vishwa Prakashan, Delhi, 1986.

CE 6009 Design of Pre-Stressed Concrete Structures: 4 Credits (3-1-0)

Unit I	Introduction to pre-stressed concrete: concept of pre-stressing, advantages and disadvantages, materials and hard wares, pre-stressing systems, pre-tensioning and post tensioning of members.	7 lectures
Unit II	Losses in pre-stress and analysis: different types of losses, analysis of pre-stress and bending stresses, pressure line concept, load balancing; Cracking moment.	7 lectures
Unit III	Shear torsion and deflection: shear and principal stresses; ultimate shear resistance, design for shear and torsion; deflection of pre-stresses members and its influence; short and long term deflections ; Codal values of deflection.	7 lectures
Unit IV	Transmission and anchorage zone: transmission length in pre-tensioned members; Bond stresses; Transverse tensile stresses; End zone reinforcements; Anchorage zone stresses in post tensioned members; Stress distribution in end block ; Anchorage zone reinforcement, Codal provisions.	7 lectures
Unit V	Composite pre-stressed beam: types of composite construction, shrinkage stresses, deflection and flexural strength at different stages.	7 lectures
Unit VI	Tension and compression members: simple pre-stressed tension members; Pre-stressing for hoop tension; Pre-stressed columns; Poles; Piles and sleepers.	7 lectures

Books:

1. Fundamentals of Prestressed Concrete, N.C. Sinha and S.K. Roy, S.Chand & Co, New Delhi, 1994.
2. Prestressed Concrete, N Krishna Raju, Tata McGraw Hill, New Delhi, 1995.
3. Prestressed Concrete, P. Dayaratnam, Oxford & IBH, New Delhi, 1985.
4. Design of Prestressed Concrete Structures, T Y Lin and Burn, John Wiley & Sons, New York, 1982.
5. Prestressed Concrete Design, M K Hurst, Chapman & Hall, London, 1988.
6. Modern Prestressed Concrete, J R Libby, CBS, New Delhi, 1986.

CE 6010 Pavement Design: 4 Credits (3-1-0)

Unit I	Pavement structures, flexible, rigid and semi-rigid pavements, components, evaluation of properties of pavement and sub-grade materials.	8 lectures
Unit II	Stress in flexible pavement, homogenous and layered system, effect of total load and tyre pressure, equivalent wheel and axle loads.	8 lectures
Unit III	Design of flexible pavements, different methods, IRC specifications.	12 lectures
Unit IV	Stress in rigid pavement, relative stiffness of slabs, stresses due to bending, warping, expansion and contraction, combined stresses, IRC recommendation and design method of reinforced slabs.	8 lectures
Unit V	Joints, loads transfer at transverse joints by dowel bars, maintenance of joints, pavement distress, maintenance and strengthening of pavements.	6 lectures

Books:

1. Principles of Pavement Design, E.T.Yoder and M.W. Hitzcak, John Wiley and Sons Inc, NY, 1975.
2. Highway Engineering, S K Khanna , C E G Justo and A.Veeraraghavan, Nem Chand & Brothers, Roorkee, India, 2015.
3. Pavement Analysis and Design (2nd Edition) Edition by Huang, Yang H. Prentice Hall, 2003.
4. Pavement Design: R Srinivasa Kumar, Universities Press, Hyderabad India, 2013.
5. Soil Engineering in Theory and Practice Vol 1: Fundamentals and General Principles, Alam Singh & G R Chowdhuri, CBS, ND, 1994.
6. IRC: 37-2012, Guidelines for the design of Flexible Pavement (Third revision). Indian Roads Congress.
7. IRC: 58-2015, Guidelines for the design of plain jointed rigid pavements for highways (fourth revision). Indian Roads Congress.

