

# CVEN - CIVIL ENGINEERING

## CVEN 601 Environmental Engineering Processes III

**Credits 3. 3 Lecture Hours.**

Biological processes that describe behavior of materials in natural and engineered environmental systems including fundamental theory of kinetics, bioenergetics, genetics and cellular functions.

**Prerequisite:** CVEN 301/EVEN 301.

## CVEN 602 Remote Sensing in Hydrology

**Credits 3. 3 Lecture Hours.**

Precipitation; evaporation; soil moisture; snow and ice; terrestrial water storage variations; land surface properties; water quality.

## CVEN 603 Environmental Engineering Management

**Credits 3. 3 Lecture Hours.**

Federal and state regulatory framework for environmental engineering; techniques for environmental control; risk assessment; evaluation of critical environmental problems with multimedia aspects.

**Prerequisite:** CVEN 301/EVEN 301 or approval of instructor.

## CVEN 604 Engineering Analysis of Treatment Systems

**Credits 3. 3 Lecture Hours.**

Theory of processes used to treat water and wastewater; applications of theory to design and operation of treatment systems, including adsorption, coagulation (including precipitation), flocculation, media filtration and membrane filtration.

**Prerequisites:** CVEN 619 and CVEN 620.

## CVEN 605 Environmental Measurement

**Credits 3. 1 Lecture Hour. 6 Lab Hours.**

Theory and practice of analytical methods used in the environmental engineering field; instrumental and wet chemical techniques used in measurement of environmental quality parameters and pollutants.

**Prerequisite:** CVEN 620 or approval of instructor.

## CVEN 606 Environmental Engineering Design

**Credits 3. 3 Lecture Hours.**

Design of engineered environmental systems for water or wastewater treatment in domestic or industrial applications.

**Prerequisite:** CVEN 604 or approval of instructor.

## CVEN 607 Engineering Aspects of Air Quality

**Credits 3. 3 Lecture Hours.**

Characterization of air contaminants; health effects and legal aspects; dispersion of pollutants in the atmosphere; technology for the control of gaseous and particulate emissions.

**Prerequisite:** CVEN 311/EVEN 311.

## CVEN 610/PHEO 650 Environmental Risk Assessment

**Credits 3. 3 Lecture Hours.**

Risk assessment of the environment and human exposure in a statistically-based approach to determine allowable levels of exposure without significant deleterious effects; the basic approach of hazard identification; data collection and analysis; toxicity assessment; risk characterization; applications in ecological and human risk assessment; risk analysis performed.

**Prerequisite:** CHEM 222 or equivalent.

**Cross Listing:** PHEO 650.

## CVEN 612 Tools for Highway Materials and Pavement Design

**Credits 3. 3 Lecture Hours.**

Theory and practice in pavement design; pavement performance; structural design of pavement layers; types of materials used in pavement layers; characterization of pavement layer materials; concepts of pavement management; hands-on application of pavement design computational tools.

**Prerequisite:** Graduate classification in civil engineering or approval of instructor.

## CVEN 613 Micromechanics of Civil Engineering Materials

**Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Discrete-particle and continuum micromechanics energy principles; finite-element and discrete-element formulations for constitutive modeling of asphalt, concrete, and coarse and fine-grained soils; adhesive and cohesive fracture and healing; stress-dependent plasticity; principles and measurement of surface energy and pseudo-strain.

**Prerequisite:** CVEN 615, CVEN 616 or approval of instructor.

## CVEN 614 Stabilization of Soil-Aggregate Systems

**Credits 3. 3 Lecture Hours.**

Theory and practice of chemical stabilization of soils and aggregate systems with traditional methods of chemical stabilization including Portland cement, lime, fly ash and by products (kiln dusts, fly ash and slag materials); selected non-traditional methods including polymers, ionic systems, and enzymes; mechanisms and methods to avoid deleterious reactions.

## CVEN 615 Structural Design of Pavements

**Credits 3. 3 Lecture Hours.**

Characteristics of pavement loads, stress analysis in pavements, design practices, construction, rehabilitation and maintenance.

