

**CE 106 COMPUTER GRAPHICS AND COMMUNICATION.**

**(3)**

Introduction to the use of scale, dimensioning, and orthographic projections. Graphical solution of spatial problems. Integrated application of computer graphics. Lecture, two hours; laboratory, four hours per week. Prereq or coreq: MA 113 or consent of instructor.

**CE 120 INTRODUCTION TO CIVIL ENGINEERING.**

**(1)**

An introduction to the civil engineering profession and the use of computer hardware and software in CE systems analysis and design. Presentations will be used to illustrate the conception, design, construction, and operation processes. Sample problems and class exercises on the various technical areas of civil engineering will make use of existing computer software packages and teamwork principles.

**CE 211 SURVEYING.**

**(4)**

A comprehensive course in the art and science of surveying as applied to civil engineering, including the use and care of surveying instruments; measurement of horizontal and vertical distances, angles and directions; collection of ground and underground data for the design and layout of roads, buildings, various mineral workings and other structures; and some aspects of the precise determination of position and direction for survey control. Lecture, three hours, laboratory, three hours per week. Prereq: CE 106 and MA 114. (Same as MNG 211.)

**CE 221 APPLIED UNCERTAINTY AND RISK ANALYSIS IN CIVIL ENGINEERING.**

**(3)**

An introduction to the applications of uncertainty, reliability, decision, and risk analysis in civil engineering. Data collection, systems analysis, and civil engineering design under uncertainty. Probabilistic analysis applied to the various areas of civil engineering: geotechnical, transportation, environmental, materials, structural, hydraulic, and water resources engineering. Civil engineering systems governed by random processes. Applications of mathematics software, Monte Carlo simulation, and time series in civil engineering. Prereq: MA 114.

**CE 303 INTRODUCTION TO CONSTRUCTION ENGINEERING.**

**(4)**

The study of the planning, administration, management, and cost of construction projects and an introduction to the methodology utilized in executing specific designs. Emphasis is placed on the organization of construction firms, development of construction documents, interpretation and analysis of engineering plans and specifications, theory of engineering economics, estimating and quantity take-off, contractual and management systems, scheduling, project administration, and inspection of construction operations. Lecture, three hours; laboratory, two hours per week. Prereq: CE 106 and engineering standing.

**CE 321 CIVIL ENGINEERING SYSTEMS.**

**(2)**

An introduction to basic principles of engineering problem solving with applications to civil engineering systems. Formulation and solution of inductive and deductive mathematical models using principles of numerical analysis and mathematical programming. Prereq or concur: CS 221.

**CE 331 TRANSPORTATION ENGINEERING.**

**(3)**

An introduction to transportation engineering. Development of transportation systems in the United States. Route geometrics and design. Traffic flow characteristics and control. Planning financing and economic analysis of transport facilities. Prereq: CE 211 and engineering standing.

**CE 341 INTRODUCTION TO FLUID MECHANICS.**

**(4)**

Fundamental principles of thermodynamics and fluid flow. Includes fluids at rest, fluids in motion. Continuity, momentum and energy relations, ideal and viscous fluids. Emphasis on incompressible fluids. Description of pumps and open channels. Prereq: PHY 231 and MA 214 and engineering standing.

**CE 351 INTRODUCTION TO ENVIRONMENTAL ENGINEERING.**

**(3)**

Overview of environmental chemistry and microbiology, water quality, water and wastewater treatment, solid and hazardous wastes management, hazardous waste remediation, and air pollution control. Emphasis on the basic science and engineering principles required to understand both natural and engineered systems, as well as the engineering approach to understanding the natural environment and specific treatment mitigation methods. Prereq: CHE 107, MA 214, PHY 231, and engineering standing.

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**CE 381 CIVIL ENGINEERING MATERIALS I. (3)**

A study of the microscopic and macroscopic structures and properties of materials used in civil engineering construction with emphasis on the relationships of their physical and mechanical properties to engineering design and application. Written reports and oral presentation of results will be required. Lecture, two hours; laboratory, three hours per week. Coreq: EM 302 and engineering standing.

