

# CIVIL ENGINEERING (C E)

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**Any experimental courses offered by C E can be found at:**

registrar.iastate.edu/faculty-staff/courses/explistsings/ (<http://www.registrar.iastate.edu/faculty-staff/courses/explistsings/>)

**Courses primarily for undergraduates:**

## **C E 111: Fundamentals of Surveying I**

(2-3) Cr. 3. F.S.

*Prereq: MATH 165, C E 160, C E 170*

Introduction to error theory. Fundamentals of observing distances, elevations, and angles. Traversing. Irregular areas. Circular and parabolic curves. Earthwork including mass diagrams. Construction staking. Computer applications and introduction to photogrammetry, geographic information systems and global positioning systems technology.

## **C E 120: Civil Engineering Learning Community**

(1-0) Cr. 1. F.S.

Integration of first-year students into the Civil Engineering program. Assignments and activities involving teamwork, academic preparation, study skills, and preparation for entry into the Civil Engineering profession. Completed both individually and in learning teams under the direction of faculty and peer mentors.

## **C E 160: Engineering Problems with Computational Laboratory**

(2-2) Cr. 3. F.S.

*Prereq: Credit or enrollment in MATH 165*

Engineering approach to solving problems and presenting results with applications to examples in civil, construction, and environmental engineering, such as problems in statics. Dimensions and units. Data processing, graphing, and curve fitting. Formulating and solving fundamental and practical engineering problems with spreadsheets and a structured programming language. Only one of ENGR 160, A B E 160, AER E 160, C E 160, CH E 160, CPR E 185, E E 185, I E 148, M E 160, and S E 185 may count towards graduation.

## **C E 170: Graphics for Civil Engineering**

(0-4) Cr. 2. F.S.

*Prereq: Satisfactory scores on mathematics placement assessments; credit or enrollment in MATH 143 or MATH 145*

Integration of fundamental graphics, computer modeling, and engineering design. Applications of multiview drawings and dimensioning. Techniques for visualizing, analyzing, and communicating 3-D geometries. Application of the design process. Freehand and computer methods.

## **C E 190: Introduction to Undergraduate Research in Civil and Environmental Engineering**

(Cross-listed with ENV E). Cr. 2. Repeatable, maximum of 4 times.

*Prereq: Permission of instructor*

Introduction to research, focusing on sub-disciplines of civil and environmental engineering. Research questions, hypotheses, literature reviews, experimental design, data collection, data analysis, and presentation. Topics chosen to introduce students to water resources, environmental engineering, transportation engineering, geotechnical/materials engineering, or structural engineering. Repeatable but only two credits may count toward graduation in C E

## **C E 206: Engineering Economic Analysis and Professional Issues in Civil Engineering**

(3-0) Cr. 3. F.S.

*Prereq: MATH 166, ENGL 250; C E 120 or equivalent; ECON 101 recommended*

Engineering/managerial analysis of the economic aspects of project proposals. Alternative sources of funds; time value of money; expenditure of capital funds and methods of evaluating alternative projects. Professionalism, licensure, liability, ethics, leadership, risk analysis, social responsibility, creative and critical thinking, and applications/impacts of regulations in civil engineering.

## **C E 274: Engineering Statics**

(3-0) Cr. 3. F.S.SS.

*Prereq: PHYS 231 and PHYS 231L, credit or enrollment in MATH 166*

Vector analysis; analysis of force systems; resultant in two and three dimensions; free-body diagrams; equilibrium; analysis of trusses, frames, and machines; friction, belts and pulleys; shear and bending moment in beams, centroid and center of mass; second moments of areas.

## **C E 306: Project Management for Civil Engineers**

(2-3) Cr. 3. F.S.

*Prereq: C E 120 or ENV E 120 and C E 170 or ENV E 190*

Project management, including work breakdown structures, cost estimating, scheduling, and project control. Civil engineering project life cycle, including planning, design, construction, and maintenance processes. Techniques in interpretation of contract documents, plan reading, and in estimating quantities.

## **C E 326: Principles of Environmental Engineering**

(2-2) Cr. 3. F.S.

*Prereq: CHEM 167 or CHEM 177 and CHEM 178, MATH 166, credit or enrollment in E M 378*

Introduction to environmental problems, water quality indicators and requirements, potable water quality and quantity objectives, water sources and treatment methods; water pollution control objectives and treatment methods; survey of solid and hazardous waste management and air pollution control.

**C E 332: Structural Analysis I**

(2-2) Cr. 3. F.S.

*Prereq: E M 324*

Loads, shear, moment, and deflected shape diagrams for beams and framed structures. Deformation calculations. Approximate methods. Application of consistent deformation methods to continuous beams and frames. Application of displacement or slope deflection methods to continuous beams and frames without sway. Influence lines for determinate and indeterminate structures. Computer applications to analyze beams and frames. Validation of computer results.

**C E 333: Structural Steel Design I**

(3-1) Cr. 3. F.S.

*Prereq: C E 332, E M 327*

AISC design methods for structural steel buildings. Design of steel tension members. Design of steel members for flexure. Design of members for compression. Beam-Column member design. Introduction to steel building systems. Steel moment frames and concentrically braced frames. Design of commonly used connections in steel buildings.

**C E 334: Reinforced Concrete Design I**

(2-2) Cr. 3. F.S.

*Prereq: C E 332, E M 327*

ACI design methods for structural concrete members. Emphasis on the analysis and design for flexure of singly reinforced and doubly reinforced sections, T-section, one-way slabs, short columns, and isolated footings. Analysis and design for shear, and serviceability. Bond, anchorage, and development of reinforcement.

**C E 355: Principles of Transportation Engineering**

(3-0) Cr. 3. F.S.