**Prerequisite:** CVEN 418.

## CVEN 616 Systems Design of Pavements

**Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Optimization of the design of rigid and flexible pavement systems; empirical and mechanistic stochastic structural subsystems; utility theory, serviceability concept, cost studies, traffic delay, environmental deterioration, rehabilitation and maintenance optimization systems.

**Prerequisite:** CVEN 418.

## CVEN 617 Traffic Engineering: Characteristics

**Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Human, vehicular and traffic characteristics as they relate to driver-vehicle-roadway operational systems; traffic studies and methods of analysis and evaluation.

**Prerequisite:** CVEN 457 or equivalent.

## CVEN 618 Traffic Engineering: Operations

**Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Advanced theory and application of traffic control; signalization and freeway operations.

**Prerequisite:** CVEN 457 or equivalent.

## CVEN 619 Environmental Engineering Processes I

**Credits 3. 3 Lecture Hours.**

Physical processes that describe behavior of materials in natural and engineered environmental systems including transport phenomenon, sorption, desorption, flocculation and sedimentation.

**Prerequisite:** CVEN 301/EVEN 301.

**CVEN 620 Environmental Engineering Processes II****Credits 3. 3 Lecture Hours.**

Chemical processes that describe behavior of materials in natural and engineered environmental systems including neutralization, precipitation, complex formation, adsorption, oxidation-reduction, coagulation, volatilization and absorption.

**Prerequisite:** CVEN 301/EVEN 301.**CVEN 621 Advanced Reinforced Concrete Design****Credits 3. 3 Lecture Hours.**

Reinforced concrete principles; analysis of rigid building frames, design of building frames, slabs, biaxially loaded columns, rectangular and circular tanks, and deep beams.

**Prerequisite:** CVEN 444 or equivalent.**CVEN 622 Properties of Concrete****Credits 3. 3 Lecture Hours.**

Materials, properties and behavior of concrete; cement, cement types, aggregate characteristics; properties of fresh concrete; structure of portland cement paste; mechanical properties of hardened concrete; durability and repair of concrete structures.

**Prerequisites:** CVEN 342.**CVEN 623 Nondestructive Pavement Evaluation****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Nondestructive measurements and analysis methods of pavement data collection to determine riding quality, vehicle dynamics, surface texture, layer thickness, stiffness, moisture and distress using seismic, laser, radar, infrared, impulse, image analysis, and wave propagation; applicable to construction quality control and evaluation of risk, reliability and remaining life of pavements.

**Prerequisite:** CVEN 616 or approval of instructor.**CVEN 624 Infrastructure Engineering and Management****Credits 3. 3 Lecture Hours.**

Defines the infrastructure deterioration problems in the United States and describes the engineering and management approaches to arrest the deterioration.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**CVEN 625 Traffic Engineering: Design****Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Design of traffic control device installations with special emphasis on traffic signal design and installation, including the design features of detector placement and operation; national and state design standards and guidelines for traffic control device installation.

**Prerequisite:** CVEN 457.**CVEN 626 Highway Safety****Credits 3. 3 Lecture Hours.**

Fundamental concepts for performing traffic safety analyses; crash data collection and database management; safety improvement programs; accident data analysis; development of statistical models; before-after studies; economic analyses; accident risk.

**CVEN 627 Engineering Surface Water Hydrology****Credits 3. 3 Lecture Hours.**

Precipitation-runoff processes; watershed and streamflow modeling; frequency analysis; erosion and sedimentation engineering; hydrologic design of hydraulic structures and nonstructural stormwater management strategies.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**CVEN 628 Advanced Hydraulic Engineering****Credits 3. 3 Lecture Hours.**

Modeling of steady and unsteady flow in natural and constructed channels and hydraulic structures; open channel hydraulics; design and analysis of hydraulic structures, canals, and flood mitigation projects; sediment and contaminant transport in river systems.

**Prerequisite:** CVEN 339/EVEN 339 or approval of instructor.**CVEN 631 System Identification and Nondestructive Damage Evaluation of Civil Engineering Structures****Credits 3. 3 Lecture Hours.**

Invasive assessment of civil structures; concepts of systems identification, damage detection, and safety evaluation; estimation of mass, damping, and stiffness properties; determination of load capacity and useful life.