**CE 382 STRUCTURAL ANALYSIS. (3)**

Statically determinate analysis of two-dimensional structures: trusses, beams and frames. Influence lines for truss and beam structures. Displacement calculations using virtual work principles. Statically indeterminate analysis includes approximate, force method and plastic analysis. Prereq: EM 302 and engineering standing.

**CE 395 INDEPENDENT WORK IN CIVIL ENGINEERING. (1-6)**

Individual work on some selected problem in the field of civil engineering. May be repeated for a maximum of six credits. Prereq: Engineering standing, consent of department chairperson and the instructor.

**CE 399 TOPICS IN CIVIL ENGINEERING (Subtitle required). (1-4)**

A detailed investigation of a topic of current significance in civil engineering such as: design of small earth dams, man and the environment, drilling and blasting, scheduling construction operations, construction equipment and methods, traffic safety, optimum structural design, environmental impact analysis, systems analysis in civil engineering, motor vehicle noise and its control. May be repeated to a maximum of eight credits, but only four credits can be earned under the same title. A particular topic may be offered at most twice under the CE 399 number. Prereq: Variable; given when topic identified and registration in the College of Engineering.

**CE 401 SEMINAR. (1)**

A discussion of the ethical and professional aspects of civil engineering practice. Concepts of loss prevention and conflict resolution. Structured small group discussion, oral presentations, and role playing. Lecture, two hours per week. Prereq: Senior classification and engineering standing.

**CE 403 CONSTRUCTION METHODOLOGY. (3)**

A study of the methodology used in construction, with an emphasis on the selection and application of resources: labor, materials, equipment, money and time. The importance of cost and quality is stressed. Weekly lab periods are used to acquaint the student with actual construction documents and to provide supervised work sessions in plan reading and basic estimating. Lecture, two hours; laboratory, three hours per week. Prereq: CE 303, CE 381, engineering standing.

**CE 429 CIVIL ENGINEERING SYSTEMS DESIGN. (4)**

The course is designed to provide the graduating civil engineer with an integration of professional practice issues with planning, design, and construction. Topics to be covered will include: development of teaming, problem solving, and decision-making skills; development of written and oral technical communication skills; procurement of professional services; integration of planning, design, and construction activities; integration of environmental, legal, political, and social issues and concerns into the project process. All activities will be conducted in teams. Lecture, three hours; laboratory three hours per week. Prereq: To be taken during the student's last semester.

**CE 451 WATER AND WASTEWATER TREATMENT. (3)**

Fundamentals of the design and operation of water and wastewater treatment facilities. Prereq: CE 341, CE 351, and engineering standing or consent of instructor.

**CE 460 FUNDAMENTALS OF GROUNDWATER HYDROLOGY. (3)**

The first course in the physics of saturated flow in porous media. Topics include groundwater occurrence, Darcian flow, well hydraulics, flow nets, layered systems flow and pollutant movement. Prereq: ME 330 or CE 341 or consent of instructor, and engineering standing. (Same as BAE 438G.)

**CE 461G HYDROLOGY. (3)**

A study of the physical laws governing the occurrence, distribution, and movement of water and contaminant substances in watershed and groundwater systems. Consideration of rainfall, runoff, and streamflow transport mechanisms. Principles and mathematical models describing the flow processes in both natural and developed watersheds. Design of water resource structures including culverts, stormsewers and stormwater detention facilities. Prereq: CE 341 and engineering standing or consent of instructor.

