DESCRIPTION OF UNDERGRADUATE COURSES

GME 100 General and Professional Ethics (2-0)2
History of ethics. Professionalism and codes of ethics. Understanding ethical problems. Theories of ethical risks. Safety and accidents. The rights and responsibilities of engineers. Ethic and institutions. Management and ethic. Ethic and globalization. Ethical issues in engineering practice.

CE 101 Civil Engineering Drawing (1-2)2
The use of drawing instruments, Lettering and symbols. Geometrical constructions. Dimensioning principles. Orthographic, isometric and oblique drawing. Sectioning. Introduction to computer aided and construction relevant drawing.

CE 104 Introduction to Civil Engineering (2-0)2
Historical background, present status and future challenges of civil engineering profession. Legal aspects, ethics and professional responsibility. Written and oral communication. Concepts of analysis, design, computational approaches, experiments. Invited experts. Site visits. Seminars related with importance of life-long learning in civil engineering.

CE 122 Statics (3-0)3
Fundamentals of statics. Scalars and vectors. Force vectors. Position vectors. Dot product. Equilibrium of particle. Free body diagrams. Two and three dimensional force systems. Force system resultants. Moment, Cross product. Couple. Equilibrium of rigid body.Two and three force members. Structural analysis.Trusses. Frames. Internal forces. Shear and bending moment diagrams. Center of gravity.Moment of inertia.
Recommended: MATH 151, EP 105

CE 164 Geology for Civil Engineers (3-0)3
Origin of the earth; formation, distribution, and properties of minerals and rocks. Processes of weathering. Geological structures. Engineering geology.

CE 203 Land Surveying (3-1)4
Introduction to the surveying, understanding maps and plans.Measurement of linear distances, leveling.Contouring vertical sections. Measurement of angles. Theory of errors and adjustment. Traverse surveying. Calculation of areas and volumes.
Recommended: MATH 152, MATH 255

CE 209 Computation for Civil Engineers (3-0)3
Types of data, operators, and expressions. Control flow. Functions and program structures. Character strings and string functions.Input and output. Storage classes and Program development.

CE 214 Statistics for Civil Engineers (3-0)3
Descriptive and inferential statistics, histograms, central tendency, dispersion, and correlation measures. Basic probability concepts, random variables. Analysis of variance, confidence intervals. Regression analysis. Quality control methods. Risk assessment.
Recommended: MATH 152

CE 222 Dynamics (3-0)3
Kinematics of particles and rigid bodies; absolute motion and relative motion in rectilinear and curvilinear paths. Kinetics of particles; equation of motion, work-energy and impulse-momentum for rectilinear and curvilinear motion. Kinematics and kinetics of systems of particles. Kinetics of rigid bodies: Euler's equations; plane motion of rigid bodies, kinetic energy of rigid bodies. Introduction to the dynamics of vibrating systems.
Recommended: CE 122

CE 223 Solid Mechanics (4-0)4
Normal and shear stress. Stresses in uniaxial and biaxial loading. State of stress and strain. Mechanical properties of materials. Stress-Strain diagrams. Hook's law.Axial load and deformations. Thermal stresses. Torsion. Angle of twist. Bending. Flexural stresses. Composite beams. Transverse shear. Shear flow in built-up members. Stress transformations. Principle stresses, Mohr's circle. Combined Loading. Design of beams, deflection of beams. Elastic curve, Integration method, Singularity functions.
Recommended: CE 122

CE 232 Engineering Economy and Management (3-0)3
Time value of money, cash flow diagrams, interest rate calculations: simple and compound interest, effective and nominal interest. Methods for comparison of alternative structure projects: present worth analysis. Construction industry and components of construction industry. Construction management methods. Delivery methods. Projects planning and scheduling process.

CE 241 Materials Science (3-0)3
Materials and properties.Atomic bonding and arrangement.Structural imperfections. Atom movements. Elastic and viscoelastic deformation of materials. Phase diagrams. Metals, ceramics, polymers.Mechanical properties and failure.Composites.Corrosion and degradation of materials. Laboratory.
Recommended: FE 103, EP 105, EP 106

CE 244 Materials of Construction (2-1)3
Cement production, cement types, hydration of cement. Concrete aggregates. Chemical and mineral admixtures. Fresh concrete, hardened concrete, concrete mix design, durability concept and concrete durability. Clay products, ferrous metals, polymers, bituminous materials, timber. Fresh and hardened concrete experimental practices in construction materials laboratory.
Recommended: CE 164,CE 223, CE 241

CE 262 Introduction to Soil Mechanics (2-1)3
Soil composition, soil classification, and compaction. Ground water fundamental and applications, Total and effective stress. Basic laboratory tests.

CE 271 Fluid Mechanics (2-1)3
Properties of Fluids; Hydrostatics and Buoyancy: Pressure and Head, Forces on Surfaces; Principles of Continuity, Motion of Fluid Flow (Laminar and Turbulence), Momentum Equation and its applications; Bernoulli and Energy Equations. Laboratory.
Recommended: CE 222

CE 274 Engineering Hydraulics (2-1)3
Dimensional analysis. Pipe flow. Design and analysis of water distribution networks. Design and analysis of pump-pipeline systems. Open channel flows. Optimum shape of open channel cross-section. Hydraulic jump. Gradually varied flows. Laboratory.

CE 323 Structural Mechanics (3-0)3
Definitions, classification, and idealized model of structures. Analysis of statically determinate structures including beams, frames and trusses. Internal loadings in structural members: Shear and moment diagrams for beams and frames. Analysis of cables and arches. Influence lines for determinate structures. Deflection analysis of determinate structures. Use of work and energy principles for deflection analysis of determinate structures.

CE 354 Principles of Transportation and Traffic Engineering (3-0)3
Introduction to transportation systems. Vehicles, network and terminals as components of transportation systems engineering. Design of transportation facilities emphasizing land transportation. Operations planning of transportation systems and traffic engineering. Models of traffic flow. Traffic analysis at intersections. Basic definitions and computations of level of service. Planning and management techniques.

CE 361 Soil Mechanics (3-0)3
Stress. Compressibility and consolidation. Shear strength. Stability of slopes. Lateral earth pressure. Basic laboratory tests.

CE 371 Engineering Hydrology (3-0)3
Introduction to hydrology. Hydrologic cycle. Precipitation: measurement and analysis of data. Streamflow. Basin. Hydrograph Analysis. Statistical methods and sustainability in hydrology.

