Department of Civil and Environmental Engineering

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Degrees offered: Bachelor of Science (BS) in Civil Engineering; BS in Environmental Engineering; Master of Engineering (ME), Master of Science (MS), Civil Engineer (CE) and Doctor of Philosophy (PhD) in Civil and Environmental Engineering

Graduate specializations: Environmental Engineering, Fluid Mechanics and Hydraulic Engineering, Geotechnical Engineering, Hazardous Waste Management, Structural Engineering and Mechanics, Transportation Engineering, Water Engineering, Water Resources Engineering and Hydrology

Undergraduate Programs

Objectives

Civil and Environmental Engineering is concerned with planning, designing, constructing, and operating various physical works; developing and utilizing natural resources in an environmentally sound manner; providing the infrastructure which supports the highest quality of life in the history of the world; and protecting public health and renovating impacted terrestrial and aquatic systems from the mismanagement of toxic and hazardous wastes. The Department of Civil and Environmental Engineering offers Bachelor of Science degrees in Civil Engineering and in Environmental Engineering. Both degrees are accredited by the Engineering Accreditation Commission of ABET.

The objectives of the undergraduate programs in Civil Engineering and Environmental Engineering are to graduate engineers who have a solid educational foundation with broad experiences in engineering, the sciences, and the humanities; and who are prepared to enter graduate school, other professional training, or the workplace as effective professionals. These graduates will understand the significance of life-long learning and the importance of ethical conduct and will be qualified to assume roles of leadership in business, community, government, and the engineering profession and contribute significantly to global society as a whole.

Outcomes

The **Program Outcomes** of the Civil Engineering undergraduate program are the following:

(a) an ability to apply knowledge of mathematics, science, and engineering principles to civil engineering problems.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data.

(c) an ability to design a system, component, or process to meet desired goals in civil engineering applications.

(d) an ability to function on multi-disciplinary teams.

(e) an ability to identify, formulate, and solve engineering problems.

(f) an understanding of professional and ethical responsibility.

(g) an ability to communicate effectively.

(h) a broad education necessary to understand the impact of engineering solutions in a global and societal context.

(i) a recognition of the need for, and an ability to engage in, lifelong learning.

(j) knowledge of contemporary issues in civil engineering.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

(l) the understanding and application of engineering knowledge of specialized areas in Civil Engineering.*

(m) the understanding of basic project management techniques and leadership.**

(n) the understanding of basic professional practices, including work procurement and legal issues.

*Students in the Civil Engineering program should gain proficiency in a minimum of four of the following six recognized major civil engineering areas. These engineering areas include : (1) environmental, (2) geotechnical, (3) hydraulics, (4) structural, (5) transportation, and (6) water resources and hydrology.

**Basic project management techniques can include multiple principles, such as the interaction between design professionals and the construction professions to construct a project, as well as the principles of cost and scheduling, drawing and plans, and project inspection.

Department of Civil and Environmental Engineering

The **Program Outcomes** of the Environmental Engineering undergraduate program are the following:

(a) an ability to apply knowledge of mathematics, science, and engineering principles to civil engineering problems.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data.

(c) an ability to design a system, component, or process to meet desired goals in civil engineering applications.

(d) an ability to function on multi-disciplinary teams.

(e) an ability to identify, formulate, and solve engineering problems.

(f) an understanding of professional and ethical responsibility.

(g) an ability to communicate effectively.

(h) a broad education necessary to understand the impact of engineering solutions in a global and societal context.

(i) a recognition of the need for, and an ability to engage in, lifelong learning.

(j) knowledge of contemporary issues in civil engineering.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Assessment

The Civil and Environmental Engineering Department employs several methods to assess the quality of the two BS programs offered by the department. Assessments are made prior to graduation by measuring the performance of students in each class. In addition, the results of the FE exam, senior exit interviews, and faculty reviews of student portfolios are used. Postgraduate assessment of Civil and Environmental Engineering graduates is also conducted up to six years after graduation. Assistance from outside reviewers is also obtained in making the assessment. For more details, see the CEE assessment website at: **http://www.engineering.usu.edu/cee/assessment/**

Requirements

Admission Requirements

Admission requirements for the Department of Civil and Environmental Engineering are the same as those described for the University on pages 30-35. Students in good standing may apply for admission to the department. In addition, students must maintain the academic requirements outlined for the College of Engineering on pages 132-133.

Bachelor of Science Degrees

The Department of Civil and Environmental Engineering offers two Bachelor of Science degrees: one in Civil Engineering and one in Environmental Engineering. The four-year programs leading to these two degrees are listed below. During the first two years, students are in a pre-engineering program. Students must successfully complete the pre-engineering program or, in the case of transfer students, substantially equivalent coursework at another institution before they are accepted into the professional program. Transfer students may apply for permission to take upper-division courses in cases where postponement of these courses will prolong the student's time to graduate.

Design is a cornerstone of engineering that requires creative thinking, technical knowledge, the ability to organize and solve complex problems, and teamwork. Engineering design activities begin during the first two years and progress in-depth as each student's proficiency increases. These design activities culminate in a major senior design course, which integrates past engineering coursework into a focused, realistic design project. An important feature of the senior design experience is that students work in teams to complete the project.