**Prerequisite:** Graduate classification in Civil Engineering, Aerospace Engineering or Mechanical Engineering.**CVEN 632 Transportation Engineering: Economics****Credits 3. 3 Lecture Hours.**

Engineering and economic principles for transportation systems; engineering evaluation using methods of travel demand, costs, equilibrium and pricing; use of economic principles for the finance, engineering and management of transportation systems.

**Prerequisite:** CVEN 672 or approval of instructor.**CVEN 633 Advanced Mechanics of Materials****Credits 3. 3 Lecture Hours.**

Stresses and strains at a point, torsion of noncircular cross sections, beams with combined axial and lateral loads, energy methods, thick walled pressure vessels, theories of failure, introduction to the theory of elasticity, theory of plates, theory of elastic stability and solution to elementary problems.

**Prerequisite:** MATH 308 or approval of instructor.**CVEN 635 Street and Highway Design****Credits 3. 3 Lecture Hours.**

Advanced concepts of the design of streets and highways, design criteria, controls and standards for design alignment, cross section, intersections and interchanges and environmental impacts of surface transport facilities.

**Prerequisite:** CVEN 456 or equivalent.**CVEN 637 Rigid Pavement Analysis and Design****Credits 3. 3 Lecture Hours.**

Introduction to mechanistic rigid pavement design concepts; development of mathematical pavement models and application of the models to design analysis; relationship of pavement response to performance and fatigue damage concepts in design; evaluation of pavement design practice and procedures for highways and airports; rigid pavement overlay design concept.

**Prerequisite:** CVEN 418.**CVEN 638 Computer Integrated Construction Engineering Systems****Credits 3. 3 Lecture Hours.**

Modeling concepts, issues and techniques of computer integrated construction engineering systems; current research and practice in design and implementation of computer integrated construction systems, with emphasis on the integration of engineering, construction planning, monitoring and control through management information systems, decision support systems, knowledge based systems and discrete event simulation systems.

**Prerequisite:** CVEN 349; approval of instructor.

**CVEN 639 Methods Improvement for Construction Engineers****Credits 3. 3 Lecture Hours.**

Application of work methods and measurements to civil engineering construction; examination of factors that affect productivity in construction; study of motivational factors; review of the principles of accident prevention.

**Prerequisites:** CVEN 405 and CVEN 473 or approval of instructor.

**CVEN 640 Project Development: Methods and Models****Credits 3. 3 Lecture Hours.**

Development of new projects; public-private partnerships; flexible design and stage-based construction; project risk analysis and management; estimating and budgeting; optimal project decisions; advanced techniques for modeling project performance.

**Prerequisite:** STAT 601 or approval of instructor.

**CVEN 641 Construction Engineering Systems****Credits 4. 3 Lecture Hours. 2 Lab Hours.**

Application of systems theory to project planning and control; probabilistic network diagramming, resource allocation, statistical bidding analysis, activity planning, financial management of construction projects and project control.

**Prerequisite:** CVEN 473 or approval of instructor.

**CVEN 642/BAEN 642 Water-Energy-Food Nexus: Toward a Sustainable Resource Management****Credits 3. 3 Lecture Hours.**

Principles and application of the Water-Energy-Food nexus to state, national and international Water-Energy-Food securities and the interlinkages between them; exploration of quantitative framework to develop and assess sustainable tradeoffs of resources; hands on experiences; relevant real world projects or case studies.

**Prerequisites:** Strong analytical background; approval of instructor.

**Cross Listing:** BAEN 642/CVEN 642.

**CVEN 644 Project Risk Management****Credits 3. 3 Lecture Hours.**

Identifies causes of risks in projects; discusses probabilistic description of risks and formulation of risk models; Bayesian methods for revising probabilities; qualitative and quantitative risk assessment; setting contingencies on budgets and schedules; risk mitigation and risk management; handling technological risk; Utility theory and game theory in management of risks.

**Prerequisites:** ISEN 644/CVEN 644; STAT 211, STAT 601 or equivalent.

**CVEN 645 Geotechnical Site Investigation****Credits 2. 2 Lecture Hours.**

Soil sampling techniques to obtain disturbed and undisturbed samples; in situ field tests including standard penetration test, cone penetration test, vane test, pressuremeter test and their use in practice; other recent advances in sampling, in situ testing and site investigation both onshore and offshore.

