

CIVIL ENGINEERING

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Civil Engineering deals with natural and man-made built environment - their planning, design, construction and management. The profession encompasses many disciplines including Structural Engineering, Geotechnical Engineering, Hydraulics & Water Resources Engineering, Environmental Engineering, Transportation Engineering, Geoinformatics, and Engineering Geosciences. It is responsible for the largest quantum of resource allocation and utilization in activities ranging from defence and industrial development to social welfare, food production and economic growth.

The undergraduate Civil Engineering professional education at IIT Kanpur starts at the second year level in the four-year B.Tech. and five year B.Tech.-M.Tech. degree programmes. Recognizing the modern pace of development in Civil Engineering, the programme provides basic education in physical sciences including solid, fluid & soil mechanics, materials, earth sciences and geoinformatics, that leads to the planning, design and construction of bridges, buildings, hydraulic structures, environmental systems, and transportation systems including highways, railways, airports, etc. Besides these broad training, students are given the option to pursue electives in any particular area of Civil Engineering. A two-semester project during the fourth year of the B.Tech. degree programme is intended to synthesize their education in several areas. As a student proceeds along the program, the emphasis shifts from analysis to design, and from skill development theoretical to the problem-solving approach.

The objective of the post-graduate program in Civil Engineering at IIT Kanpur is the education of engineers with a deep understanding of scientific principles underlying their specialisation so that they can make fundamental contributions to the field through research and development of advanced technology. Currently, research facilities are available for advanced work in the areas of hydraulics and water resources engineering, environmental engineering, geotechnical engineering, structural engineering, transportation systems engineering, engineering geosciences, and geoinformatics. The five year B.Tech.-M.Tech. Dual Degree students and the two year M.Tech. Degree students undertake research work during the last year of their programme. Facilities are provided for both analytical and experimental research work in well-developed laboratories having modern equipment. Along with courses and research in the major area, students also take courses from other Departments in related fields and basic sciences.

The Department also administers a two year M.Tech. interdisciplinary programme in Environmental Engineering and Management. Details of this programme are given elsewhere in this bulletin.

The Ph.D. programme offers training to the students in four areas : coursework, experimental techniques, independent analytical study, and written & oral presentation.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

FOUR YEAR B.TECH. PROGRAMME

S E M E S T E R				
	FIRST	SECOND	THIRD	FOURTH
C O U R S E	PHY102 MTH101 HSS-I-1/ ENG112N TA101 ESC102 PE101	PHY101 CHM101 PHY103 MTH102 ESC101 CE100 PE102	MTH203 CHM201 ESO204 ESO212 CE251	HSS-I-2 ESO218 TA201 CE222 CE242
S E M E S T E R				
	FIFTH	SIXTH	SEVENTH	EIGHTH
C O U R S E	CE331 CE321 CE361 CE371 CE311	CE322 CE312 CE332 CE362 CE373 CE382	CE451 CE491	CE492

In addition to above, the student must complete the following credits :

DE	12 Credits
OE	12 Credits
HSS-2	08 Credits
SE	08 Credits

The above template is valid for Y6 and Y7 batch students or students joining later in CE. The students of other batches must contact the DUGC Convener, CE for their course templates.

FIVE YEAR B.TECH.-M.TECH. DUAL DEGREE PROGRAMME

SEMESTER					
FIRST	SECOND	THIRD	FOURTH	FIFTH	
PHY102 MTH101 HSS-I-1/ ENG112N TA101 ESC102 PE101	PHY101 CHM101 PHY103 MTH102 ESC101 CE100 PE102	MTH203 CHM201 ESO204 ESO212 CE251	HSS-I-2 ESO218 TA201 CE222 CE242	CE321 CE331 CE361 CE371 CE311	
SEMESTER					
SIXTH	SEVENTH	EIGHTH	SUMMER I	NINTH	TENTH
CE 312 CE322 CE332 CE 362 CE373 CE382	CE451 DE-PG-1 DE-PG-2	DE-PG-3 DE-PG-4 DE-PG-5 DE-PG-6 CE699 (4 Credits)	CE 699 (4 Credits)	DE-PG-7 CE699 12 Credits	CE699 16 Credits

PE - 4 Credits; SE – 4 Credits; HSS-II - 8 Credits; in 5th - 8th Semester

Two Year M.Tech. Programme

SEMESTER			
FIRST	SECOND	THIRD	FOURTH
PG-1 PG-2 PG-3 PG-4	PG-5 PG-6 PG-7 PG-8	CE-699 16 Credits	CE-999 16 Credits

Ph.D. Programme

SEMESTER					
FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH
PG-1 PG-2 PG-3 PG-4	CE-799 16 Credits	CE-799 16 Credits	CE-799 16 Credits	CE-799 16 Credits	CE-799 16 Credits

COURSE DESCRIPTIONS

UNDERGRADUATE COURSES

CE 100 L-T-P-D-[C] 1-0-2-0-[0]	INTRODUCTION TO CIVIL ENGINEERING Overview of Civil Engineering; Civil Engineering Landmarks: Impact (social, economic, environmental) of Civil Engineering on Society; Future directions: Job opportunities in Civil Engineering; Case studies: Hands-on projects, demonstrations, and Field visit.
CE 222 L-T-P-D-[C] 3-1-0-1-[4]	STRUCTURAL ANALYSIS Prereq. ESO 204 Stability and Determinacy of Structures, Analysis of Statically Determinate Structures, Review of shear force and bending moment diagrams in beams and frames, Plane trusses: Deflection of trusses: Deflection of beams and frames: Influence line diagrams and moving loads, Analysis of Statically Indeterminate Structures, Force and stiffness methods of analysis, Plane trusses by using method of consistent deformations, Beams and frames: Plane trusses by using direct stiffness method
CE 242 L-T-P-D-[C] 3-0-2-1-[4]	ENGINEERING GEOSCIENCES Earth System: Lithosphere, Hydrosphere, Cryosphere and atmosphere and their interactions Solid Earth : Shape, size, interior of the solid earth. Geological materials: rocks, soils, minerals (clay mineralogy), Engineering and Genetic classification of soils, rocks, rock cycle, rock-water interaction. Earth Processes and their consequences, Geomorphological features, structures (folds, faults) Earthquakes: Causes, classification, magnitude, intensity, Historical earthquakes, Seismic hazards zoning, strong ground motion, earthquake prediction Landslides and Subsidence: Causes, classification and monitoring; Groundwater: Groundwater resources and quality of ground water Geology of India : Physiographic and tectonic divisions; Mineral resources. Geophysical mapping: seismic, resistivity, radar, geotomography, logging Remote sensing, GIS and GPS : Basic principles and their applications in

monitoring Lithosphere, Hydrosphere, Cryo-sphere and Atmosphere; **Criteria** for site selections for Dam, tunnels, waste/radioactive disposal sites

CE 251

L-T-P-D-[C]

3-0-2-1-[4]

CONSTRUCTION MATERIALS

Introduction and overview of course: Constituents of concrete (Cement, Aggregates): Proportioning of concrete, Fresh concrete, Hardened concrete, Quality control (Sampling, Acceptance, etc.), Transportation and placing, Testing of concrete (including NDT), Admixtures (Chemical, mineral), Concrete and environment; Steel: Manufacture, different types of steel, Steel in Civil Engineering (Structural, reinforcing bars, wires); Bitumen and bituminous mixes: Source, composition, characterization, Various forms, Tests on bitumen Preparation/characterization of bituminous mixes. Mix design, Tests - Dynamic modulus, fatigue, creep and stability;

Bricks and brick masonry: Manufacture, Properties, classification and specifications, Brick masonry and principles of design of masonry structures;

Other materials: Timber, geotextiles, FRPs, Epoxy-coated bar.