CE 364 Foundation Engineering (3-0)3
Site exploration and characterization. Bearing capacity and settlement analysis and design of shallow foundations. Introduction to pile foundations and retaining structures.
Recommended Course: CE 262 Introduction to Soil Mechanics

CE 372 Water Resources Engineering (3-0)3
Reservoirs. Dams. Spillways and energy dissipation structures. Water supply and sewerage. Irrigation and drainage.
Recommended Course: CE 271 Fluid Mechanics

CE 381 Reinforced Concrete Theory (3-0)3
Basic principles of reinforced concrete behaviour. Basic principles of contemporary structural safety concepts. Ultimate strength analysis and design of axially loaded columns; beams under simple bending; eccentrically loaded columns with slenderness effect, members under shear.
Recommended: CE 122 Statics

CE 383 Steel Structures (3-0)3
Behaviour of steel structures. Tension members and compression members. Beams. Combined bending and compression. Types and behaviour of connections : riveted, bolted, and welded.
Recommended: CE 122 Statics

CE 385 Structural Analysis - I (3-0)3
Definition of indeterminacy of structures. Approximate analysis of indeterminate structures. Displacement methods for analysis: Slope deflection, moment-distribution methods. Stiffness method for structural analysis. Computerized implementation of the stiffness method and use of instructional softwares.
Recommended Course: CE 122 Statics

CE 386 Structural Design (3-0)3
Slab systems, design of solid, joint and block joint slab systems. Unfavourable loading conditions in structures: checker board loading. Approximate methods for analysis of structures under gravity loading. Earthquake loading. Approximate methods for analysis of structures under lateral loading,
Recommended Course: CE 122 Statics

CE 400 Engineering Orientation (4-0)4
Engineering applications. Internship practices. Innovation. Project development and management. Research development and technology management. Construction planning. Technology assessment. Principles of site management. Business and administration disciplines. Occupational health and safety. Communication and multidisciplinary working in business life.

CE 402 Layout of Works (3-0)3
Setting out circular and transition curves. Slope skating. Sight rails and boning rods. Building layout. Contouring. Earth work volumes.

CE 406 Computation Methods in Civil Engineering (3-0)3
Advanced FORTRAN programming. Use of computer for the application of numerical methods; solution of linear equations and matrix operations, numerical differentiation and integration, least squares and linear regression. Optimisation. Applications to civil engineering problems in structures, hydraulics, surveying, foundations, transportation. **Recommended:** CE 209

CE 423 Mechanical Behaviour of Construction Materials (3-0)3
Classification of materials. Mechanical properties and behaviour of civil engineering materials such as steel, aliminium, composites and concrete subjected to static, dynamic, creep and fatigue loads under environments and stress states typical of service conditions. Evaluation of testing of mechanical properties of concrete.

CE 425 Introduction to Structural Stability (3-0)3
Buckling theory, Euler buckling theory, Buckling under eccentrik loadings, Secant buckling theory, Effects of non-linear material behaviour on buckling loads, Buckling behaviour of different structural materials, Tangent modulus bucling load, Reduced modulus buckling loads, Effects of geometrical imperfections on buckling loads, Effects of Manufacturing Methods on Buckling, Introduction to Plate Buckling Theory, Design Specifications, their thories; applications and safety factors

CE 428 Natural Resources Economics (3-0)3
Introduction to computer applications in civil engineering. Integration of design, data management, computer programing and problem-solving skills with computer tools and technigues. Topics include systems analysis, optimization, database management, computer programing and data structures.

CE 431 Natural Resources Economics (3-0)3
Economic evaluation and application of economic principles in natural resources. Economic and financial feasibility. Financial analysis. Depreciation analysis period, present worth, amortisation. Fixed costs; energy costs operation costs, maintenance and repair costs; cost escalation. Application of economic procedures in natural resources development.
Recommended: CE 231

CE 432 Construction Machinery (3-0)3
Construction equipment and machinery. Machine elements. Driving machinery. Pumps and compressors. Hoisting and conveying equipment; cranes, continuous conveyors, reciprocating conveyors. Drilling and pile driving equipment. Excavating and compacting equipment. Crushing and screening plants. Concrete and asphalt plants. Ventilation systems.
Recommended: CE 222, CE 223

CE 433 Architecture for Civil Engineers (3-0)3
Principles of architecture. Design procedures in different types of buildings. Building components; walls, roofs, roof coverings, openings in walls and slabs. Project drawing.

CE 434 Construction Planning (3-0)3
Economical and juridical basis of construction planning. Methods of planning. Gannt charts, cyclogrammes, networks, probabilistic and deterministic networks (CPM and PERT). Arrow and precedence systems. Resource and cost analysis. Computer applications. Control procedures. Problems encountered during implementation.

CE 435 Construction Site Techniques (3-0)3
Principles of construction job layout: Working schedules; materials, manpower and equipment requirements on the job; organisation for building, bridge, tunnel, airport, dam and harbour sites. Rock drilling and blasting operations. Service roads, service bridges, narrow gauge railroads.

CE 436 Forms and scaffolding (3-0)3
General objectives and economic considerations in formwork and scaffolding design and construction. Form materials and fastening elements used. Fresh concrete pressure, wall, slab, beam and column forms. Bridge forms, thin shell roof forms and slipforms.

CE 437 Structural Elements (3-0)3
Analysis of structural load bearing requirements and practices with special emphasis on the description of basic load bearing structural elements such as foundations, columns, beams, floors or slabs, types of load bearing walls, bridge, piers, rollers.

CE 438 Building Components (3-0)3
Analysis of constructional and functional requirements and practices with special emphasis on the description of basic construction elements and components in buildings, such as foundations, floors, walls roofs, vertical and horizontal joints,

insulating materials and components, doors, windows, floors, ceilings, stairs, shafts, chimneys with special reference to moisture, vapour and heat insulation and fire safety.

CE 439 Solar Energy Applications in Buildings (3-0)3
The solar radiation spectrum and its utilisation. Solar energy collectors. Solar house design. Storage systems. Passive solar heating and cooling systems. Natural cooling in hot arid regions. Solar heating of green houses. Integration of solar systems in architectural and urban design.

CE 441 Contract Planning (3-0)3
Introduction. Planning process. Pre-tender planning. Pre-contract planning. Contract planning techniques. Short term contract planning, monthly site meetings. Weekly planning techniques. Weekly site reports. Weekly progress reporting.
Recommended: CE 331

CE 443 Natural Stones and Masonry (3-0)3
Introduction. Features and classification of industrial rocks and minerals. Uses of natural stones in civil engineering; masonry cladding. Stone masonry construction, wall patterns, pavement, curbs aggregates, building stones, road stones and ballasts, materials for embankment dams, cements and fillers, materials for bricks and glass.

CE 444 Properties of Fresh and Hardened Concrete (3-0)3
The coarse content covers workability, consistency, bleeding, stiffening, setting, air-entrainment, unit weight, uniformity, batching, mixing, conveying, placing, compaction and curing. Moreover, properties of hardened concrete in terms of nature and significance of concrete strength, kinds of strength, compressive strength, tensile strength, fatigue strength; durability, shrinkage and volume changes are discussed.