The student who is majoring in or planning to major in Civil Engineering or Environmental Engineering needs to be aware of the College of Engineering requirements concerning admission to the college, pre-engineering program, admission to professional engineering programs, University Studies, and other academic requirements. Additional information concerning these items is given in the College of Engineering write-up on pages 131-133. It is the responsibility of the student to be aware of these rules and regulations. **Passing the Fundamentals of Engineering Exam is required for graduation.**

The Civil and Environmental Engineering Department strongly recommends that students have a high-end calculator, such as an HP calculator, that has the capabilities to do units, matrices, and programs in BASIC. Although not a requirement at this time, CEE students are strongly encouraged to have a modern desktop or laptop personal computer. Since computer technology is changing rapidly, students should seek advice from a knowledgeable professional on hardware and software requirements before purchasing a computer.

Students in the Civil Engineering program must establish proficiency in at least four areas of Civil Engineering. Proficiency is established through a combination of material covered in required courses, as well as by establishing depth through the selection of technical electives. Proficiency must be established in four of the following areas: Environmental Engineering, Fluid Mechanics/ Hydraulics, Geotechnical, Structures, Transportation, or Water Resources. The courses must be selected from the approved Technical Elective courses.

Undergraduate Course Requirements for Civil Engineering (128 credits)[1]

Pre-engineering Program: Freshman and Sophomore

Freshman Year (31-34 credits)

Fall Semester (16 credits)

MATH 1210 (QL)[2] Calculus I 4
CHEM 1210[2] Principles of Chemistry I 4
CHEM 1215[2] Chemical Principles Laboratory I 1
CEE 1880[2] Civil and Environmental Engineering Orientation and Computer Applications 1
CEE 2240[2] Engineering Surveying 3
University Studies Breadth course 3

Spring Semester (15-18 credits)

MATH 1220 (QL)[2] Calculus II 4
GEO 1110 (BPS)[2] The Dynamic Earth: Physical Geology (4 cr) **or**
GEOG 1000 (BPS) Physical Geography (3 cr) ..... 3 or 4
ETE 2270[2] Computer Engineering Drafting 2
BIOL 1010 (BLS) Biology and the Citizen 3
PHYS 2200 Elements of Mechanics (prereq. to PHYS 2220) ..... (2)
University Studies Breadth course 3

Sophomore Year (30 credits)

Fall Semester (15 credits)

PHYS 2220 (BPS/QI)[2] General Physics—Science and Engineering II (prereq. AP Physics or PHYS 2200) 4
MATH 2210 (QI)[2] Multivariable Calculus 3
ENGR 2010[2] Engineering Mechanics Statics 2
ENGL 2010 (CL2)[2] Intermediate Writing: Research Writing in a Persuasive Mode 3
University Studies Breadth course 3

Spring Semester (15 credits)

ENGR 2030[2] Engineering Mechanics Dynamics 3
ENGR 2140[2] Strength of Materials 2
ENGR 2450[2] Engineering Numerical Methods 2
CEE 2870[2] Sophomore Seminar 1
MATH 2250 (QI)[2] Linear Algebra and Differential Equations 4
University Studies Breadth course 3

[1]Passing the Fundamentals of Engineering Exam is required for graduation. The exam is offered in October and April. Application must be made 120 days in advance. The exam is usually taken during fall semester of the junior or senior year.
[2]These courses are required for admission to the Professional Engineering Program (PEP).

Professional Engineering Program: Junior and Senior

Junior Year (33 credits)

Fall Semester (17 credits)

CEE 3010 Mechanics of Materials 2
CEE 3030 Uncertainty in Engineering Analysis 2
CEE 3500 Civil and Environmental Engineering Fluid Mechanics 3
CEE 3610[3] Environmental Management 3
CEE 3870 (CI)[3] Professional/Technical Writing in Civil and Environmental Engineering 2
CEE 4200 Engineering Economics 2
Engineering Science Elective 3

Spring Semester (16 credits)

CEE 3020 Structural Analysis 2
CEE 3510 Civil and Environmental Engineering Hydraulics 3
CEE 3880 Civil Engineering Design I 1
CEE Group A course[4] 3
CEE Group A course[4] 4
Engineering Science Elective 3

[3]CEE 3610 and 3870 must be taken concurrently.

Senior Year (33-35 credits)

Fall Semester (17 credits)

CEE 4870 (CI) Civil Engineering Design II 2
CEE Senior Design elective course[5] 3
CEE Technical Elective course[5] 3
CEE Technical Elective course[5] 3
CEE Technical Elective Group B course[5] 3
University Studies Depth Social Sciences (DSS) course 3

Spring Semester (16-18 credits)

CEE 4880 (CI) Civil Engineering Design III 2
CEE Group A course[4] 3
CEE Group A course[4] 3-4
CEE Group A course[4] 3
CEE Technical Elective course[5] 3
University Studies Depth Humanities and Creative Arts (DHA) course 2-3

[4]Students must complete *all five* of the following Group A Courses. The order in which they are taken will dictate the choice of technical elective courses (as they are prerequisites for various technical elective courses).