CE311

L-T-P-D-[C]

3-1-0-0-[4]

Engineering Hydrology (prerequisite – none) :

Precipitation, Infiltration and Evapotranspiration : Forms of precipitation, measurement, depth-duration and intensity- duration frequency relations, Evaporation - process, measurement, and estimation, Infiltration process, measurement, and estimation. Evapotranspiration measurement and estimation; Runoff and Hydrographs : Rainfall Runoff correlations, Flow duration curve. Mass curve, Droughts and floods, Factors affecting flow hydrograph, Unit hydrograph, its analysis and S-curve hydrograph, Synthetic and instantaneous unit hydrographs ; Statistical analysis : Hydrologic Routing, Risk, reliability, and safety factor, Flood frequency studies ; Flood forecasting : Rational method Time Area curves, Design flood ; Channel and flood routing ; Groundwater hydrology : Flow equations Confined and unconfined flow, Well hydraulics, Steady and unsteady flow, Well losses, Specific capacity ; Irrigation Engineering

CE 312

L-T-P-D-[C]

2-1-2-0-[4]

Hydraulic Engineering (Prerequisite- ESO212)

Pipe Flow : Boundary Layer Concepts, Turbulent Flow, Pipe Networks : Open channel Flow : Uniform Flow, Critical Flow, Gradually Varied Flow, Rapidly Varied Flow, spatially Varied flow ; Unsteady flow : Pipes , Open Channels ; Flow measurement : Viscosity, Pressure , Velocity and turbulence measurements; Forces on immersed Bodies : Drag and lift.

<p>CE 321 L-T-P-D-[C] 3-2-0-1-[4]</p>	<p>DESIGN OF STEEL STRUCTURES</p> <p>Introduction to Design: Design Loads and Load Combinations, Working Stress Design, Plastic Design, LRFD Methods, Introduction to Steel and Steel Structures, Design of tension members, Design of structural fasteners: rivets, bolts and welds, Design of compression members, Design of flexure members: Beams-rolled sections, built-up sections, Plate Girders - riveted/bolted and welded, Design of eccentric connections: riveted/bolted and welded, Design of beam-columns and column bases, Design of steel industrial sheds, Wind Design, Introduction to inelastic actions and plastic hinges: Application of PD and LRFD</p>	<p>Prereq. ESO 204</p>
<p>CE 322 L-T-P-D-[C] 3-2-0-1-[4]</p>	<p>DESIGN OF REINFORCED CONCRETE STRUCTURES</p> <p>Introduction: Structural Systems, Materials, Loadings and Structural Analysis, Introduction to Design of Concrete Structures, Working Stress Design, Ultimate Load Design, Limit State Design, Working Stress Design: For Bending Moment and Shear Force - Rectangular Beams, Limit State Design: For Compression - Columns, For Bending Moment and Shear Force - Beams, For Torsion- Beams, For Combined Compression and Flexure - Beam-Columns, Slabs - One-way; Two-way, Connections (Joints), Design of RC Frame Buildings, Earthquake Design, Ductile Detailing, (Introduction to Capacity Design Concept), Design of Other Structural Components, Flat Slabs; Footings; Walls; Stair Cases.</p>	<p>Prereq. ESO 204</p>
<p>CE 331 L-T-P-D-[C] 3-0-2-1-[4]</p>	<p>SOIL MECHANICS</p> <p>Preview of Geotechnical Problems in Civil Engineering and Infrastructure Development, Description of soil, Engineering geology of soils and their formation, earthquakes and their effects, Stresses within a soil, effective stress principle, stress point and stress path, Soil - water systems- capillarity, flow, Darcy's law, permeability, and tests for its determination, different heads, piping, quicksand condition, seepage, flownets, flow through dams, filters, Compressibility and consolidation characteristics, maximum past stress, OCR, determination of coefficients of consolidation and secondary compression (creep), consolidation under construction loading, Strength and direct and triaxial shear tests, Mohr - Coulomb strength criterion, drained, consolidated undrained and undrained tests, strength of loose and dense sands, NC and OC soils, dilation, pore pressures, Skempton's coefficients, etc. Compaction characteristics, water content - dry unit weight relationships, OMC, max. dry unit weight, field compaction control, etc. Introduction to Geosynthetics, classification, functions, properties - physical, mechanical, hydraulic, environmental, etc. Stability of slopes, limit equilibrium methods, ordinary methods of slices and simplified Bishop method, factors of safety.</p>	<p>Prereq. CE 242</p>

<p>CE 332 L-T-P-D-[C] 2-1-2-1-[4]</p>	<p>GEOTECHNICAL ENGINEERING</p> <p>Introduction, examples of foundation problems - case studies, Characterisation of ground, site investigations, methods of drilling, sampling, in situ test - SPT, CPT, plate load and dynamic tests, groundwater level, etc. Bearing capacity, general, local and punching shear failures, corrections for size, shape, depth, water table, compressibility, etc., ultimate and allowable stresses, methods based on in situ tests, Settlements of foundations, stress in soils (Boussinesq, Westergaard, Mindlin solutions), one and two dimensional cases, immediate, consolidation and creep settlements, methods based on in situ tests, Limit State Design, stability and serviceability states, load and strength factors, Types of foundations - shallow/deep, isolated, combined, mat, etc., contact pressure distributions, soil - foundation interactions, basics of structural design, Ground Improvement Techniques, methods for difficult or problematic ground conditions- soft soils, loose sands, seismic conditions, expansive or collapsible soils, etc., preloading, vertical drains, stone columns, heavy tamping, grouting, etc. Earth Pressure theories, Coulomb and Rankine approaches, c-f soils, smooth and rough walls, inclined backfill, depth of tension crack, Retaining structures, gravity, cantilever, counterfort, reinforced earth, etc., design and checks for stability, Deep foundations, piles, pile groups, well foundations, under-reamed piles, pre-cast, driven cast in situ and bored piles, shaft and base resistances, downdrag, pile load tests, Selected Topics-machine foundations/introduction to environmental geotechnique/application of geosynthetic, etc.</p>	<p>Prereq. CE 331</p>
<p>CE 342 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>ENGINEERING APPLICATIONS OF GEOLOGIC STRUCTURES</p> <p>Rock deformation in nature, Recognition and classification of folds: Faults, Joints, Unconformities; Rock decay and weathering, Interpretation of Geologic maps, Stereograms, airphotos, Satellite imageries; Geophysical methods; Techniques of Field measurement, Applications in foundations, Building Materials, Tunnelling, Underground structures, Landslides, Slope stability, Earthquakes, Mineral exploration, Ground water pollution, Case histories.</p>	<p>Prereq. CE 242</p>
<p>CE 354 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>COMPUTER AIDED DESIGN IN CIVIL ENGINEERING</p> <p>Engineering design principles, interactive design using workstations, and software tools. Programming languages, data structures and their design, Computer graphics, introduction to GKS, Starbase Libraries. Computer aided drafting, data base management system, simulation and optimization. Applications in Civil Engineering, structural design.</p>	
<p>CE 361 L-T-P-D-[C] 3-0-2-1-[4]</p>	<p>ENVIRONMENTAL QUALITY AND POLLUTION</p> <p>Introduction and Scope, Ecology and Environment, Environmental Quality and Pollution, Pollutants, Wastes, Disposal of Wastes, Solid Waste Management,</p>	

Hazardous Waste: Definition; Measurement; Control measures; Management, Air Pollution Control, Noise Pollution, Environmental Impact, Environmental Audit, Laboratory Experiments.