CE 6011 Earth and Earth Retaining Structures: 4 Credits (3-1-0)

Unit I	Lateral earth pressure; Rankine's and Coulomb's theories of active and passive earth pressures; Effect of wall shape, wall friction, backfill and surcharge; Methods of computing active and passive earth pressure.	12 lectures
Unit II	Graphical constructions for computing active and passive earth pressures; Stability of retaining walls; Anchored bulk heads.	10 lectures
Unit III	Arching in soil; Tunnels and shafts; Earth pressure on temporary supports in cuts; Relaxation and creep effects on earth pressure.	8 lectures
Unit IV	Earth and rock fill dams; Selection of sites; Material and dam cross-section; Design of dams; Stability; Slope stability; Construction and performance.	12 lectures

Books:

1. Soil Mechanics, Craig, R. F., Routledge, 1997.
2. Engineering Properties of Soil and Rock, Bell, F. G., Blackwell Science Inc., London, 1999.
3. Elements of Soil Mechanics, Smith, G. N., Blackwell Science Inc., London, 1998.
4. Soils in Construction, Schroeder, W. L. and Dickenson, S. E., Prentice Hall Inc, NJ, 1995.
5. Basic Soil Mechanics, Whitlow, R., Addison-Wesley Pub. Co, NY, 1995.
6. Geotechnical Engineering of Embankment Dams, Fell, R., Mac Gregor, P. and Stapledon, D., Balkema Publishers, 1992.
7. Design of Small Dams, United States Department of the Interior, Oxford & IBH, New Delhi, 1974.

CE 6012 Mathematical Modeling in Environmental Engineering: 4 Credits (3-1-0)

Unit I	Principles of modelling, continuity equations, mass balance relationships, mathematical models for ideal and field reactors.	10 lectures
Unit II	Water quality modelling, mathematical models for rapid and slow sand filters.	10 lectures
Unit III	Biological & biochemical reaction, reaction kinetics of aerobic and anaerobic processes, process mechanisms for different treatment systems.	10 lectures
Unit IV	Development of mathematical models for different biological treatment systems such as activated sludge process, rotating biological contactor, aerobic & anaerobic filters, UASB reactors and hybrid reactors, solution techniques for various models.	12 lectures

Books:

1. Principle of Surface Water Quality Modeling and Control, R.V. Thomann & J.A. Mullor, Harper & Row Publications, New York, 1984.
2. Physico-Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Intersciences, New York, 1976.
3. Process Chemistry for Water and Wastewater Treatment, Benefield, Judkins & Weand, Prentice Hall Inc., New Jersey, 1982.
4. Stream Sanitation Engineering, E.B. Phelps, John Wiley and Sons, New York, 1982
5. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 1991.
6. Air Pollution & its Control, Perkins, McGraw Hill International, New York, 1986.
7. Environmental Engineering, H.S. Peavy, D.R. Rowe & G. Tachobanoglous, McGraw Hill International, New York, 1985.
8. Environmental Engineering, G. Kiely, McGraw Hill International, New York, 1997.

CE 6013 Advanced Wastewater Treatment Techniques: 4 Credits (3-1-0)

Unit I	Introduction, necessity for advanced wastewater treatment, various treatment techniques.	10 lectures
Unit II	Removal of residual suspended solids by granular medium filtration and micro-screening, control of nutrients, biological nitrification and denitrification.	12 lectures
Unit III	Removal of nitrogen by physical, chemical & biological process, removal of phosphorous by biological methods.	10 lectures
Unit IV	Removal of toxic compounds and refractory organics, removal of dissolved inorganic substances.	10 lectures

Books:

1. Pollution & its Containment, ICE, London, 1984.
2. Physico-Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Interscience, New York, 1976.
3. Hazardous Waste Management, La Grega, Buckingham & Evans, McGraw Hill International, New York, 1994.
4. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 1991.
5. Water Technology, Gray, Viva Book Private Limited, New Delhi, 1999.
6. Biological Control of Nitrogen in Wastewater Treatment, D. Barnes and P J Bliss, E & F N Spoon, London, 1983.