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- CE 471G SOIL MECHANICS. (4)**  
A study of the strength, deformation and hydraulic properties of soils and their relationship to settlement, stress distribution, earth pressure, bearing capacity and slope stability. Design of footing foundations and retaining walls. Written and oral presentations of student projects will be required. Lecture, three hours; laboratory, three hours per week. Prereq: EM 302; prereq or concur: GLY 220; and engineering standing or consent of instructor.
- CE 482 ELEMENTARY STRUCTURAL DESIGN. (3)**  
Application of principles of solid mechanics to the design of steel, timber, and reinforced concrete members and structures. Emphasis on basic ideas and their application to practical design of relatively simple structures according to the building code. Credit may not be used to satisfy degree requirements if credit is earned in CE 485G, or CE 486G, or CE 487G. Prereq: CE 382 and engineering standing.
- CE 486G REINFORCED CONCRETE STRUCTURES. (3)**  
Theory and design of beams, slabs, girders and columns as related to building frames and bridges. Introduction to pre-stressed concrete, elastic design and ultimate strength design. Concur: CE 487G; prereq: CE 382 and engineering standing, or consent of instructor.
- CE 487G STEEL STRUCTURES. (3)**  
Design criteria and methods. Behavior and design of structural steel beams, columns, beam-columns, and bolted and welded connections. Analysis and design of composite steel/concrete beams. Torsion of open and closed sections. Considerations of instability of beams, columns, and plates in design. Plastic analysis and design of continuous structures. Introduction to computerized structural analysis and design. Concur: CE 486G; prereq: CE 382 and engineering standing, or consent of instructor.
- CE 503 CONSTRUCTION ESTIMATING. (3)**  
This course investigates the principles of predicting and controlling the cost of construction projects. Items studied include feasibility studies, preliminary and detailed estimating, budgeting, monitoring and variance analysis. Computer applications for construction estimating will be stressed. Prereq: CE 403 and engineering standing or consent of instructor.
- CE 505 CONSTRUCTION PROJECT PLANNING AND MANAGEMENT. (3)**  
A study of the planning process and fundamental management procedures for construction projects. Special attention given to: planning of methods and resources; use of schedules; monitoring time; managing cash flow and costs; and overall project administration and record keeping. Prereq: CE 403 and engineering standing; or consent of instructor.
- #CE 507 CONSTRUCTION SAFETY AND HEALTH. (3)**  
The course will develop an understanding of safety and health; cost and human impact; hazard and risk analyses; psychological facts of organizational culture and climate; design safe work procedures for the execution of particular types of work; and individual versus management level improvement in safety and health procedures in the construction process. Prereq: Engineering standing and CE 303 or consent of instructor.
- CE 517 BOUNDARY LOCATION PRINCIPLES. (3)**  
Procedures for locating or relocating the boundaries of real property; records searching, technical aspects of field work, preparation of descriptions and survey reports, land data systems, legal aspects, special problems. Prereq: CE 211 or CE 215, engineering standing or consent of instructor.
- CE 518 ADVANCED SURVEYING. (3)**  
Principles of precise survey procedures in triangulation, trilateration, traverse and leveling; adjustment computations; theory and practice of electronic distance measurement; basic geodesy and state plane coordinate systems; applications to the horizontal and vertical control of engineering projects: review of modern land surveying problems and procedures. Lecture, two hours; laboratory, three hours per week. Prereq: MA 214, CE 211 or CE 215, and engineering standing.
- CE 521 ENGINEERING ECONOMY. (3)**  
Economic evaluation and financial analysis of engineering alternatives in which the goal of economic efficiency is applied to engineering design. Prereq: Engineering standing.

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**CE 525 CIVIL ENGINEERING APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. (3)**

CE 525 focuses on GIS as a tool in Civil Engineering. The terms and concepts related to Geographic Information Systems are introduced. The management of spatial databases, particularly those related to Civil Engineering, is covered. Students will collect data using a Global Positioning System (GPS). Students will be required to use the GIS ArcInfo to solve a specific individual spatial problem that they propose based on several Civil Engineering databases available to them. Lecture, two hours; laboratory, three hours per week. Prereq: Engineering standing and one of the following: CE 331, CE 341, or CE 471G.