Engineering Science Electives (6 credits minimum)
Students in the Civil Engineering program must complete two engineering science electives chosen from the three courses below. The addition of two engineering science courses in place of one technical elective is required of all students entering the Civil Engineering Professional Program August 2007 and beyond.

ETE 2210 Electrical Engineering for Nonmajors (F,Sp,Su) 4
MAE 2160 Material Science (F,Sp) 3
MAE 2300 Thermodynamics I (Sp,Su) 3

Group A Courses

CEE 3080 Design of Reinforced Concrete Structures (Sp) 3
CEE 3210 Introduction to Transportation Engineering (Sp) 3
CEE 3430 Engineering Hydrology (Sp) 3
CEE 3640 Water and Wastewater Engineering (Sp) (4 cr) **or**
CEE 3780 Solid and Hazardous Waste Management (F) (3 cr) **or**
CEE 5860 Air Quality Management (F) (3 cr) ..... 3 or 4
CEE 4300 Engineering Soil Mechanics (Sp) 4

[5]Civil Engineering students are required to complete a Senior Design elective course concurrent with CEE 4870. In addition, they must complete four Technical Elective Courses (one of which must be selected from Group B), for a total of 12 credits. Following is a list of Technical Elective Courses and Senior Design Elective Courses.

Technical Elective Courses (15 credits minimum required)
Students in the Civil Engineering program must complete a senior design elective (see list below). They must also establish proficiency in *at least four* areas of Civil Engineering by taking a *minimum of two courses* in each area. Proficiency in **Environmental Engineering** is established by taking BIOL 1010; CEE 3610; and CEE 3640, 3780, or 5860. Proficiency in **Structures** is established by taking ENGR 2010, 2140; and CEE 3010, 3020, 3080. Proficiency in **Fluid Mechanics and Hydraulics** is established by taking ENGR 2030; and CEE 3430, 3500, 3510. Students will also demonstrate proficiency in *one of* Geotechnical Engineering, Transportation Engineering, or Water Resources Engineering by taking a Group B course (see list below).

Proficiency in **Geotechnical Engineering** is established by taking ENGR 2030; GEO 1110 (recommended) or GEOG 1000; CEE 4300; and *either* CEE 5350 or 5380. Proficiency in **Transportation Engineering** is established by taking CEE 3210; and *one of* CEE 5190, 5220, 5230, or 5240. Proficiency in **Water Resources Engineering** is established by taking CEE 3430; and *one of* CEE 5450, 5460, or 5470.

The sum of the Group B class, the Senior Design Elective, and other technical electives from the approved list must be at least 15 credits.

CEE 3670 Transport Phenomena in Bio-Environmental Systems (Sp) . 3
CEE 3780 Solid and Hazardous Waste Management (F) 3
CEE 5010 Matrix Analysis/Finite Element (F) 3
CEE 5050 Design of Wood and Masonry Structures (Sp) 3
CEE 5070 Structural Steel Design (F) 3
CEE 5080 Numerical Methods in Elasticity (F) 3
CEE 5100 Infrastructure Evaluation and Renewal (Sp) 3
CEE 5190 Geographic Information Systems for Civil Engineers (Sp) ... 3
CEE 5220 Traffic Engineering (Sp) 3
CEE 5230 Geometric Design of Highways (Sp) 3
CEE 5240 Urban and Regional Transportation Planning (F) 3
CEE 5350 Foundation Analysis and Design (F) 3
CEE 5380 Earthquake Engineering (Sp) 3
CEE 5430 Groundwater Engineering (F) 3
CEE 5450 Hydrologic Modeling (Sp) 3
CEE 5460 Water Resources Engineering (F) 3
CEE 5470 Sedimentation Engineering (Sp) 3
CEE 5500 Open Channel Hydraulics with an Emphasis on Gradually Varied Flow (F) 3

CEE 5540 Hydraulic Structures Design (F) 3
CEE 5550 Hydraulics of Closed Conduits (Sp) 3
CEE 5690 Natural Systems Engineering (F) 3
CEE 5720 Natural Systems Modeling (Sp) 3
CEE 5860 Air Quality Management (F) 3
CEE 5870 Hazardous Waste Incineration (Sp) 2
CEE 5880 Remediation Engineering (F) 3
CEE 5900 Cooperative Practice (F,Sp,Su) 3
ETE 2210[7] Electrical Engineering for Nonmajors (F,Sp,Su) 4
MAE 2160[7] Material Science (F,Sp) 3
MAE 2300[7] Thermodynamics I (Sp,Su) 3

Senior Design Elective Courses (3 credits required)
CEE 3780 Solid and Hazardous Waste Management (F) 3
CEE 5070 Structural Steel Design (F) 3
CEE 5230 Geometric Design of Highways (Sp) 3
CEE 5350 Foundation Analysis and Design (F) 3
CEE 5460 Water Resources Engineering (F) 3
CEE 5470 Sedimentation Engineering (Sp) 3
CEE 5500 Open Channel Hydraulics with an Emphasis on Gradually Varied Flow (F) 3
CEE 5540 Hydraulic Structures Design (F) 3

