Zachry Department of Civil Engineering

http://engineering.tamu.edu/civil

Department Head: R. L. Autenrieth

Graduate Advisor: Y. Zhang

A variety of courses are offered in civil engineering to permit a student to study one of nine specialty areas. The department is especially well equipped to offer research and courses in coastal and ocean engineering; construction engineering management; environmental engineering; geotechnical engineering; water resources engineering; materials engineering; structural engineering and transportation engineering.

Modern facilities and current equipment are available to enhance study and instruction in civil engineering. These facilities include the following laboratories: fluid and wave mechanics, construction materials, materials science, sensors, soil mechanics, biological, high bay, Offshore Technology Research Center and several facilities shared with the Texas A&M Transportation Institute.

No foreign language is required for the PhD in civil engineering. Students pursuing a PhD or DEng are required to pass the Civil Engineering qualifying exam.

Ocean Engineering

http://engineering.tamu.edu/civil

Ocean engineering is the application of basic engineering principles to the analysis, design, construction, and management of systems that operate in the ocean environment. The graduate ocean engineering program is broad-based and is designed to fit the needs of graduates from most engineering disciplines and naval architecture. Typical ocean engineering application areas include: beach protection and nourishment, coastal structures, coastal erosion, development of ocean energy resources, instrumentation for coastal and offshore measurements, marine dredging and dredged material placement, moored and towed systems, ocean mining, offshore petroleum recovery, offshore structures, ports and harbors, search and salvage, suspended and dissolved constituent transport, undersea pipelines and cables, and submersible vehicles.

The graduate degree programs include coursework leading to the Master of Science (MS), Master of Engineering (ME), Doctor of Engineering (DEng), and Doctor of Philosophy (PhD) degrees in Ocean Engineering. Students entering the graduate degree program have widely varied engineering backgrounds. Each graduate student is expected to become well versed in the appropriate support disciplines, particularly mathematics, ocean wave mechanics, and hydromechanics. The student is expected to achieve reasonable competence in the principal areas of offshore structures, coastal and port engineering, coastal and estuarine processes, dredging and/or mining processes, or marine hydrodynamics. The graduate program is designed to provide students with knowledge of engineering in the ocean environment and to establish a base for ocean engineering research. Graduate courses are given in ocean wave theory, hydromechanics, oceanography, mathematics, coastal engineering, estuarine hydrodynamics, sediment transport, dynamics of offshore structures, marine dredging, port and harbor design, laboratory modeling, nonlinear hydrodynamics, computational fluid dynamics, and advanced offshore and coastal numerical methods.

The laboratory facilities for the Ocean Engineering Program are among the most comprehensive in the nation for testing offshore and coastal systems. The facilities are located in the Reta and Bill Haynes ’46 Coastal Engineering Laboratory, Offshore Technology Research Center, and the Civil Engineering Laboratory Building.

No foreign language is required for the PhD in ocean engineering or DEng. Students pursuing PhD or DEng are required to pass the Ocean Engineering qualifying exam.

Faculty

Anderson, Stuart, Professor
Civil Engineering
PhD, University of Texas, 1989

Aubeny, Charles, Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 1992

Autenrieth, Robin, Professor
Civil Engineering
PhD, Clarkson University, 1986

Barroso, Luciana, Associate Professor
Civil Engineering
PhD, Stanford University, 1999

Batchelor, Bill, Professor
Civil Engineering
PhD, Cornell University, 1976

Beason, William, Associate Professor
Civil Engineering
PhD, Texas Tech University, 1980

Birely, Anna, Assistant Professor
Civil Engineering
PhD, University of Washington, 2012

Biscontin, Giovanna, Tees Research Associate Professor
Civil Engineering
PhD, University of California, Berkeley, 2001

Bracci, Joseph, Professor
Civil Engineering
PhD, University at Buffalo, State University of New York, 1992

Briaud, Jean-Louis, Professor
Civil Engineering
PhD, University of Ottawa, Canada, 1979

Brumbelow, James, Associate Professor
Civil Engineering
PhD, Georgia Institute of Technology, 2001

Burris, Mark, Professor
Civil Engineering
PhD, University of South Florida, 2001
Cahill, Anthony, Associate Professor
Civil Engineering
PhD, John Hopkins University, 1998

Chang, Kuang-An, Professor
Civil Engineering
PhD, Cornell University, 1999

Chen, Hamn, Professor
Civil Engineering
PhD, University of Iowa, 1982

Chu, Kung-Hui, Associate Professor
Civil Engineering
PhD, University of California, Berkeley, 1998

Damnjanovic, Ivan, Associate Professor
Civil Engineering
PhD, University of Texas, 2006

England, Peter, Instructional Associate Professor
Civil Engineering
PhD, Texas Tech University, 2011