- CE 362N** **WATER SUPPLY AND WASTE-WATER ENGINEERING** **Prereq. CE 361**
L-T-P-D-[C]
3-0-0-1-[4] Water and Wastewater Quantity Estimation, Water Distribution and Sewerage Systems, Elements of Water Supply Scheme, Water/Wastewater Quality Enhancement, Physicochemical Processes, Surface and Ground Water Treatment, Biological Processes for Water and Wastewater Quality Enhancement, Elements of Wastewater Disposal Schemes, Rural Water Supply and Sanitation, Visit to Water and Wastewater Effluent Treatment Plants.
- CE 371** **GEOINFORMATICS**
L-T-P-D-[C]
3-0-3-1-[4] Introduction to surveying, Linear measurements, Compass surveying, Levelling and Contouring, Plane Tabling (PT), Theodolites, Tacheometric surveys, Errors and adjustments, Triangulation, Introduction to photogrammetry and remote sensing, EDM/Total Station/GPS.
- CE 373** **SURVEY AND GEOLOGY CAMP, 4 UNITS** **Prereq. CE 242, CE 371**
- Survey Camp:** Reconnaissance and establishing the stations; Base line measurements, Triangulation readings on various stations; computation and preparation of triangulation map; contouring; preparation of map; preparation of report.
- Geology Camp:** Reconnaissance of the area; Elementary geological field mapping of rock formations and structural details; Geomorphic processes Preparation of report.
- CE 382** **TRANSPORTATION ENGINEERING** **Prereq. CE251, CE331**
L-T-P-D-[C]
3-0-3-1-[4] Analysis of Traffic Flow, Design of Traffic facilities, Pavement Analysis, Pavement Design, Highway Construction, Highway Maintenance.
- CE 412** **HYDRAULIC MACHINES**
L-T-P-D-[C]
3-0-0-0-[4] Fundamentals of hydraulic turbine theory; Turbine performance characteristics and selection of turbines; Design of radial flow and axial flow turbines and Pelton turbines; Fundamentals of Rotodynamic pumps; Centrifugal and axial flow pumps; special duty pumps; cavitation in hydraulic machines.

<p>CE 414 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>RIVERENGINEERING</p> <p>Introduction; Sediment load; Resistance to flow; Regime theories, River training; River modelling; Social and Environmental impacts.</p>	
<p>CE 421 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>STRUCTURAL DESIGN III</p> <p>Design of prestressed concrete structures: limit state design of beams and ties, introduction to miscellaneous structures; design of simple bridges and liquid retaining structures; introduction to design of masonry structures.</p>	<p>PREREQ. CE 322</p>
<p>CE 422 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>ADVANCED STRUCTURAL MECHANICS</p> <p>Matrix structural analysis: displacement and force methods; stress analysis: general state of stress, failure criterion, stress concentration, fatigue failure; analysis of simple problems of plates and shells.</p>	<p>PREREQ. CE 222</p>
<p>CE 423 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>INTRODUCTION TO EARTHQUAKE ENGINEERING</p> <p>Causes of earthquakes and seismic waves, Magnitude, intensity and energy release, Characteristics of earthquakes, Seismic risk; EQ response of structures, Single-degree-of freedom dynamics, Concept of response spectra and introduction to multi-degree-of-freedom systems; Design response spectrum, Idealization of structures, Response spectrum analysis, Equivalent lateral Force concepts; Philosophy of earthquake resistant design, Ductility, Redundancy & over-strength, Damping, Supplemented damping, Base Isolation, Code provisions; Seismic behaviour of concrete, steel and masonry structures, Material properties, Behaviour and analysis of members under cyclic loads, Seismic detailing provisions, Review of damage in past earthquakes.</p>	<p>PREREQ. ESO 204</p>
<p>CE 424 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>SPECIAL TOPICS IN STRUCTURAL DESIGN</p> <p>Detailed engineering design of two to three of the following structures: multistorey buildings, industrial buildings, steel towers, bridges, retaining structures, chimneys.</p>	<p>PREREQ. CE 321, CE 322</p>
<p>CE 432 L-T-P-D-[C] 3-1-0-0-[4]</p>	<p>GROUND IMPROVEMENT TECHNIQUES</p> <p>Need for improvement, Compaction, Preloading, dewatering, admixtures, grouting, heat treatment, ground freezing, inclusion, anchorage, micropiles, stone columns, heavy tamping Electro-kinematic stabilization, Physical and Chemical improvement. Soil reinforcement, Principles, geosynthetics. Vertical drains, Ground anchorage, rock bolting, soil nailing, Deep mixing with lime cement. Emerging trends.</p>	

<p>CE 434 L-T-P-D-[C] 3-1-0-0-[4]</p>	<p>CONSTITUTIVE MODELLING OF SOILS</p> <p>Stress, Strain, elasticity, plasticity. Introduction to the Mechanics of Soils - Critical State Soil Mechanics. Behaviour of soil before failure. Evaluation of Model Parameters.</p>
<p>CE 436 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>MACHINE FOUNDATION DESIGN</p> <p>Principles of dynamics and vibrations, Single degree and Multi degree of freedom systems - free and forced vibrations, Introductions to vibration of continuous systems - wave propagation in soil media, Laboratory and In-situ determination of dynamic soil properties, Introduction to machine foundations and its practical considerations for construction, IS code of practice, Examples.</p>
<p>CE 442 L-T-P-D-[C] 3-0-0-0-[4]</p>	<p>PHYSICAL AND ENVIRONMENTAL GEOLOGY PREREQ. CE 242</p> <p>The Dynamic earth systems, Classification of Geologic materials, Weathering and soil formation, Surface water, Ground water, Oceans and coastlines, Atmospheric and Oceanographic Processes, Techniques of Terrain evaluation, Exploration and utilization of Natural Resources, Man's role in environmental changes, Geologic studies for pollution Abatement, Summary of field and experimental Data.</p>
<p>CE 451 L-T-P-D-[C] 3-0-0-1-[4]</p>	<p>SYSTEMS ANALYSIS IN CIVIL ENGINEERING</p> <p>Introduction to the course and its importance, Optimization methods: -Introduction, Problem formulation, Introduction to mathematical principles in optimization, Solution techniques for linear and integer problems, Introduction to non-linear problems, Civil Engineering Case Studies. Project scheduling, PERT, Inventory and crew scheduling, Decision-making in uncertain environment, Recapitulation of probability theory, Introduction to Game theory, Model Calibration: -Parameter Estimation (point and interval), Hypothesis testing. Examples using Software Packages.</p>
<p>CE 452 L-T-P-D-[C] 3-0-0-1-[4]</p>	<p>PRINCIPLES OF CONSTRUCTION MANAGEMENT</p> <p>Introduction to construction management, Life Cycle of a construction project; Construction equipment and technology; Analysis for technical feasibility; Environmental impact, Economic feasibility; Capital budgeting and investment analysis; Risk analysis in construction projects; Building, Industrial and infrastructure construction-interdisciplinary nature of construction projects; Specifications and quality control; Types of contracts, (Lump Sum, Unit rate, BOT, BOLT, etc.); Estimation of quantities, Legal Issues-construction by-laws, Arbitration; Safety issues in construction projects; Case studies.</p>

CE 454
L-T-P-D-[C]
2-1-0-0-[3]

CONCRETE ENGINEERING

Fundamental concrete science (Mixing, transportation, placing and curing of concrete, properties of fresh and hardened concrete. Using chemical and mineral admixtures); Special concretes, (Mass concrete, hot and cold weather concrete; self compacting, fibre reinforced, and high strength concretes); special construction methods (Mechanized construction, Roller compaction and shotcreting, preplaced aggregate and antiwashout concretes); Special reinforcing materials (Epoxy-coated reinforcing bars, Fiber reinforced plastics); Case studies.

Laboratory studies: Effect of addition of chemical admixtures on properties of paste and mortar. (flow table and setting time measurement). Properties of cement grouts (flow through funnel and bleeding); compare performance of hand-mixed and machine-mixed mortar and concrete; Properties of concrete and some non-destructive tests, Laboratory demonstrations.

CE 455
L-T-P-D-[C]
3-0-0-0-[4]

VIBRATION OF ELASTIC SYSTEM

Concepts of dynamics and Vibrations; Discrete and continuous systems; Damped and undamped systems; Single and Multidegree of Freedom systems; Analytical methods; Transform Methods, Impulse and Earthquake response; Earthquake response spectra, Response of multidegree of freedom systems; Numerical Methods for free and forced Vibration Analysis; Continuous systems; Vibration Control.

