Civil Engineering

Civil engineers plan, design, supervise the construction, operate, maintain, inspect, retrofit, and manage many of the facilities and systems in both public and private sectors that are essential to modern life. The civil engineering profession is one of the most stable and most diverse of the engineering disciplines. Civil engineers are employed by consulting firms, public agencies, and start and operate their own business. Workplaces range from construction sites to design offices. Most civil engineers work with some engineering or construction aspect of private and/or public facilities, such as airports, bridges, buildings, coastal structures, dams, environmental remediation of contaminated sites, harbors, highways, offshore structures, pipelines, railroads, transportation systems, tunnels, water collection systems, water distribution systems, water and wastewater treatment facilities, and waterways. Civil engineers are on the forefront of applying the newest technology innovations in engineering and construction.

Civil engineering projects are unique because they require individual planning, analysis, design, construction supervision, performance monitoring, management and retrofitting. Civil engineering projects often require technical, governmental, legal, financial, and social evaluations. The primary objective is to provide the best service for the users while minimizing costs and other undesirable impacts.

The mission of the Zachry Department of Civil Engineering (http://engineering.tamu.edu/civil) at Texas A&M University is to prepare our graduates to become professional engineers and leaders in the civil and ocean engineering profession by providing our students with a solid education that will enable them to integrate fundamental scientific engineering principles and that will couple with the latest technological advances to facilitate the development of their problem solving skills. Additionally, the department provides opportunities for enhancement of the students’ educational experience through meaningful interactions with the profession, professionally-centered student activities and exposure to the broad field of civil engineering through seminars, practitioner visits, and Professional Day activities.

The faculty of the Zachry Department of Civil Engineering strives to ensure that our ever-evolving educational programs accomplish several objectives. First, our faculty must prepare the students to address the current and future civil and/or ocean engineering needs of the State of Texas, the nation and the world by being able to recognize the important geopolitical and public policy needs; and solve technical problems. In addition, the Department provides a curriculum that integrates scientific and technical knowledge with an appreciation for social, economic and political concerns. The curriculum and programs provide opportunities for our students to:

1. build leadership skills,
2. learn professionalism and ethical responsibility, and
3. develop and understanding of the need to engage in lifelong learning.

Finally, the faculty of the Zachry Department of Civil Engineering at Texas A&M University promotes the highest academic standards of excellence, quality, and ethics in both our undergraduate and graduate programs, and in doing so create both a culture of excellence and a community of scholars. Through our programs, our faculty and graduates provide local, state, national, and international leadership to a profession that must solve the civil and/or ocean engineering problems facing an increasingly complex society.

The program educational objectives for the undergraduate civil engineering program within the Department of Civil Engineering at Texas A&M University are to produce graduates:

1. who are prepared to enter civil engineering practice and/or continue their education through study in graduate and professional programs,
2. most of whom will become practicing civil engineers with most of these becoming licensed professional engineers, and
3. many of whom will pursue advanced studies.

The undergraduate program in civil engineering within the Zachry Department of Civil Engineering at Texas A&M is accredited by the Engineering Accreditation Commission of ABET, www.abet.org. Graduate programs in civil engineering are also available. These programs allow further specialization and offer more in-depth study to address more complex technical and management issues. Graduate degrees also offer additional employment opportunities.

Before commencing course work in the major, students must be admitted to the major or have the approval of the department.