**CE 531 GEOMETRIC DESIGN AND OPERATIONS OF ROADWAYS. (3)**

Analysis of transportation facilities through a diagnostic study of transportation systems with emphasis on design, capacity and safety. Engineering practice oriented toward open-ended design solutions, mostly focused on roadway design. Prereq: CE 211, CE 331, and engineering standing.

**CE 533 RAILROAD FACILITIES DESIGN AND ANALYSIS. (3)**

Principles of railroad location, construction, rehabilitation, maintenance, and operation with emphasis on track structure design and analysis, bridges and bridge loading, drainage considerations, track geometry effects, and operating systems analysis. Prereq: CE 331, CE 381, CE 382; concur: CE 471G and engineering standing.

**CE 534 PAVEMENT DESIGN, CONSTRUCTION AND MANAGEMENT. (3)**

Design, analysis, construction, and management of flexible and rigid pavements. Stresses and strains, pavement materials, subgrade soil stabilization, bases and subbases, quality control, drainage, pavement-type selection, and pavement management. Prereq: CE 381, prerequisite or concurrent CE 471G, and engineering standing.

**CE 539 TRANSPORTATION SYSTEMS DESIGN. (3)**

This course focuses on the design of urban intersections and the procedures used to evaluate the operational level of urban roadway systems. First, a review of urban intersection design principles and aspects is presented. Second, traffic signal timing techniques are reviewed and students are required to use two software packages for evaluation of traffic operation of urban roadway systems. The focal point of the course is a group design project where solutions to accommodate all transportation modes and their issues along a corridor in Lexington are sought. Fieldwork and data collection are part of this course. Lecture, two hours; laboratory, one hour. Prereq: CE 211 and CE 331; CE 531 prereq or concur.

**CE 541 INTERMEDIATE FLUID MECHANICS. (3)**

Application of basic fluid mechanics to problems of importance to civil engineering practice. This includes flow measuring, closed conduit flow and pipe networks, open channel flow, turbomachinery (pumps), hydraulic structures, culvert flow. Prereq: CE 341, CS programming course, and engineering standing or consent of instructor. (Same as BAE 541.)

**CE 542 INTRODUCTION TO STREAM RESTORATION. (3)**

Introduction to principles of fluvial geomorphology for application in restoring impaired streams. Topics include channel formation processes (hydrology/hydraulics), stream assessment, sediment transport, in-stream structures, erosion control, habitat, and monitoring. Prereq: CE 341 (or equivalent) and engineering standing or consent of instructor. (Same as BAE 532.)

**CE 546 FLUVIAL HYDRAULICS. (3)**

Rainfall physics, principles of erosion on upland areas and construction sites, stable channel design in alluvial material, mechanics of sediment transport, river mechanics, reservoir sedimentation. Prereq: CE 341 or ME 330 and engineering standing. (Same as BAE 536.)

**CE 549 ENGINEERING HYDRAULICS. (3)**

Analysis of flow in closed conduits and natural and artificial open channels. Design of hydraulic structures. Prereq: CE 541 and engineering standing, or consent of instructor. (Same as BAE 545.)

**CE 555 MICROBIAL ASPECTS OF ENVIRONMENTAL ENGINEERING. (3)**

Environmental microbiology for engineering students with emphasis on microbially mediated chemical cycles microbial ecology, and industrial microbiology. Prereq: CHE 105 and 107, engineering standing or consent of instructor.

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**CE 556 SOLID AND HAZARDOUS WASTE MANAGEMENT. (3)**

Study of the generation and management of solid and hazardous wastes. Application of engineering principles to the collection, transport, processing, resource recovery and ultimate disposal of these wastes. Prereq: CE 471G, CE 521 or consent of instructor and engineering standing. (Same as BAE 556.)

**CE 579 GEOTECHNICAL ENGINEERING. (3)**

Application of the principles of soil mechanics and structural mechanics to the design of retaining walls, bracing for excavations, footings, mat and pile foundations and to the analysis of the stability of earth slopes. Prereq: CE 471G and engineering standing.