CE 6014 Environmental Impact Assessment and Audit: 4 Credits (3-1-0)

Unit I	Introduction, definition, principle & methods of environmental impact assessment (EIA), current status of EIA.	10 lectures
Unit II	Socio- economic impact, impacts of noise, traffic, landscape, air and climate, soils and geology etc., case studies.	10 lectures
Unit III	Impact predictions and monitoring, interactions between impacts - predictions and integrating of interactions.	12 lectures
Unit IV	Environmental audit.	10 lectures

Books:

1. Pollution & its Containment, ICE, London, 1984.
2. Physico-Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Interscience, New York, 1976.
3. Methods of Environmental Impact Assessment, Peter Morris & Riki Therivel, UCL Press, London, 1995.
4. Environmental Risks and Hazards, S.L. Cutter, Prentice Hall of India Pvt. Ltd., New Delhi, 1999.
5. Environmental Impact Assessment: Theory and Practice, P Wathern, Unwin Hyman, London, 1988.

CE 6015 Solid Waste Management: 4 Credits (3-1-0)

Unit I	Introduction, principles of solid waste management, material flow in society, functional elements of solid waste management.	6 lectures
Unit II	Classification and characteristics of solid wastes – physical, chemical and biological of characteristics and its determination.	8 lectures
Unit III	Solid waste generation in a society and estimation of generation rate, on-site handling and storage, equipment used.	8 lectures
Unit IV	Collection of solid wastes, transfer and transport, processing of solid wastes, equipment used.	8 lectures
Unit V	Ultimate disposal of solid wastes, sanitary landfills, processes occurring in sanitary land-fills, control of gases and leachate. Energy recovery – methods and means, day-to-day solid waste management	12 lectures

Books:

1. Integrated Solid Waste Management, Engineering Principles and Management Issues, George Tchobanoglous, Hilary Theisen and Samuel Vigil. McGraw-Hill Edition (India) Private Limited, New York. 2015.
2. Hazardous Waste Management, La Grega, McGraw Hill International, New York, 1994.
3. Environmental Pollution: Solid Waste, S G Misra and D Prasad, Venus Publishing House, New Delhi, 1992.
4. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, McGraw Hill, New Delhi, 1991.
5. Environmental Engineering, H.S. Peavy, D.R. Rowe & G. Tachobanoglous, McGraw Hill International, New York, 1985.
6. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.

CE 6016 Industrial Pollution and Control: 4 Credits (3-1-0)

Unit I	Introduction, types of industrial pollution: water, air, land and noise pollution, causes and effects.	8 lectures
Unit II	Pollution monitoring and principal control measures.	6 lectures
Unit III	Industrial wastes, types, characteristics, standards, treatment methods and disposal.	12 lectures

Unit IV	Case studies of some typical industries- textiles, leather, fertilizer, pulp & paper mill, slaughterhouse & sugar industries & petroleum refinery.	10 lectures
Unit V	Basic concepts of ecology & ecological balance.	6 lectures

Books:

1. Wastewater Treatment, M.N. Rao & A.K. Data, Oxford & IBH, New Delhi, 1987.
2. Environmental Engineering, Gerard Kiely, McGraw Hill, New York, 1997.
3. Hazardous Waste Management, M D La Grega, P L Buckingham & J.C. Evans., McGraw Hill International, New York, 1994.
4. Industrial Pollution and Control, S.P. Mahajan, Tata McGraw Hill, New Delhi, 1985.
5. Air Pollution, M.N.Rao & H.V.N. Rao, Tata McGraw Hill, New Delhi, 1989.
6. Industrial Water Pollution Control, W W Eckenfelder Jr, McGraw Hill International, Singapore, 1989.