Ocean Engineering

Ocean engineering is the application of basic engineering principles to the analysis, design, construction, and management of systems that operate in the ocean environment or near shore. 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, subsea pipelines and cables, submersible vehicles, and underwater acoustics. Employment opportunities exist with private industry, defense contractors, consulting firms, and government agencies. Ocean engineering students are encouraged to pursue summer internships and may participate in the University cooperative education program. The curriculum leading to a Bachelor of Science degree in ocean engineering is administered by the Coastal and Ocean Engineering Division of the Zachry Department of Civil Engineering. The undergraduate program in ocean engineering within the Zachry Department of Civil Engineering at Texas A&M is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The mission of the Ocean Engineering Program is to conduct research, serve the public, and educate students in a broad program of instruction encompassing traditional and emerging areas of ocean engineering. Graduates are prepared for entering engineering practice, continuing onto graduate study, life-long learning and professional development. Students develop a sense of professionalism and an appreciation for the obligations of a professional engineer. The Program offers ocean engineering continuing education activities for the people and marine industry of the state, nation and international community. The Program serves the public and engineering profession in Texas and the nation through participation of faculty and students in public and professional activities. Applied and fundamental research is conducted that contributes
to the better understanding of ocean engineering and supports student educational development.

The objectives of the Ocean Engineering Program are to graduate students that are qualified to contribute to the ocean engineering profession and society, gain employment in ocean engineering and related engineering fields with private and government organizations, and advance to positions of increased responsibility. Some graduates become professional engineers and members of ocean engineering related professional societies, pursue company training and continuing education activities, and attend technical conferences. Some graduates pursue graduate studies in ocean engineering and related fields and receive post baccalaureate degrees.

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. These facilities include a large deep water wave basin, a towing tank, a wave channel, a shallow water wave basin and data acquisition systems. Additional information is available on the Zachry Department of Civil Engineering website.

Before commencing course work in the major, students must be admitted to the major or have the approval of the department.

**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

Biscontini, 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

Chinn, Timothy, Professor Of The Practice  
Civil Engineering  
BS, Texas A&M University, 1980

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

Hurlbaut, 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 Zealand, 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

Miller, Gretchen, Assistant Professor
Civil Engineering
PhD, University of California, Berkeley, 2009

Morgan, James, Associate Professor
Civil Engineering
PhD, University of Illinois, 1979

Niedzwecki, John, Professor
Civil Engineering
PhD, The Catholic University of America, 1977

Noshadravan, Arash, Research Assistant Professor
Civil Engineering
PHD, University of Southern California, 2011

Olivera, Francisco, Associate Professor
Civil Engineering
PhD, University of Texas, 1996

Otey, Jeffrey, Instructional Assistant Professor
Civil Engineering
MEN, Texas A&M University, 1994

Park, Philip, Assistant Professor
Civil Engineering
PhD, University of Michigan, 2012

Quadrifoglio, Luca, Associate Professor
Civil Engineering
PhD, University of Southern California, 2005

Randall, Robert, Professor
Civil Engineering
PhD, University of Rhode Island, 1972

Reinschmidt, Kenneth, Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 1965

Sakhaei Far, Assistant Professor
Civil Engineering
PHD, North Carolina State University, 2011

Sanchez Castilla, Associate Professor
Civil Engineering
PhD, Universidad Politecnica de Catalunya (UPC), Barcel, 2004
Scarfuto, Jessica, Assistant Lecturer
Civil Engineering
MS, Texas A&M University, 2014

Shidlovskaya, Anna, Visiting Professor
Civil Engineering
PHD, National Mineral Resources University, 2005

Socolofsky, Scott, Associate Professor
Civil Engineering
PhD, Massachusetts Institute of Technology, 2001

Walewski, John, Associate Professor Of The Practice
Civil Engineering
PhD, University of Texas, 2005

Wang, Binbin, Lecturer
Civil Engineering
PHD, University of Wisconsin - Milwaukee, 2013

Wang, Xiubin, Associate Professor
Civil Engineering
PhD, University of California, Irvine, 2001

Woods, Calvin, Senior Professor
Civil Engineering
PHD, The University of Texas - Austin, 1964

Wurbs, Ralph, Professor
Civil Engineering
PhD, Colorado State University, 1978

Ying, Qi, Associate Professor
Civil Engineering
PhD, University of California, Davis, 2004

Zhang, Jun, Professor
Civil Engineering
PhD, Massachusetts Inst of Technology, 1987