*Prereq: C E 111*

Introduction to planning, design, and operations of transportation facilities. Road user, vehicle and roadway characteristics. Technological, economic and environmental factors. Asset management, transportation planning, capacity analysis, traffic control, geometric design, traffic safety.

**C E 360: Geotechnical Engineering**

(3-3) Cr. 4. F.S.

*Prereq: E M 324, credit or enrollment in GEOL 201 or CON E 241*

Introduction to geotechnical engineering and testing. Identification and classification tests, soil water systems, principles of settlement, stresses in soils, and shear strength testing; slope stability, retaining walls, bearing capacity.

**C E 372: Engineering Hydrology and Hydraulics**

(3-0) Cr. 3. F.S.

*Prereq: E M 378, a course in statistics from the approved department list*

The hydrologic cycle: precipitation, infiltration, runoff, evapotranspiration, groundwater, and streamflow. Hydrograph analysis, flood routing, frequency analysis and urban hydrology. Applied hydraulics including pipe and channel flow with design applications in culverts, pumping, water distribution, storm and sanitary sewer systems. Design project required.

**C E 382: Design of Concretes**

(2-3) Cr. 3. F.S.

*Prereq: E M 274*

Physical and chemical properties of bituminous, portland, and other cements; aggregate properties and blending; mix design and testing of concretes; admixtures, mixing, handling, placing and curing; principles of pavement thickness design.

**C E 383: Design of Portland Cement Concrete**

(0-2) Cr. 1. F.S.

*Prereq: E M 274*

For Con E students only. Physical and chemical properties of portland cement and p.c. concrete. Mix design and testing of p.c. concrete. Credit for both C E 382 and C E 383 may not be applied for graduation.

**C E 388: Sustainable Engineering and International Development**

(Cross-listed with A B E, E E). (2-2) Cr. 3. F.

*Prereq: Junior classification in engineering*

Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report. Meets International Perspectives Requirement.

**C E 395: Global Perspectives in Transportation**

Cr. 3. Repeatable, maximum of 2 times. S.

Background on historical civil engineering design and construction. Impacts of historical, cultural, social, economic, ethical, environmental, and political conditions on the design and construction of various infrastructure projects outside the United States. Global road safety and intermodal operations. Addressing transportation problems in a large metropolitan area.

Meets International Perspectives Requirement.

**C E 396: Summer Internship**

Cr. R. Repeatable. SS.

*Prereq: Permission of department and Engineering Career Services*

Summer professional work period. Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

**C E 398: Cooperative Education (Co-op)**

Cr. R. Repeatable. F.S.

*Prereq: Permission of department and Engineering Career Services*

Professional work period. One semester per academic or calendar year. Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

**C E 403: Program and Outcome Assessment**

Cr. R. F.S.

*Prereq: Verification of undergraduate application for graduation by the end of the first week of class. Permission of instructor for students who are scheduled for summer graduation*

Assessment of C E Curriculum and educational objectives. Assessments to be reviewed by the CE Department to incorporate potential improvements. Offered on a satisfactory-fail basis only.

**C E 413: Applied and Environmental Geophysics**

(Dual-listed with C E 513). (Cross-listed with ENSCI, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging systems and radar.

**C E 417: Land Surveying**

(2-3) Cr. 3. S.

*Prereq: C E 111*

Legal principles affecting the determination of land boundaries, public domain survey systems. Locating sequential and simultaneous conveyances. Record research, plat preparation, and land description. Study of selected court cases.

**C E 420: Environmental Engineering Chemistry**

(Dual-listed with C E 520). (Cross-listed with ENSCI). (2-3) Cr. 3. F.

*Prereq: C E 326, CHEM 178*

Principles of chemical and physical phenomena applicable to the treatment of water and wastewater and natural waters; including chemical equilibria, reaction kinetics, acid-base equilibria, chemical precipitation, redox reactions, and mass transfer principles. Individual laboratory practicals and group projects required.

**C E 421: Environmental Biotechnology**

(Dual-listed with C E 521). (2-2) Cr. 3. F.

*Prereq: C E 326*

Fundamentals of biochemical and microbial processes applied to environmental engineering processes, role of microorganisms in wastewater treatment and bioremediation, bioenergetics and kinetics, metabolism of xenobiotic compounds, waterborne pathogens and parasites, and disinfection. Term paper and oral presentation.

**C E 424: Air Pollution**

(Dual-listed with C E 524). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 424A: Air Pollution: Air quality and effects of pollutants**

(Dual-listed with C E 524A). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 424B: Air Pollution: Climate change and causes**

(Dual-listed with C E 524B). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 424C: Air Pollution: Transportation Air Quality**

(Dual-listed with C E 524C). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: C E 524A; PHYS 231 and PHYS 231L or CHEM 178; MATH 166 or 3 credits in statistics. Senior classification or above.*

**C E 424D: Air Pollution: Off-gas treatment technology**

(Dual-listed with C E 524D). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: C E 524A, C E 524B; Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

**C E 424E: Air Pollution: Agricultural sources of pollution**

(Dual-listed with C E 524E). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 428: Water and Wastewater Treatment Plant Design**

(2-2) Cr. 3. S.

*Prereq: C E 326*

Physical, chemical and biological processes for the treatment of water and wastewater including coagulation and flocculation, sedimentation, filtration, adsorption, chemical oxidation/disinfection, fixed film and suspended growth biological processes and sludge management. Design project.

**C E 439: Seismic Methods in Geology, Engineering, and Petroleum Exploration**

(Dual-listed with C E 539). (Cross-listed with GEOL). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

Physics of elastic-wave propagation. Seismic surveys in environmental imaging, engineering, and petroleum exploration. Reflection and refraction techniques. Data collection, processing, and geological interpretation. Field work with state-of-the-art equipment.