**Prerequisites:** CVEN 365; CVEN 435 or equivalent.

**CVEN 646 Foundations on Expansive Soils****Credits 3. 3 Lecture Hours.**

Properties of partially saturated soils, analysis of beams and plates on foundations, slab-subgrade friction, design of slabs and drilled piers, soil improvement techniques, risk analysis and foundation rehabilitation operations.

**Prerequisites:** CVEN 365 and MATH 308 or approval of instructor.

**CVEN 647 Numerical Methods in Geotechnical Engineering****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Formulation and application of finite element and discrete element methods in solving geotechnical engineering problems related to seepage, diffusion, elasticity, plasticity, fracture and dynamic motion of soil masses, stability and convergence problems and use of existing computer programs in working applied problems.

**Prerequisite:** Degree in engineering or approval of instructor.

**CVEN 648 Advanced Numerical Methods in Geotechnical Engineering****Credits 3. 3 Lecture Hours.**

Formulation and application of finite difference and finite element methods in geotechnical problems related to elasticity, plasticity, seepage, consolidation, dynamic response, and pile analysis; constitutive models of soil behavior; and analysis of nonlinear systems.

**Prerequisites:** MEMA 646 or equivalent; CVEN 651 or registration therein.

**CVEN 649 Physical and Engineering Properties of Soil****Credits 4. 3 Lecture Hours. 3 Lab Hours.**

Introduction to physico-chemical properties of soils; soil structure; soil classification; permeability; principle of effective stress; stress-deformation and strength characteristics; partly saturated soils; testing procedures.

**Prerequisites:** CVEN 365 and CVEN 435 or approval of instructor.

**CVEN 650 Stochastic Mechanics****Credits 3. 3 Lecture Hours.**

Introduction to the use of Bayesian inference methods to solve mechanical inverse problems with varying evidence conditions; experimental observations, model complexity and expert beliefs; representation of the probabilistic calibration of models with varying parameters in space and time, in the form of boundary conditions, material properties, and even numerical parameters; improves the scientific and engineering inferences stemmed from research practice.

**CVEN 651 Geomechanics****Credits 3. 3 Lecture Hours.**

Fundamentals of mechanics of deformable bodies; theory and application of elasticity, plasticity, viscoelasticity and approximate rheological models to soil mechanics problems.

**Prerequisite:** Approval of instructor.

**CVEN 652 Soil Dynamics****Credits 3. 3 Lecture Hours.**

Dynamic properties of soil; wave propagation in an elastic medium; analysis of dynamic soil-structure interaction and machine foundations; earthquake engineering; soil liquefaction; seismic design of foundations, dams, retaining walls and pipelines.

**Prerequisite:** MATH 308.

**CVEN 653 Bituminous Materials****Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Origin, production, specifications and tests of bituminous materials and mixtures used in flexible pavements including mix design, construction, maintenance and quality assurance processes.

**Prerequisite:** Approval of instructor.

**CVEN 654/ISEN 643 Strategic Construction and Engineering Management****Credits 3. 3 Lecture Hours.**

Strategic and systems perspectives applied to construction and engineering management projects, organizations and industries; system dynamics methodology to model construction and engineering systems; understanding drivers of performance; feedback and high leverage points for performance improvement.

**Prerequisite:** Graduate classification or approval of instructor.**Cross Listing:** ISEN 643/CVEN 654.**CVEN 655 Structural Reliability****Credits 3. 3 Lecture Hours.**

Uncertainties in structural mechanics; probabilistic models for load and resistance variables, fundamentals of structural reliability theory, advanced first-order second moment methods and reliability of complex structural systems; applications to selected structures.

**Prerequisites:** CVEN 345 and CVEN 421.**CVEN 656 Bridge Engineering****Credits 3. 3 Lecture Hours.**

Overview of design of highway bridges, and an introduction to maintenance of highway bridges; history of bridge engineering, types of bridges and materials of construction, design rules, loads, inspection, rating and preventive maintenance, esthetics.