**CE 581 CIVIL ENGINEERING MATERIALS II. (3)**

Design, evaluation, and construction of portland cement concrete and hot mix asphalt (HMA). Advanced topics related to high performance concrete and asphalt materials are covered in this course. Prereq: CE 381 and engineering standing.

**CE 582 INTERMEDIATE STRUCTURAL ANALYSIS. (3)**

Analysis of indeterminate, truss, frame and arch structures using energy principles associated with the flexibility and stiffness methods; influence line functions for indeterminate structures; and use of available computer programs for structural analysis and matrix operations. Prereq: CE 382 and engineering standing; or consent of instructor.

**CE 584 DESIGN OF TIMBER AND MASONRY STRUCTURES. (3)**

Current and historic design methods of buildings and their components using wood, wood products, bricks, and concrete blocks. Prereq: Courses in steel and reinforced concrete design at the senior level, or consent of instructor. (Same as ARC 584.)

**CE 585 CIVIL ENGINEERING FAILURES. (3)**

Fundamentals of failure investigation and forensic engineering; Failure types and mechanisms; Case studies and discussions on various constructed facilities. Prereq: CE 382 or consent of instructor, and engineering standing.

**CE 586 PRESTRESSED CONCRETE. (3)**

Fundamental basis and underlying principles for the analysis and design of prestressed concrete. Working stress and ultimate strength design methods, full and partial prestressing. Design for shear and torsion, deflection, crack control, and long-term effects, and prestress losses. Composite beams, continuous beams, slabs, short and slender columns, precast structures and their connections. Prereq: CE 486G and engineering standing.

**CE 589 DESIGN OF STRUCTURAL SYSTEMS. (3)**

Design loads. Structural systems and bracing. Analysis and design of buildings and bridges. Use of computer systems for design projects. Written and oral presentations required. Prereq: CE 486G and CE 487G; prereq or concur: CE 579; or consent of instructor.

**CE 595 INDEPENDENT WORK IN CE. (1-4)**

Individual work on some selected problem in the field of civil engineering. May be repeated for a maximum of six credits. Prereq: Consent of department chairperson and the instructor; with engineering standing.

**CE 599 TOPICS IN CIVIL ENGINEERING (Subtitle required). (1-4)**

A detailed investigation of a topic of current significance in civil engineering such as: design of small earth dams, man and the environment, drilling and blasting, scheduling construction operations, construction equipment and methods, traffic safety, optimum structural design, environmental impact analysis, systems analysis in civil engineering, motor vehicle noise and its control. May be repeated to a maximum of eight credits, but only four credits can be earned under the same title. A particular topic may be offered at most twice under the CE 599 number. Prereq: Variable; given when topic is identified; plus engineering standing.

**PREREQUISITE FOR GRADUATE WORK:** Students desiring to take any of the following courses should have a thorough working knowledge of chemistry, physics and mathematics. For major work, a candidate must hold a bachelor's degree in civil engineering or its equivalent.

