DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Civil and Environmental Engineering consists of the application of scientific principles to the design, construction, and maintenance of public and private works that constitute the infrastructure for human populations. From a historical aspect, the pyramids of Egypt, the water resources systems that supported the agricultural society of ancient Babylonia and Assyria, the public buildings of Greece and Rome, the roads that linked the Roman Empire, and the railroads and barge canals of the early United States were all civil engineering projects that served the people of their times. Today’s civil engineers are still involved in building and maintaining the infrastructure necessary for modern society to function. A civil engineer may be involved in the design and construction of highways, bridges, buildings, water conveyance systems, water and wastewater treatment plants, dams, airports, and other constructed projects. Civil engineers may also be involved in planning for traffic controls, flood plain management, remediation of contaminated soils or groundwater, and water and air quality management. The graduates of civil engineering programs may work with consulting engineering firms, governmental agencies, construction contractors, or manufacturing industries.

In the foreseeable future, population growth and relocation should create a steady demand for infrastructure growth. The concept of environmentally sensitive and resource sustainable development is emerging as the tenet for future growth. Civil engineers will have to apply evolving technologies and develop innovative solutions to ensure wise stewardship of our limited natural resources. Students who enter civil engineering can anticipate a challenging and rewarding career.

Lower-division courses in civil engineering consist of a common core of basic courses in science, mathematics, and engineering required of most students within the college. Required course work in the junior and senior years provides the student with a broad background in civil engineering subjects while 18 credits of technical electives permit some specialization at the undergraduate level. For civil engineering student interest in geology, there is an option to complete a minor in Geologic Engineering.

The Department of Civil and Environmental Engineering occupies the first floor of the Buchanan Engineering Laboratory Building with some additional office and laboratory spaces in the basement and on the second floor of the building. Maintenance and replacement of existing equipment is provided by funds from research projects, from alumni donations, from lab fees, and from state educational funds. Instructional and research equipment include modern computing and data acquisition equipment.

The Department offers three graduate degree programs in civil engineering:

1. Master of Science (30 credits, with thesis),
2. Master of Engineering (33 credits, non-thesis), and
3. Doctor of Philosophy.

It also offers the Master of Science in Geological Engineering (both thesis and non-thesis options). Course work requirements in each of the degree programs are relatively flexible depending on student interest and course availability. Financial assistance is available on a competitive basis in the form of teaching and research assistantships. Students interested in graduate studies should select a specialty area in which they wish to study. Foreign students must have a TOEFL score of at least 550 for admission to any departmental graduate degree program. We do not currently require the GRE.

Graduate study is offered with specialization in environmental engineering, structures and structural mechanics, highway and pavement materials, geotechnical engineering, transportation, hydraulics, ecohydrology and water resources, and geological engineering. Interdisciplinary programs of study are encouraged for interested students. As examples, students specializing in environmental engineering may do considerable work in chemical engineering or microbiology, while specialization in geotechnical engineering may involve study in geology or mining engineering.

The mission of the Department of Civil and Environmental Engineering is to provide a high quality education at both the undergraduate and graduate level, emphasizing the needs of Idaho and the region. The goals and objectives of the program include graduating students that will be:

1. competent in the fundamentals of engineering,
2. capable of designing and describing civil engineering systems and processes
3. aware of the social and economic implications of engineered projects, and
4. responsible, ethical, and committed to life-long learning.

Additionally, the department is committed to:

1. maintaining experienced, professional instructors (all are licensed professional engineers), modern facilities, and close interaction between the department and the professional engineering community in Idaho,
2. extending the knowledge base in civil engineering through research, continuing education, technology transfer, and professional practice, and
3. providing these services in the most cost effective manner for both the students and the taxpayers.

Progress toward these goals and objectives is assessed by student performance on the nationally administered Fundamentals of Engineering Exam, exit interviews with graduating students, surveys of graduated students and their employers, and by an external advisory committee composed of practicing civil engineers from the state and the region.

The Bachelor of Science program in Civil Engineering is accredited by the Engineering Accreditation Commission of Accreditation Board for Engineering and Technology (ABET).

Patricia J. S. Colberg, Department Chair (104 Buchanan Engineering Laboratory 83844-1022; phone 208-885-5041).

*ABDEL-RAHIM, Ahmed S; 2002; Professor of Civil Engineering (P.E.); Director, National Institute for Advanced Transportation Technology; Ph.D.; 1998; Michigan State University.

BABOVIC, Valdan; 1997; Adjunct Assistant Professor of Civil and Environmental Engineering; Ph.D.; 1995; International Institute for Infrastructure.
*BAYOMY, Fouad M; 1991; Professor of Civil Engineering (P.E.); Ph.D.; 1982; Ohio State University.

*BENJANKAR, Rohan Man; 2016; Research Assistant Professor in Civil and Environmental Engineering; Ph.D.; 2009; University of Idaho.

BUFFINGTON, John M; 2013; Adjunct Faculty of Civil and Environmental Engineering; Ph.D.; 1998; University of Washington.