CE 445 Highway Materials (3-0)3
Natural sources and use of asphalt. Production and classification of asphalt. Chemistry of asphalt. Physical properties of asphalt. Classification and properties of mineral aggregates for asphalt concrete. Test on aggregates. Aggregate mix proportions. Types of asphalt-aggregate combinations and their applications. Significant properties of asphalt aggregate mixtures. Asphaltic concrete mix design.
Recommended: CE 244

CE 446 Concrete Technology (3-0)3
Principles of mix design. Statistical concepts for quality control. Inspection and testing of materials. Special concreting methods. Cold and hot weather concreting, pumped concrete, ready-mixed concrete, shotcrete. Fly-ash, silica fume; super-plasticizers. Special types of concrete: architectural concrete, mass concrete, rollcrete, high-density concrete, light-weight concrete, airport runway concrete.
Recommended: CE 244

CE 447 High Performance Concrete Structures (3-0)3
This course deals with the use of high performance concrete (HPC) in structures. Topics include: HPC principles, relevant properties of HPC, materials and mechanical properties, producing and curing HPC, shrinkage problems, temperature effects, design issues, and case studies.

CE 451 Traffic Engineering (3-0)3
Modes of transportation, urban transportation, studies and planning. Road user, vehicle and road characteristics, volume, speed, travel time and delay studies. Traffic control devices, intersection design.

CE452 Urban Traffic Planning (3-0)3
Traffic control devices; traffic signs and markings, signals, intersections; at grade and grade separated, design and control, pedestrian control. Pedestrian crossing; design criteria, design and management.

CE 453 Railway Engineering (3-0)3
Historical development of railways. General definitions. Rolling stock traction: Motive power of the machines of traction. Track geometry: Grades and curves. Location procedure construction. Superstructure: Principles of Planning and Study of technical and economical aspects. Operational principles of railways.
Recommended: CE 351

CE 454 Airport Engineering (3-0)3
Developments in air transportation. Air traffic control and airways. Aircraft characteristics related to airport design. Airport site selection. Airport configuration and airport capacity. Types and standards of airports. Geometric design of landing area. Airport lighting and drainage.
Recommended: CE 351

CE 455 Highway Engineering (3-0)3
Historical development of highways. Definitions. Vehicle and road user characteristics. General characteristics of highway traffic. Highway capacity. Highway location. Elements of geometric design of highways. Horizontal and vertical curves. Transition curves. Construction of subgrade, subbase, base courses. Pavement types.

CE 457 Highway Design (3-0)3
Stopping and passing sight distances, zero line application simple horizontal curve, clothoids and their field application, compound and reverse curves, transition and super-elevation, surface and subsurface drainage, culvert design, retaining walls, types of pavements, material characteristics for

subgrade, subbase, base, binder and wearing courses.

CE 460 Introduction to Earthquake Geotechnical Engineering (3-0)3
Earthquake conceptions in seismological, geotechnical and structural aspects. Content includes: Earthquake characteristics and mechanism, soil properties under earthquakes, soil-structure interactions, earthquake damage, earthquake design codes, design principles under earthquake loadings.

CE 461 Experimental Soil Mechanics (3-0)3
Experimental concepts by both laborotory tests and data processing; Physical properties including water content, specific gravity grain size distribution and Atterberg limits, standard and modified proctor, consolidation and shear strength parameters; Elements of experimental techniques, data modelling, report writing.

CE 462 Soil Mechanics II (3-0)3
Formation and physical properties of soils. Ground improvement techniques. Elastic and plastic behaviour of soils. Correction of consolidation settlement for construction period. Numerical solution of consolidation equation. Vertical sand drains. Stability of natural slopes, fills and cuts; short-term and long-term analysis. Stability of earth dams.
Recommended: CE 361

CE 463 Design of Geotechnical Structures (3-0)3
Applications of basic soil mechanics theories in the design of geotechnical structures; Design of retaining structures: Cantilever and anchored sheet piles, braced excavations, reinforced earth walls, principles of anchorage design. Case studies with geotechnical problems.

CE 464 Geotechnical Exploration (3-0)3
Site investigation, exploration planning. Boring, sampling, testing and reporting. Description and evaluation of in-situ and laboratory tests.

CE 465 Earth Structures (3-0)3
Highway and railway fills, earth dams. General principles of design, the choice of type of dam. The circular arc method of stability analysis; the prediction of pore pressures during construction, steady seepage and rapid draw down. Special methods of analysis for puddle-core and rock-fill dams. Design in earthquakes areas.
Recommended: CE 361

CE 466 Foundation Engineering II (3-0)3
Piles and pile foundations. Types of pile. Pile foundation design; axial load and pull-out capacity. Settlement analysis single and group piles. Pile load test and analysis. Behavior of group piles. Load capacity of laterally loaded piles.

CE 467 Natural Hazards (3-0)3
Energy sources of hazards, Plate tectonics and Earthquakes, Volcanism, Mass movements, Climate change and weather, Floods, Waves and Fire.

CE 473 Irrigation and Drainage Engineering (3-0)3
Introduction. Irrigation methods and practices. Surface, subsurface, sprinkler and trickle irrigation. Comparison of irrigation systems. Capacity determination of irrigation projects; demand, rotation, continuous flow and unit area unit water systems. Irrigation networks; open channels, pipes, canalets (flumes) and sprinklers. Drainage networks; open drains and tile drains. Capacity of drainage networks. Irrigation structures. Operation and maintenance irrigation projects.
Recommended: CE 372

CE 474 Dam Engineering (3-0)3
Purpose of dams, types of dams, selection of dam sites and sizes, hydraulics of dams, planning of dams and reservoirs, dam construction materials, types of spillways, basic data for project function, environmental investigation and impact, measurement and computation of reservoir area and volume, dam safety.

CE 475 Physical Hydrology (3-0)3
Fundamentals of hydrologic processes. Precipitation; infiltration; runoff generation; evaporation and transpiration; and snowmelt. Representation of hydrologic processes in hydrologic models.

CE 476 Groundwater Engineering (3-0)3
The occurrence, sources distribution and movement of groundwater. Aquifer types, differential equations of confined and unconfined aquifers. Well hydraulics. Graphical, analytical, numerical and experimental solution of groundwater budget, groundwater investigations. Wells; well drilling construction and operation (planning and execution). Salt water intrusion. Karstic aquifers. Economical and legal aspects of groundwater development.
Recommended: CE 164, CE 274, CE 372

CE 477 Water Supply and Sewerage Engineering (3–0)3
Water demand, population estimations, municipal and industrial water supply. Water supply and sewerage in buildings. Water distribution in a city and design criteria. Sewerage systems. Design of sanitary and storm sewers. Introduction to water and wastewater treatment.
Recommended Course:CE 271 and CE 371.

CE 478 Pipe Hydraulics (3-0)3
Properties of Liquids, Mass, Volume, Density, Specific Weight, Viscosity, Pressure Drop due to Friction, Friction Factor, Pressure, Velocity, Local head loses, Pipe Analysis, Series Piping, Paralel

Piping, Pipe Networks, Pipe Loops, Pump Analysis, Flow Measurement.