CE 462
L-T-P-D-[C]
2-0-0-0-[3]

ENVIRONMENTAL MANAGEMENT IN INDUSTRIES

PREREQ. CE 361

Sources and types of wastes: solid, Liquid, and gaseous wastes; Control and Removal of specific pollutants in Industrial wastewaters: eg. Oil and grease. cyanide, Flouride, Toxic organics, Heavy metals, Radioactivity etc.; Solid and Hazardous wates: definitions, concepts and managemnt aspects; Control of gaseous emissions: Identification of chimney and fugitive sources, their quantification, fuel quality, combustion processes. Particulate and gaseous pollutant control; Recent trends in Industrial waste management: Cradle to Grave concept, life cycle analysis and clean technologies; Case studies of various industries: Dairy, Fertilizer, Distillary, Sugar, Pulp and paper, Iron and Steel, Metal plating, Thermal power plants, etc.; Environmental audit: Definitions and concepts, environmental audit vs. accounts audit, compliance audit relevant methodologies, regulations; Introduction to ISO and ISO 14000, Preparation and implementation of environmental Management Plans.

CE 463 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT
 L-T-P-D-[C] **PREREQ. CE 361 & CE 362**
 3-0-0-0-[4]

Environmental legislations and international treaties, Environmental systems and their interactions, global/regional environmental issues, Environmental Impact Assessment (EIA), definitions, methodologies and concept of sustainable development, Environmental toxicology, Risk Assessment, in environmental management, Principles of risk assessment, pollutant exposure assessment, conceptual models and ecological risk.

CE 472 PRINCIPLES OF REMOTE SENSING
 L-T-P-D-[C]
 3-0-0-0-[4]

Introduction; Energy source and radiation principles; Remote sensing systems, Multispectral scanners (MSS); Thermal infrared line scanner, sideways looking airbourne radar; Spectral pattern recognition - visual and digital techniques; Classification; Data acquisition from LANDSAT, SPOT, ERS, IRS; Analysis of digital data products from MSS and TM; Digital enhancement techniques (LAB); Application of remote sensing in resource evaluation.

CE 491 PROJECT I,
 L-T-P-D-[C]
 0-0-4-0-[2]

CE 492 PROJECT II
 L-T-P-D-[C]
 0-0-6-0-[3]

Topics should preferably be design, development, design aid type and interdisciplinary. The project should aim at training the students in going through all important phases of project studies starting from establishing the need through collection of data, analysis, design, development, drawing, cost estimates and project reports. Wherever appropriate some alternatives which meet the same needs should also be considered and evaluated using appropriate evaluation criteria.

POSTGRADUATE COURSES

CE 602 ADVANCED MATHEMATICS FOR CIVIL ENGINEERS
 L-T-P-D-[C]
 3-0-0-0-[4]

Linear differential equations; Fourier integrals and transforms; Partial differential equations; Numerical methods in general; Numerical methods for differential equations; Linear algebra; Numerical methods in linear algebra; Data analysis, Probability theory; Mathematical statistics.

CE 610 HYDRAULIC STRUCTURES
 L-T-P-D-[C]
 3-0-0-0-[4]

Advanced topics in the design and construction of dams: spillways, stilling basin

Intake works, tunnels and penstocks, gates, surge tanks, power house structures, etc.

CE 611
L-T-P-D-[C]
3-0-0-0-[4]

ENGINEERING HYDRAULICS (3-0-0-4)

Basics: dimensional analysis, equations of continuity, motion, and energy, irrotational flow, drag and lift of immersed bodies; Pipe flow: laminar flow, turbulent flow, boundary layer theory, wall turbulent shear flow, free turbulent shear flow; Open Channel flow: energy-depth relationships, uniform flow, gradually varied flow, hydraulic jump, rapidly varied flow, spatially varied flow, unsteady flow.

CE 612
L-T-P-D-[C]
2-0-2-0-[4]

FLUID MECHANICS LABORATORY

Verification of momentum equation; Friction loss in pipes; Rainfall-runoff relationship; Flow over sharp crested weir; Flow in pipe networks; Bernoulli theorem; Fall velocity of objects; Point velocity measurement by ADV; Reynolds' apparatus; Venturimeter and orifice meter; Energy loss in bends; Ground water flow/ well abstraction; Hydrogen bubble flow visualization; Hydraulic jump; Flow past a cylinder

CE 613
L-T-P-D-[C]
3-0-0-0-[4]

SEDIMENT TRANSPORTATION (3-0-0-4)

Properties of sediment, incipient motion, bed load, suspended load, total load, sediment measurements, regime concept, bed form mechanics, plan form and stream bed variations of rivers, reservoir sedimentation, erosion and deposition, sediment control, sediment transport in pipes.

CE 614
L-T-P-D-[C]
3-0-0-0-[4]

HYDROLOGIC ANALYSIS AND DESIGN

The hydrologic processes: precipitation, evaporation, infiltration, groundwater, and stream flow; Hydrologic measurements and networks; Analysis of discrete and continuous hydrologic data: harmonic analysis, statistical analysis including frequency analysis, correlation, and regression analysis and multivariate analysis, time series analysis and its applications; System analysis and synthesis; Linear and non - linear, lumped and distributed parameter systems; Queing models, simulation analysis; Hydrologic design of water resources systems.

CE 617
L-T-P-D-[C]
3-0-0-0-[4]

GROUNDWATER SYSTEMS ANALYSIS

Prereq. CE 614

Digital simulation models for groundwater development, application of finite difference and finite element methods for solving problems in groundwater development and management; Analog methods: direct electric analog, viscous flow analog and other analogs; Optimisation methods, models for conjunctive

development of surface and groundwater; Special problems in ground-water development and management; Artificial recharge, ground subsidence, salt water intrusion and others.

CE 619

L-T-P-D-[C]

3-0-0-0-[4]

WATER RESOURCES ENGINEERING

Water resources systems: components of the system, objectives of water resources development, development, planning, and design, construction and operation of water resources systems; System demands, geographic and geological aspects; Hydrological implications, economic, social and political consideration in system development; Benefits and costs; Economic objectives: mathematical and econometric principles in optimal system design, numerical and digital computer methods in hydraulic and water resources engineering.

CE 620

L-T-P-D-[C]

3-0-0-0-[4]

STRUCTURAL DYNAMICS (3-0-0-4)

Loading: nature of dynamic loading, harmonic, random, types of dynamic loading; Continuous systems: rods (axial vibrations), beams (shear, axial and axial-shear-flexural vibrations); Discrete mass systems: SDOF (free and forced vibrations), MDOF (generalized coordinates, eigenvalue analysis, matrix and modal time history analysis); Introduction of random vibration: stochastic processes, stochastic analysis of linear dynamical systems to Gaussian inputs, SDOF, MDOF.

CE 621

L-T-P-D-[C]

3-0-0-0-[4]

ENGINEERING MECHANICS

Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain: deformation and velocity gradients, Lagrangian and Eulerian description and finite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Fundamental physical principles: conservation of mass, linear momentum, angular momentum, and energy, second law of thermodynamics; Constitutive theory: St. Venant's principal, linear elasticity and generalized Hook's law, Stokesian and Newtonian fluids, Navier-Stokes equations, Bernoulli equation, linear viscoelasticity, yield criteria; Applications: Airy stress function, two-dimensional elastostatics problems, torsion.

CE 622

L-T-P-D-[C]

3-0-0-0-[4]

STABILITY OF STRUCTURES

Criteria for design of structures: stability, strength, and stiffness; Classical concept of stability; Stability of discrete systems: linear and nonlinear behaviour; Stability of continuous systems: stability of columns: axial-flexural buckling, lateral bracing of columns, combined axial-flexural-torsion buckling; Stability of frames: member buckling versus global buckling, slenderness ratio of frame members; Stability of beams: lateral-torsion buckling; Stability of plates: axial-

flexural buckling, shear flexural buckling, buckling under combined loads; Introduction to inelastic buckling and dynamic stability.