## CE

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- CE 601 CONSTRUCTION EQUIPMENT. (3)**  
Analysis of construction equipment use and economics. Selection and matching equipment for productivity and cost effectiveness. Mathematical simulation of construction operations. Prereq: CE 403, CE 503, or consent of instructor.
- CE 602 CONSTRUCTION PROJECT MANAGEMENT. (3)**  
Management of construction projects: planning, estimating, scheduling and control; organization; site management; material management; safety management; quality management; construction labor relations; productivity management; claims. Prereq: CE 503, CE 505, or consent of instructor.
- CE 605 NEW ENGINEERING ENTERPRISES. (3)**  
The course covers the theory and actual practices of organization, management and operation of engineering companies. Primary emphasis on construction companies; however, the principles apply to most service oriented engineering companies. Students will be required to do several independent exercises related to establishing an engineering company. Prereq: CE 505, graduate standing in engineering, or consent of instructor.
- CE 631 URBAN TRANSPORTATION PLANNING. (3)**  
A detailed review of the transportation planning process; inventory methodologies; trip generation, distribution and assignment with associated mathematical models and theories; prediction of future travel; land and use models; modal split; developing and testing proposed systems; simulation. Prereq: CE 531 or equivalent and STA 381, or 681 or equivalent statistics course. (Same as GEO 643.)
- CE 633 AIR TRANSPORT ENGINEERING. (3)**  
Planning location and design of airports, STOL ports, and heliports. Air traffic operations, performance and control as related to facility requirements. Role of governmental agencies. Prereq: CE 531 or consent of instructor.
- CE 634 TRAFFIC CHARACTERISTICS. (3)**  
Vehicle operating characteristics; driver, pedestrian and roadway characteristics as they individually, and collectively as traffic stream characteristics, are related to the planning design and operation of highway facilities. Prereq: CE 531 and STA 381, or consent of instructor.
- CE 635 HIGHWAY SAFETY. (3)**  
A detailed review of the impacts of safety considerations on highway design and planning, focusing on the highway environment, its users (both vehicles and drivers) and their interactions. The role of special interest groups (tracking industry, insurance agencies) is also examined. Prereq: CE 539 or consent of instructor.
- CE 641 MECHANICS OF LIQUID FLOW IN PIPES. (3)**  
Steady and unsteady one-dimensional pipe flow. Water hammer and surge tank analysis. Steady two-dimensional pipe flow. Digital and analog computer applications. Prereq: CE 549.
- CE 642 OPEN CHANNEL FLOW. (3)**  
The study of open channel flow fundamentals and concepts. Topics include uniform flow, varied flow, steady and unsteady flow, energy dissipators, flow transitions, controls, analytical and numerical solutions in 1D and 2D applications. Prereq: CE 541 or consent of instructor. (Same as BAE 642.)
- #CE 643 MECHANICS OF SEDIMENT TRANSPORT. (3)**  
Fundamentals of turbulence in rivers and sediment transport will be taught including recent theory, derivation of governing equations, experimental methods, modeling, and design based on sediment thresholds. Prereq: CE 341 or consent of instructor. (Same as BAE 643.)
- CE 651 FUNDAMENTALS OF WATER QUALITY CONTROL I. (3)**  
Theory and practices of water and wastewater treatment with emphasis on physical and chemical processes for municipal and industrial wastewater treatment. Prereq: CE 451 or consent of instructor.
- CE 652 FUNDAMENTALS OF WATER QUALITY CONTROL II. (3)**  
Theory and practices of wastewater treatment with emphasis on biological treatment processes for municipal and industrial wastewater treatment. Prereq: CE 451 or consent of instructor.

**CE 653 WATER QUALITY IN SURFACE WATERS. (3)**

Water quality requirements for various beneficial uses. Analysis of dispersion, advection, evaporation, natural aeration, biological oxidation and photosynthesis; their effects on the physical, chemical and biological quality of waters in streams, lakes, reservoirs, estuaries and other surface waters. Eutrophication. Prereq: MA 214 and CE 451, or consent of instructor. (Same as BAE 653.)

**CE 655 WATER SANITATION AND HEALTH. (3)**

Prevention of water-related diseases by appropriate supply and sanitation practices with designs applicable to small systems and rural areas of developing nations. Prereq: Previous college-level courses in chemistry and/or biology, CE 451, or consent of instructor. (Same as CPH 790.)

**CE 660 GROUNDWATER HYDROLOGY. (3)**

The equations of saturated and unsaturated groundwater flow, the formulation of boundary value problems, and some analytical methods of solution. Solutions using Fourier series, solutions involving the Fourier transform and the Fourier sine and cosine transforms. The Boltzman transformation, development of the Philip solution for horizontal and vertical flow. Mathematical statement of the saturated and unsaturated groundwater pollution problem and some analytical methods of solution. The semigroup solution of the resulting evolution equation, examples of solutions using the Laplace transform and the Fourier transform, more complex solutions in two-dimensional and three-dimensional domains, solutions for distributed sources in time and in space, solutions for time-varied boundary conditions. Prereq: MA 214, CE 461G or equivalent. (Same as BAE 638.)