Zhang, Yunlong, Associate Professor
Civil Engineering
PhD, Virginia Tech, 1996

Zollinger, Dan, Professor
Civil Engineering
PhD, University of Illinois at Urbana-Champaign, 1989

Majors

• Bachelor of Science in Civil Engineering
• Bachelor of Science in Civil Engineering, Coastal and Ocean Engineering Track
• Bachelor of Science in Civil Engineering, Construction Engineering and Management Track
• Bachelor of Science in Civil Engineering, Environmental Engineering Track
• Bachelor of Science in Civil Engineering, General Civil Engineering Track
• Bachelor of Science in Civil Engineering, Geotechnical Engineering Track
• Bachelor of Science in Civil Engineering, Structural Engineering Track
• Bachelor of Science in Civil Engineering, Transportation Engineering Track
• Bachelor of Science in Civil Engineering, Water Resources Engineering Track
• Bachelor of Science in Ocean Engineering

Courses

• Civil Engineering
• Ocean Engineering

Civil Engineering

CVEN 207 Introduction to the Civil Engineering Profession
Credit 1. 1 Lecture Hour.
Introduction to the study and practice of civil engineering; specialized subdisciplines of civil engineering; professionalism and professional registration; engineering ethics; exercises in engineering technical communications.
Prerequisite: ENGL 104.

CVEN 221 Engineering Mechanics: Statics
Credits 3. 2 Lecture Hours. 2 Lab Hours.
(2-2) General principles of mechanics; concurrent force systems; statics of particles; equivalent force/moment systems; centroids and center of gravity; equilibrium of rigid bodies; trusses, frames, and machines; internal forces in structural members; friction; second moments of areas.
Prerequisites: MATH 251 or MATH 253 or registration therein; PHYS 218; admitted to major degree sequence in civil engineering.

CVEN 250 Introduction to Graphics and Visualization Applications in Civil Engineering Design
Credits 2. 1 Lecture Hour. 3 Lab Hours.
Graphical communication in the civil engineering design process; introduction to industry standard software; construction documents and contract drawings in civil engineering applications; data analysis; introduction to project visualization.

CVEN 289 Special Topics in...
Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.
Selected topics in an identified area of civil engineering. May be repeated for credit.
Prerequisite: Approval of department head.

CVEN 301 Environmental Engineering
Credits 3. 3 Lecture Hours.
Water quality; material balances; chemical, physical and biological processes; water quality modeling; water and wastewater treatment; air quality; solid and hazardous waste management.
Prerequisites: CHEM 107; CVEN 302 or registration therein; MATH 308 or registration therein.