**Prerequisite:** CVEN 345.**CVEN 657 Dynamic Loads and Structural Behavior****Credits 3. 3 Lecture Hours.**

Dynamic modeling of single, multidegree of freedom and continuous systems; dynamic load factors; damping; mode superpositions; numerical integration; dynamic behavior of structures and structural elements under action of dynamic loads resulting from wind, earthquake, blast, impact, moving loads and machinery.

**Prerequisites:** MATH 308 and MEMA 467 or approval of instructor.**CVEN 658 Civil Engineering Applications of GIS****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Use of geographic information system (GIS) concepts and methods to solve civil engineering problems; emphasis on different areas of civil engineering. Class presentations and laboratory sessions used to familiarize students with computer software.

**Prerequisite:** Graduate classification.**CVEN 659 Behavior and Design of Steel Structures****Credits 3. 3 Lecture Hours.**

Buckling and post-buckling strength of stiffened and unstiffened plate elements and members; torsional behavior and design of beams; stability of frames; frames subject to sidesway; bracing design; non-destructive evaluation and application of fracture mechanics principles to welded structures.

**Prerequisite:** 3 credit hours of structural steel design or approval of instructor.**CVEN 662 Experimental Methods in Civil Engineering****Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Introduction to experimental methods, instrumentation, data acquisition and data processing; experimental aspects of static and dynamic testing in the various areas of civil engineering; overview of laboratory work with several hands-on applications in the laboratory.

**Prerequisite:** Graduate classification in engineering.**CVEN 663 Structural Stability****Credits 3. 3 Lecture Hours.**

Buckling of columns, frames, arches, rings, plates and shells, lateral and torsional buckling of beams, Newmark's method, equilibrium method, Rayleigh-Ritz, variational principles; Galerkin method, Trefftz method, review of current literature.

**Prerequisites:** MATH 308; approval of instructor.**CVEN 664 Water Resources Engineering Planning and Management****Credits 3. 3 Lecture Hours.**

Managing water resources; the planning process, systems analysis methods; institutional framework for water resources engineering; comprehensive integration of engineering, economic, environmental, legal and political considerations in water resources development and management.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**CVEN 665 Water Resources Systems Engineering****Credits 3. 3 Lecture Hours.**

Linear and non-linear optimization models and simulation models for planning and management of water systems; single- and multi-objective analysis and deterministic and stochastic techniques.

**Prerequisites:** CVEN 339/EVEN 339; CVEN 422 or equivalent.**CVEN 666 Foundation Structures****Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Geological and soil mechanics principles including load bearing capacity, soil pressure and settlement; design of shallow foundation sub-structures including pedestals, spread footings, combined footings, mats and underream footings; design of deep foundations including piles and drilled piers; retaining walls, cofferdams and sheet piles.

**CVEN 667 Slope Stability and Retaining Walls****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Slope stability; failure analysis including methods of slices; risk analysis; earthquake analysis; monitoring; remedial measures; retaining structures; basic theories; gravity walls; cantilever walls; tieback walls; mechanically stabilized walls; soil nailing; deflecting-based analysis.

**Prerequisites:** CVEN 365 or equivalent; graduate classification.**CVEN 668 Advanced EPC Project Development****Credits 3. 3 Lecture Hours.**

Examination of the advanced project development process-business planning and pre-project planning for engineering, procurement and construction (EPC); a process approach is followed; includes project technical and economic feasibility; scope definition; project risks; preliminary budgeting; scheduling and parametric estimating; execution strategies; negotiations; organizational design and development.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**CVEN 669 Design of Structures for Hazardous Environmental Loads****Credits 3. 3 Lecture Hours.**

Introduction to wind and earthquake engineering with focus on studying the characteristics and effects of various types of windstorms and earthquakes; development of tools that can be used in specifying wind and earthquake loads on structures.

**Prerequisite:** Approval of instructor.

**CVEN 670 Behavior and Design of Composite Structures****Credits 3. 3 Lecture Hours.**

Design of composite structural systems comprising structural steel and reinforced concrete; composite slabs on steel beams; composite slabs on formed metal deck; columns; moment frame systems; shear wall systems; braced frame systems; dual systems; introduction to retrofitting applications.