CE 6017 Principles and Practices in Geotechnical Engineering: 4 Credits (3-1-0)

Unit I	Theory of consolidation in three dimensions, Primary and Secondary consolidation; Significance of effective stress principles; Significance of coefficient of consolidation; Probable causes of secondary consolidation, Settlement computations.	12 lectures
Unit II	Shear strength of soils - concept of octahedral stress and strain, stress path, strength - pore pressure relationships; Chi factor, mechanisms of strength generation, Hvorslev's parameters, Energy correction.	10 lectures
Unit III	Slope stability analysis - Alam Singh's rectangular plot method, Janbu's stability charts, Greenwood's simple solution, slopes in clay of increasing strength, wedge failure theory.	10 lectures
Unit IV	Well foundation - analysis and design methods, Terzaghi's theory of rigid bulk heads, Benerjee and Gangopadhyay method based on elastic theory, ultimate soil resistance method, IRC recommendations.	10 lectures

Books:

1. Geotechnical and Foundation Engineering: Design and Construction, Day, Robert W., McGraw Hill, NY, 1999.
2. Principles of Soil Mechanics and Foundation Engineering, Murthy, V.N.S., UBSPD, New Delhi, 2001.
3. Soil Engineering Part-I: Fundamentals and General Principles, Singh, Alam and Chowdhary, G.R., CBS, New Delhi, 1994.
4. Geotechnical Engineering: Principles and Practices, Coduto, Donald P., Prentice Hall Inc, NJ, 1998.
5. Principles of Foundation Engineering, Das, B. M., PWS & ITP Publications, London, 1999.
6. Geotechnical Engineering: Soil Mechanics and Foundation Design Set, Cernica, John N., John Wiley & Sons, NY, 1996.
7. Solving Problems in Soil Mechanics, Sutton, B. H. C., Addison - Wesley Pub. Co, NY, 1993.
8. Manual of Soil Laboratory Testing, Vol. I, II, & III, Head, K. H., John Wiley & Sons, NJ, 1996.

CE 6018 Open Channel Hydraulics: 4 Credits (3-1-0)

Unit I	Uniform flow, properties, design of channel for uniform flow.	10 lectures
Unit II	Gradually varied flow theory, computation of surface profiles in gradually varied flow, Rapidly varied flow.	10 lectures
Unit III	Flow over spillways; Hydraulic jump: location, control and stabilization; Channel design and transitions.	10 lectures
Unit IV	Unsteady flow: basic equations; Uniformly progressive flow; Velocity of flood wave.	12 lectures

Books:

1. Open Channel Hydraulics, V.T. Chow, McGraw Hill International, New York, 1959.
2. Open Channel Flows, M Hanif Chowdhury, Prentice Hall Inc, NJ, 1993.
3. Flow in Open Channels, Subramanya K, Tata McGraw Hill, New Delhi, 1997.
4. Flow through Open Channels, Ranga Raju K G , Tata McGraw Hill, New Delhi, 1994.

CE 6019 Water Resources System: 4 Credits (3-1-0)

Unit I	Objectives and methods of water resources development.	6 lectures
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Unit II	Economic analysis, and discounting techniques; Condition of project optimality.	12 lectures
Unit III	Analytical optimization techniques for multipurpose water resources projects by linear, non-linear and dynamic programming.	14 lectures
Unit IV	Optimization by simulation; Mathematical model for large scale multipurpose projects.	10 lectures

Books:

1. Water Resource Systems Planning & Analysis, Loucks, D.P., J.R. Stedinger & D.A. Haith, Prentice Hall, Inc., N.J., 1981.
2. Water Resources System, Hall, W.H., and J. Dracup, McGraw Hill International, NY, 1970.
3. System Analysis and Design. R J Augilar, Prentice Hall Inc, NJ, 1973.
4. Operation Research, Taha, H.A., Prentice Hall of India, New Delhi, 1997.
5. Introduction to Optimum Design, J.S. Arora, Mc Graw Hill, NY, 1989.