**C E 446: Bridge Design**

(Dual-listed with C E 546). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: C E 333, C E 334*

Bridge design in structural steel and reinforced concrete. Application of AASHTO Bridge Design Specifications. Analysis techniques for complex structures. Preliminary designs include investigating alternative structural systems and materials. Final designs include preparation of design calculations and sketches. Design project.

**C E 448: Building Design**

(Dual-listed with C E 548). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: C E 333, C E 334*

Building design in structural steel and reinforced concrete. Investigation of structural behavior. Gravity and lateral load resisting systems. Application of current building codes and design specifications. In-depth analysis of gravity and wind loads on buildings. Review of building designs. Preliminary designs include investigating alternative structural systems. Approximate methods of structural analysis for gravity and lateral loads. Final designs include preparation of design calculations and sketches. Design project.

**C E 449: Structural Health Monitoring**

(Dual-listed with C E 549). (3-0) Cr. 3.

*Prereq: Senior classification in Engineering or permission of instructor*

Introductory and advanced topics in structural health monitoring (SHM) of aeronautical, civil, and mechanical systems. Topics include sensors, signal processing in time and frequency domains, data acquisition and transmission systems, design of integrated SHM solutions, nondestructive evaluation techniques, feature extraction methods, and cutting-edge research in the field of SHM. Graduate students will have a supervisory role to assist students in 449 and an additional design project or more in-depth analysis and design.

**C E 451: Urban Transportation Planning Models**

(Dual-listed with C E 551). (3-0) Cr. 3. F.

*Prereq: C E 355 and a course in statistics from the approved departmental list*

Urban transportation planning context and process. Project planning and programming. Congestion, mitigation, and air quality issues. Transportation data sources. Travel demand and network modeling. Use of popular travel demand software and applications of geographic information systems.

**C E 453: Highway Design**

(2-2) Cr. 3. F.

*Prereq: C E 306, C E 355*

Introduction to highway planning and design. Design, construction, and maintenance of highway facilities. Level-of-service, stopping sight distance, highway alignment, earthwork and pavement design. Design project, oral reports and written reports. Computer applications.

**C E 460: Foundation Engineering**

(3-0) Cr. 3. F.S.

*Prereq: C E 360*

Fundamentals of foundation engineering. Exploration, sampling, and in-situ tests. Shallow and deep foundations. Settlement and bearing capacity analyses. Stability of excavations and earth retaining structures. Design project.

**C E 462: Site Evaluations for Civil Engineering Projects**

(Dual-listed with C E 562). (2-3) Cr. 3.

*Prereq: C E 360 or instructor approval*

Identification and mapping of engineering soils from aerial photos, maps, and soil surveys. Planning subsurface investigations, geomaterials prospecting, geotechnical hazards, geomorphology, in situ testing and sampling, geophysical site characterization, instrumentation and monitoring, interpretation of engineering parameter values for design.

**C E 467: Geomaterials Stabilization**

(Dual-listed with C E 567). (2-2) Cr. 3.

*Prereq: C E 360, C E 382 or C E 383, or instructor approval*

Soil and aggregate physical, chemical and biological stabilization procedures. Stabilization analysis and design. Ground modification and compaction methods. Geosynthetics application and design.

**C E 473: Groundwater Hydrology**

(Dual-listed with C E 573). (3-0) Cr. 3. F.

*Prereq: C E 372*

Principles of groundwater flow, hydraulics of wells, superposition, slug and pumping tests, streamlines and flownets, and regional groundwater flow. Contaminant transport. Computer modeling. Design project. Extra assignments required for graduate students.

**C E 483: Pavement Analysis and Design**

(Dual-listed with C E 583). (3-0) Cr. 3. S.

*Prereq: C E 360 and C E 382*

Analysis, behavior, performance, and structural design of pavement systems. Topics include climate factors, rehabilitation, life cycle design economics, material and system response, pavement foundations and traffic loadings. Development of models for and analysis of pavement systems. Use of transfer functions relating pavement response to pavement performance. Evaluation and application of current and evolving pavement design practices and procedures. Mechanistic-based pavement design techniques and concepts. Analysis of the effects of maintenance activities on pavement performance and economic evaluation of pavement systems. Design project.

**C E 484: Advanced Design of Concretes**

(Dual-listed with C E 584). (2-3) Cr. 3.

*Prereq: C E 382*

Asphalt binder characterization, fundamentals of asphalt rheology, asphalt materials behavior under loading and temperature effects. High-strength, lightweight, fiber-reinforced, and self-consolidating portland cement concretes, mix design, properties, advanced performance testing. Design project.

**C E 485: Civil Engineering Design**

(2-2) Cr. 3. F.S.

*Prereq: C E 206, C E 306, C E 326, C E 333 or C E 334, C E 355, C E 360, C E 372, C E 382, SP CM 212. Course enrollment limited to final graduating semester.*

The civil engineering design process, interacting with the client, identification of the engineering problems, development of a technical proposal, identification of design criteria, cost estimating, planning and scheduling, codes and standards, development of feasible alternatives, selection of best alternative, and oral presentation.

**C E 488: Sustainable Civil Infrastructure Systems**

(Dual-listed with C E 588). (3-0) Cr. 3. F.

*Prereq: Junior or higher classification in engineering or science*

Sustainable planning, life cycle analysis, appropriate engineering design, investment levels and overall rating of civil engineering infrastructure systems, including highway, bridge, airport, rail, dam, power and port facilities. Complementary assessment of future civil infrastructure sustainability impacts and challenges in relation to autonomous and electric vehicle development. Overview regarding US and global availability and supply of critical infrastructure commodities (e.g., cement, stone, metals, phosphorus, uranium, etc.). Directed course readings and multiple project/design reports.

**C E 489: Pavement Preservation and Rehabilitation**

(Dual-listed with C E 589). Cr. 3. F.S.