CE 479 Hydroelectric Powerplants (3-0)3
Major components of hydroelectric powerplants; types of hydroelectric powerplants; surface water hydrology; and hydroelectric powerplant project examples.

CE 480 Open Chanel Hydraulics (3-0)3
Basic Principles, Definitions, Basic Equations, Dimensional Analysis, Specific Energy, Discharge Diagram, Critical Depth, Momentum, Hydraulic Jump, Stilling Basins, Bridge Piers, Uniform Flow, Compound Channels, Flood Control Channels. Gradually Varied Flow, Classification of Water Surface Profiles, Spatially Varied Flow, Governing Eqations of Unsteady Flow, Derivation of SaintVenant Eguations, Simplified Methods of Flow Routing.

CE 483 Experimental Stres Analysis (3-0)3
Basic stres strain relations; demanstration of experimental methods of determining stresses and strains; use of mechanical strain, electric strain, and strain gages, optical photoelastic equipment, models.

CE 484 Prestressed Concrete (3-0)3
Prestressed concrete simple beams: Stresses in service, at transfer. Loss of prestress. Ultimate limit states: flexure, shear torsion. Deflections (elastic). Continuous beams: primary and secondary moments (elastic analysis). Tendon concordancy, concept of line of pressure. Piles, circular prestressing. Design of detailing.
Recommended: CE 384, CE 481

CE 485 Structural Analysis II (3-0)3
Analysis of beams and frames having non-prismatic members. Influence lines for indeterminate beams. Qualitative influence lines for frames. Practical structural analysis under vertical and horizontal loads (two cycle moment distribution, elastic line, portal, cantilever, Muto and Smith methods).Computer applications for structural analysis.

CE 487 Dynamics of Structures I (3-0)3
Dynamic effects on structures. Single degree of freedom systems. Free vibrations. Forced vibrations. Support motion. Multi-degree freedom systems. Free vibration of discrete systems. Modal superposition. Introduction to vibrations of infinite degree of freedom systems. Approximate methods in structural design. Earthquake codes of practice.

CE 488 Introduction to Matrix Methods in Structural Analysis (3-0)3
Review of matrix algebra and solution of linear equations; energy concepts and principle of virtual work; fundamentals of flexibility and staffness methods; coordinate transformation and matrix assemblage; computer-oriented direct stiffness method and computer code developments; secondary effects; support settlement and temperature change, introduction to the finite element method.

CE 489 Timber Structures (3-0)3
General design considerations: Advantages and disadvantages of timber as a structural material, timber strength and properties. Connection elements, grooved connections. Design of tension, compression and flexural members. Trusses: types, connections.

CE 490 Introduction to Earthquake Resistant Design (3-0)3
Cause of earthquakes, characteristics of earthquake ground motions, earthquake magnitude and response analysis of simple structures. Derivation of elastic response spectra and earthquake design criteria. Free and forced vibration analysis of frame structures. Modal spectra analysis and equivalent design codes, design applications.

CE 499 Civil Engineering Design (3-0)3
Integration of information, ideas, and concepts from previous courses of different disciplines of civil engineering into a comprehensive design effort. Methodology for formulating and solving civil engineering design considering engineering ethics, professional responsibility and life-long learning. Preparation of a detailed technical report and oral presentation of the design process.

DESCRIPTION OF GRADUATE COURSES

CE 501 Mathematical Methods in Engineering (3-0)3
Permutations and determinants, linear spaces. Inner product subspaces. Matrix algebra. Special theory in finite-dimensional spaces: eigenvalues and eigenvectors, resolvent diagonalisation. Jordan form. Quadratic forms, function of a matrix. Exterior algebra. Matrix differential equations and stability autonomous system. Dual spaces and the concept of tensors. Tensor algebra. Curvilinear coordinates as covariant differentiation. Differential operators. Differential forms. Stoke's theorem and its consequences. Introduction to calculus of variations, transform techniques.

CE 502 Partial Differential Equations (3-0)3
Pfaff forms. First order differential equations. Cauchy problems. Method of characteristics. Method of envelopes. Classification of second order equations, characteristics. Propagation of singularities. Initial and boundary value problems for one-dimensional wave equation. Riemann's method. Cauchy-Kowalewski theorem. Uniqueness theorem. Laplace equation fundamental solutions. Dirichlet and Neumann problems. Green's function.. Higher-order equations. Method of Fourier transforms.

CE 503 Initial and Boundary Value Problems (3-0)3
Introduction to the theory of complex variables. Contour integration, analytical continuity. Initial value problem for ordinary differential equations of the Fuchs type, regular and irregular points, singular integral equations. Volterra integral equations. Fourier and Laplace transforms.

CE 504 Numerical Analysis with Engineering Application (3-0)3
Interpolation polynomials, numerical integration and differentiation; Taylor series, Fourier series, Fourier cubic spline, and least squares polynomial approximations; numerical solution of initial-value problems by Prediction-Correction and Runge-Kutta methods; numerical solution of boundary-value problems by finite difference method; numerical solution of integral equations; approximate solution of ordinary differential equations by weighted residuals and Galerkin methods; approximate solution of variational problems by Rayleigh-Ritz method.

CE 505 Introduction to Expert Systems (3-0)3
Introduction. Definition and Background Information. Its Benefits. Organisation of Expert Systems. Development Stages. Expert Systems Tools: LISP, PROLOG and Expert System Shells. Inference Engine: Forward Chaining, Backward Chaining. Evaluation of Development Tools. Knowledge Elicitation Techniques.

CE 506 Finite Element Method (3-0)3
Introduction to the finite element method for analysis of structural systems. Formulation and implementation of frame, plane stress, plane strain, axisymmetric, torsional, solid, plate and shell elements. Topics: strong and weak forms of the problem, variational principles and the principle of minimum potential energy, the finite element method as an extension of the Rayleigh-Ritz method, shape functions, isoparametric mapping, numerical integration, convergence requirements, and error estimation.

CE 507 Geographic Information Systems (GIS) in Engineering Applications (3-0)3
A computer based management system for analysing and visualization of geographically referenced data. Content includes: Introduction to GIS and GIS components, data types and database models in GIS, map projections and coordinate systems, GIS softwares, GIS functions, engineering applications such as surface modeling, eathquake analysis, data manupulating in pipelines and transportation systems.

CE 508 Environmental Geotechnics (3-0)3
Forms of wastes, disposal methods and regulations. Site selection and site investigations for land fills. Geotechnical aspects of landfills. Barrier technology and slurry trench cut-off walls. Stability of landfills. Construction problems in waste disposal sites. Use of waste materials in construction industry.

CE 509 Seismic Hazard Analysis (3-0)3
Identification and evaluation of earthquake sources. Deterministic seismic hazard analysis. Probabilistic seismic hazard analysis. Predictive relationship. Probability computation.

CE 510 Civil Engineering System Analysis I (3-0)3
Modeling in civil engineering. Statistical evaluation of modeling. Linear regression analysis. Non-Linear regression analysis. Stepwise regression analysis. Design of experiments. Main effects of plot. Interaction effects plot.