CVEN 302 Computer Applications in Engineering and Construction
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Application of computers to solution of civil engineering problems using various numerical methods; structured computer programming; mathematical modeling and error analysis; solution of algebraic and differential equations; numerical differentiation and integration; curve-fitting; root-finding.
Prerequisites: ENGR 112; MATH 308 or registration therein; admitted to major degree sequence in civil engineering.
CVEN 303 Civil Engineering Measurement
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Introduction to geodetic positions, datums, map projections; theory of civil engineering measurements and errors applied to horizontal and vertical control, curves, earthwork and mapping using state-of-the-art technology for data capture; processing and presentation of result.
Prerequisite: MATH 151; admitted to major degree sequence in civil engineering.
CVEN 305 Mechanics of Materials
Credits 3. 3 Lecture Hours.
Applications of conservation principles and stress/deformation relationships for continuous media to structural members; axially loaded members; thin-walled pressure vessels; torsional and flexural members; shear; moment; deflection of members; combined loadings; stability of columns; nonsymmetrical bending, shear center; indeterminate members; elastic foundations.
Prerequisite: CVEN 221.
CVEN 306 Materials Engineering for Civil Engineers
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Introduction to scientific concepts of civil engineering materials; relationship between macroscopic material properties and response and microscopic properties; physical, mechanical, surface, fracture, and rheological properties of civil engineering materials including metals, composites, and polymers.
Prerequisites: CHEM 107, PHYS 208, CVEN 221; MATH 308 or registration therein; CVEN 305 or registration therein.
CVEN 307 Transportation Engineering
Credits 3. 3 Lecture Hours.
Fundamental principles and methods in planning, design, and operation of transportation systems; driver and vehicle performance capabilities; highway geometric and pavement design principles; traffic analysis and transportation planning.
Prerequisite: CVEN 302 or registration therein.
CVEN 311 Fluid Dynamics
Credits 3. 3 Lecture Hours.
Fluid properties; statics; kinematics; basic conservation principles of continuity, energy and momentum; similitude and hydraulic models; incompressible flow in pipes; fluid dynamic drag.
Prerequisites: MATH 251 and CVEN 221; CVEN 302 or registration therein.
CVEN 315 Sensor Technology for the Built Environment
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Fundamentals of sensor technology including laboratory safety, error analysis, statistical analysis, electric circuits, data acquisition, signal conditioning, signal analysis, strain gages, laser technology, image acquisition and analysis, fiber optic sensors, wireless sensors; its applications in civil engineering; and hands-on demonstrations relevant to the natural and built environment.
Prerequisites: CVEN 302, junior or senior classification, or approval of instructor.
CVEN 322 Civil Engineering Systems
Credits 3. 3 Lecture Hours.
Economic analysis and evaluation of engineering projects; application of systems analysis to civil engineering design; systems synthesis and optimization techniques; assignments apply engineering economics, statistical methods and optimization techniques to civil engineering problems.
Prerequisite: STAT 211 or registration therein; CVEN 302 or registration therein; admitted to major degree sequence in civil engineering.
CVEN 333 Project Management for Engineers
Credits 3. 3 Lecture Hours.
Basic project management for engineering undergraduates; project development and economic justification; estimating; scheduling; network methods; critical path analysis; earned value management; recycling and rework; project organizational structures; project risk assessment; resource allocation; ethics; characteristics of project managers.
Prerequisite: Junior or senior classification in Dwight Look College of Engineering.
Cross Listing: ISEN 333 and MEEN 333.
CVEN 339 Water Resources Engineering
Credits 3. 3 Lecture Hours.
Quantitative hydrology, precipitation, hydrograph analysis, reservoir and stream routing; groundwater, Darcy equation, well equation, well design; probability concepts in design; water law; dams; reservoirs; spillways; open channel and pipe network hydraulics; pumps; urban stormwater drainage; flood damage mitigation.
Prerequisite: CVEN 311.
CVEN 342 Materials of Construction
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Physical and mechanical properties of construction materials; portland cement concrete, bituminous materials, wood, ferrous and non-ferrous metals, glass, plastics and masonry units; proportioning of concrete mixes including admixtures.
Prerequisites: CVEN 302 or registration therein; CVEN 305 and CVEN 306; ENGL 203, ENGL 210, ENGL 241 or ENGL 301.
CVEN 343 Portland Cement Concrete Materials for Civil Engineers
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Physical and chemical characteristics of Portland cement concrete systems; constituent materials; mixture proportioning; fresh concrete characteristics; hardened concrete properties; durability characteristics; and concrete construction methods.
Prerequisites: CVEN 302 or registration therein; CVEN 305 and CVEN 306; ENGL 203, ENGL 210, ENGL 241 or ENGL 301.
CVEN 345 Theory of Structures
Credits 3. 3 Lecture Hours.
Structural engineering--functions of structure, design loads, reactions and force systems; analysis of statically determinate structures including beams, trusses and arches; energy methods of determining deflections of structures; influence lines and criteria for moving loads; analysis of statically indeterminate structures including continuous beams and frames.
Prerequisites: CVEN 302 or registration therein; CVEN 305.
CVEN 349 Civil Engineering Project Management
Credits 3. 3 Lecture Hours.
Basic elements of management of civil engineering projects; roles of all participants in the process--owners, designers, contractors and suppliers; emphasis on contractual aspect of the process--project estimating, planning and controls.
Prerequisite: CVEN 302 or registration therein; CVEN 322 or CVEN 422.
CVEN 363 Engineering Mechanics: Dynamics
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Application of first principles to model dynamic particles and rigid body systems with ordinary differential equations; solutions to models using analytical and numerical approaches; interpreting solutions/performance measures; linear vibrations; modeling of civil engineering systems and evaluating dynamic response to natural hazards.
Prerequisites: CVEN 302, CVEN 305 and MATH 308.
CVEN 307 Soil Mechanics and Foundation Engineering
Credits 3. 3 Lecture Hours.
Tests performed to determine the physical and engineering properties of soils used in design and construction; effects of soil properties on foundation design; analysis of settlement, shear failure, and stability; stability and settlement of soil structures; chapter coverage: soil mechanics; geotechnical engineering design; soil mechanics; soil exploration; soil testing; and soil classification.
Prerequisites: CVEN 345; CVEN 342 or CVEN 343; senior classification in civil engineering or CVEN 365.