*Prereq: C E 382*

Overview of pavement preservation and pavement rehabilitation techniques. Overview and selection of materials used in pavement preservation and rehabilitation strategies. Evaluating suitability of pavement preservation and pavement rehabilitation strategies based on existing structure, pavement distresses and non-condition factors. Use of recycled pavement materials in pavement reconstruction techniques.

**C E 490: Independent Study**

Cr. 1-3. Repeatable. F.S.SS.

*Prereq: Permission of instructor*

Independent study in any phase of civil engineering. Pre-enrollment contract required. No more than 6 credits of C E 490 may be counted towards engineering topics electives.

**C E 490H: Independent Study: Honors**

Cr. 1-3. Repeatable. F.S.SS.

*Prereq: Permission of instructor*

Independent study in any phase of civil engineering. Pre-enrollment contract required. No more than 6 credits of C E 490H may be counted towards engineering topics electives.

**Courses primarily for graduate students, open to qualified undergraduates:**

**C E 501: Preconstruction Project Engineering and Management**

(3-0) Cr. 3.

*Prereq: Credit or enrollment in CON E 422 or C E 306 or graduate standing*

Application of engineering and management control techniques to construction project development from conceptualization to notice to proceed. Emphasis is on managing complex projects using 5-dimensional project management theory.

**C E 502: Construction Project Engineering and Management**

(3-0) Cr. 3.

*Prereq: Credit or enrollment in CON E 422 or C E 594A or permission of instructor*

Application of engineering and management control techniques to complex construction projects. Construction project control techniques, project administration, construction process simulation, quality management, and productivity improvement programs.

**C E 503: Construction Finance and Business Management**

(3-0) Cr. 3.

*Prereq: Credit or enrollment in CON E 422 or C E 594A or permission of instructor*

Fundamental theories and applied methods for financial management of construction projects and companies. Construction accounting, cash flow analysis, financial planning and management, and risk analysis. Case studies.

**C E 505: Design of Construction Systems**

(3-0) Cr. 3.

*Prereq: C E 333, C E 360, CON E 322, CON E 340; or graduate standing*

Advanced design of concrete formwork and falsework systems. Design for excavation and marine construction including temporary retaining structures and cofferdams. Aggregate production operations, including blasting, crushing, and conveying systems. Rigging system design.

**C E 506: Case Histories in Construction Documents**

(3-0) Cr. 3.

*Prereq: Graduate standing or permission of instructor*

Study of cases involving disputes, claims, and responsibilities encountered by management in construction contract documents. Analysis of methods of resolving differences among the owner, architect, engineer, and construction contractor for a project.

**C E 510: Information Technologies for Construction**

(3-0) Cr. 3.

*Prereq: Graduate standing or permission of instructor*

Information technologies including microcomputer based systems, management information systems, automation technologies, computer-aided design, and expert systems and their application in the construction industry. Overview of systems acquisition, communications, and networking.

**C E 513: Applied and Environmental Geophysics**

(Dual-listed with C E 413). (Cross-listed with ENSCI, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging systems and radar.

**C E 520: Environmental Engineering Chemistry**

(Dual-listed with C E 420). (Cross-listed with ENSCI). (2-3) Cr. 3. F.

*Prereq: C E 326, CHEM 178*

Principles of chemical and physical phenomena applicable to the treatment of water and wastewater and natural waters; including chemical equilibria, reaction kinetics, acid-base equilibria, chemical precipitation, redox reactions, and mass transfer principles. Individual laboratory practicals and group projects required.

**C E 521: Environmental Biotechnology**

(Dual-listed with C E 421). (Cross-listed with ENSCI). (2-2) Cr. 3. F.

*Prereq: C E 326*

Fundamentals of biochemical and microbial processes applied to environmental engineering processes, role of microorganisms in wastewater treatment and bioremediation, bioenergetics and kinetics, metabolism of xenobiotic compounds, waterborne pathogens and parasites, and disinfection. Term paper and oral presentation.

**C E 522: Water Pollution Control Processes**

(Cross-listed with ENSCI). (2-2) Cr. 3.

*Prereq: C E 421 or C E 521*

Fundamentals of biochemical processes, aerobic growth in a single CSTR, multiple events in complex systems, and techniques for evaluating kinetic parameters; unit processes of activated sludge system, attached growth systems, stabilization and aerated lagoon systems, biosolids digestion and disposal, nutrient removal, and anaerobic treatment systems.

**C E 523: Physical-Chemical Treatment Process**

(Cross-listed with ENSCI). (2-2) Cr. 3.

*Prereq: C E 520*

Material and energy balances. Principles and design of physical-chemical unit processes; including screening, coagulation, flocculation, chemical precipitation, sedimentation, filtration, lime softening and stabilization, oxidation, adsorption, membrane processes, ion exchange and disinfection; recovery of resources from residuals and sludges; laboratory exercises and demonstrations; case studies in mineral processing and secondary industries.



**C E 524: Air Pollution**

(Dual-listed with C E 424). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 524A: Air Pollution: Air quality and effects of pollutants**

(Dual-listed with C E 424A). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 524B: Air Pollution: Climate change and causes**

(Dual-listed with C E 424B). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 524C: Air Pollution: Transportation Air Quality**

(Dual-listed with C E 424C). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: C E 524A; PHYS 231 and PHYS 231L or CHEM 178; MATH 166 or 3 credits in statistics. Senior classification or above.*

**C E 524D: Air Pollution: Off-gas treatment technology**

(Dual-listed with C E 424D). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: C E 524A, C E 524B; Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

**C E 524E: Air Pollution: Agricultural sources of pollution**

(Dual-listed with C E 424E). (Cross-listed with A B E, ENSCI). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

**C E 528: Solid and Hazardous Waste Management**

(Cross-listed with ENSCI). (3-0) Cr. 3.