CADWELL, Jillian R; 2013; Adjunct Faculty of Civil and Environmental Engineering; Ph.D.; 2008; University of Colorado.

*CHANG, Kevin; 2013; Assistant Professor of Civil Engineering; Ph.D.; 2005; University of Washington.

*COATS, Eric R; 2006; Associate Professor of Civil Engineering (P.E.); Affiliate Faculty of Chemical and Materials Engineering; Ph.D.; 2005; Washington State University.

*COLBERG, Patricia J; 2015; Professor of Civil Engineering; Department Chair, Department of Civil and Environmental Engineering; Ph.D.; 1983; Stanford University.

EL-BADAWY, Sherif; 2012; Adjunct Faculty of Civil Engineering; Ph.D.; 2006; Arizona State University.

*FIEDLER, Fritz R; 2000; Associate Professor of Civil Engineering (P.E.); Ph.D.; 1997; Colorado State University.

*GOODWIN, Peter; 1996; Professor of Civil Engineering (P.E.); Director, Center for Echohydraulics Research; Affiliate Professor of Biological Engineering; Ph.D.; 1986; University of California Berkeley.

*IBRAHIM, Ahmed; 2015; Assistant Professor of Civil Engineering; Ph.D.; 2010; University of Missouri.

IMBERGER, Jorg; 2003; Adjunct Professor in Civil Engineering; Ph.D.; 1970; University of California Berkeley.

*JUNG, S.J.; 1990; Professor of Geological Engineering; Ph.D.; 1989; West Virginia University.

*KASSEM, Emad A; 2015; Assistant Professor of Civil Engineering; Ph.D.; 2008; Texas A&M University.

*LIU, Chyr Pyng; 1986; Professor of Civil Engineering (P.E.); Affiliate Professor of Mechanical Engineering; Ph.D.; 1976; University of Michigan.

*LOWRY, Michael; 2009; Associate Professor of Civil Engineering; Ph.D.; 2004; University of Washington.

LUCE, Charles H; 2004; Adjunct Assistant Professor of Civil Engineering; Ph.D.; 2000; Utah State University.

MARKS, Danny; 2003; Adjunct Professor of Civil Engineering; Ph.D.; 1988; University of California Santa Barbara.

*NIELSEN, Richard J; 1986; Associate Professor of Civil Engineering (P.E.); Department Chair, Department of Civil Engineering; Ph.D.; 1986; Stanford University.

*PORTER, P Steven; 1992; Associate Professor of Civil Engineering (P.E.); Affiliate Associate Professor of Environmental Science; Ph.D.; 1986; Colorado State University.

SACK, Ronald L; 2014; Adjunct Faculty of Civil Engineering; Ph.D.; 1964; University of Minnesota.

*SHARMA, Sunil; 1986; Professor of Civil Engineering (P.E.); Ph.D.; 1986; Purdue University.

*TONINA, Daniele; 2009; Associate Professor of Civil Engineering; Affiliate Faculty of Biological Engineering; Ph.D.; 2005; University of Idaho.

*TRANMER, Andrew Wendall; 2016; Research Assistant Professor in Civil Engineering; Ph.D.; 2013; University of Idaho.

TUTHILL, David R; 2007; Adjunct Professor of Civil Engineering; Ph.D.; 2002; University of Idaho.

WRIGHT, Nigel G; 2001; Adjunct Associate Professor of Civil Engineering; Ph.D.; 1988; University of Leeds.

*YAGER, Elowyn M; 2007; Associate Professor of Civil Engineering; Affiliate Faculty of Geological Sciences; Ph.D.; 2006; University of California Berkeley.

*YAGER, Elowy M; 2007; Associate Professor of Civil Engineering; Affiliate Faculty of Geological Sciences; Ph.D.; 2006; University of California Berkeley.

**Majors**

- Civil Engineering (B.S.C.E.) ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-bsce](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-bsce))

**Minors**

- Geological Engineering Minor ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/geological-engineering-minor](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/geological-engineering-minor))

**Civil and Environmental Engineering Graduate Program**

Graduate study is offered with specialization in the following subdisciplines of civil engineering: hydraulics and water resources engineering, environmental and sanitary engineering, structural engineering and structural mechanics, geotechnical engineering, and transportation engineering.

- Civil Engineering (M.S.) ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-ms](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-ms))

- Civil Engineering (M.Engr.) ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-mengr](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-mengr))

- Civil Engineering (Ph.D.) ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-phd](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/civil-engineering-phd))

- Geological Engineering (M.S.) ([https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/geological-engineering-ms](https://catalog.uidaho.edu/colleges-related-units/engineering/civil-environmental-engineering/geological-engineering-ms))
Civil Engineering

CE 115 Introduction to Civil Engineering
1 credit
Introduction to civil engineering problem solving skills, development of
software use skills, graphical analysis, data analysis, and oral and written
communication skills. One weekly two hour laboratory with up to 3 out-of-
class activities.
Prereq: Major in civil engineering.
CE 200 (s) Seminar
Credit arranged.
CE 203 (s) Workshop
3 credits.
CE 204 (s) Special Topics
Credit arranged.
CE 211 Engineering Surveying
3 credits
Theory of measurements, basic equations for survey computations, types
of distribution of errors, topographical and land surveying introduction
to geographic information systems and global positioning systems,
coordinate geometry and coordinate transformations, site engineering
projects using land development software, application of surveying
methods to construction; site engineering, and civil engineering projects
surveying instruments. Two lecture and one 3-hour lab a week; periodic
field data collection and one or two field trips.
Prereq: MATH 143 or MATH 170 or MATH 175, and ENGR 105. A minimum
grade of 'C' or better is required for all pre/coreqs.