Group B Elective Courses (3 credits required)
CEE 5190 Geographic Information Systems for Civil Engineers (Sp) ... 3
CEE 5220 Traffic Engineering (Sp) 3
CEE 5230 Geometric Design of Highways (Sp) 3
CEE 5240 Urban and Regional Transportation Planning (F) 3
CEE 5350 Foundation Analysis and Design (F) 3
CEE 5380 Earthquake Engineering (Sp) 3
CEE 5450 Hydrologic Modeling (Sp) 3
CEE 5460 Water Resources Engineering (F) 3
CEE 5470 Sedimentation Engineering (Sp) 3

Undergraduate Course Requirements for Environmental Engineering[6]

Pre-engineering Program: Freshman and Sophomore

Freshman Year (30-31 credits)

Fall Semester (16 credits)
MATH 1210 (QL)[8] Calculus I 4
CHEM 1210[8] Principles of Chemistry I 4
CHEM 1215[8] Chemical Principles Laboratory I 1
CEE 1880[8] Civil and Environmental Engineering Orientation and Computer Applications 1
CEE 2240[8] Engineering Surveying 3
University Studies Breadth course 3

Spring Semester (14-15 credits)
BIOL 1010 (BLS)[8] Biology and the Citizen 3
MATH 1220 (QL)[8] Calculus II 4
ETE 2270[8] Computer Engineering Drafting 2
PHYS 2200[8] Elements of Mechanics 2
GEO 1110 (BPS)[8] The Dynamic Earth: Physical Geology (4 cr) **or**
GEOG 1000 (BPS) Physical Geography (3 cr) ..... 3 or 4

Sophomore Year (32 credits)

Fall Semester (16 credits)
MATH 2250 (QI)[8] Linear Algebra and Differential Equations 4
ENGR 2010[8] Engineering Mechanics Statics 2
ENGL 2010 (CL2)[8] Intermediate Writing: Research Writing in a Persuasive Mode 3
PHYS 2220 (BPS/QI)[8] General Physics—Science and Engineering II (prereq: AP Physics or PHYS 2200) 4
University Studies Breadth course 3

Spring Semester (16 credits)
ENGR 2030[8] Engineering Mechanics Dynamics 3
ENGR 2140 Strength of Materials 2
ENGR 2450[8] Engineering Numerical Methods 2
MAE 2300[8] Thermodynamics I 3
CEE 2890[8] Environmental Engineering Sophomore Seminar 1
CEE 3030 Uncertainty in Engineering Analysis 2
University Studies Breadth course 3

[6] Passing the Fundamentals of Engineering Exam is required for graduation. The exam is offered in October and April. Application must be made 120 days in advance. The exam is usually taken during fall semester of the senior year.
[7] If a student takes *all three* Engineering Science classes, the third one counts as a technical elective.
[8] These courses are required for admission to the Professional Engineering Program (PEP).

Professional Engineering Program: Junior and Senior

Junior Year (32 credits)

Fall Semester (15 credits)
CEE 3500 Civil and Environmental Engineering Fluid Mechanics 3
CEE 3610[9] Environmental Management 3
CEE 3780 Solid and Hazardous Waste Management 3
CEE 3870 (CI)[9] Professional/Technical Writing in Civil and Environmental Engineering 2
PSC 3000 Fundamentals of Soil Science 4

Spring Semester (17 credits)
CEE 3430 Engineering Hydrology 3
CEE 3510 Civil and Environmental Engineering Hydraulics 3
CEE 3640 Water and Wastewater Engineering 4
CEE 3670 Transport Phenomena in Bio-Environmental Systems 3
CEE 3890 Environmental Engineering Design I 1
New course in Environmental Chemistry 3

Senior Year (31-32 credits)

Fall Semester (16 credits)
PUBH 3310 Occupational Health and Safety 3
CEE 4200 Engineering Economics 2
CEE 4790 (CI)[10] Environmental Engineering Design II 2
CEE 5610 Environmental Quality Analysis 3
CEE 5860 Air Quality Management 3
CEE Senior Design Elective course[10] 3

Spring Semester (15-16 credits)
CEE 4890 (CI) Environmental Engineering Design III 2
Technical Elective course (Area 1, 2, or 3)[11] 2
Technical Elective course (Area 4 or 5)[11] 3
University Studies Breadth course 3
University Studies Depth Humanities and Creative Arts (DHA) and Depth Social Sciences (DSS) courses 5-6

[9] CEE 3610 and 3870 must be taken concurrently.
[10] Environmental Engineering students are required to complete a Senior Design elective course concurrent with CEE 4790. Available Senior Design elective courses are listed below.
[11] Environmental Engineering students must select at least two Technical Elective courses (totaling 4 credits) chosen from the specialty areas (options) listed below.