CE 6020 Elements of Earthquake Engineering: 4 Credits (3-1-0)

Unit I	Introduction, origin, propagation, intensity, magnitude and measurement of earthquake size, seismic zoning, risks and consequences.	8 lectures
Unit II	Overview of free and forced vibrations of SDOF; Base isolation; Response spectra.	10 lectures
Unit III	Multi-degree of Freedom System (MDOF); Vibration absorber, modal analysis for displacement and element forces.	8 lectures
Unit IV	Codal provisions for aseismic design of multistory buildings and water towers.	8 lectures
Unit V	Codal provisions for aseismic design of dams, stack like structures- chimneys, bridges; Ductility, demand and ductility capacity.	8 lectures

Books:

1. Elements of Earthquake Engineering, Jai Krishna and A R Chandrasekaran, Nem Chand & Brothers, 1990.
2. Structural Dynamic: Theory and Computations, Mario Paz, CBS, New Delhi, 1985.
3. Dynamics of Structures, Anil K Chopra, Prentice Hall of India, New Delhi, 2000.
4. Dynamics of Structure, Clough and Penzien, McGraw Hill International, New York, 1993.
5. An Introduction to the Theory of Seismology, K E Bullen and B A Bolt, Cambridge University Press, Cambridge, 1985.
6. Earthquake Resistant Design of Masonry Buildings, M Tomazevic, Imperial College Press, London, 1999.
7. Relevant BIS Codes; IS: 1893, IS: 4326, IS: 13920.

CE 6021 Ground Improvement Techniques: 4 Credits (3-1-0)

Unit I	Principles of ground improvement; Strengthening of rocks by pressure grouting, rock reinforcement, and rock freezing.	8 lectures
Unit II	Compaction of soils: theories, factors affecting compaction, field compaction control, shallow and deep compaction methods, vibroflotation and dynamic compaction.	8 lectures
Unit III	Admixture stabilization: stabilization mechanisms, lime, cement and bitumen stabilization, geotechnical applications.	8 lectures
Unit IV	Construction in problematic soils: requirements, incremental or stage construction, renewal of soils by excavation, light weight structural fills, displacement by loading and replacement- micropiles, sand compaction piles, stone columns; Strengthening by in-situ mixing, deep lime column method, slurry injection and jet grouting, jet pile method.	12 lectures
Unit V	Reinforced earth, principles and applications; Geotextiles: principles and applications.	6 lectures

Books:

1. Method of Treatment of Unstable Grounds, Bell, Butterworth, London, 1975.
2. Soil Improvement- History, Capabilities and Outlook, ASCE publication , 1978
3. Soil Engineering in Theory and Practice Vol III: Special Topics, Ed: Alam Singh, Asia Publishing House, New Delhi, 1997.

- Reinforced Earth, T S Ingold, Thomas Telford Ltd, London, 1982.

CE 6022 Systems Approach in Civil Engineering : 4 Credits (3-1-0)

Unit I	Concept of system design, structure of systems, design process, analysis and design, conventional Vs. optimum design.	6 lectures
Unit II	Economic considerations in design: concept of time value of money and interest, interest formulae, cash flow diagrams, economic bases for comparing alternate projects.	8 lectures
Unit III	Concept of optimization, design variables, objective functions and constraints, formulation of linear programming problems slack and surplus variables, solution of LP problem by graphical methods.	8 lectures
Unit IV	Simplex method of solving LP problem artificial variables, two phase simplex, discrete and integer programming by graphical and simplex method (Branch and Bound Method), Duality of an LP problem; Statement and formulation of Transportation and Assignment problems.	12 lectures
Unit V	Minimum weight design of steel structures, formulation based on plastic analysis and solution by graphical methods, examples on beams and frames.	8 lectures

Books:

- Introduction to Optimum Design, J.S. Arora, Mc Graw Hill, NY, 1989.
- System Analysis and Design, R.J. Angilar, Prentice Hall Inc. NJ, 1973.
- Engineering Design, G.Dieter, Mc Graw Hill, NY, 1987.
- Optimization Methods, K.V. Mittal and C. Mohan, New Age International, New Delhi, 1996.
- Plastic Methods of Structural Analysis, B.G. Neal, Chapman and Hall, London, 1965.