*Prereq: C E 326 or background courses in both environmental chemistry and microbiology; junior or higher standing*

Evaluation, characterization, assessment, planning and design of solid and hazardous waste management systems, regulatory requirements, material characterization and collection, minimization and recycling, energy and materials recovery, composting, off-gas treatment, incineration, stabilization, and landfill design. Design of treatment and disposal systems, including physical, chemical, and biological treatment, solidification, incineration, secure landfill design, and final disposal site closure plus restoration.

**C E 532: Structural Analysis II**

(3-0) Cr. 3. F.

*Prereq: C E 332*

Analysis of indeterminate structural problems by the consistent deformation and generalized direct displacement methods. Direct stiffness method for 2-D frames, grids, 3-D frames. Special topics for the stiffness method.

**C E 533: Structural Steel Design II**

(3-0) Cr. 3.

*Prereq: C E 333*

Theoretical background and development of AISC Specification equations. In-depth analysis and design of tension members, columns, beams, beam-columns, and plate girders. Emphasis on Load and Resistance Factor Design. Elastic and inelastic buckling of members and member elements. Investigation of amplification factors for members subject to combined bending and axial load and to combined bending and torsion. Effective Length Method and Direct Analysis Method of design. Approximate Second-Order Analysis. Biaxial bending. Torsion and combined bending and torsion of W-shapes.

**C E 534: Reinforced Concrete Design II**

(2-2) Cr. 3.

*Prereq: C E 334*

Advanced topics in reinforced concrete analysis and design. Moment-curvature and load-deflection behavior. Design of reinforced concrete long columns, two-way floor slabs, and isolated and combined footings. Design and behavior considerations for torsion, biaxial bending, and structural joints. Strut-and-tie modeling.

**C E 535: Prestressed Concrete Structures**

(3-0) Cr. 3.

*Prereq: C E 334*

Design of prestressed concrete structures, review of hardware, stress calculations, prestress losses, section proportioning, flexural design, shear design, deflections, and statically indeterminate structures.

**C E 539: Seismic Methods in Geology, Engineering, and Petroleum Exploration**

(Dual-listed with C E 439). (Cross-listed with GEOL). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

Physics of elastic-wave propagation. Seismic surveys in environmental imaging, engineering, and petroleum exploration. Reflection and refraction techniques. Data collection, processing, and geological interpretation. Field work with state-of-the-art equipment.

**C E 541: Dynamic Analysis of Structures**

(3-0) Cr. 3.

*Prereq: E M 345 and credit or enrollment in C E 532*

Single and multi-degree-of-freedom systems. Free and forced vibrations. Linear and nonlinear response. Modal analysis. Response spectra. Seismic analysis.

**C E 542: Structural Analysis by Finite Elements**

(3-0) Cr. 3.

*Prereq: C E 532*

Use of the finite element method for the analysis of complex structural configurations. Plane stress, solid, Axisymmetric and plate elements. Numerical integration. Use of general purpose finite element programs.

**C E 545: Seismic Design**

(3-0) Cr. 3.

*Prereq: C E 333, C E 334*

Seismic hazard in the United States. Engineering characteristics of ground motions. Structural damage in past earthquakes. Capacity design philosophy for seismic resistant design. Conceptual design of structures. Capacity design process including design of structural members.

**C E 546: Bridge Design**

(Dual-listed with C E 446). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: C E 333, C E 334*

Bridge design in structural steel and reinforced concrete. Application of AASHTO Bridge Design Specifications. Analysis techniques for complex structures. Preliminary designs include investigating alternative structural systems and materials. Final designs include preparation of design calculations and sketches. Design project.

**C E 548: Building Design**

(Dual-listed with C E 448). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: C E 333, C E 334*

Building design in structural steel and reinforced concrete. Investigation of structural behavior. Gravity and lateral load resisting systems. Application of current building codes and design specifications. In-depth analysis of gravity and wind loads on buildings. Review of building designs. Preliminary designs include investigating alternative structural systems. Approximate methods of structural analysis for gravity and lateral loads. Final designs include preparation of design calculations and sketches. Design project.

**C E 549: Structural Health Monitoring**

(Dual-listed with C E 449). (3-0) Cr. 3.

*Prereq: Senior classification in Engineering or permission of instructor*  
Introductory and advanced topics in structural health monitoring (SHM) of aeronautical, civil, and mechanical systems. Topics include sensors, signal processing in time and frequency domains, data acquisition and transmission systems, design of integrated SHM solutions, nondestructive evaluation techniques, feature extraction methods, and cutting-edge research in the field of SHM. Graduate students will have a supervisory role to assist students in 449 and an additional design project or more in-depth analysis and design.

**C E 551: Urban Transportation Planning Models**

(Dual-listed with C E 451). (3-0) Cr. 3. F.

*Prereq: C E 355 and a course in statistics from the approved departmental list*  
Urban transportation planning context and process. Project planning and programming. Congestion, mitigation, and air quality issues. Transportation data sources. Travel demand and network modeling. Use of popular travel demand software and applications of geographic information systems.

**C E 552: Traffic Safety, Operations, and Maintenance**

(3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: C E 355*

Engineering aspects of highway traffic safety. Reduction of crash incidence and severity through highway design and traffic control. Accident analysis. Safety in highway design, maintenance, and operation.

**C E 553: Traffic Engineering**

(3-0) Cr. 3. F.

*Prereq: C E 355*

Driver, pedestrian, and vehicular characteristics. Traffic characteristics; highway capacity; traffic studies and analyses. Principles of traffic control for improved highway traffic service. Application of appropriate computing software and tools.

**C E 556: Transportation Data Analysis**

(3-0) Cr. 3.