Senior Design Elective Courses
CEE 5690 Natural Systems Engineering (F) 3
CEE 5810 Biochemical Engineering (F) 3
CEE 5830 Management and Utilization of Biological Solids and Wastewater (F) 3
CEE 5880 Remediation Engineering (F) 3

Technical Elective Courses
Solids—Area 1
CEE/PUBH 5670 Hazardous Chemicals Handling and Safety (Sp)..... 2
CEE/BIE 5680 Soil-based Waste Management (Sp) 2
CEE/PUBH 5730 Analysis and Fate of Environmental Contaminants (F)..... 3
CEE/BIE 5830 Management and Utilization of Biological Solids and Wastewater (F) 3
CEE 5870 Hazardous Waste Incineration (Sp) 2
CEE 5880 Remediation Engineering (F) 3

Water—Area 2
CEE 5430 Groundwater Engineering (F)..... 3
CEE/PSC 5620 Aquatic Chemistry (F) 3
CEE 5720 Natural Systems Modeling (Sp) 3
CEE/PUBH 5730 Analysis and Fate of Environmental Contaminants (F)..... 3
CEE/BIE 5810 Biochemical Engineering (F)..... 3

Air—Area 3
CEE 5710 Pollution Prevention and Industrial Ecology (Sp, Alt Years)..... 2
CEE 5750 Air Quality Measurements (Sp) 2
CEE/PUBH 5790 Accident and Emergency Management (Sp) 3
CEE 5870 Hazardous Waste Incineration (Sp) 2

Natural Systems—Area 4
CEE 5690 Natural Systems Engineering (F)..... 3
WATS 4500 Limnology: Ecology of Inland Waters (Sp) 3
WATS 4530 Water Quality and Pollution (F) 3

Occupational Safety and Health—Area 5
PUBH 4310 Industrial Hygiene Recognition of Hazards (F)..... 4
PUBH 4320 Industrial Hygiene Chemical Hazard Evaluation (Sp) 3
PUBH 4330 Industrial Hygiene Physical Hazards (Sp)..... 3
PUBH 5330 (QI) Industrial Hygiene Chemical Hazard Control (F)..... 3
CEE/PUBH 5670 Hazardous Chemicals Handling and Safety (Sp)..... 2
CEE 5710 Pollution Prevention and Industrial Ecology (Sp)..... 2
CEE/PUBH 5790 Accident and Emergency Management (Sp) 3

Departmental Honors

Students who would like to experience greater academic depth within their major are encouraged to enroll in departmental honors. Through original, independent work, Honors students enjoy the benefits of close supervision and mentoring, as they work one-on-one with faculty in select upper-division departmental courses. Honors students also complete a senior project, which provides another opportunity to collaborate with faculty on a problem that is significant, both personally and in the student's discipline. Participating in departmental honors enhances students' chances for obtaining fellowships and admission to graduate school.

In the Department of Civil and Environmental Engineering, departmental honors can be earned by completing 20 credits of upper-division honors engineering courses. Students should work with the department in selecting appropriate courses.

Interested students should contact the Honors Program, Main 15, (435) 797-2715, honors@usu.edu. Additional information can be found online at: **http://www.usu.edu/honors/**

Additional Information

For more information about Bachelor of Science requirements and the sequence in which courses should be taken, see major requirement sheet, available from the Civil and Environmental Engineering Department, or online at: **http://www.usu.edu/majorsheets/**

Concurrent BS/Master's Program

The concurrent BS/Master's program allows engineering students to begin taking graduate-level classes during their senior year. This permits them to complete requirements for *both* the BS degree *and* the master's degree concurrently during two years. Students in this program have a greater selection of graduate courses, since many graduate courses are taught during alternate years. In addition, the student's senior design project could be a start for a graduate design project or thesis. After completing their BS degree, students in the program can earn a master's degree in only one additional year. Both the BS and the master's degree can generally be earned with 150-152 total credits, although students should note that a Plan C MS requires 3 extra credits. Finally, students with a master's degree can expect a much higher starting salary following graduation. (For more information, see *College of Engineering* section of this catalog, pages 133-134.)

Graduate Programs

The ME degree emphasizes professional practice and coursework. A minimum of 30 credits of technical and scientific coursework is required. The MS degree emphasizes research and the preparation of a significant publication. A minimum of 30 credits, 6 to 9 of which shall be thesis research, is required for an MS. In special cases, as decided by the student's supervisory committee, a second MS is available with a Plan B option, which requires 30 credits, including 3 credits of CEE 6970, Thesis Research. The CE degree, which prepares students for professional engineering careers, requires 60 credits beyond the bachelor's degree, or 30 credits beyond the master's degree, including a technical engineering report. The PhD degree represents high scholarly achievement demonstrated by independent research and competence in an area of specialization approved by the student's supervisory committee.

Admission Requirements

See general admission requirements, pages 36-37. Admission committees consider GRE scores and experience, undergraduate record and curriculum, and formal recommendations. A student without an undergraduate civil and environmental engineering background may be required to complete selected undergraduate courses prior to admission as a fully matriculated graduate student.

Graduate Program Divisions

The graduate program in the Department of Civil and Environmental Engineering is administered through five academic divisions, as described below.