CE 511 Civil Engineering System Analysis II (3-0)3
Soft computing. Neural Networks. Genetic programming. Fuzzy Logic. Neuro-Fuzzy. Applications of soft computing techniques for the analysis and design of civil engineering problems.

CE 512 Computerized Report Writing and Data Analysis (3-0)3
The aim of this course is to introduce functional features of current word editor and spreadsheet programs related to report writing and data analysis to Graduate students in order to equip them with methods and practices facilitating their Thesis work.

CE 514 Statistics in Hydrology and Water Resources (3-0)3
Probability distributions used in hydrology. Analytical and numerical solutions of hydrologic models. Linear and multiple regression analysis.

CE 515 Data Mining I (3-0)3
Data mining, function approximation in data mining techniques for function approximation and their applications in the analysis of civil engineering problems.

CE 516 Data Mining II (3-0)3
Data mining, classification in data mining, applications of data mining techniques for the analysis and design of civil engineering problems regarding with classification.

CE 517 Physical Hydrology (3-0)3
Data mining, classification in data mining, applications of data mining techniques for the analysis and design of civil engineering problems regarding with classification.

CE 519 Advanced Structural Dynamics (3-0)3
Dynamic loads, dynamic characteristics of structural systems (SDF), damped vibrations, response of SDF systems to harmonic loading, to periodic loading, to general dynamic loading, generalized SDF systems. Rayleigh method, vibration isolation, multi-degree-of-freedom systems (MDS), equations of motions, undamped free vibrations, orthogonality contions,dynamic response, mode shapes, forced vibrations, mode superposition analysis, numerical methods for determination of mode shapes and frequencies, Rayleigh method, systems with distributed parameters, equations of motion, axial, shear and bending vibrations, earthquake response of SDF systems, response spectra, earthquake response of MDF systems, methods for modal combination, numerical methods.

CE 520 Advanced Mechanics of Materials (3-0)3
Advanced topics in stres analysis, deflection and stiffness, energy methods, failure analysis, fracture mechanics, statistical considerations, impact, fatigue. Introduction to finite element method.

CE 521 Experimental Methods in Structural Engineering (3-0)3
Principles of model analysis. Design and construction of models. Loading systems: Loading principles, Methods of load application, Loading frames. Load distribution arrangements. safety considerations. Strain measurement systems; electrical strain gauges. Other strain (or stress) indicators. Displacement measurement systems. Rotation and curvature measurements. Dynamic measurements. Non-destructive testing principles. Calibration. Principles of data recording. Principles of data analysis.

CE 522 Nonlinear Finite Element Analysis (3-0)3
Nonlinear deformation and ultimate load analysis of frame, plate and shell structures. Lagrangian formulations for nonlinear analysis of solid and structures, including consistent linearization and nonlinear state determination. Incremental-iterative approaches for solution of nonlinear problems, basic techniques in computational plasticity. Software implementation of nonlinear finite elements.

CE 523 Theory of Plates (3-0)3
Classical theory of plates. Classification. Cylindrical bending. Pure bending. General small deflection theory. Boundary conditions. Applications of cartesian and polar coordinates. Approximate methods. Yield line theory, yield criteria. Fundamentals of yield line theory of slabs.

CE 524 Theory of Shells (3-0)3
Derivation of shell equations for an arbitrary orthogonal curvilinear coordinate system. Reduction of equations into simpler cases. Numerical methods for shell problems. Associated problems and features related to digital computers.

CE 525 Theory of Matrix Structural Analysis (3-0)3
Nominal analysis versus actual response. Principle of virtual displacements to evaluate equilibrium. Principles of virtual forces. Cross-sectional rigidities. Betti's law for influence coefficients, physical description of flexibility and stiffness coefficients. Force and displacement transfortaions. Matrix formulation of section and member responses. Transformation of member flexibility and stiffness. Fixed end forces. Automated matrix displacement and force methods of structural analysis. Nonlinear analysis.

CE 526 Portland Cement Concrete Pavements (3-0)3
Portland Cement Concrete mix design and production. Paving operations. Saw and seal operations. Subgrade preparation. Base selection. Drainage selection, design and construction. Bonded and unbonded concrete overlays. Whitetopping and Ultra-Thin Whitetopping. Concrete pavement restoration; Quality Assurance and Quality Control in Concrete Pavement Construction.

CE 527 Theory of Elasticity (3-0)3
Analysis of stres. Analysis of strain. Elasticity; equations of elasticity and general theorems; two dimensional problems in cartesian and polar coordinates, special problems in three dimensional elasticity, variational methods.

CE 528 Advanced Computational Mechanics (3-0)3
Computational methods for solution of problems in structural mechanics. Finite element method for displacement and mixed variational solutions of problems in elasticity and inelasticity. Treatment of constrains araising from near in compressibility in

solids, transverse shear effects in beams, palates and shells, and/or contact between structures. Programming methods for finite element implementation.

CE 529 Inelastic Analysis of Structures (3-0)3
Inelastic analysis of frames, plates and shells. Plastic behaviour and limit analysis theorems. Static and kinematic methods for calculating collapse loads. Yield surfaces for plates and shells, plastic potential flow law and load capacity. Viscoelastic bahaviour and rheologic models. Creep of concrete and its effects in structures.

CE 530 Scientific Research Methods in Civil Engineering (3-0)3
Guidelines for defining a research Project. Managing the research Project. Research methodologies. Producing a proposal. Executing the research. Reporting the results. Discussing major research issues. Research supervision. Qualitative and quantitative studies. Techniques for data collection. Analysis and experimentation. Models, and simulations. Investigation into management and economics. Writing and presentation of technical reports, essays, thesis.

CE 531 Advanced Construction Management (3-0)3
Management in Engineering and Construction Industry. Development and Organisation of Projects. Applications and Requirements for Management Organisations. Preconstruction Management Activities. Bidding and Award. Construction Process. Applications of Project Control.

CE 532 Productivity Management (3-0)3
Introduction to Productivity: Concept and definition. Productivity improvement factors: Internal, External, Hard and Soft Factors. Productivity Analysis. Productivity Appraisal. Total Productivity. Labour Productivity. Managing Organisation Effectiveness. Productivity Improvement Strategy, Program and Organisation Approaches.

CE 533 Economic Decision Analysis in Construction (3-0)3
Background Information. Economics Analysis. Investment. Cash Flows. Calculation of Return. Principles of Appraising Project. Project Yield, Taxation and Inflation. Risk Analysis. Project Uncertainties. Project Finance, break-even analysis. Project Budgetary Control.

CE 534 Computer Applications in Construction (3-0)3
Computer Software and File Systems. Application Development Tools. Procedural Languages. Spreadsheets. Databases. Artificial Intelligence Based Expert Systems. Application Packages on Estimating. Cost Engineering and Project Planning and Scheduling. Case Studies.