**CE 662 STOCHASTIC HYDROLOGY. (3)**

Hydrologic random variables and probability distributions. Statistical measures, development and use of Monte Carlo simulations in the generation of precipitation fields. Statistical tests of hydrologic data. Point frequency and regional frequency analysis. Analysis of hydrologic time series. Long-term trend, harmonic analysis of periodicity, autocorrelation, spectral analysis. Correlation and regression analysis. Linear stochastic models. Introduction to stochastic processes in hydrology, real-time hydrologic forecast (Kalman filter), pattern recognition, and stochastic differential equations. Prereq: MA 214, CE 461G or equivalent. (Same as BAE 662.)

**CE 665 WATER RESOURCES SYSTEMS. (3)**

Application of systems analysis, mathematic modeling, and optimization in water resources management and design. Solution of engineering problems found in water supply, water quality, urban drainage, and river basin development and management by use of linear, nonlinear, and dynamic programming models. Prereq or concur: CE 421 and CE 569 or consent of instructor. (Same as BAE 665.)

**CE 667 STORMWATER MODELING. (3)**

Introduction to deterministic and parametric modeling approaches for mathematically simulating stormwater runoff and quality. Emphasis on modeling concepts and model formulation. Analysis of deterministic component models and their linkage. Formulation of existing parametric models. Presentation of methods for parameter optimization and regionalization. Demonstration of linkage between the two approaches with illustrative examples. Prereq: CE 341 and CE 461G, or consent of instructor. (Same as BAE 667.)

**CE 671 ADVANCED SOIL MECHANICS. (3)**

Detailed study of soil behavior. Specific topics include soil classification and structure, strength and deformational behavior, compaction, consolidation, and stress distribution in earth masses. Prereq: CE 471G or consent of instructor.

**CE 672 LANDFILL DESIGN. (3)**

This course deals with the geotechnical aspects of the design of landfills for the disposal of municipal solid waste. Since landfill design is driven by state and federal regulations, time is taken to review these regulations. Landfills are evaluated as engineered systems consisting of multiple components. Each component is investigated individually, and methods are developed to predict and quantify the performance of these components so that appropriate materials, design criteria, and construction methods can be selected to assure that the landfill will function with minimal environmental impact. Prereq: CE 471G. (Same as BAE 672.)

**CE 676 GROUNDWATER AND SEEPAGE. (3)**

Permeability and capillary flow in soils, mathematical theory of flow through porous media. Flow through anisotropic, stratified and composite sections. Solution by flow net, conformal mapping and numerical methods. Seepage toward wells. Dewatering and drainage of soils. Prereq: CE 471G or consent of instructor.