Structural Engineering

The structural engineer is involved in the design, construction, repair, and retrofit of all types of structures: buildings, bridges, dams, and many others. The safety of the structures we occupy and utilize every day is the responsibility of structural engineers. They must be able to evaluate the loads placed on a structure, determine their effects on the

structure, and select the appropriate materials and structural elements, or repair strategy, to withstand these loads. Today's structural engineer is using new space materials in the design of new structures or the retrofit of older structures.

Mathematics, physics, and materials science constitute a foundation for structural engineering. Structural analysis and design are added to this foundation and become the focus of the structural engineering program. Graduate students in the structures program also engage in structural mechanics, numerical methods, structural dynamics, geotechnical engineering, and the study of new structural materials. Current research in the structures area is focusing on the dynamic characteristics of structures, their potential response to earthquakes, and new seismic retrofit measures, using advanced composite materials, for older structures. Materials research is focusing on cementious materials and constitutive modeling.

Geotechnical Engineering

Engineering studies of soils are concerned with the physical and engineering properties of soils and how these are related to engineering projects.

Traditional geotechnical engineering includes the application of engineering principles to the analysis and/or design of building foundations, earth embankments, retaining walls, drainage systems, earthquake motion, buried structures, and other systems involving soil and rock. Engineers and architects cannot ignore the problems of investigating properties of soils in connection with engineering construction. Undergraduate and graduate courses offered by the department provide the basic knowledge necessary for the design of foundations and various types of earth structures. Fundamental concepts and their application are emphasized so that the student will be properly trained for his or her initial job, as well as being prepared to understand future development in this field.

The Geotechnical Engineering Division, in cooperation with the Environmental Engineering Division, is offering a new program in Geoenvironmental Engineering. This new program uses the strengths of both divisions to provide a program involving the geotechnical aspects of hazardous waste management, the investigation of hazardous waste sites, and the design of hazardous waste containment systems.

The geotechnical division has a strong research program. Current research projects in this division include studies on liquefaction, seismic slope stability, pile foundations, landslides, mechanically stabilized embankments, risk analysis of dams, finite element analysis of soil-structure systems, and the long-term properties of clay soils used in hazardous waste containment systems.

Water Engineering

The water engineering program is a multidisciplinary graduate program in the College of Engineering and is intended to enable engineers and scientists interested in water to obtain graduate degrees in the areas of fluid mechanics and hydraulics, hydrology, groundwater, and water resources engineering. Core courses and departmental offerings cover these fundamental areas, as well as essential numerical and statistical methods. The water engineering faculty are committed to a strong academic program. The curriculum offered is one of the most comprehensive offered in the U.S. Elements of ongoing research projects are routinely and effectively incorporated into the classes. The program combines training, research, and experience to understand the water issues and water resources management challenges in the United States and internationally. Graduate students can supplement departmental offerings by selecting courses in Mathematics and Statistics; Watershed Sciences; Applied Economics; Economics; Geology; Biological and Irrigation Engineering; Mechanical and Aerospace Engineering; and Plants, Soils, and Climate. This ensures that graduates are well-grounded in the fundamentals, but have a breadth of training and are prepared to contribute professionally to the solution of multidisciplinary local, national, and international water problems. Graduate students in the water program have the opportunity for research support through the Utah Water Research Laboratory (UWRL) while working on theses or dissertations. Excellent laboratory and computing facilities are available. Strong, continuous state and federal research funding keeps the research topics and facilities current. Specialty areas within the program comprise fluid mechanics and hydraulics, hydrology, groundwater, and water resources engineering.

Fluid mechanics and hydraulic engineering covers both fundamental principles and theory and their applications in a variety of engineering fields. Elementary fluid mechanics, based on fundamental principles of conservation of mass, energy, and momentum, is the logical core for all water-related engineering programs. Consequently, other specialties in water engineering study fluid mechanics. Students specializing in fluid mechanics and hydraulics emphasize theoretical fluid mechanics, hydraulic design, numerical methods, and laboratory hydraulic techniques. A good variety and balance of courses supporting research in theoretical fluid mechanics, open channel hydraulics, hydraulic design, transients, sedimentation, municipal water system design, and cavitation are available at the graduate level. Graduates in fluid mechanics and hydraulics find employment in a broad range of professional engineering fields, including consulting, university teaching and research, and state and federal government agencies.

Hydrology is a branch of geoscience concerned with the origin, distribution, movement, and properties of waters of the earth. The hydrologic cycle encompasses the atmosphere, the land surface, lakes and oceans, and the subsurface. Complex, interacting processes at varied time and space scales describe the hydrologic cycle. The concepts and practice of hydrology derive from an integration of field observations, laboratory investigations, and conceptual, mathematical, chemical, statistical, and probabilistic models.

The hydrology program at USU has strength in both theoretical and applied aspects of modern hydrology. Past and present research focuses on a broad spectrum of hydrologic problems. These range from climate modeling, rainfall processes, floods, droughts, terminal lake analyses, soil erosion, and stream water quality models to groundwater contamination characterization and remediation and watershed analyses. A particular emphasis of the program is on an understanding of the global water and energy cycles at nested scales from the hemisphere to the continent to the watershed from a holistic perspective that recognizes the two-way linkages between water reservoirs and fluxes through oceans, atmosphere, land surface and subsurface, and biota.