*Prereq: C E 355, a Statistics course at the 300 level or higher*

Analysis of transportation data, identification of data sources and limitations. Static and dynamic data elements such as infrastructure characteristics, flow and operations-related data elements. Spatial and temporal extents data for planning, design, operations, and management of transportation systems. Summarizing, analyzing, modeling, and interpreting data. Use of information technologies for highways, transit, and aviation systems.



**C E 557: Transportation Systems Analysis**

(3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: C E 355, 3 credits in statistics or probability*

Travel studies and analysis of data. Transportation systems forecasts and analyses. Statewide, regional, and local transportation system planning. Network level systems planning and operations. Optimization of systems.

**C E 558: Transportation Systems Development and Management**

(3-0) Cr. 3.

*Prereq: C E 355*

Study of designated problems in traffic engineering, transportation planning, and development. Forecasting and evaluation of social, economic, and environmental impacts of proposed solutions; considerations of alternatives. Formulation of recommendations and publication of a report. Presentation of recommendations in the host community.

**C E 559: Transportation Infrastructure/Asset Management**

(3-0) Cr. 3.

*Prereq: C E 355*

Engineering management techniques for maintaining and managing infrastructure assets. Systematic approach to management through value engineering, engineering economics, and life cycle cost analysis. Selection and scheduling of maintenance activities. Analysis of network-wide resource needs. Project level analysis.

**C E 560: Fundamentals of Soil Mechanics**

(3-0) Cr. 3.

*Prereq: C E 360 or instructor approval*

Nature of soil deposits, seepage, settlement and secondary compression, consolidation theories and analysis, failure theories, stress paths, introduction to critical state soil mechanics, constitutive models, soil strength under various drainage conditions, liquefaction of soil, pore pressure parameters, selection of soil parameters.

**C E 561: Applied Foundation Engineering**

(3-0) Cr. 3.

*Prereq: C E 460 or instructor approval*

Analysis and design of shallow and deep foundations, lateral earth pressure theories and retaining structures, field investigations, in-situ testing, and foundations on problematic soils. Foundation engineering reports.

**C E 562: Site Evaluations for Civil Engineering Projects**

(Dual-listed with C E 462). (2-3) Cr. 3.

*Prereq: C E 360 or instructor approval*

Identification and mapping of engineering soils from aerial photos, maps, and soil surveys. Planning subsurface investigations, geomaterials prospecting, geotechnical hazards, geomorphology, in situ testing and sampling, geophysical site characterization, instrumentation and monitoring, interpretation of engineering parameter values for design.

**C E 563: Experimental Methods in Geo-Engineering**

(2-2) Cr. 3.

*Prereq: C E 360 or instructor approval*

Principles of geo-engineering laboratory testing including the conduct, analysis, and interpretation of permeability, consolidation, triaxial, direct and ring shear, and direct simple shear tests. Issues regarding laboratory testing versus field testing and acquisition, transport, storage, and preparation of samples for geotechnical testing. Field and laboratory geotechnical monitoring techniques, including the measurements of deformation, strain, total stress and pore water pressure.

**C E 564: Application of Numerical Methods to Geotechnical Design**

(3-0) Cr. 3.

*Prereq: C E 560 or instructor approval*

Application of numerical methods to analysis and design of foundations, underground structures, and soil-structure interaction. Application of slope stability software. Layered soils, bearing capacity and settlement for complex geometries, wave equation for piles, and foundation vibrations.

**C E 565: Fundamentals of Geomaterials Behavior**

(2-3) Cr. 3.

*Prereq: C E 382 or instructor approval*

Atoms and molecules, crystal chemistry, clay minerals, structure of solids, phase transformations and phase equilibria. Surfaces and interfacial phenomena, colloid chemistry, mechanical properties. Applications to soils and civil engineering materials. Overview of state-of-the-art instrumental techniques for analysis of the physicochemical properties of soils and civil engineering materials.

**C E 567: Geomaterials Stabilization**

(Dual-listed with C E 467). (2-2) Cr. 3.

*Prereq: C E 360, C E 382 or C E 383, or instructor approval*

Soil and aggregate physical, chemical and biological stabilization procedures. Stabilization analysis and design. Ground modification and compaction methods. Geosynthetics application and design.

**C E 568: Dynamics of Soils and Foundations**

(3-0) Cr. 3.

*Prereq: C E 360, E M 345 or instructor approval*

Dynamic soil properties and their measurement. Foundation dynamics and soil-structure interaction. Sources and characteristics of dynamic loads. Vibration of single- and multi-degree-of-freedom systems. Vibration of continuous systems; 1D, 2D, and 3D analyses, wave propagation. Liquefaction concepts and analysis methods. Introduction to geotechnical earthquake engineering.

**C E 569: Ground Improvement**

(3-0) Cr. 3.

*Prereq: C E 360 or instructor approval*

Classification of ground improvement methods. Dynamic compaction, vibrocompaction, preloading using fill surcharge, vacuum or a combination of both and prefabricated vertical drains, vibro replacement or stone columns, dynamic replacement, sand compaction piles, geotextile confined columns, rigid inclusion, column supported embankment, microbial methods, particulate and chemical grouting, lime and cement columns, jet grouting, and deep cement mixing.

**C E 570: Applied Hydraulic Design**

(2-2) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: C E 372*

Flow characteristics in natural and constructed channels; principles of hydraulic design of culverts, bridge waterway openings, spillways, hydraulic gates and gated structures, pumping stations, and miscellaneous water control structures; pipe networks, mathematical modeling. Design project.

**C E 571: Surface Water Hydrology**

(Cross-listed with ENSCI). (3-0) Cr. 3. S.

*Prereq: C E 372*

Analysis of hydrologic data including precipitation, infiltration, evapotranspiration, direct runoff and streamflow; theory and use of frequency analysis; theory of streamflow and reservoir routing; use of deterministic and statistical hydrologic models. Fundamentals of surface water quality modeling, point and non-point sources of contamination.