CE 535 Project planning (3-0)3
This course will cover the Scheduling in construction projects (Gantt charts, Critical Path Method (CPM), PERT, LOB etc.), time-cost trade off problems, resource allocation, computer applications by using softwares such as PRIMAVERA and Microsoft Project Planner.

CE 536 Risk Management in Construction (3-0)3
The background to risk and uncertainty. Risk management systems, tools and techniques (Sensitivity, breakeven, scenario analysis, Monte Carlo simulation). Utility and risk attitude. Risk and the construction project-money, time and technical risks. Case studies.

CE 537 Legal Aspects in Construction (3-0)3
General information on construction industry and governing laws, Code of Obligations, documents in a contract file, types of contracts and contractorship licenses, State Bidding Law, control regulations for public works, general specifications for public works, documents kept on site, technical specifications, quantity measurement and monthly payments, final account and payment, settlement of disputes, safety in construction, FIDIC contracts, BOT and BO projects.

CE 538 Transportation Systems Modeling (3-0)3
Problem-motivated introduction to methods, models and tools fort he analysis and design of transportation networks including their planning operation and control. Capacity of critical elements of transportation networks.Traffics flows and deterministic and probabilistic delay models.Formulation of optimization models for planning and scheduling of freight,transit and airline systems, and their solution using software packages.User-and system-optimal traffic assignment.Control of traffic flows on highways,urban grids, andairspace.

CE 539 Computational Methods in Transportation Eng. I (3-0)3
The main objective of this course is to give computational ability,while providing an Introduction to algoritm design,programming structures,and data structures.Transportation Engineering calculation software including programming languages, speadsheets, and simulation software.Application of computing methods to transport engineering problems and data analysis with different programming languages and software's such as Java.Pyhton,C++ and MATLAB. This course is a computer -based course in mathematics and problem-solving.The most important skill to be learned in this course is algorithm design and new technological tools in Transport Engineering and searching new opportunities for future.

CE 540 Experimental Design and Analysis (3-0)3
Performance studies of experimental systems. Determination of standard error of a testing system. Minimum variations in the property to be measured: sensitivity, accuracy, repeatability. Analysis of variance one and two-dimensional analyses of variance. Use of Fisher and Student tests. Tests of hypotheses. Design methods: block., factorial, fractional factorial and Latin and Greco Latin Squares design. Interpretation techniques; erroneous tests, regression analysis, multiple correlation.

CE 541 Bituminous Materials (3-0)3
Properties and behavior of bituminous materials and their effect on flexible pavement preformance. Analysis and design of asphalt concrete. Testing and evaluation of hotmix asphalt mixtures. Pavement construction and quality assurance methods. Recycling of mixtures.

CE 542 Pavement Analysis and Design (3-0)3
Course Description Analysis, behavior, performance, and structural design of pavements for highways. Characteristics of pavement materials. Stresses, strains and deflections in pavements. Pavement performance. Design of overlays by using different methods.

CE 543 Composite Materials (3-0)3

Definition, history, types and general properties of composite materials. Basic structure property relations, viscosity of suspensions, mechanical models of structure; parallel, in-series, disperse-phase models. Agglomerates; concrete, mix design optimization, bituminous mixtures. Masonry. Fiber reinforced composites, material behavior under compression, effect of fiber orientation. Laminated composites, orthotropic materials under plain stress, macro mechanical behavior of a lamina, biaxial strength theories.

CE 544 Concrete as a Composite Material (3-0)3
Review of concrete technology and analytical approaches to the production of properties of two phase composite materials. Consideration of concrete as a two phase particle reinforced composite and outline of similar approaches for prediction of its mechanical properties. High-strength concretes, light-weight concretes, creep and shrinkage, application of fracture mechanics to concrete.

CE 545 Deformation and Fracture Theories (3-0)3
Introduction to mechanical behaviour of materials. States of stress and strain . Constitutive equations: generalized Hooke's Law, constitutive equations for viscoelastic materials, plastic deformation, yield criteria. Residual stresses. Theory of dislocations: types of dislocations, energy of dislocations, movement and generation of dislocations: mechanism of plastic deformation in crystalline solids, the Bauschinger effect. Brittle Fracture: Griffith's theory. Ductile fracture: formation and propagation of cracks, factors affecting ductile fracture, the ductile-brittle transition in fracture. Fatigue failure: mechanism of the failure, formation of crack and fatigue fracture, factor affecting fatigue.

CE 546 Viscoelasticitiy (3-0)3
Definitions. Mathematical background: Heaviside step function and Dirac function. Laplace transforms, integral equations. Linear viscoelasticitiy: constitutive equations under combined loadings; viscoelastic response under combined loadings; viscoelastic response under cyclic loading, creep compliance and relaxation modulus, damping. Nonlinear viscoelasticity, kernel functions. Stress analysis in viscoelastic materials. Viscoelastic behaviour of some engineering materials, plastics, metals at high temperatures, concrete.

CE 547 Corrosion of Plain and Reinforced Concrete (3-0)3
Definition and properties of corrosive media: sea water, industrial waste water. Lime in cement and aggregates. Composition of concrete. Mechanisms of corrosion of concrete. Mechanisms of corrosion of metals, corrosion of steel. Corrosion of reinforcement in concrete. Prevention and repair: insulation by impervious materials, cathodic protection passivation, use of inhibitors, shotcreting, grouting.

CE 548 Durability of Building Materials (3-0)3
Factors causing deterioration of materials. Durability of building Stones. Decay and preservation of timbers. Mechanism of metal corrosion. Corrosion protection for metals. Deterioration of concrete. Mechanisms of concrete corrosion. Effects of various chemicals, sea water ground water and industrial wastes. Protective measures against concrete corrosion. Corrosion of steel reinforcement in concrete.

CE 549 Material Modelling (3-0)3

Identification and rheological classification of real solids, experimental techniques and identification, schematic representation of real behavior and fracture.

CE 550 Nondestructive Testing and Evaluation in Structural Engineering (3-0)3

Identification and evaluation of nondestructive test techniques for the structural material quality, evaluation of test results and application to structural analysis.

CE 551 Hydrogeology (3-0)3
Origin, occurrence, distribution and movement of groundwater. Water bearing properties of rocks. Well

hydraulics. Quality of groundwater, groundwater exploration. Drilling development and competition of water wells. Groundwater budget. Problems in coastal aquifers.

CE 552 Advanced Hydrology II (3-0)3
Statistical models in hydrology, properties of models, multiple variable models, linearizable models, convolution water yield models. Multivariate models; component regression, factor analysis, non-linear least squares. Time series analysis; autocorrelation, cross correlation, spectral analysis, Markov chains, moving average models.

CE 553 Water Resources System Engineering (3-0)3
Fundamentals of Dynamic programming. Nonlinear Programming: Classical optimization methods, quadratic programming, geometric programming, separable programming. Search techniques: One dimensional and multivariate search methods. Computer applications and case studies in water resources engineering. Introduction to simulation methods for design of water resource systems.