CE 6023: Water Pollution Engineering: 4 Credits (3-1-0)

Unit I	Sources of water pollution, laws and regulations, measures of water quality, water quality criteria, decay kinetics.	10 lectures
Unit II	Pollution in rivers and streams: contaminant transport process, Longitudinal dispersion, dissolve oxygen models in rivers, introduction to waste load allocation model,	12 lectures
Unit III	Groundwater quality modeling: groundwater flow equation, hydrodynamic dispersion, advection-dispersion equations, point and non-point source problems.	10 lectures
Unit IV	Water quality in lakes and reservoirs: Natural processes, Eutropication and nutrient recycling, water quality model, restoration and management.	10 lectures

Books :

- Water supply and pollution control, Viessman, Jr. Warren, Hammer, M. J., Perez, E. M. and Chadik, P. A. PHI Learning Private Limited, New Delhi, 2009.
- Environmental Engineering, G. Kiely, McGraw Hill Singapore, 1998.
- Water Quality Engineering in Natural Systems, D. A. Chin, John Wiley & Sons, 2006

CE 6024 Advanced Concrete Technology: 4 Credits (3-1-0)

Unit I	Cement: Hydration products of cement, Microstructure of hydrated cement paste (hcp), Transition zone, effects of microstructures of hcp on engineering properties of concrete; Structure of concrete, Fracture mechanics of concrete, Future trend of development in concrete.	7 lectures
Unit II	Mix Proportioning of high strength concrete and special concretes by BIS, IRC, ACI and British methods.	7 lectures

Unit III	Advanced cementitious composites: Fibre reinforced concrete (FRC), specific requirements FRC for blast proof structures and airfield; Polymer concrete composites.	7 lectures
Unit IV	High workability concrete for multi-storeyed buildings: Pumpable, Self compacting, High performance and Extra high performance of concrete.	7 lectures
Unit V	Low workability concrete for highways and dams: Dry lean concrete, Pavement quality concrete, Roller compacted concrete, Mass concrete	7 lectures
Unit VI	Durability assessment of concrete structures: ND tests of concrete; Permeability of concrete under different pressure conditions; Degradation of concrete; Health assessment, repair and rehabilitation of major concrete structures.	7 lectures

Books:

1. Properties of Concrete, A. M. Neville, Longman, ELBS, London, 1996.
2. Concrete Microstructure, Properties and Materials, P. K. Mehta and Paulo J. M. Monterio, Indian Concrete Institute, 1997.
3. Advanced Concrete Technology, Zongjin Li, John Wiley & Sons, 2011.
4. Handbook on Advanced Concrete Technology, N. V. Nayak and A. K. Jain, Narosa Publishing House, New Delhi, 2012
5. Handbook on repair and rehabilitation of RCC building, CPWD, 2002.
6. IRC:44 Guidelines For Cement Concrete Mix Design For Pavements (Second Revision), 2008.
7. IRC:SP:62-2014, Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads.
8. IRC:SP:49-2014 Guideline for the Use of Dry Lean Concrete as Sub-Base for rigid Pavement.
9. IS 456 : 2000, Plain and Reinforced Concrete - Code of Practice, (4th Revision), BIS.
10. IS 10262 : 2009, Concrete Mix Proportioning – Guidelines BIS.
11. IS 383, 1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, BIS.

CE 6025 Urban Planning and Design: 4 Credits (3-1-0)

Unit I	Theories and concepts of urban planning; garden city, linear city, industrial town, redevelopment.	7 lectures
Unit II	Development plan, town planning schemes, neighborhood.	7 lectures
Unit III	Elements of aesthetics in town planning, perspective on spatial planning; Urban-rural nexus.	7 lectures
Unit IV	Planning surveys & planning norms.	7 lectures
Unit V	Elements of urban settlements, transportations utility services, amenities, housing, informal sectors.	7 lectures
Unit VI	Urban threshold, suburb development; Laws related to planning.	7 lectures

Books :

1. Urban Pattern, Gallion A.B., CBS Publication, New Delhi, 1986.
2. Human Settlement that We Need, C.A. Doxiadis, Tata McGraw Hill, New Delhi, 1976.
3. Policies in Urban Planning, William Solesbury, Pergamon Press, Oxford, 1974.
4. Urban Design, Feddric Gibberd, Architectural Press, London, 1963.
5. The Architecture and Urban Design, Houghton, Evans, Architectural Press, London, 1983.
6. Urban Landuse Planning, Chapin, University of Illinois Press, Urbana, Illinous, 1965.
7. Models of Cities & Regions, Wilson A.G., Rees P.H., and Leight C.M., John Wiley & Sons, NY, 1977.