CE 623

L-T-P-D-[C]

1-0-2-3-[4]

EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING

Similitude and structural models: dimensional analysis, Buckingham's Pi theorem, scale factors and dynamic similitude; Uses and applications of models: types of model investigation, indirect and direct models, elastic and inelastic models (steel, concrete and masonry), size effects; Analysis of experimental data: error and uncertainty in experiment, measurement systems, accuracy in models and reliability of results; Test planning, design and implementation: testing sequence and experimental plan, loading systems, devices, actuators and their control; Instrumentation: mechanical, electrical, electronic system and their calibration, various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, full-field measurements; Data acquisition system and data processing: analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archiving; Lab exercises: experiments to illustrate buckling of structural members; load-deformation behaviour of beams, columns, joints, and frames under various loads, mode shapes, natural frequency, damping factors from free and forced vibrations, shake table tests.

CE 624

L-T-P-D-[C]

3-0-0-0-[4]

ADVANCED STRUCTURAL ANALYSIS

Basics of structural analysis: static & dynamic loading, linear & nonlinear structural behaviour, geometric & material nonlinearity, hysteretic behaviour; Classical linear analysis of frames and trusses: displacement method, slope deflection equations & matrix displacement method, effect of foundation settlement and temperature; Geometric nonlinear analysis of frames and trusses: displacement method, nonlinear slope-deflection equations & nonlinear behaviour, linearized iterative matrix displacement method, geometric stiffness matrix, tangent stiffness matrix, P- Δ effect, buckling of frames, tension structures; Material nonlinear analysis of frames: basics of plasticity, distributed plasticity & lumped plasticity, incremental nonlinear analysis.

CE 625

L-T-P-D-[C]

3-0-0-0-[4]

MASONRY STRUCTURES

Properties of constituents: units - burnt clay, concrete blocks, mortar, grout, reinforcement; Masonry bonds and properties: patterns, shrinkage, differential movement, masonry properties - compression strength ; Stresses in masonry walls: vertical loads, vertical loads and moments - eccentricity & kern distance, lateral loads - in-plane, out-of-plane; Behaviour of masonry walls and piers: axial and flexure, axial- shear and flexure, Behaviour of Masonry Buildings: unreinforced masonry buildings - importance of bands and corner & vertical reinforcement, reinforced masonry buildings - cyclic loading & ductility of

masonry walls; Behaviour of masonry infills in RC frames: strut action; Structural design of masonry in buildings: methods of design - WSD, USD, seismic design - seismic loads, code provisions, infills, connectors, ties; Seismic evaluation and strengthening of masonry buildings: methods - in-situ, non-destructive testing; Construction practices and new materials.

CE 626

L-T-P-D-[C]

3-0-0-0-[4]

ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES

Design of reinforced concrete structures: methods of design - WSD, LSD, ULD, LRFD, review of LSD - flexure, axial-flexure, shear, torsion; Strut and Tie Models: basics - B and D Regions, modeling of P, V, M, T, P-V-M, supports and load points; Capacity design concept: flexure design, shear design, strong-column weak-beam philosophy; Beam-column Joints: loading, effects under seismic loading, beam bar anchorage, transverse reinforcement; Collapse Mechanisms: basics - beam, storey and sway mechanisms, progressive versus gradual collapse, demand-capacity ratios - incremental DCRs & pushover analysis, Ductility of Reinforced Concrete Structures: material ductility- steel & concrete, section ductility, member ductility, structural ductility.

CE 627

L-T-P-D-[C]

3-0-0-0-[4]

ADVANCED DESIGN OF STEEL STRUCTURES

Properties of steel: mechanical properties, hysteresis, ductility; Hot-Rolled Sections: compactness and non-compactness, slenderness, residual stresses; Design of steel structures: inelastic bending - curvature, plastic moments, design criteria - stability, strength, drift; Stability criteria: stability of beams - local buckling of compression flange & web, lateral-torsional buckling, stability of columns - slenderness ratio of columns, local buckling of flanges and web, bracing of column about weak axis, method of design - allowable stress design, plastic design, load and resistance factor design; Strength Criteria: beams - flexure, shear, torsion, columns - moment magnification factor, effective length, P-M interaction, bi-axial bending, joint panel zones; Drift criteria: P- Δ effect, deformation-based design; Connections: types - welded, bolted, location - beam-column, column-foundation, splices.

CE 628

L-T-P-D-[C]

3-0-0-0-[4]

DURABILITY OF CONCRETE STRUCTURES

Concrete and the environment: interaction; Overview of concrete deterioration: alkali-aggregate reaction, corrosion, carbonation; Permeability of concrete and its measurement: penetration of carbon dioxide and chlorides into concrete, corrosion of steel in concrete - electrochemistry of corrosion, micro and macro cell corrosion, corrosion cells and currents, role of concrete, prevention of corrosion; Corrosion induced longitudinal cracks: nature and properties of corrosion products; Alkali aggregate reaction: reactive minerals, mechanism of

deterioration, identification and tests; Codal provisions for durability; Nondestructive testing; repair/rehabilitation of structures.

CE 629

EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES

L-T-P-D-[C]

3-0-0-4-[4]

Characteristics of earthquakes; Earthquake response of structures; Concept of earthquake resistant design; Code provisions of design of buildings; Design of liquid storage tanks; Liquefaction; Non-engineered construction; Special topics: bridges, dams, strengthening of existing buildings.

CE 630

ROCK MECHANICS

L-T-P-D-[C]

3-0-0-0-[4]

Physical properties and classification of intact rock and rock masses, rock exploration, engineering properties of rock, stresses in rock near underground openings; Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design.

CE 631

ADVANCED GEOTECHNICAL ENGINEERING

L-T-P-D-[C]

3-0-0-0-[4]

Soil composition and soil structure; Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Shear strength and stress-strain relationships of soils; Stability of slopes; Arching effects; Buried Structures

CE 632

FOUNDATION ANALYSIS AND DESIGN

L-T-P-D-[C]

3-0-0-0-[4]

Settlement and bearing capacity: shallow spread footings, mats, and deep foundations; Foundation models, contact pressure distribution for footings, rafts, piles; Retaining Structures; Soil-structure interaction studies; Case studies.

CE 633

REINFORCED EARTH STRUCTURES

L-T-P-D-[C]

3-0-0-0-[4]

Reinforcing materials; Advantage of RE; Behaviour of Reinforced earth walls; Soil reinforcement interaction internal and external stability condition; Field application of RE; Randomly reinforced earth and analysis of reinforced soils; Testing of soil reinforcements; Development, fabrication, design, and applications of geotextiles, geogrids, geonets, and geomembranes.

CE 634

GROUND IMPROVEMENT TECHNIQUES

L-T-P-D-[C]

3-0-0-0-[4]

Engineering properties of soft, weak and compressible deposits; Principles of treatment-loading (static and Dynamic); Accelerated flow; Reinforcement; Drainage

and filters, Injections, thermal, electrical and Chemical Methods; Preloading; Dynamic Consolidation; Vertical drains; Granular piles; Soil nailing; Anchors; Design methods and case studies.

CE 635

L-T-P-D-[C]

3-0-0-0-[4]

FOUNDATION DYNAMICS

Dynamics of elastic systems; Single and multi-degrees of freedom systems; Empirical and semi-empirical approaches to the theory of soil dynamics; Elastic theories of soil dynamics; Wave propagation; Dynamic soil properties; Design of machine foundations; Vibration isolation; Pile dynamics.