**C E 572: Analysis and Modeling Aquatic Environments**

(Cross-listed with ENSCI). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: C E 372*

Principles of surface water flows and mixing. Introduction to hydrologic transport and water quality simulation in natural water systems. Advection, diffusion and dispersion, chemical and biologic kinetics, and water quality dynamics. Applications to temperature, dissolved oxygen, primary productivity, and other water quality problems in rivers, lakes and reservoirs. Deterministic vs. stochastic models.

**C E 573: Groundwater Hydrology**

(Dual-listed with C E 473). (3-0) Cr. 3. F.

*Prereq: C E 372*

Principles of groundwater flow, hydraulics of wells, superposition, slug and pumping tests, streamlines and flownets, and regional groundwater flow. Contaminant transport. Computer modeling. Design project. Extra assignments required for graduate students.

**C E 576: Environmental Flows**

(3-0) Cr. 3.

*Prereq: E M 378 or equivalent*

Analysis and applications of flows in civil engineering, environmental engineering, and water resources. Primary topics include conservation laws, laminar flow, turbulence, mixing, diffusion, dispersion, water waves, and boundary layers. Associated applications include particle settling, transfer at air-water and water-sediment boundaries, flow and friction in pipes and open channels, contaminant transport, waves in lakes, jets, plumes, and salt wedges.

**C E 581: Geotechnical and Materials Engineering Seminar**

Cr. R. Repeatable. F.S.

*Prereq: Graduate classification*

(1-0) Students and outside/invited speakers give weekly presentations about the ongoing research work and Geotechnical and Materials Engineering issues. Offered on a satisfactory-fail basis only.

**C E 583: Pavement Analysis and Design**

(Dual-listed with C E 483). (3-0) Cr. 3. S.

*Prereq: C E 360 and C E 382*

Analysis, behavior, performance, and structural design of pavement systems. Topics include climate factors, rehabilitation, life cycle design economics, material and system response, pavement foundations and traffic loadings. Development of models for and analysis of pavement systems. Use of transfer functions relating pavement response to pavement performance. Evaluation and application of current and evolving pavement design practices and procedures. Mechanistic-based pavement design techniques and concepts. Analysis of the effects of maintenance activities on pavement performance and economic evaluation of pavement systems. Design project.

**C E 584: Advanced Design of Concretes**

(Dual-listed with C E 484). (2-3) Cr. 3.

*Prereq: C E 382*

Asphalt binder characterization, fundamentals of asphalt rheology, asphalt materials behavior under loading and temperature effects. High-strength, lightweight, fiber-reinforced, and self-consolidating portland cement concretes, mix design, properties, advanced performance testing. Design project.

**C E 586: Advanced Asphalt Materials**

(2-3) Cr. 3.

*Prereq: C E 382*

Advanced asphalt concrete (SUPERPAVE) mix designs. Aggregates. Admixtures. Production and construction, quality control and inspection. Nondestructive testing. Pavement thickness design. Materials engineering reports.

**C E 587: Advanced Portland Cement Concretes**

(2-3) Cr. 3.

*Prereq: C E 382 or C E 383*

Hydraulic cements, aggregates, admixtures, and concrete mix design; cement hydration and microstructure development; fresh, early-age, and mechanical properties of concrete; concrete distress examination, damage mechanism, and prevention.

**C E 588: Sustainable Civil Infrastructure Systems**

(Dual-listed with C E 488). (3-0) Cr. 3. F.

*Prereq: Junior or higher classification in engineering or science*

Sustainable planning, life cycle analysis, appropriate engineering design, investment levels and overall rating of civil engineering infrastructure systems, including highway, bridge, airport, rail, dam, power and port facilities. Complementary assessment of future civil infrastructure sustainability impacts and challenges in relation to autonomous and electric vehicle development. Overview regarding US and global availability and supply of critical infrastructure commodities (e.g., cement, stone, metals, phosphorus, uranium, etc.). Directed course readings and multiple project/design reports.

**C E 589: Pavement Preservation and Rehabilitation**

(Dual-listed with C E 489). Cr. 3. F.S.

*Prereq: C E 382*

Overview of pavement preservation and pavement rehabilitation techniques. Overview and selection of materials used in pavement preservation and rehabilitation strategies. Evaluating suitability of pavement preservation and pavement rehabilitation strategies based on existing structure, pavement distresses and non-condition factors. Use of recycled pavement materials in pavement reconstruction techniques.

**C E 590: Special Topics**

Cr. 1-5. Repeatable. F.S.SS.

Pre-enrollment contract required.

**C E 591: Seminar in Environmental Engineering**

Cr. R. Repeatable. F.S.

*Prereq: Graduate classification*

(1-0) Contemporary environmental engineering issues. Outside speakers. Review of ongoing research in environmental engineering. Offered on a satisfactory-fail basis only.

**C E 594: Special Topics in Construction Engineering and Management**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Some topics have a set number of credits and some topics have the number of credits vary. Emphasis for a particular offering will be selected from the following topics:

**C E 594A: Special Topics Construction Engineering and Mgt.: Planning and Scheduling**

Cr. 3.

*Prereq: C E 306 or graduate standing*

Studies in planning and scheduling including scheduling and estimating. Credit may not be applied for graduation for Construction Engineering undergraduate students.

**C E 594B: Special Topics Construction Engineering and Mgt.: Computer Applications for Planning and Scheduling**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in computer applications for planning and scheduling.

**C E 594C: Special Topics Construction Engineering and Mgt.: Cost Estimating**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in cost estimating.

**C E 594D: Special Topics Construction Engineering and Mgt.: Computer Applications for Cost Estimating**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in computer applications for cost estimating.

**C E 594E: Special Topics Construction Engineering and Mgt.: Project Controls**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in project controls.