CE 6026 Theory of Elasticity: 4 Credits (3-1-0)

Unit I	Analysis of stress and strain in 3D, stress-strain relationships; Differential equation of equilibrium compatibility of strains.	10 lectures
Unit II	Plane stress and plane strain problem, two-dimensional problems in rectangular and polar co-ordinates.	8 lectures
Unit III	General theorems in elasticity and their applications, principle of superposition.	8 lectures
Unit IV	Strain energy; Energy principles; Virtual work; Castigliano's theorem, principle of least work.	8 lectures

Unit V Problems of torsion and bending of bars. 8 lectures

Books:

1. Theory of Elasticity, S. Timoshenko & J. N. Goodier, Mc Graw Hill International, NY, 1982.
2. Applied Elasticity, Zhilun Xu, Wiley Eastern Ltd., New Delhi, 1992.
3. Introduction to Solid Mechanics, Irving H. Shames, Prentice Hall of India, New Delhi, 1989.
4. A Treatise on the Mathematical Theory of Elasticity, A.E.H. Love, Dover, New York, 1927.

CE 6027 Finite Element Methods: 4 Credits (3-1-0)

Unit I Basic concepts of FEM, matrix techniques, vibrational methods, concept of an element, displacement models, iso-parametric elements, formulation of element stiffness based on direct, vibrational and weighted residual techniques, mixed and hybrid models. 10 lectures

Unit II Discretization of a body or structure, co-ordinates and shape functions, interconnection at nodes, construction of stiffness matrix and loads for assemblage by different approaches, Boundary condition, solution to one dimensional problems. 8 lectures

Unit III Beams and frames: truss and beam elements, finite element formulations, load vector, boundary conditions, shear force and bending moment, beams on elastic support, plane frames. 8 lectures

Unit IV Two dimensional problems: constant strain triangles, triangular, rectangular and iso-parametric elements, finite element modelling, boundary conditions, numerical integration, axisymmetric problems. 8 lectures

Unit V Three dimensional problems: tetrahedral and prismatic elements, degenerate forms, finite element formulation, stress calculations, solution to three dimensional problems. 8 lectures

Books:

1. Introduction to the Finite Element Method, C.S. Desai and J.F. Abel, Affiliated East-West Press, New Delhi, 1977.
2. The Finite Element Method, O.C. Zienkiewicz Tata Mc Graw Hill, New Delhi, 1979.
3. Introduction to Finite Elements in Engineering, T.R. Chandrapatla and Ashok D. Belegwondn, Prentice Hall of India, New Delhi, 1991.
4. Finite Element Procedures in Engineering Analysis, Klans-Jiirgen Bathe, Prentice Hall of India, New Delhi, 1990.
5. Energy and Finite Element Methods in Structural Mechanics Irving H. Shames and Clive L. Dym, Wiley Eastern Ltd, New Delhi, 1995.

CE 6028 Urban Transportation Systems Planning: 4 Credits (3-1-0)

Unit I Introduction to transportation planning; Urban Travel and Transportation Systems Characteristics, systems approach to transportation planning; types of models; concept of travel demand and supply; socio-economic, land use, network, and transport system characteristics affecting transportation planning; study area definition, zoning principles, cordon and screen lines, data collection through primary and secondary sources, sampling techniques; 12 lectures

Unit II Travel Demands Forecasting; four-stage sequential modeling approach; trip generation; trip distribution; modal split; trip assignment; 12 lectures

Unit III Transport Behavior of Individuals and Households, land use-transport models; public transport planning, integration of different modes; 10 lectures

Unit IV Travel demand management measures; case studies. Introduction to Urban Freight Transportation and Urban Mass Transportation Systems. 08 lectures

Books:

1. Modelling Transport, J. de D. Ortuzar and L.G. Willumsen, John Wiley and Sons, 2001.
2. Transportation Engineering – An Introduction, C.J. Khisty and B.K. Lall, Prentice Hall of India Pvt. Ltd., 2002.
3. Transportation Engineering and Planning, C. S. Papacostas and P. D. Prevedouros, Prentice Hall of India Pvt. Ltd., 2001.
4. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.