CE 636

L-T-P-D-[C]

3-0-0-0-[4]

GEOTECHNICAL EARTHQUAKE ENGINEERING

Introduction; Seismic Hazards: Mitigation of Seismic Hazards, seismology and earthquakes, strong ground motion, seismic hazard analysis; Wave propagation in unbounded media: in semi-infinite bodies, in layered soils and attenuation of stress waves; Dynamic soil properties; Ground response analysis; Effect of local site conditions on ground motion; Liquefaction: evaluation of liquefaction hazards, effects of liquefaction; Case studies.

CE 637

L-T-P-D-[C]

3-0-0-0-[4]

CONSTITUTIVE MODELING OF FRICTIONAL MATERIALS

Role of constitutive modeling; Importance of laboratory testing with relation to constitutive modeling; Elasticity: linear, quasilinear, anisotropic; Plasticity basics: yield criteria, flow rule, plastic potential, hardening/softening; Rate Independent Plasticity: mohr-Coulomb, non-linear failure criteria, Drucker-Prager, and cap models; Critical state soil mechanics: critical state concept, cam-clay models, simulation of single element test using cam-clay, consolidation, drained and undrained triaxial test; Stress-dilatancy theory; Work hardening plasticity theory: formulation and implementation; Applications of elasto-plastic models; Special Topics: hypoelasticity-plasticity, disturbed state concept.

CE 638

L-T-P-D-[C]

1-0-3-3-[4]

GEOTECHNICAL INVESTIGATIONS FOR CE PROJECTS (1-0-3-3)

Subsurface exploration planning, drilling and sampling techniques, field and laboratory tests, instrumentation and monitoring of field data, report preparation.

CE 639

L-T-P-D-[C]

3-0-0-0-[4]

ANALYTICAL AND NUMERICAL METHODS IN GEOMECHANICS

Finite difference, finite element and other analytical methods of solution to (i) Elasticity and stability problems in Geomechanics, (ii) Analysis of response of soil media to applied loads, (iii) Limiting equilibrium, Failure theories, Method of characteristics, (iv) Limit analysis, etc.

CE 640 L-T-P-D-[C] 3-0-0-4-[4]	EARTH SYSTEM PROCESSES Introduction; Controls of earth system processes, geomorphic systems, threshold and equilibrium, scale of analysis; Endogenic processes and landforms, global morphology and plate margin landforms; Exogenic processes and landforms, fluvial, coastal, aeolian and lacustrine processes & landforms; Endogenic-exogenic interactions; Long-term landscape development; Interaction between lithosphere, hydrosphere, atmosphere and cryosphere.
CE 641 L-T-P-D-[C] 3-0-0-0-[4]	ENVIRONMENTAL GEOLOGY Earth-environment interaction; Fundamental concepts of environmental geology, Environment of water, sediments and soils, Weathering, soil formation and erosion; Water quality controls in nature; Environmental impact of resource exploration and use; Land use management; Geological considerations of toxic and radioactive waste disposal; Environment vs. development.
CE 642 L-T-P-D-[C] 3-0-0-0-[4]	GEOLOGICAL HAZARDS Geological hazards and environmental impact; Landslides: cause, classification, zonation and protection; Earthquakes: historical seismicity, classification, interplate and intraplate earthquakes, effect on ground structures, magnitude and intensity scales, seismic zonation; Floods: hydrology and types of floods, nature and extent of flood hazard, flood hazard zoning, flood control and protection; Land subsidence; Snow avalanches; Rock bursts; Mapping, monitoring and management of geological hazards.
CE 643 L-T-P-D-[C] 3-0-0-0-[4]	RESOURCE EXPLORATION TECHNIQUES Introduction to earth, ocean and snow and their environments; Various resources (water, hydrocarbon, minerals) and their occurrences, nature and characteristics; Physical and engineering properties of various resources; Airborne, ground and borehole techniques: seismic, electrical, electromagnetic, radar, gravity, magnetic, self-potential, radioactive geotomography and logging techniques; Estimation of resources; Impact of growing population on earth, ocean and snow resources.
CE 644 L-T-P-D-[C] 3-0-0-0-[4]	SATELLITE REMOTE SENSING AND GIS FOR GEO-RESOURCE EVALUATION Basic principles of image interpretation and GIS; Interpretation of regional geological and geomorphological features; River basin studies; Identification of groundwater potential zones; Lake and wetland studies; Water quality mapping; Vegetation Mapping and forestry applications; Applications in glaciology and snow hydrology; Applications in oceanography and coastal zone mapping; Mineral resources evaluation; Microwave remote sensing and its application in monitoring earth resources, snow surface, ocean and atmosphere; Application of thermal

infrared data for mapping surface moisture and rock types and environmental studies.

CE 645

L-T-P-D-[C]

3-0-0-0-[4]

PHOTOGEOLOGY IN TERRAIN EVALUATION

Introduction to physical and structural geology; Landforms and drainage patterns; Elements of photogeology; Stereoscopy; Elementary photogrammetry; Photographic systems, types of cameras, films and filters; Photo-interpretation key; Quantitative interpretation of toposheets and airphotos; Applications in engineering geology, landuse, land wastage, hydrogeology, mineral exploration and change detection.

CE 646

L-T-P-D-[C]

3-0-0-0-[4]

GLOBAL CLIMATE CHANGE

Introduction to global climate; Global climatic models; Methods of reconstructing climate; Quaternary climates, sea level changes, glacial/interglacial cycles; Geological records of climate change, sedimentology, stable isotopes, geochemistry; Geochronology - relative and numerical methods; Vegetation dynamics, migration history, response of vegetation to climatic reversals; Pre-quaternary climates, evolution of climate through geological time.

CE 647

L-T-P-D-[C]

3-0-0-0-[4]

PALEOSEISMOLOGY AND TECTONIC GEOMORPHOLOGY

Plate tectonic and its relation to earthquakes; Historical and modern seismicity; Mapping of active tectonic landforms in different tectonic environments; Field techniques in paleoseismology, identification of old (prehistoric) earthquake by trenching, estimation of magnitude, slip rates, and recurrence interval of faults, prediction of future earthquake, identification of paleo-liquefaction features; Dating techniques; Correlation of paleoseismic data with existing geodetic and geophysical data; Delineation of seismogenic faults and their related seismic hazard; Seismic hazard assessment (SHA).

CE 648

L-T-P-D-[C]

1-0-4-4-[4]

LABORATORY PRACTICES IN GEOSCIENCE

Remote sensing applications: features extractions from remote sensing data, reflectance and NDVI calculations and change analysis; Resistivity survey: determination of layered parameters (resistivity and thickness of layers); Shallow seismic survey: determination of layered parameters (seismic velocity and thickness of overburden); Ground penetrating radar: identification of sub-surface utility, data acquisition and processing, mapping of shallow sub-surface sedimentary sequence, mapping of shallow sub-surface deformation; GPS: measurement of location with the help of GPS geo-referencing of the satellite data, determination of crustal movements using GPS; Core logging: facies characterization and stratigraphic mapping from sediment cores; Grain size analysis: grading of

sediments; Magnetic susceptibility: measurement of susceptibility of sediments and rocks samples.

CE 650

L-T-P-D-[C]

2-1-0-4-[4]

DIGITAL SIMULATION

Methodology of system simulation; Mathematical modelling of systems and processes including analysis and interpretation of data; Verification of models; Data generation and validation; Sample size and variance reduction; Special Simulation Languages like SIMULA: design of Computer Simulation Experiments; Response surface analysis; Analysis of Simulated data. Case studies from different fields. A project on a specific problem.

CE 671

L-T-P-D-[C]

3-0-2-5-[4]

INTRODUCTION TO REMOTE SENSING

Remote sensing system; Physics of remote sensing, EMR characteristics and interaction in atmosphere and with ground objects; Sensor types characteristics: types of resolution, FOV, IFOV, PSF; RS satellites and data products; Image processing, interpretation elements; Classification; Geometric and radiometric distortions, Geo-referencing, resampling methods; Atmospheric errors and removal; Satellite orbits and characteristics; Applications of optical and microwave remote sensing techniques in Civil Engineering.