CVEN 309 pavement 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; introduction to pavement management concepts.
Prerequisites: CVEN 307; CVEN 342 or CVEN 343.

CVEN 413 Natural Environmental Systems
Credits 3. 3 Lecture Hours.
Water quality assessment of natural environmental systems; development and calibration of models to describe fate and transport of contaminants in aquatic systems; application of models to design of water quality control facilities.
Prerequisites: CVEN 301.

CVEN 414 Case Histories in Geotechnical Engineering
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Examination of geotechnical problems through the use of case studies associated with foundations, waste disposal, slope stability, retaining structures, soil improvement and other civil engineering works.
Prerequisite: CVEN 365.

CVEN 415 Geotechnical Engineering Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
A design course covering prediction of settlement, analysis of the stability of slopes, prediction of bearing capacity of shallow and deep foundations and determination of earth pressures acting on retaining structures; a general course in geotechnical engineering design for undergraduates and for graduate students not primarily interested in the geotechnical field, but desiring additional study beyond the introductory undergraduate level.
Prerequisite: CVEN 365.

CVEN 417 Bituminous Materials
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Origin, production, specifications and tests of bituminous materials and paving mixtures used in construction and maintenance of roads and pavements, pavement surface properties, pavement distress and correction alternatives.
Prerequisites: Senior classification in engineering; CVEN 342 or CVEN 343 or approval of instructor.

CVEN 418 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; introduction to pavement management concepts.
Prerequisites: CVEN 307; CVEN 342 or CVEN 343.

CVEN 435 Geotechnical Engineering Design
Credits 3. 2 Lecture Hours. 3 Lab Hours.
A design course covering prediction of settlement, analysis of the stability of slopes, prediction of bearing capacity of shallow and deep foundations and determination of earth pressures acting on retaining structures; a general course in geotechnical engineering design for undergraduates and for graduate students not primarily interested in the geotechnical field, but desiring additional study beyond the introductory undergraduate level.
Prerequisite: CVEN 365.

CVEN 436 Case Histories in Geotechnical Engineering
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Examination of geotechnical problems through the use of case studies associated with foundations, waste disposal, slope stability, retaining structures, soil improvement and other civil engineering works.
Prerequisite: CVEN 365.

CVEN 444 Structural Concrete Design
Credits 3. 3 Lecture Hours.
Behavior, design, and detailing of reinforced concrete structural members according to the ACI Building Code Requirements; design for ultimate limit states (flexible, shear, and axial loads) and serviceability requirements (cracking and deflection); applications include continuous beams and moment frames.
Prerequisites: CVEN 345; CVEN 342 or CVEN 343 or registration therein.