5. Principles of Urban Transport Systems Planning, B.G. Hutchinson, McGraw- Hill Book Co., New York, 1974.
6. Traffic Engineering and Transport Planning, L.R. Kadiyali, Khanna Publishers, New Delhi, 2000.
7. Public Transportation, G. E. Gray and L. A. Hoel, Prentice Hall, New Jersey, 1992.

CE 6029 Traffic Engineering: 4 Credits (3-1-0)

Unit I	Driver behavior, traffic information and control systems, traffic studies- volume, speed and delay studies,	10 lectures
Unit II	Elements of traffic flow theory, characteristics of uninterrupted traffic, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, design of signalized intersections, capacity and LOS of signalized intersections, actuated signal control, signal coordination,	10 lectures
Unit III	Traffic Analysis and Management: Capacity and Level of Service concepts, Queuing models and applications, Basics of traffic management. Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection.	12 lectures
Unit IV	Design of parking, lighting and terminal facilities, simulation of traffic systems, statistics and probability in traffic engineering, trends in traffic engineering.	10 lectures

Books:

1. Traffic Engineering, Roger P. Roess, William R. McShane & Elena S. Prassas, Prentice-Hall, 1990.
2. Traffic Engineering – Theory and Practice, Pignataro L. J., Prentice Hall, 1973.
3. Principles of Transportation Engineering, P. Chakorborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.
4. Transportation Engineering: An Introduction, C. J. Khisty and B. K. Lall, Prentice- Hall India, 2003.
5. Traffic System Analysis, Wohl M. and Martin B. V., McGraw-Hill Book Company, 1967.
6. Traffic Engineering, L. R. Kadiyali, Khanna Publishers, 2000.
7. Traffic Flow Fundamentals, A. D. May, Prentice–Hall, 1990.
8. Transportation Engineering and Planning, C.S. Papacostas, Prentice-Hall India, 2001.
9. Highway Capacity Manual (HCM), Transportation Research Board, USA, 2000

CE 6030 Geodetic Surveying : 4 Credits (3-0-2)

Unit I	Triangulation system, strength of figures, selection and inter-visibility of stations, signals & towers, base line measurement, reduction to mean sea level, satellite stations, reduction to centre.	10 lectures
Unit II	Theory of errors and triangulation adjustments- types of errors, principle of least squares, laws of weights, normal equations, method of correlates, station and figure adjustments.	12 lectures
Unit III	Photogrammetry- definition & scope, branches of photogrammetry, photogrammetric methods, stereo-pairs, relief displacement and tilt distortion, flight planning, ground control, plotting instruments.	10 lectures
Unit IV	Astronomical survey- terms and definitions, formula of spherical trigonometry, methods used culmination of stars, circumpolar stars, measurement of times and their conversions, instruments used; Related practice.	10 lectures

Books:

1. Surveying Vol. II & III, B.C. Punamia, Laxmi Publication, New Delhi, 1994.
2. Surveying & Levelling Vol. II, T.P. Kanetkar & S.V. Kulkarni, Pune Vidyarthi Griha Prakashan, Pune, 1985.
3. Surveying Vol. II, S.K. Duggal, Tata McGraw Hill, New Delhi, 1996.
4. Plane & Geodetic Surveying for Engineers Vol. II, David Clark, C.B.S., New Delhi, 1983.
5. A Text Book of Advanced Surveying, R. Agor, Khanna Publishers, Delhi, 1994.
6. Surveying, A. Barmister & S. Raymond, Longman, English Language Book Society, London, 1984.