**Prerequisites:** CVEN 444; CVEN 446 or equivalent; graduate classification.

**CVEN 671 Behavior and Design of Prestressed Concrete Structures****Credits 3. 3 Lecture Hours.**

Introduction to the behavior and design of prestressed concrete structural members for several limit states; including flexure, shear, torsion and deflection; exposure to composite beams; indeterminate systems; bridge design and construction.

**Prerequisites:** CVEN 444; graduate classification in civil engineering or approval of instructor.

**CVEN 672 Engineering and Urban Transportation Systems****Credits 3. 3 Lecture Hours.**

Characteristics of transportation engineering systems; transportation engineering data collection; modeling effects of engineering project planning, trip generation, trip distribution, mode choice and traffic assignment; use and interpretation of engineering modeling results; engineering project analysis.

**Prerequisite:** CVEN 307; graduate classification in engineering or urban and regional planning or approval of instructor.

**CVEN 673 Transport Phenomena in Porous Media****Credits 3. 3 Lecture Hours.**

Transport phenomena in porous media with special emphasis on fundamentals and applications to various geo-environmental problems.

**Prerequisites:** CVEN 311/EVEN 311 and MATH 308 or approval of instructor.

**CVEN 674 Groundwater Engineering****Credits 3. 3 Lecture Hours.**

Advanced groundwater hydrology, groundwater contamination, groundwater modeling, multiple-phase flow, salt water intrusion, artificial recharge, sustainable groundwater management.

**Prerequisite:** CVEN 462/EVEN 462, GEOL 410, or equivalent; or approval of instructor.

**CVEN 675 Stochastic Hydrology****Credits 3. 3 Lecture Hours.**

Analysis, simulation and forecasting of hydro-climatic variables.

**Prerequisites:** CVEN 421 and CVEN 463/EVEN 463 or approval of instructor.

**CVEN 679 Experimental Fluid Mechanics Modeling****Credits 3. 3 Lecture Hours.**

Dimensional analysis; modeling laws; measurement techniques and instrumentation; experimental control and data acquisition; sampling theory and signal processing; applications to coastal, ocean, and hydraulic engineering models.

**Prerequisite:** Approval of instructor.

**CVEN 680 Advanced Computation Methods for Fluid Flow****Credits 3. 3 Lecture Hours.**

Unsteady three-dimensional Navier-Stokes equations in general nonorthogonal curvilinear coordinates; algebraic and elliptic grid generation; turbulence modeling for complex flows; advanced numerical methods for unsteady incompressible turbulent flows; large-eddy simulations; Reynolds-averaged Navier-Stokes simulation; chimera domain decomposition and interactive zonal approach.

**Prerequisite:** CVEN 688 or approval of instructor.

**CVEN 681 Seminar****Credits 0-1. 0-1 Other Hours.**

Reports and discussion of current research and selected published technical articles.

**CVEN 682 Environmental Remediation of Contaminated Sites****Credits 3. 3 Lecture Hours.**

Aspects of characterization and design of plans for remediation of sites contaminated with hazardous wastes; review of federal and state regulations; risk assessment; remedial technology screening and design of remedial plans.

**Prerequisites:** CVEN 601, CVEN 619, CVEN 620.

**CVEN 683 Dynamic Soil Structure Interaction****Credits 3. 3 Lecture Hours.**

Introduction to basic concepts of wave propagation; soil dynamics; applications to the design of machine foundations; geotechnical earthquake engineering; soil effects on the characteristics of earthquake motions; liquefaction; dynamic stiffness of foundations; seismic soil structure interaction.

**Prerequisite:** Graduate classification.

**CVEN 684 Professional Internship****Credits 1 to 3. 1 to 3 Other Hours.**

Training under the supervision of practicing professional engineers in settings appropriate to the student's professional objectives, away from Texas A&M campus. May be taken three times for credit.

**Prerequisites:** Approval of the department head and two semesters of graduate work completed.

**CVEN 685 Directed Studies****Credits 1 to 12. 1 to 12 Other Hours.**

Enables majors in civil engineering to undertake and complete with credit in their particular fields of specialization limited investigations not within their thesis research and not covered by other courses in established curriculum.