Epps, Jon, Visiting Professor
Civil Engineering
PhD, University of California, Berkeley, 1968

Falzarano, Jeffrey, Professor
Civil Engineering
PhD, University of Michigan, 1990

Ford, David, Associate Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 1995

Fry, Gary, Associate Professor
Civil Engineering
PhD, University of Illinois, 1995

Gao, Huilin, Assistant Professor
Civil Engineering
PhD, Princeton University, 2005

Gharaibeh, Nasir, Associate Professor
Civil Engineering
PhD, University of Illinois, 1997

Grasley, Zachary, Associate Professor
Civil Engineering
PhD, University of Illinois, 2006

Hawkins, Harvey, Associate Professor
Civil Engineering
PhD, Texas A&M University, 1993

Horrillo, Juan, Assistant Professor
Civil Engineering
PHD, University of Alaska at Fairbanks, 2006

Hueste, Marybeth, Professor
Civil Engineering
PhD, University of Michigan, 1997

Hurlebus, Stefan, Associate Professor
Civil Engineering
DEN, University of Stuttgart, Germany, 2002

James, Ray, Associate Professor
Civil Engineering
PhD, University of Texas, Austin, 1976

Jones, Harry, Associate Professor
Civil Engineering
PhD, University of Illinois, 1969

Kaihatu, James, Associate Professor
Civil Engineering
PhD, University of Delaware, 1994

Kanta, Lufthansa, Instructional Assistant Professor
Civil Engineering
PHD, Texas A&M University, 2009

Keating, Peter, Associate Professor
Civil Engineering
PhD, Lehigh University, 1987

Kim, Moohyun, Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 1988

Little, Dallas, Professor
Civil Engineering
PhD, Texas A&M University, 1979

Lord, Dominique, Associate Professor
Civil Engineering
PhD, University of Toronto, 2000

Lytton, Robert, Professor
Civil Engineering
PhD, University of Texas, Austin, 1967

Ma, Xingmao, Associate Professor
Civil Engineering
PHD, Missouri University of Science and Technology, 2004

Mander, John, Professor
Civil Engineering
PhD, University of Canterbury, New Zeland, 1984

Martin, Amy, Professor
Civil Engineering
PhD, University of California, Berkeley, 1997

Masad, Eyad, Professor
Civil Engineering
PhD, Washington State University, 1998

Medina Cetina, Associate Professor
Civil Engineering
PhD, John Hopkins University, 2007

Mercier, Richard, Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 1985
Masters
- Master of Engineering in Civil Engineering
- Master of Engineering in Ocean Engineering
- Master of Science in Civil Engineering
- Master of Science in Ocean Engineering

Doctoral
- Doctor of Philosophy in Civil Engineering
- Doctor of Philosophy in Ocean Engineering

Courses

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.
Prerequisites: CVEN 301.

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 or approval of instructor.

CVEN 604 Engineering Analysis of Treatment Systems
Credits 3. 3 Lecture Hours.
Theory of processes used to treat water, wastewater and hazardous wastes; applications of theory to design and operation of treatment systems, including biological treatment, adsorption, coagulation, filtration and precipitation.
Prerequisites: CVEN 601, CVEN 619, 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.

CVEN 609 Environmental Control of Oil and Hazardous Materials
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Oil and hazardous material (OHM) spills in the engineering design process; evaluation of OHM properties and their behavior and impact to environmental systems; prevention programs and documents, technology for spill containment and removal; contingency planning cycle including administrative site-specific plans and resource acquisition; response organization; restoration and documentation.
Prerequisite: CVEN 301 or approval of instructor.

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.

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.
Prerequisites: CVEN 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. Content applies 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 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.

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 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 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.
Production, specifications and tests of bituminous materials; design
and evaluation of asphaltic concrete for construction and maintenance;
inspection control of streets, parking and highway paving surfaces.
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; node 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 669 Design of Structures for Hazardous Environmental Loads
Credits 3. 3 Lecture Hours.
Examines the advanced project development process-business planning and pre-project planning for engineering, procurement and construction (EPC); a process approach is followed. Issues covered are 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 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: 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 and MATH 308 or approval of instructor.

CVEN 674 Groundwater Engineering
Credits 3. 3 Lecture Hours.
Groundwater hydrology, theory of groundwater movement, steady-state flow, potential flow, mechanics of well flow, multiple-phase flow, salt water intrusion, artificial recharge, groundwater contamination and models.

Prerequisite: CVEN 311 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 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
Credit 1. 2 Lab 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 2. 1 to 2 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 two 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 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: loans vs. bonds; risk identification, quantification, and management; engineering due-diligence; pricing risk premium; hedging using civil engineering design strategies.
CVEN 717/ISEN 642 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.
Cross Listing: ISEN 642.

CVEN 740 Advanced Constitutive Behavior of Cemnetitious 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. Stacked with CVEN 418.