CVEN 445 Matrix Methods of Structural Analysis
Credits 3. 3 Lecture Hours.
Analysis of framed structures using linear algebra concepts; matrix algebra and solution of linear algebraic equations; energy principles and virtual work; stiffness; coordinate transformations; use of commercial software for structural analysis.
Prerequisites: CVEN 345 and CVEN 363.
CVEN 446 Structural Steel Design  
Credits 3.3 Lecture Hours.  
Design of structural steel elements found in building structures, including tension members, compression members, beams, beam-columns and base plates; design of bolted and welded simple connections; design of bolted eccentric connections; design of bolted and welded partially and fully restrained connections.  
**Prerequisite**: CVEN 345.

CVEN 451 Public Works Engineering  
Credits 3.3 Lecture Hours.  
Public works engineering; service demand estimates; water, wastewater and solid waste collection systems; urban drainage; code enforcement and public decision making.  
**Prerequisites**: CVEN 301 and CVEN 339.

CVEN 454 Urban Planning for Engineers  
Credits 3.2 Lecture Hours. 3 Lab Hours.  
Urban planning from an engineering point of view; determinants of land use patterns, planning data collection and analysis; location and design requirements for various land uses; interrelationship of transportation and land use; and methods of plan development.  
**Prerequisite**: CVEN 307.

CVEN 455 Urban Stormwater Management  
Credits 3.3 Lecture Hours.  
Hydrologic, hydraulic, and general civil engineering design and implementation of stormwater systems including drainage and detention storage facilities, floodplain regulation measures, and flood control structures; stormwater aspects of land development and public works engineering; flood hydrology and hydraulics; institutional aspects of urban stormwater management.  
**Prerequisite**: CVEN 339 or approval of instructor.

CVEN 456 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, pavement, intersections and highway drainage elements.  
**Prerequisite**: CVEN 307.

CVEN 457 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**: CVEN 307.

CVEN 458 Hydraulic Engineering of Water Distribution Systems  
Credits 3.3 Lecture Hours.  
Pressure conduit hydraulics; design, modeling, and analysis of water conveyance and distribution systems including pipelines, pipe networks, and pumps.  
**Prerequisite**: CVEN 339 or approval of instructor.

CVEN 463 Engineering Hydrology  
Credits 3.3 Lecture Hours.  
Occurrence, distribution and properties of natural waters of the earth; measurement and engineering analysis of hydrologic phenomena including precipitation, streamflow and groundwater, hydrologic design of water resources development and management projects.  
**Prerequisite**: CVEN 339.

CVEN 473 Engineering Project Estimating and Planning  
Credits 3.2 Lecture Hours. 3 Lab Hours.  
Application of cost estimating and planning techniques for civil engineering projects; introduction to labor, materials and equipment costing; productivity analysis; indirect and general overhead costs; preparation of approximate and definitive estimates; and integration of time/cost relationships through critical path method and resource leveling.  
**Prerequisites**: CVEN 349; senior classification.

CVEN 483 Analysis and Design of Structures  
Credits 3.2 Lecture Hours. 3 Lab Hours.  
Overall procedure of analysis and design including functions, loads, layouts of force systems; analysis, specifications, cost comparisons, and maintenance as applied to typical building structures.  
**Prerequisites**: CVEN 365 or registration therein; CVEN 444 and CVEN 446.

CVEN 485 Directed Studies  
Credits 1 to 3. 1 to 3 Other Hours.  
Research and design problems of limited scope approved on an individual basis intended to promote independent study; results of study presented in writing.  
**Prerequisite**: Approval of department head.

CVEN 489 Special Topics in...  
Credits 1 to 4. 0 to 4 Lecture Hours. 0 to 4 Lab Hours.  
Selected topics in an identified area of civil engineering. May be repeated for credit.  
**Prerequisite**: Approval of department head.

CVEN 491 Research  
Credits 1 to 4. 1 to 4 Other Hours.  
Research conducted under the direction of faculty members in civil engineering. May be repeated 2 times for credit.  
**Prerequisites**: Junior or senior classification and approval of instructor.

Ocean Engineering

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 waterborne 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 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.