**CVEN 686 Offshore and Coastal Structures****Credits 3. 3 Lecture Hours.**

Fundamental design and analysis techniques; offshore platforms for shallow and deep water, pile supported, gravity based and floating platforms; new design problems faced by offshore industry will be examined by class during the semester.

**Prerequisite:** Approval of instructor.

**CVEN 687 Foundation Engineering****Credits 3. 3 Lecture Hours.**

Settlement and bearing capacity analysis of foundations; computer programs used to analyze axially-loaded piles, laterally-loaded piles and sheet-pile walls.

**Prerequisites:** CVEN 365; approval of instructor.

**CVEN 688 Computational Fluid Dynamics****Credits 3. 3 Lecture Hours.**

Finite-difference and finite-element methods and basic numerical concepts for the solution of dispersion, propagation and equilibrium problems commonly encountered in real fluid flows; theoretical accuracy analysis techniques.

**Prerequisites:** Undergraduate course in fluid mechanics; MATH 601 and/or basic course in linear algebra; knowledge of one programming language.

**CVEN 689 Special Topics in...****Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 6 Lab Hours.**

Selected topics in an identified area of civil engineering. May be repeated for credit.

**Prerequisites:** Approval of instructor and department head.

**CVEN 691 Research****Credits 1 to 23. 1 to 23 Other Hours.**

Research for thesis or dissertation.

**CVEN 695 Frontiers in Civil Engineering Research****Credits 1 to 3. 1 to 3 Lecture Hours.**

The present status of investigative work in a variety of civil engineering fields; content selected based on visiting lecturers of distinguished international recognition in their fields of research.

**Prerequisite:** Approval of instructor.

**CVEN 696 Urban Traffic Facilities****Credits 3. 3 Lecture Hours.**

Driver, vehicle and roadway characteristics related to design and operation of traffic facilities; selection and design of traffic control devices and information systems for streets and highways; accident analysis and tort liability related to traffic engineering.

**Prerequisite:** Graduate classification.

**CVEN 699 Engineering Risk Analysis****Credits 3. 3 Lecture Hours.**

Introduction to applications of probability theory, statistics, and decision analysis to civil engineering problems; emphasis on probabilistic modeling and analysis of civil engineering problems, Bayesian statistics, risk analysis, and decision under uncertainty.

**Prerequisite:** STAT 211 or approval of instructor.

**CVEN 701 Mixing and Transport in Natural Civil Engineering Systems****Credits 3. 3 Lecture Hours.**

Introduction to mass transport in the hydrosphere with application to natural civil engineering systems; Fick's law; advective, reacting, diffusion equation; turbulence; dispersion; classical solutions to the diffusion equation; mixing in rivers, lakes, groundwater, estuaries, and the atmosphere; boundary exchange; outfall design.

**Prerequisite:** CVEN 311/EVEN 311 or equivalent.

**CVEN 705 Professional Skills Development for Civil Engineering Industry****Credits 2. 2 Lecture Hours.**

Learning skills needed to identify and secure employment in the Civil Engineering industry, to target and pursue opportunities using various techniques, interviewing skills, resume building.

**Prerequisites:** MEN, MS or PhD classification in CVEN or approval of instructor.

**CVEN 710 Civil Engineering Project Finance****Credits 3. 3 Lecture Hours.**

Fundamentals of financing civil engineering projects; Public-Private Partnerships (PPPs); interdependencies between engineering and financing decisions; equity and debt markets; type of debt instruments including loans vs. bonds; risk identification, quantification, and management; engineering due-diligence; pricing risk premium; hedging using civil engineering design strategies.

**CVEN 717 Engineering Project Control****Credits 3. 3 Lecture Hours.**

Project controls bridge from information-based to physical-based development processes; includes detailed design, testing of designs, design realization, and preparation of facilities for steady state operations; application of basic project control theories, tools, and methods to development projects.

**Prerequisite:** Graduate classification in civil engineering or industrial and systems engineering or approval of instructor.

**CVEN 740 Advanced Constitutive Behavior of Cementitious Materials****Credits 3. 3 Lecture Hours.**

Advanced multi-scale constitutive behavior of cementitious materials, including composite behavior, elasticity, viscoelasticity, aging, free strains, poromechanical behavior, thermal and moisture strains, and thermal, moisture, and ionic transport; focus on experimental observation and analytical modeling.