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- CE 679 GEOTECHNICAL EARTHQUAKE ENGINEERING. (3)**  
Introduction to seismology. Dynamic and earthquake response of soils using standard analysis. Liquefaction of soils under cyclic loading. Measurements of dynamic properties of soils. Earthquake resistant design of retaining walls, foundations, slopes, and earth dams. Soil improvement methods for seismic resistant design. Current state-of-the-art techniques in geotechnical earthquake engineering. Prereq: CE 579.
- CE 681 ADVANCED CIVIL ENGINEERING MATERIALS. (3)**  
Fundamental aspects of mechanical behavior of civil engineering materials. Rheology and fracture of asphalt and Portland cement concrete materials. Prereq: CE 381.
- CE 682 ADVANCED STRUCTURAL ANALYSIS. (3)**  
Theory and application of energy principles for plane and space frames; material and geometric nonlinearities; and nonlinear solution schemes. Prereq: CE 582 or consent of instructor.
- CE 684 SLAB AND FOLDED PLATE STRUCTURES. (3)**  
Design and analysis of reinforced concrete floor slabs and folded plate roofs. Elastic and inelastic methods. Prereq: CE 582 or consent of instructor.
- CE 686 ADVANCED REINFORCED CONCRETE THEORY. (3)**  
Background and origin of modern reinforced concrete design procedures and codes. Comparison of American and foreign methods of analysis. Review of current research and projection to anticipated future changes in design and construction practices. Prereq: CE 486G or consent of instructor.
- CE 687 ADVANCED METAL STRUCTURES. (3)**  
Background and origin of modern structural steel design procedures and codes. Applications of various methods to structural buckling problems. Instability of beams, columns, frames, and plates. Considerations of buckling and interaction of buckling modes in design. Post-buckling analysis and design of cold-formed steel, and other metal structures. Plastic analysis and design of steel frames. Factors related to metal structural design. Prereq: CE 582 or consent of instructor.
- CE 699 TOPICS IN CIVIL ENGINEERING (Subtitle required). (1-4)**  
An advanced level presentation of a topic from one of the major areas of civil engineering such as hydraulics, geotechnics, structures, transportation, surveying, or water resources. Course with a given subtitle may be offered not more than twice under this number. Prereq: Variable; given when topic identified; graduate standing.
- CE 748 MASTER'S THESIS RESEARCH. (0)**  
Half-time to full-time work on thesis. May be repeated to a maximum of six semesters. Prereq: All course work toward the degree must be completed.
- CE 749 DISSERTATION RESEARCH. (0)**  
Half-time to full-time work on dissertation. May be repeated to a maximum of six semesters. Prereq: Registration for two full-time semesters of 769 residence credit following the successful completion of the qualifying exams.
- CE 767 DISSERTATION RESIDENCY CREDIT. (2)**  
Residency credit for dissertation research after the qualifying examination. Students may register for this course in the semester of the qualifying examination. A minimum of two semesters are required as well as continuous enrollment (Fall and Spring) until the dissertation is completed and defended.
- CE 768 RESIDENCE CREDIT FOR MASTER'S DEGREE. (1-6)**  
May be repeated to a maximum of 12 hours.
- CE 769 RESIDENCE CREDIT FOR DOCTOR'S DEGREE. (0-12)**
- CE 779 ADVANCED GEOTECHNICAL ENGINEERING. (3)**  
Application of the principles of soil mechanics to the design and analysis of foundations and earth structures. Prereq: CE 579 and CE 671 or consent of instructor.

**CE 782 DYNAMICS OF STRUCTURES. (3)**

Review of methods of analysis of simple structural systems. Effects of wind, earthquake, traffic and machinery loads. Matrix methods for complex dynamic structural systems, random vibrations of structures. Prereq: CE 582 or consent of instructor.

**CE 783 STRUCTURAL FINITE ELEMENT ANALYSIS. (3)**

Theoretical, conceptual and computational aspects of the finite element method are presented. Development of the element relationships, element calculations, assembly and efficient solution of the finite element method are emphasized. Finite element formulations developed for 2D, 3D axisymmetric and plate bending problems in structural mechanics for both static and dynamic applications. Prereq: MA 432G and EGR 537, or CE 682 or consent of instructor.

**CE 784 SHELL STRUCTURES. (3)**

Design and analysis of reinforced concrete shell structures, including domes, barrel shells, hyperbolic paraboloids and cylindrical tanks. Prereq: CE 684 or consent of instructor.

**CE 790 SPECIAL RESEARCH PROBLEMS IN CIVIL ENGINEERING. (1-6)**

Individual work on some selected problems in one of the various fields of civil engineering. Laboratory, six hours. May be repeated to a maximum of nine credits. Prereq: Consent of the chairperson of the department.

**CE 791 SPECIAL DESIGN PROBLEMS IN CIVIL ENGINEERING. (1-6)**

Individual work on some selected problems in one of the various fields of civil engineering. Laboratory, six hours. May be repeated to a maximum of nine credits. Prereq: Consent of the chairperson of the department.