CVEN 750 Finite Element 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 445 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, biocomposite, 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: 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: 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.

OCEN 201 Introduction to Ocean Engineering
Credits 3.3 Lecture Hours.
Survey of ocean engineering; concepts and theories of wave-structure interaction; sources of technical information; coastal and ocean structures, moorings, laboratory models; underwater systems; naval architecture; ocean instrumentation; materials and corrosion; hydrographic surveying and positioning, recent developments in ocean engineering.
Prerequisite: CVEN 221 or registration therein.

OCEN 300 Ocean Engineering Wave Mechanics
Credits 3.3 Lecture Hours.
Physical and mathematical fundamentals of ocean wave behavior; mechanics of wave motion; use of statistics and probability to develop design wave criteria.
Prerequisite: CVEN 311, OCEN 201 or registration therein.

OCEN 336 Fluid Dynamics Laboratory
Credit 1.2 Lab Hours.
Introduction to laboratory techniques, calibration principles, reports and fluid measurements; determination of fluid properties; visualization of types of flow; experiments in closed conduit flow of air, water and oil; fluid drag and turbomachinery tests; open channel and gravity wave demonstrations.
Prerequisite: CVEN 311 or registration therein.
OCEN 362 Hydromechanics
Credits 3. 3 Lecture Hours.
Kinematics of fluids; differential analysis of fluid flow; incompressible, irrotational and turbulent flow; Navier-Stokes equations; flow of viscous fluids; open-channel flow.
Prerequisites: CVEN 311; MATH 308; junior or senior classification.

OCEN 400 Basic Coastal Engineering
Credits 3. 3 Lecture Hours.
Mechanics of wave motion; wave refraction, diffraction and reflection; wave forecasting; shore processes; planning of coastal engineering projects; design of seawalls, breakwaters, beach nourishment, and fixed and floating installations; dredging; risk analysis.
Prerequisites: OCEN 300 or approval of instructor; CVEN 311; junior or senior classification.

OCEN 401 Underwater Acoustics for Ocean Engineers
Credits 3. 3 Lecture Hours.
Fundamentals of underwater acoustics, SONAR equations, propagation of underwater sound, acoustic transducers and arrays, noise in the ocean environment, design and prediction of SONAR systems, ocean engineering applications of underwater sound.
Prerequisite: CVEN 311.

OCEN 402 Principles of Naval Architecture
Credits 3. 3 Lecture Hours.
Elementary principles of naval architecture; ship geometry and hydrostatics; load line and classification regulations; concept of intact and damaged stability; resistance and propulsion of water-borne vehicles; applications to the design consideration of semi-submersibles, catamarans and drilling rigs.
Prerequisite: CVEN 311.

OCEN 403 Dynamics of Offshore Structures
Credits 3. 3 Lecture Hours.
Prediction of loads due to wind, current and waves; introduction to concepts of linear structural dynamics and to the design of ocean structures; mooring and towing analysis; fluid-structure interactions; vibration of submerged structures; offshore pipelines; introduction to risk analysis.
Prerequisites: OCEN 300 or approval of instructor; CVEN 345, CVEN 363 or registration therein.

OCEN 407 Design of Ocean Engineering Facilities
Credits 4. 1 Lecture Hour. 6 Lab Hours.
Design of structures, equipment and systems for the ocean; environmental, logistical and reliability requirements; complete design process followed through group design project; delineation of alternatives, constraints, economics and environmental consequences included to strengthen real-life problem solving skills.
Prerequisites: OCEN 400, OCEN 402, OCEN 403 or approval of instructor.

OCEN 408 Underwater and Moored System Design
Credits 3. 3 Lecture Hours.
Basic principles of thermodynamics, fluid dynamics and human respiration physiology applied to design of underwater habitats, submersibles and diving bells; breathing gas supply for diving systems; heat transfer for underwater systems; pressure vessel design; remotely operated vehicles; subsea flowlines and manifold systems; and design of towed and moored systems.
Prerequisites: CVEN 311; MEEN 315 or approval of instructor.

OCEN 410 Ocean Engineering Laboratory
Credit 1. 3 Lab Hours.
Fundamental techniques and instrumentation for field and laboratory measurements pertaining to ocean engineering experiment planning; data analysis and data presentation; written reports describing planning, analysis and results of experiments.
Prerequisites: OCEN 400, OCEN 402, OCEN 403; junior or senior classification.

OCEN 475 Environmental Fluid Mechanics
Credits 3. 3 Lecture Hours.
Examines fluid and mass transport in naturally occurring flows; topics include molecular and turbulent diffusion; dispersion; river, estuary, and ocean mixing; dissolution boundary layers; tidal mixing; offshore wastewater outfalls; introduction to environmental quality numerical modeling.
Prerequisite: CVEN 311.