Groundwater engineering is concerned with fluid flow and transport of contaminants in the subsurface environment. It encompasses the theory of flow in porous media; groundwater hydrology; fate and transport of contaminants in subsurface; and analytical, numerical, and stochastic modeling of such processes. Emphasis is placed on the quantitative analysis of physical and chemical principles governing these processes and on the application of these principles to practical field problems, with all their difficulties related to the complex structure of subsurface formations. Examples of such problems include groundwater supply and management, capture zone analysis, well hydraulics, subsurface cleanup technologies, health risk assessment, and analysis and remediation of groundwater contamination. These problems are of a multidisciplinary nature, and their solutions require

a multidisciplinary approach, involving, among others, soil and water chemistry, chemical engineering, and economics. The groundwater professional is an important team player in solving such problems.

Water Resources Engineering prepares engineers to be lead members in water resources planning teams, often charged with coordinating the information and concepts supplied from other disciplines. This need for breadth requires considerable flexibility in the training and arrangement of degree programs.

Water resources engineers draw principles from hydrology, fluid mechanics, hydraulics, environmental engineering, economics, ecology, political science, and other disciplines in the design and operation of projects and nonstructural methods for water resources planning and management. They need a sound understanding of how water storage, delivery, and other management systems function; of criteria used in evaluating and selecting among alternatives; of the techniques of operations research that can be used in systems design; and of the institutional aspects of decision-making in the public sector. A focus area of the program is to develop decision support systems for sustainable water quantity and quality management in the United States and in developing regions of the world. Evolving information sources and tools, such as spatial data sets encoded in geographical information systems, climate forecasts, and cognitive models of the human decision process and societal group dynamics, are being integrated in representative institutional contexts.

An internationally-recognized specialized program has been developed in dam safety risk assessment. Students take classes in dam engineering; hydrology and hydraulics; geotechnical engineering; geology; decision analysis; risk assessment; probability and statistics; and natural resources economics, planning, and management. Students work on practical applications, as well as research projects, for improving the state-of-the art.

Environmental Engineering

The Division of Environmental Engineering is a multidisciplinary graduate program in the College of Engineering and provides coursework and research experience to enable engineers and scientists interested in the environment to obtain graduate degrees relating to potable water and waste treatment, toxic and hazardous wastes management, air quality management, natural systems engineering, and environmental impact assessment. The program provides an interdisciplinary educational approach to fundamental principles that can be applied to environmental phenomena. Research and training projects are a part of the program and provide the student with appropriate research experience leading to a thesis or dissertation.

Hazardous Waste Management. This specialization has been developed within the broader scope of the environmental engineering program to provide an integrated approach for students with a BS in engineering or natural sciences to deal with the complex issues of toxic and hazardous waste. Aspects of toxic/hazardous waste management, including characterization, treatment, disposal, control, monitoring, and environmental impacts, are dealt with in this program.

Natural Systems Engineering is the study of the interaction of engineered systems with nature, emphasizing impacts to aquatic ecosystems. Techniques include assessment of aquatic habitat through computer simulation and model verification, quantification of aquatic habitat using remote sensing systems, and data analysis and display through integrated statistical and GIS approaches. These tools are used to evaluate impacts on threatened and endangered species, habitat enhancement, instream flow assessments, fish habitat, stream sediment, and hydraulic features.

A *bioprocess engineering program* has been developed as a cooperative effort between the Division of Environmental Engineering and the Biological and Irrigation Engineering Department. This program provides students with specialized coursework and research experience in areas of bioreactor processing of environmental materials and engineering scale-up of biologically-based environmental reactions. Areas of specialization include waste to energy, fermentation, composting, and industrial waste (agricultural and chemical) reuse, recycling, and technologies based on biological processes, as well as engineering optimization of aquatic habitats.

Transportation Engineering

The graduate program in Transportation Engineering offers education and research opportunities in transportation systems planning, design, and management. It is designed to enable aspiring planners, engineers, and managers to obtain advanced degrees while specializing in infrastructure management, traffic network analysis, facility design, traffic operations, transportation economics and finance, and project appraisal. Up-to-date computer and laboratory facilities, as well as the Transportation Division's close links with local and state transportation agencies, enable students to gain hands-on experience and practical perspectives.

Past and present research undertaken by the Transportation Division faculty and researchers ranges from microscopic traffic flow simulation, dynamic route assignment, and network reliability to traffic accident modeling, pavement management, video image processing, and intelligent transportation systems. The focus remains on efficient and effective solutions to transportation problems.

Transportation Division course offerings expose students to the theoretical and practical aspects of goods and passenger transportation. State-of-the-art analytical tools and new research findings are introduced into the courses through periodic revision of notes, examples, problem sets, and computer software. Students are encouraged to design their own programs of study according to their personal and professional goals. Due to the multi-disciplinary nature of transportation, students are encouraged to include in their program of study course offerings from other programs in CEE, as well as from Mathematics and Statistics, Environment and Society, Applied Economics, Economics and Finance, Management, and Sociology.