CE 557 Computational Methods in Transportation Eng. II (3-0)3
This course introduces programming languages and techniques used by physical scientists: Java, C++, MATLAB, Python, Java and Mathematica. Designing transportation engineering problem in computer systems and comparative advantages and disadvantages of different languages. And approaching to transportation problems using statistical (multible regression analysis, experimental design etc.), mathematical (numeric optimization, linear and non linear equation team solving them using computer environments.

CE 558 Transportation Systems Analysis: Demand and Economics (3-0)3
The course introduces transportation systems analysis, stressing demand and economic aspects. Covers the key principles governing transportation planning, investment, operations and maintenance. Introduces the microeconomic concepts central to transportation systems. Topics covered include economic theories of the firm, the consumer, and the market, demand models, discrete choice analysis, cost models and production functions, and pricing theory. Application to transportation systems include congestion pricing, technological change, resource allocation, market structure and regulation, revenue forecasting, public and private transportation finance, and project evaluation; covering urban passenger transportation, freight, aviation and intelligent transportation systems.

CE 559 Critical State Soil Mechanics (3-0)3
Stresses, Strains, Elasticity, Seepage, One-dimensional Consolidation, Granta-gravel, Cam-clay and the Critial State Concept, Interpretation of Data from Axial Test on Saturated Clays, Coulomb's Failure Equation and the Choice of Strength Parameters, Two-dimensional Fields of Limiting Stress.

CE 560 Advanced Soil Mechanics (3-0)3
The nature of soils. Stresses within a soil mass. States of stress. Mohr circle. Stress paths. Effective stress principle. Stress-strain relationships. Concepts from elastic theory. Capillarity in soil. Swelling and shrinkage. Consolidation theory. Settlement in sands. (F)

CE 561 Measurement of Soil Properties (3-0)3
Measurement of Engineering properties of soils in laboratory and field. Soil sampling. Determination of shear strength parameters using. Triaxial and Direct Shear Testing equipment. Compressibility and Compaction characteristics of soils. Use of Geophysical methods.

CE562 Soil Improvement Techniques (3-0)3
Soil structures and its effect on engineering performance. Mechanical modification; Dynamic compaction, vibrocompaction and vibroreplacement. Hydraulic modification. Modification by Admixtures; cement, lime and polymer stabilisation.

CE 563 Deep Excavation and Retaining Structures (3-0)3
Earth retaining structures for deep excavations. Lateral supporting elements: Ground anchors and struts. Types, components, installation dimensioning and bearing capacity of anchors.

CE 564 Stability of Slopes (3-0)3
Main landslide types. Geological investigation of landslides. The stability analysis. Short and long term condition. Factor of safety of slopes. Corrective measures.

CE 565 Measurement of Rock Properties (3-0)3
Measurement of engineering physical and mechanical properties of rock in laboratory and field. Measurement of shear strength, compressibility and permeability. Measurement techniques in the laboratory and field for determining shear strength and compressibility.

CE 566 Environmental Geotechnics (3-0)3
The course basically deals mainly with the inorganic environment, the geo-and hydrospnere. Civil engineering, and geotechnics as a part of it, is often misunderstood in two ways. It is either seen as architectural consturuction, or it is considered a nature- destroying activity. It is highlighted in the course that producsts of civil engineering must be in balance with nature. If not, extraordinary expenses are needed for maintenance, or for preserving nature to

keep the project “operation or existence”; otherwise the Project will not be longstanding. The course places emphasis on the work of engineers, the environment in wich they work, the use and reliability of their ground-testing and ground characterization methods, the planning and design process, and finally the devices with which projects can be made to fit nature and meet the goals.

CE 567 Soil Dynamics (3-0)3
Principles of soil dynamics. Content includes: Fundamentals of vibration and wave propagation, strong ground motion, properties of dynamically loaded soils, ground response analyses, local site effects, liquefaction of soils, foundation vibrations.

CE 568 Site Response Analysis (3-0)3
Computation of soil amplifications under earthquake excitation. Content includes: Spectral characteristics of earthquake motion, kinematics of soil structure and impedance functions, earthquake response analysis of horizontally layered sites, one dimensional analyses methods, a computer program for one dimensional analysis.

CE 569 Principles of Seismic Microzonation (3-0)3
Consideration of dynamic properties of local soils within a seismically sensitive region to determine earthquake design parameters for buildings. Content includes: Microzonation techniques and methodology, damage assesment, microzonation methods with respect to soil amplification, liquafaction potential and slope stability, case studies for microzonation of a working region.

CE 570 Simulation Methods in Hydrology (3-0)3
Introduction to simulation and mathematical modeling. Types and management of data. Structures of simulation models. Calibration and accuracy of models. Deterministic models. Stochastic models. Applications.

CE 571 Water Resources Planning and Development (3-0)3
Sources of water. Planning of water resources development. Optimization of water resources in relation to irrigation, municipal and other needs. Planning of river basins. Water demand and requirements. Reservoir operation for various needs; municipal irrigation, and hydroelectric power. Economics of water resources.

CE 572 Hydropower in Engineering (3-0)3
Reservoir operation studies, water storage capacities, load curve. Power generation and storage. Pumps and turbines. Hydropower plants in multisectorial plants.

CE 573 Advanced Hydrology (3-0)3
Systems approach to the hydrologic cycle. Deterministic treatments of catchment behavior. Statistical models in hydrology. Presentation of advanced topics in hydrology.

CE 574 Soil and Water Conservation Engineering (3-0)3
Soil erosion principles. Soil loss equations. Wind erosion control. Contouring, terracing and conservation structures. Earth embankments. Headwater and flood control. Open channels. Farm pond and small reservoir design.

CE 575 Erosion and Sedimentation Eng. (3-0)3
Principles of upland erosion and reservoir sedimentation. Reservoir sediment yield. Scouring and pier design. Optimal design of earth channels.

CE 576 Modelling in Water Resources (3-0)3
Simulation and modelling-hydrograph synthesis-drainage of agricultural lands-frequency analysis-flood routing-water surface profiles-water supply net designing sewerage piping net design-reservoir operation.

CE 577 Coastal Hydraulics (3-0)3
Tides and currents-waves-coastal sediment transport-coast and bed morphology-planning and protection of beaches-waves and structures-the acquisition of data.

CE 578 Advanced Civil Engineering Hydraulics (3-0)3
Review of fundamentals. Analysis and computation of steady and unsteady flow in open channels. Flow resistance finite element method in the design of hydraulic structures. Reservoir hydraulics. Design of dams. Design of irrigation and drainage systems.

CE 579 Hydraulic Modelling (3-0)3
Purpose of Modelling-Dimensional analysis Similarity theory and similitude analysis-Physical modelling: free surface-closed conduits-coastal modelling-the method of synthesis scaling and scale errors-applications.