CE 672

L-T-P-D-[C]

3-0-0-0-[4]

MACHINE PROCESSING OF REMOTELY SENSED DATA

Image processing system; Preprocessing of remotely sensed data; Radiometric and Geometric distortions and corrections; Image enhancement; Image transformations; Pattern recognition.

CE 673

INSTRUMENTATION, LABORATORY AND FIELD PRACTICES IN GEOINFORMATICS (3 CREDITS)

Use of automatic and digital levels, electronic theodolites, total stations, plane tabling; Control surveys using GPS, Total station and triangulation methods (adjustment and computations of coordinates); Cartography and report writing.

CE 674

L-T-P-D-[C]

2-0-2-4-[4]

GLOBAL POSITIONING SYSTEM

Basic concepts: pseudo range and carrier phase measurements; Signal structure; GPS coordinate systems: WGS-84, GPS time; GPS Errors and biases; GPS orbital Geometry and Navigational solution; Surveying with GPS; Planning and field observations; Data post-processing; GIS and GPS integration; Other satellite based navigational systems: GLONASS, GALILEO, modernization plans of navigational satellites.

CE 675
L-T-P-D-[C]
2-0-2-4-[4]

GEOGRAPHICAL INFORMATION SYSTEM

Introduction; GIS data: spatial and non-spatial, spatial data model: raster, tessellation, vector, 2.5D model; Topology and topological models; Spatial referencing using coordinates and geographic identifiers, metadata; Spatial data acquisition; Attribute data sources; Spatial and attribute data input; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Quality of spatial data; GIS analysis functions: Retrieval, classification, measurement, neighborhood, topographic, interpolation, overlay, buffering, spatial join and query, connectivity, network functions, watershed analysis, viewshed analysis, spatial pattern analysis, spatial autocorrelation, trend surface analysis; GIS presentation functions: Visual communication theory, design theory, data visualization methods, exporting data; Modern trends: Internet GIS, 3D GIS, physical modeling under GIS environment.

CE 676
L-T-P-D-[C]
2-0-3-4-[4]

PRECISION REMOTE SENSING

Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laser interaction with objects; Airborne Altimetric LiDAR: principle: topographic and bathymetric LiDAR, multiple return, full wave digitization; Components of a LiDAR system, INS technology, INS-GPS integration, measurement of laser range, calibration; Flight planning; LiDAR geolocation models; Accuracy of various components of LiDAR and error propagation, error analysis of data and error removal; Data classification techniques, raw data to bald earth DEM processing, uses of return intensity and full waveform in information extraction, LiDAR data integration with spectral data; LiDAR applications: building, tree, power line extraction; LiDAR data visualization; Photogrammetry: metric and non-metric cameras; Geometry of near vertical and tilted photographs, heights and tilt distortions; Rectification and orthophotographs; Stereoscopy, parallax equation and stereo measurements for height determination; Orientation- interior, exterior, relative, and absolute, Mathematical model relating image, model and object space; Collinearity and coplanarity conditions, DLT; Image matching techniques; Strip and block triangulation and adjustment; Automatic DTM and Orthophoto production.

CE 677
L-T-P-D-[C]
3-0-0-0-[4]

GEOSPATIAL DATA PROCESSING

Geodetic reference systems: ICRF and ITRF, Geodetic datums, Earth ellipsoid; basic geometric geodesy; Coordinate systems and transformation; Map projections, geoid and geoidal heights and undulations; Observations and mathematical model, precision and accuracy, rejection of observations, weights and cofactors, correlation and covariance, propagation of errors and variance-covariance; Least squares adjustment computations; Sequential processing and Kalman Filtering; Variance-covariance of adjusted data, error ellipse and error ellipsoid; Statistical

analysis of adjusted data; Introduction to GPS; Code and phase measurements; Models for single point positioning and relative positioning using code and phase data; Methods of interpolation; Geostatistical tools: variogram and krigging.

CE 680

L-T-P-D-[C]

3-0-0-0-[4]

TRAFFIC FLOW MODELLING AND SIMULATION

Traffic flow characteristics; deterministic and stochastic models of stream flows; Car following models, stability and diffusion phenomena in traffic; Boltzmann models. Signalized and unsignalized intersections, Coordination and optimization of network of signalized intersections; pedestrian flow problems. Fundamentals of traffic simulation modeling. Simulation methodologies and model design. Simulation languages, Study of large scale simulation models such as VTI, Transyt, Sigop, etc.

CE 681

L-T-P-D-[C]

3-0-0-0-[4]

ANALYSIS AND DESIGN OF PAVEMENT SYSTEMS

Subsystems of Pavement Design; Basis of Pavement Design; Development of various design methods for highway and airport pavements; Pavement support conditions, Properties of components and design tests; Materials of Construction and Construction procedures for different types; Soil Stabilizations methods; Quality control and tolerance; Mathematical models for pavement systems; Landing gears; vehicle pavement interaction; Computer Programming for various pavement analysis and design methods; pavement management process, pavement evaluation and performance; Design alternatives-Analysis, Evaluation and Selection.

CE 682

L-T-P-D-[C]

4-0-0-5-[4]

ANALYSIS AND DESIGN OF TRANSPORTATION INFRASTRUCTURE

Introduction to supply and demand sides of transportation engineering, analysis of transportation demand (including topics such as category analysis, gravity model, entropy models, choice models, user equilibrium models, etc.). Introduction to public transportation. Designing efficient public transport systems (including topics such as route development, schedule development, pricing strategies, etc.). Concept of structural, functional and drainage design of pavement structure. Design of flexible and rigid pavement - various approaches. Cost and reliability considerations. Pavement maintenance issues. Pavement distresses, distress evaluation, maintenance measures, and network level maintenance strategy.

CE 683

L-T-P-D-[C]

3-0-0-0-[4]

TRAFFIC ENGINEERING

Microscopic and macroscopic traffic parameters, traffic flow models, car-following models, capacity and level of service analysis, design of traffic facilities like unsignalized and signalized intersections, inter changes, expressways, traffic signs, parking areas etc., simulation of traffic streams.

CE 684 L-T-P-D-[C] 3-0-0-0-[4]	URBAN TRANSPORTATION SYSTEM Dimensions of the widening role of urban transportation system planning; the planning process; land use and transport system models; comparison and evaluation of various models; transportation impact study methodologies; strategies for the evaluation of alternative transportation plans and plan implementation; Regional analysis and plan implementation; Regional Analysis and development concepts; the role of transportation planning in the overall regional system; methodology and models for regional transportation system planning; implementation framework and case studies.
CE 685 L-T-P-D-[C] 3-0-0-0-[4]	RAIL TRANSPORTATION SYSTEMS PLANNING AND DESIGN Rail Transportation System; Demand analysis and forecasting for passenger and freight traffic costing and pricing principles, project analysis and design; project interdependencies and programming techniques; systems analysis and systems planning; macroeconomic transportation simulator; case studies and implementation strategies.
CE 688 L-T-P-D-[C] 3-0-0-0-[4]	AIRPORT SYSTEMS PLANNING AND DESIGN Air Transport-structure and organization, the challenges and the issues, Forecasting air travel demand-trend forecasts and analytical methods; Air freight demand, Characteristics of the aircraft as they affect airport; Airport planning-requirements: site selection, layout plan and financial plan; Air traffic control lighting and signing; Airport capacity and configuration; Geometric design of runway, taxiway and aprons; passenger terminal functions, passenger and baggage flow, design concepts, analysis of flow through terminals, parking configurations and apron facilities; Air cargo facilities-flow through cargo terminals, unitized systems; Airport drainage and pavement design; Airport access problem; Environmental impact of airports.
CE 689 L-T-P-D-[C] 1-0-4-4-[4]	CHARACTERIZATION OF PAVEMENT MATERIALS AND ANALYSIS OF PAVEMENTS Components of a pavement structure. Experimental characterization of pavement materials - bituminous mix, aggregates, subgrade, cemented material. Material modeling - visco-elastic, visco-plastic behaviour. Load stresses in pavements, generalized multi-layer solution - Burmister layer, slab, foundation models. Static and dynamic analysis. Fatigue and rutting modeling and calibration. Temperature stresses in pavements. Estimation of cumulative damage.
CE 690 L-T-P-D-[C] 0-0-6-3-[4]	LABORATORY COURSE IN TRANSPORTATION ENGINEERING (0-0-6-3) Experiments to characterize pavement materials like, viscosity tests, ageing

tests, skid tests, etc. Experiments to characterize bituminous mixes, like mix design related experiments, moisture sensitivity related experiments, etc. Experiments related to traffic data collections on speed, volume, travel time, delay, etc. Traffic studio (students will learn to use geometric design software and video data analysis software). Demonstrations of various equipments including possible visits to advanced labs and road systems.