**Prerequisite:** CVEN 343 or CVEN 622 or approval of instructor.

**CVEN 741 Tools for Highway Materials and Pavement Design****Credits 3. 3 Lecture Hours.**

Theory and practice in pavement design; pavement performance; structural design of pavement layers; types of materials used in pavement layers; characterization of pavement layer materials; concepts of pavement management; hands-on application of pavement design computational tools.

**Prerequisite(s):** Graduate classification in civil engineering or approval of instructor.

**CVEN 749 Advanced Visualization and Building Information Modeling in Structural Engineering Design****Credit 1. 1 Lecture Hour.**

Graphical communication in the structural engineering design process; introduction to Building Information Modeling (BIM); construction documents and contract drawings in structural engineering applications, data analysis and project visualization.

**Prerequisites:** Graduate classification.

**CVEN 750 Finite Element Theory and Applications in Structural Engineering****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Role of the finite element method (FEM) in structural engineering; use of commercial finite element software; application of FEM method for various structural engineering problems; selection of appropriate FEM models; types of elements and mesh sizes; use and interpretation of FEM results.

**Prerequisite:** CVEN 444, CVEN 445, and CVEN 446; graduate classification in civil engineering or approval of instructor.

**CVEN 751 Advanced Dynamics and Control of Civil Engineering Structures**

**Credits 3. 3 Lecture Hours.**

Laplace transforms; nonlinear dynamics; base isolation; viscous dampers; classical control; state-space formulation; LQR controllers; estimator design; compensator design; advanced control techniques; emphasis on the issues and applications to bridges, buildings and other large civil structures.

**Prerequisite(s):** CVEN 657, MEMA 647 or equivalent, or approval of instructor.

**CVEN 752 Smart Structures**

**Credits 3. 3 Lecture Hours.**

Fundamentals of smart structures including structural dynamics, damping, sensors, control concepts, smart materials, modeling of smart structures, and signal processing; semi-passive concepts, energy harvesting, semi-active concepts, active vibration control, active noise control, shape adaptation, and structural health monitoring.

**Prerequisite:** CVEN 363 or equivalent or graduate classification in CVEN or approval of instructor.

**CVEN 753/MEMA 634 Damage Mechanics of Solids and Structures**

**Credits 3. 3 Lecture Hours.**

Damage mechanics; constitutive modeling of damage behavior of materials; application of thermodynamic laws; computational techniques for predicting progressive damage and failure; plasticity; viscoplasticity; viscoelasticity; cohesive zone modeling; fatigue and creep damage; damage in various brittle and ductile materials (e.g., metal, concrete, polymer, ceramic, asphalt, biomaterial, composites).

**Prerequisite:** CVEN 633 or approval of instructor.

**Cross Listing:** MEMA 634/CVEN 753.

**CVEN 754 Advanced Structural Design Studio**

**Credits 3. 1 Lecture Hour. 6 Lab Hours.**

Comparative design, construction, and service-life performance analysis of integrated and complex structural systems, including design loads, load paths, and structural detailing requirements; comparison of alternative structural system solutions; investigation into new technologies and structural design and/or construction approaches; examples drawn from bridges, buildings and other large civil structures.

**Prerequisites:** CVEN 659 or registration therein, CVEN 671 or registration therein, CVEN 750 or registration therein, or approval of instructor.

**CVEN 765 Advanced Civil Engineering Systems**

**Credits 3. 3 Lecture Hours.**

Formulation of decision making problems at different hierarchical levels including strategic, planning and operational; includes application problems in project selection, networks, allocation, routing/scheduling, distribution, and multi-objective; introduction to exact and approximate solving techniques including optimization, heuristics, simulation, and decision analysis; solution interpretation and sensitivity analyses.

**Prerequisite:** CVEN 322 or approval of instructor.

**CVEN 766 Highway Design**

**Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Theory and practice in highway design; highway classification and design criteria, location studies, design of vertical and horizontal alignment, cross section, intersections, environmental factors, and highway drainage elements.

**Prerequisites:** CVEN 307 or approval of instructor.