OCEN 481 Seminar
Credit 1. 1 Lecture Hour.
Responsibilities and obligations of new ocean engineers; professional ethics, membership in professional societies and professional registrations; case studies and lectures presented by staff and practicing engineers. Must be taken on a satisfactory/unsatisfactory basis.
Prerequisite: OCEN 300.

OCEN 485 Directed Studies
Credits 1 to 6. 1 to 6 Other Hours.
Special problems in various areas of ocean engineering assigned to individual students or to groups; readings and assignments given and frequent consultations held.
Prerequisite: Approval of program head.

OCEN 489 Special Topics in...
Credits 1 to 4. 1 to 4 Lecture Hours.
Selected topics in an identified field of ocean engineering. May be repeated for credit.
Prerequisite: Approval of instructor.

OCEN 491 Research
Credits 1 to 4. 1 to 4 Other Hours.
Research conducted under the direction of faculty member in ocean engineering. May be repeated 2 times for credit. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.
Prerequisites: Junior or senior classification and approval of instructor.

OCEN 630 Dynamics of Ocean Vehicles
Credits 3. 3 Lecture Hours.
Dynamics and stability of motion of immersed and floating structures and ocean vehicles; maneuverability and control; behavior of ocean vehicles and stationary platforms in waves. Design considerations leading to motion reduction; applications to surface vessels, submersibles and drilling rigs.
Prerequisites: CVEN 311, MEEN 459 or equivalent, or approval of instructor.

OCEN 671 Ocean Wave Mechanics
Credits 3. 3 Lecture Hours.
Wave theory and applications to engineering problems; linear and non-linear theories of regular gravity waves; wave properties and transformation in shoaling water; spectral analysis of irregular waves; forecasting, hindcasting and theoretical spectra.
Prerequisite: Prerequisite: CVEN 311 or equivalent.
OCEN 672 Coastal Engineering  
Credits 3.3 Lecture Hours.  
Effects of waves on coastal structures; design of seawalls, breakwaters, jetties, harbors, ship channels and pipelines; intentional and accidental discharge of pollutants; diffusion and spreading; oil spill containment and collection.  
**Prerequisite:** OCEN 671.

OCEN 673 Nonlinear Hydrodynamic Problems in Ocean Engineering  
Credits 3.3 Lecture Hours.  
Nonlinear hydrodynamic problems involved with the complex offshore structures in high sea environment; nonlinear waves application of Volterra model to weakly nonlinear systems; generation of nonlinear model waves; nonlinear hydrodynamic interaction between waves and structure; dynamic analysis of nonlinear response of integrated offshore structures.  
**Prerequisites:** OCEN 671 and OCEN 678.

OCEN 674 Ports and Harbors  
Credits 3.3 Lecture Hours.  
Basic port planning including site selection, environmental factors and economic conditions; design of wharves, quays, jetties, breakwaters, terminals, navigational channels and fenders; harbor sedimentation and maintenance dredging; design of fishing, small craft and recreation boat harbors.  
**Prerequisite:** Approval of instructor.

OCEN 675 Nonlinear Wave Dynamics  
Credits 3.3 Lecture Hours.  
Nonlinear wave-wave interactions in steep ocean waves significantly affect wave properties and long-term wave evolution. Strong and weak wave interactions and their respective effects on waves are studied, using various perturbation methods. Applications are shown through using Hybrid Wave Models to analyze wave measurements and predict wave loads on structures.  
**Prerequisite:** OCEN 671.

OCEN 676 Dynamics of Offshore Structures  
Credits 3.3 Lecture Hours.  
Review of concepts of linear structural dynamic analysis for time and frequency domain simulations, functional design of off-shore platforms, pipelines, floating structures and moorings; environmental loading problems; hydrodynamic phenomena including wind and current interaction, vortex shedding and wave forces; structure-fluid interaction models.  
**Prerequisites:** OCEN 671 or approval of the instructor.

OCEN 677 Environmental Fluid Mechanics  
Credits 3.3 Lecture Hours.  
Introduction to fluid and mass transport in naturally occurring flows; topics include molecular and turbulent diffusion; dispersion; river, estuary, and ocean mixing; dissolution boundary layers; tidal mixing; offshore wastewater outfalls; introduction to environmental quality numerical modeling.  
**Prerequisite:** CVEN 311 or equivalent.

OCEN 678 Fluid Dynamics for Ocean and Environmental Engineering  
Credits 3.3 Lecture Hours.  
General conservation laws; Navier-Stokes equations; steady and unsteady Bernoulli’s equation; potential flow theory and basics of panel methods; laminar and turbulent boundary layer; dispersion and diffusion processes in laminar and turbulent flow; flow past a body of any shape.  
**Prerequisite:** Prerequisite: CVEN 311 or equivalent.