Financial Assistance

Both departmental and formal grant support are available to graduate students and are awarded on a competitive basis. Students requesting financial support should apply to the department by March 15 for the coming academic year.

A number of fellowships are available through the University and the department. Teaching assistantships are available through the department and research assistantships are available through the Utah Water Research Laboratory and departmental faculty members who have ongoing projects or who hold special research grants from the University, private companies, or state and federal agencies.

Acceptance to pursue graduate studies in the Civil and Environmental Engineering Department does not guarantee the student financial assistance. Inasmuch as funds are limited, the assistantships are awarded by the department to cover specific teaching assignments and by the faculty members to provide for research as funds are available.

Department of Civil and Environmental Engineering

Civil and Environmental Engineering Faculty

Professors
A. Bruce Bishop, engineering systems and planning
David S. Bowles, risk assessment, hydrology, water resources engineering
William J. Doucette, environmental analytical chemistry
R. Ryan Dupont, hazardous waste management, bioremediation
Jagath J. Kaluarachchi, subsurface hydrology, water resources
Mac McKee, water resources planning and analysis
William J. Rahmeyer, hydraulics, hydraulic structures, scour and erosion
David K. Stevens, treatment process analysis
David G. Tarboton, hydrology and water resources
Kevin C. Womack, structural mechanics

Research Professors
Thomas B. Hardy, ecological system modeling, statistical analysis
Darwin L. Sorensen, aquatic microbiology

Professors Emeritus
Loren R. Anderson, geotechnical engineering
Jay M. Bagley, hydrology, water resources
W. O. Carter, structures
Calvin G. Clyde, fluid mechanics and groundwater
Gordon H. Flammer, hydraulics
William J. Grenney, water resources
Trevor C. Hughes, water resources systems analysis
C. Earl Israelsen, hydrology, hydraulics, water resources, erosion control
Roland W. Jeppson, numerical modeling
Fred W. Kiefer, Jr., geotechnical engineering
Elliot Rich, structural engineering
J. Paul Riley, water resources systems, hydrology
J. Paul Tullis, hydraulics, hydraulic structures, and hydromachinery
Reynold K. Watkins, geotechnical engineering

Adjunct Professors
Lloyd H. Austin, water resources
Steve C. Chapra, water-quality modeling
George G. Goble, deep foundations and structural dynamics
Roger D. Hansen, water resources
Jeffrey R. Keaton, geotechnical engineering, engineering geology
Upmanu Lall, climate modeling, statistical hydrology, water resource systems
Christopher M. U. Neale, remote sensing, biological and irrigation engineering
Neil Parrett, performance and safety of dams
Norman E. Stauffer, Jr., engineering hydrology and computer modeling
Alan Steinberg, road maps for intelligence
Daniel A. Stone, environmental chemistry

Associate Professors
Paul J. Barr, reinforced concrete, bridge design
James A. Bay, geotechnical engineering
Joseph A. Caliendo, geotechnical engineering
Anthony Chen, network analysis and logistics, transportation planning
Marvin W. Halling, structural dynamics, earthquake engineering
Sonia S. Manuel-Dupont, technical communication
Randal S. Martin, environmental engineering (air pollution)
Michael J. McFarland, environmental engineering (biosolids)
Laurie S. McNeill, environmental engineering (drinking water)
Robert T. Pack, geomatics and engineering geology
Blake P. Tullis, hydraulics, hydraulics structures, and hydromachinery
Gilberto E. Urroz, hydraulics, hydraulic structures

Research Associate Professor
Joan E. McLean, fate and behavior of metals in the subsurfaces

Adjunct Associate Professors
Danny Marks, snow hydrology
Eva C. Nieminski, water quality
Anthony Turhollow, transportation
Ross A. Woods, water

Associate Professor Emeritus
J. Derle Thorpe, engineering materials, measurements

Assistant Professors
Kevin Heaslip, transportation
Bethany T. Neilson, environmental engineering
John D. Rice, geotechnical engineering
David Rosenberg, water resources
Keri L. Ryan, structural dynamics, structural control

Research Assistant Professors
Luis Bastidas, hydrology
Sanjay Chauhan, dam safety, risk assessment, hydrologic modeling
Michael C. Johnson, hydraulics

Adjunct Assistant Professors
Steven L. Barfuss, hydraulics
Charles H. Luce, forest hydrology

Affiliate Faculty
Robert W. Hill, professor, Biological and Irrigation Engineering; irrigation and water resource extension
Jack Keller, professor emeritus, Biological and Irrigation Engineering; sprinkle and drip irrigation
Gary P. Merkley, professor, Biological and Irrigation Engineering; conveyance systems
Judith L. Sims, research associate professor, Biological and Irrigation Engineering; soil biology
Ronald C. Sims, Department Head and professor, Biological and Irrigation Engineering; biological process engineering
Wynn R. Walker, professor, Biological and Irrigation Engineering; Associate Dean, College of Engineering; surface irrigation

Course Descriptions

Civil and Environmental Engineering (CEE), click here