**C E 594F: Special Topics Construction Engineering and Mgt.: Computer Applications for Project Controls**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in computer applications for project controls.

**C E 594G: Special Topics Construction Engr and Mgt: Integration of Planning, Scheduling and Project Controls**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in integration of planning, scheduling and project controls.

**C E 594J: Special Topics Construction Engineering and Mgt.: Trenchless Technologies**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in trenchless technologies.

**C E 594K: Special Topics Construction Engineering and Mgt.: Electrical and Mechanical Construction**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in electrical and mechanical construction.

**C E 594L: Spl Topics Construction Engr and Mgt.: Adv Building Construction Topics - LEED for New Construction**

Cr. 3. SS.

*Prereq: CON E 352 or C E 306 or graduate standing or permission of instructor*

Studies in advanced building construction topics including LEED.

**C E 594M: Special Topics Construction Engineering and Mgt.: Design Build Construction**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in design build construction.

**C E 594N: Special Topics Construction Engineering and Mgt.: Industrial Construction**

Cr. 3.

*Prereq: Graduate standing or permission of instructor*

Studies in industrial construction.

**C E 594O: Special Topics Construction Engineering and Mgt.: Highway and Heavy Construction**

Cr. 3.

*Prereq: CON E 322 or C E 306 or graduate standing*

Studies in highway and heavy construction.

**C E 594P: Special Topics Construction Engineering and Mgt.: Advanced Building Energy Systems and Technologies**

Cr. 3.

*Prereq: CON E 352 or graduate standing or permission of instructor*

Studies in advanced building technologies including building energy modeling, building energy performance and efficiency assessments, and demand side management for smart grid applications.

**C E 594Q: Special Topics Construction Engineering and Mgt.: Construction Quality Control**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in construction quality control.

**C E 594R: Special Topics Construction Engineering and Mgt.: Risk Management**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in risk management.

**C E 594S: Special Topics Construction Engineering and Mgt.: Building Information Modeling**

Cr. 1-3. Repeatable.

*Prereq: Permission of instructor*

Studies in building information modeling.

**C E 595: Research Methods in Construction Engineering and Management**

(1-0) Cr. 1.

*Prereq: Graduate standing or permission of instructor*

Assigned readings and reports on research methods to solve construction engineering and management problems such as alternative project delivery methods, asset management, data mining, construction procurement, robotics, project controls, automation, construction visualization, etc. Identification of research methods and priorities, selection and development of research design, and critique of research in construction engineering and management.

**C E 595A: Research Methods Seminar in Construction Engineering and Management: Qualitative Methods**

(1-0) Cr. 1.

*Prereq: Graduate standing or permission of instructor*

Assigned readings and reports on qualitative research methods to assess and solve construction engineering and management problems.

**C E 595B: Research Methods Seminar in Construction Engineering and Management: Quantitative Methods**

(1-0) Cr. 1.

*Prereq: Graduate standing or permission of instructor*

Assigned readings and reports on quantitative research methods to assess and solve construction engineering and management problems.

**C E 595C: Research Methods Seminar in Construction Engineering and Management: Technical Reporting**

(1-0) Cr. 1.

*Prereq: Graduate standing or permission of instructor*

Assigned readings and reports on research methods for planning and preparation of technical reports with construction engineering and management projects.

**C E 596: Special Topics in Transportation Engineering**

Cr. arr. Repeatable.

*Prereq: C E 355*

**C E 599: Creative Component**

Cr. 1-3. Repeatable.

Pre-enrollment contract required. Advanced topic for creative component report in lieu of thesis.

**Courses for graduate students:****C E 622: Advanced Topics in Environmental Engineering**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 622A: Advanced Topics in Environmental Engineering: Water Pollution Control**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 622B: Advanced Topics in Environmental Engineering: Water Treatment**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 622C: Advanced Topics in Environmental Engineering: Solid and Hazardous Waste**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 622D: Advanced Topics in Environmental Engineering: Water Resources**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 622E: Advanced Topics in Environmental Engineering: Instrumental Methods for Environmental Analyses**

(2-0) Cr. 2. Repeatable.

*Prereq: Permission of environmental engineering graduate faculty*

Advanced concepts in environmental engineering.

**C E 650: Advanced Topics in Transportation Engineering**

(3-0) Cr. 3. Repeatable.

*Prereq: Permission of Transportation Engineering graduate faculty*

**C E 650A: Advanced Topics in Transportation Engineering: Highway Design**

(3-0) Cr. 3. Repeatable.

*Prereq: Permission of Transportation Engineering graduate faculty*

**C E 650B: Advanced Topics in Transportation Engineering: Traffic Operations**

(3-0) Cr. 3. Repeatable.

*Prereq: Permission of Transportation Engineering graduate faculty*

**C E 650C: Advanced Topics in Transportation Engineering: Big Data Analysis**

(3-0) Cr. 3. Repeatable.

*Prereq: Permission of Transportation Engineering graduate faculty*

Topics in transportation engineering related to data analysis.

**C E 650D: Advanced Topics in Transportation Engineering: Traffic Simulation**

Cr. 3. Repeatable.

*Prereq: Permission of Transportation Engineering graduate faculty*

**C E 690: Advanced Topics**

Cr. 1-3. Repeatable. F.S.SS.

Pre-enrollment contract required.

**C E 691: Seminar in Transportation Planning**

Cr. 1. Repeatable. F.S.

Provides an overview of current transportation issues; speakers provide seminars on a variety of timely transportation topics.

**C E 697: Engineering Internship**

Cr. R. Repeatable.

*Prereq: Permission of coop advisor, graduate classification*

One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

**C E 699: Research**

Cr. 1-30. Repeatable.

*Prereq: Pre-enrollment contract required*

Advanced topic for thesis/dissertation.