CE 580 Design of Irrigation Structures (3-0)3
Fundamentals of irrigation and drainage hydraulics. Basic planning of irrigation and drainage projects. Design of canals nets. Design of conveyance structures, protective structures, measurement structures.

CE 581 Computational Fluid Dynamics (3-0)3
Finite differences, stability and errors. Methods for wave, heat, Laplace and Burger's equations. Numerical methods for the Navier-Stokes equations. Numerical models for boundary layers. Temperature and concentration solutions. Grid generation. Computation of turbulent flows.

CE 582 Groundwater Hydraulics (3-0)3
Groundwater and Aquifers; Groundwater Balance; Groundwater motion; Fundamental Equations of Groundwater Flow; Initial and Boundary Conditions; Methods of Solutions; Hydraulics of Well;

Hydrodynamics Dispersion; Modelling of Aquifer Systems; Salt Water Intrusion; Groundwater Management.

CE 583 Computer-Aided Engineering (3-0)3
Advanced methods for computer-aided engineering, with emphasis on structural design and analysis. Data abstraction methods for engineering systems. Database models and systems. Fundamentals of geometric modeling and computer graphics. Engineer-computer interfaces. Methodologies for developing computer-aided engineering systems.

CE 584 Eartquake-Resistant Design (3-0)3
Design of structures to resist earthquakes and other dynamic excitations. Characterization of earthquakes for design. Development of design criteria for elastic and inelastic structural response. Seismic performance of various structural systems. Prediction of nonlinear seismic behavior. Basis for code design procedures. Preliminary design of steel and reinforced concrete structures. Evaluation of earthquake vulnerability of existing structures and rehabilitation of seismic deficiencies.

CE 585 Introduction to Turbulence (3-0)3
Importance of fluid flow, descriptions of turbulence, history of study of turbulence, derivations RANS equations, Vortex stretching and Reynolds stress, general difficulties with RANS, The Kolmogorov theory of turbulence, Large-Eddy simulation, The Navier-Stokes equations as a dynamical system.

CE 586 Introduction to Turbulence Models (3-0)3
Introduction, turbulent scales, voricity, classification of turbulent models, Reynols-Averaged Navier Stokes models (RANS), linear eddy-viscosity models, Reynolds stress models, large eddy simulations (LES), direct numerical simulations, RANS versus LES.

CE 587 Structural Dynamics (3-0)3
Dynamic disturbances. Single and multi-degree freedom systems. Continuous systems. Equations of motion. Energy methods in structural dynamics. Applications in structural design. Earthquake response of structures.

CE 588 Structural Optimization (3-0)3
Structural optimization via calculus of vibrations. Application of techniques of mathematical programming to optimize trusses, beams, frames, columns and other structures. Sensitivity calculations of structural response. Approximation techniques and dual and optimality criteria methods.

CE 589 Nonlinear Structural Analysis (3-0)3
Theory, modeling, and computation for analysis of structures with material and geometric nonlinearities. Sources of nonlinearity. Solution strategies for static and dynamic loads. Modeling of inelastic materials and members. P-delta and large deformation theory. Analysis of stability. Practical applications.

CE 590 Introduction to Computing for Engineers (3-0)3
Creating variables, basic arithmetic operators, elementary functions, matrix generation, elementary matrices, array operations, basic plotting, solving linear equations, algorithm of programming, control flow and operators, debugging, main characteristics of programming languages.

CE 593 Renewable Energy Resources (3-0)3
Solar thermal energy, solar photovoltaics, hydropower, small-scale hydropower, hydrokinetic power, tidal power, water energy, wind energy.

CE 594 Open Channel Hydraulics (3-0)3
Basic principles, definitions, basic equations, dimensional analysis, specific energy, discharge diagram, critical depth, momentum, hydraulic jump, stilling basins, bridge piers, uniform flow, compound channels, flood control channels, gradually varied flow, classification of water surface profiles, spatially varied flow, governing equations of unsteady flow, derivation of Saint-Venant equations, simplified methods of flow routing.

CE 595 Experimental Methods in Civil Engineering Hydraulics (3-0)3
Dimensional analysis. Principles of similitude. Hydraulic similitude. Types of measurements. Selection of instruments. Measurement accuracy and errors. Water level measurement. Sea surface elevation (waves) measurements. Flow velocity measurement. Flow visualisation. Pressure measurement. Stres and force measurement. Sediment transport measurement. Movable-bed Bathymety measurement. Laboratory photo documentation. Data analysis.

CE 596 Coastal Pollution (3-0)3
Various aspects and problems of water pollution control, sources and types of pollutants. Hydraulics of turbulent jets and plumes. Turbulent diffusion, dispersion. Bacterial disappearence. Sea outfall design. Heated dischargers. Oil pollution. Estuarine pollution of marinas.

CE 597 Bridge Hydraulics (3-0)3
Introduction. Water Surface Profiles at Bridge Sites. Flow Through Bridges. Basic Concepts of Sediment Transport. Vortex Systems Around Bridge Piers. Mechanism of Local scour around Bridge Piers and Abutments. Hydrologic and Hydraulic design Parameters. Hydroeconomic analysis for Bridges.

Scour Countermeasures for Bridge Piers and Abutments.

CE 598 (M.S.) Research and Thesis (Non-credit)

CE 599 (M.S.) Research and Thesis (Non-credit)

CE 698 Ph. D. Research and Thesis (Non-credit)
Program of research leading to Ph. D. degree arranged between the student and a faculty member. Students register to this course in fall semester while the research program or write up of thesis is in progress.

CE 699 Ph. D. Research and Thesis (Non-credit)
Program of research leading to Ph. D. degree arranged between the student and a faculty member. Students register to this course in spring semester while the research program or write up of thesis is in progress.

CE 701–750 Graduate Seminar (2-0) (Non-credit)
Directed study and research for Masters level graduate students on a subject of mutual interest to student and faculty member. Course content will depend on interests of the student and faculty member. A paper is to be prepared and presented by the enrolled graduate student at the end of the semester.

CE 751–799 Graduation Project (3-0) (Non-credit)
A one-semester experimental and/or theoretical research project supervised by a faculty member. The project topic is determined by the adviser and the student. A written final report is required at the end of the semester.

CE 801–899 Special Studies (4-0) (Non-credit)
This special studies course is design to introduce students to topics of contemporary importance or special interest that fall outside the scope of the curriculum. Supervisor discusses problems related to individuals MS level work and guides MS level students to generate new ideas in their particular research areas. The course is aimed to enhance research and interchange state-of-the-art information in technological and scientific fields.

CE 901-999 Special Topics (4-0) (Non-credit)
This special studies course is designed to introduce Ph.D level students to topics of contemporary importance or special interest that fall outside the scope of the curriculum. Supervisor discusses problems related to individuals Ph.D level work and guides Ph.D. level students to generate new ideas in their particular research areas. The course is aimed to enhance research and interchange state-of-the-art information in technological and scientific fields.