CE 699

M.TECH. THESIS (CREDIT MAX. 16 UNITS)

CE 710

INTRODUCTION TO AI TECHNIQUES

L-T-P-D-[C]

3-0-0-0-[4]

Expert Systems (ES): history of ES, basic concepts of ES, definition and components of ES, inference engines and reasoning mechanisms e.g. forward reasoning, backward reasoning, and mixed reasoning, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, and selected case studies of ES applications to engineering and sciences; Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks, supervised and unsupervised learning methods-standard back-propagation (BP), conjugate gradients BP, self organizing networks, etc., development of ANN models for specific problems and selected case studies; Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, constraint handling in GAs, and selected case studies involving GA applications to engineering.

CE 712

TRANSIENTS IN PIPES

L-T-P-D-[C]

3-0-0-0-[4]

Causes of transients; Governing Equations; Method of characteristics; Transients in pumping schemes and hydro electric schemes; Transient bubble flow; Transient control.

CE 713

UNSTEADY OPEN-CHANNEL FLOW

L-T-P-D-[C]

3-0-0-0-[4]

Review of basic equations; 2 D Shallow water flow equations: Boussinesq equations, Finite - difference solutions: explicit and implicit methods; Dambreak flow analysis; Supercritical flow computation; Sediment routing models.

CE 714

STOCHASTIC HYDROLOGY

L-T-P-D-[C]

3-0-0-0-[4]

Statistical methods in hydrology, probability distribution of hydrologic variables, hypothesis testing and goodness of fit, flood frequency analysis, single and multiple regression analysis, classification of time series, characteristics of

hydrologic time series, statistical principles and techniques for hydrologic time series modelling, time series modelling of annual and periodic hydrologic time series (including AR, ARMA, ARIMA, and DARMA models), multivariate modelling of hydrologic time series, practical considerations in time series modelling applications.

CE 715
L-T-P-D-[C]
3-0-0-0-[4]

WATER RESOURCES SYSTEMS ENGG. AND MANAGEMENT

Economics of water resources systems: principles of engineering economics; Microeconomics and efficient resource allocation, conditions of project optimality; Planning for multipurpose water resource projects; Introduction to mathematical optimization techniques; Multiobjective optimization; Application of optimization techniques; Water resources planning under uncertainty; Stochastic planning models; Application of simulation models.

CE 716
L-T-P-D-[C]
3-0-0-0-[4]

MANAGEMENT AND MODELLING OF ENVIRONMENTAL SYSTEMS

Human - environment relationship, normative criteria, descriptive and prescriptive models, limits of growth; Environmental and natural resources economics, pollution control policy, growth in a finite environment; Environmental protection laws; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes; Planning and management of environmental systems: optimization techniques, stochastic modelling, statistical inferences; Large scale systems; Optimal monitoring network design, identification of sources; Risk reliability and uncertainty in environmental systems; Topics in groundwater and surface water quality management.

CE 717
L-T-P-D-[C]
3-0-0-0-[4]

GROUNDWATER HYDROLOGY AND POLLUTANT TRANSPORT

Groundwater as a resource, general problems of chemical contamination in groundwater; Fluid potential, heterogeneity and anisotropy; Aquifers, aquitrads and general geology, well hydraulics, parameter estimation; Steady and transient flow equations, unsaturated flow equation; Pollutant transport in groundwater, chemical and transport processes, numerical modeling and solution, break through curves; Seawater intrusion in coastal aquifers; Modelling of pollutant transport in the unsaturated zone; Optimization models for management of groundwater quantity and quality; Optimal monitoring network design; Multiple objective management; Conjunctive management of surface and groundwater; Special topics.

CE 721
L-T-P-D-[C]
3-0-0-0-[4]

RANDOM VIBRATIONS

Random processes; Stochastic response of linear structural systems: normal

mode approach; Level crossing; Peak and envelop statistics; Application to wind and earthquake engineering; Non-stationary processes; Nonlinear random vibrations.

CE 722

L-T-P-D-[C]

3-0-0-0-[4]

THEORY OF PLATES AND SHELLS

Some results from differential geometry: curves in 3D space - parameterized equation for curves, arc length as a parameter; surfaces - parametric description, curvilinear co-ordinates, first and second fundamental forms, principal curvature co-ordinates, derivatives of unit vectors, equations of Gauss and Codazzi; Membrane theory of shells: equilibrium equations, applications to shells of revolution under axisymmetric loads, applications to cylindrical shells under asymmetric loads, strain-displacement relations, application in calculation of displacements; Bending theory of shells: kinematic assumptions and strain-displacement relations, stress measures and equilibrium equations, constitutive relations, cylindrical shell under axi-symmetric loads, bending of cylindrical shells; Bending theory of flat plates: thin plates, Kirchoff theory - strain displacement relations, stresses and stress resultants, constitutive equations, equilibrium equations, boundary conditions, derivation of theory from principle of virtual work, rectangular plates-solution by double Fourier series, circular plates, edge effects, anisotropic and layered plates, thick plates-Reissner-Mindlin-Naghadi type theories, moderate deflection analysis and buckling of plates.

CE 730

L-T-P-D-[C]

3-0-0-0-[4]

SOIL STRUCTURE INTERACTION

Contact pressure distribution, foundation models, Limit analysis of rafts and foundations; Soil structure interaction studies pertaining to buried structures; Analysis and design of deep foundations; Modern trends in the design of earth retaining structures.

CE 733

L-T-P-D-[C]

3-0-0-0-[4]

GEOENVIRONMENTAL DESIGN ASPECTS OF SOLID WASTE MANAGEMENT

Identification, characterization and regulatory requirements for disposal of hazardous, nonhazardous and domestic wastes. Waste Management-Recycling, com-posting, incineration and various disposal methods. Site selection and Geo-environmental investigations. Natural attenuation process and mechanism of attenuation. Design practices of solid wastes. Tailing dams for disposal of flyash, coal, copper, iron and other metal wastes. Single and double lined landfill design, linear material clay, geosynthetics amended soils and other admixtures. Leachate collection and detection system. Landfill construction. Construction quality control and performance monitoring. Application of geosynthetics in waste disposal design.

- CE 751** **ADVANCED STATISTICAL METHODS FOR CIVIL ENGINEERS**
L-T-P-D-[C]
3-0-0-0-[4] Basics of Probability, its distributions, experimental error and its characteristics, adjustment computations, sampling theory, theory of point and interval estimation, hypotheses testing, regression analysis, robust estimators and certain other statistical tests.
- CE 752** **FUZZY SYSTEMS: THEORY AND APPLICATIONS**
L-T-P-D-[C]
3-0-0-0-[4] Fuzzy sets, fuzzy numbers, fuzzy relations, fuzzy measures, fuzzy logic and the theory of uncertainty and information; applications of the theory to inference and control, clustering, image processing and data handling.
- CE 799** **PH.D. THESIS (CREDIT MAX. 16 UNITS)**