CE 215 Civil Engineering Analysis and Design
3 credits
Application of basic science, mathematics, and fundamental engineering
principles to solution of civil engineering design problems; use of
structured programming concepts in design; develop oral and written
communication skills.
Prereq: CE 115, ENGR 105, and MATH 170. A minimum grade of 'C' or
better is required for all pre/coreqs.
Coreq: PHYS 211/211L. A minimum grade of 'C' or better is required for all
pre/coreqs.
CE 298 (s) Internship
Credit arranged.
CE 299 (s) Directed Study
Credit arranged.
CE 322 Hydraulics
4 credits
Applied principles of fluid mechanics; closed conduit flow, hydraulic
machinery, open channel flow; design of hydraulic systems. Laboratory
exercises on closed conduit flow, hydraulic machinery, open channel flow
and mixing process. Three lec a week and 4-6 labs a semester.
Prereq: CE 215, MATH 310, PHYS 211, ENGR 220 and ENGR 335. A minimum
grade of 'C' or better is required for all pre/coreqs.

CE 325 Fundamentals of Hydrologic Engineering
3 credits
Cross-listed with BE 355.
Principles of hydrologic science and their application to the solution of
hydraulic, hydrologic, environmental, and water resources engineering
problems.
Prereq: MATH 310, STAT 301, and ENGR 335. A minimum grade of 'C' or
better is required for all pre/coreqs.

CE 330 Fundamentals of Environmental Engineering
3 credits
Principles of engineered environmental systems, including physical,
chemical, and microbiological processes; types and effects of pollutants;
regulations; treatment of water, wastewater, sludges, and solid waste;
control of air and agricultural pollution. Two lectures and one 3-hour lab a
week.
Prereq: ENGR 335, Chem 111, CE 215 and MATH 310. A minimum grade
of 'C' or better is required for all pre/coreqs.

CE 342 Theory of Structures
3 credits
Stresses and strains in statically determinate and indeterminate beam,
truss, and rigid frame structures; effects of moving loads; matrix
displacement method. Two lec and one 3-hr lab a wk.
Prereq: ENGR 350, MATH 275, MATH 310, and PHYS 211/211L. A
minimum grade of 'C' or better is required for all pre/coreqs.

CE 357 Properties of Construction Materials
4 credits
Principles of construction materials, composition, physical and
mechanical properties, test methods, data analysis and interpretations,
and report writing; materials covered are aggregates, cements, concretes,
metals, wood, and composites. Three lec and two hrs of lab.
Prereq: CE 215, ENGR 350, MATH 310. A minimum grade of 'C' or better is
required for all pre/coreqs.
Coreq: STAT 301. A minimum grade of 'C' or better is required for all pre/
coreqs.

CE 360 Fundamentals of Geotechnical Engineering
4 credits
Soil composition, descriptions, and classification systems; permeability
and seepage; capillarity and suction; total, effective, and neutral stresses,
compression and volume changes; shear strength; compaction. Three
lectures, and 2 hours of lab a week.
Prereq: CE 215, ENGR 350, ENGR 350, and MATH 310. A minimum grade
of 'C' or better is required for all pre/coreqs.

CE 372 Fundamentals of Transportation Engineering
4 credits
Intro to planning, design, and operation of highway and traffic; public
transportation, and airport systems. Three lectures and one 3-hour lab a
week; periodic field data collection and one or two field trips.
Prereq: STAT 301 and CE 211. A minimum grade of 'C' or better is required
for all pre/coreqs.
Coreq: ENGL 317. A minimum grade of 'C' or better is required for all pre/
coreqs.

CE 398 (s) Internship
Credit arranged.
CE 400 (s) Seminar
Credit arranged.
CE 403 (s) Workshop
Credit arranged.
CE 404 (s) Special Topics
Credit arranged.
CE 411 Engineering Fundamentals
1 credit
Review of basic engineering and science material covered in
Fundamentals of Engineering exam. Offered for the nine to ten week
period prior to the exam date. Graded P/F.
Prereq: Senior standing or Permission.
CE 413 Bridge Design
3 credits
Structural systems for bridges, loading analysis by influence lines, slab and girder bridges, composite design, pre-stressed concrete, rating of existing bridges, specifications and economic factors.
Prereq: CE 441 or CE 444.

CE 421 Engineering Hydrology
3 credits
Hydrologic design including: statistical methods, rainfall analysis and design storm development, frequency analysis, peak discharge estimation, hydrograph analysis and synthesis, flow routing, and risk analysis.
Prereq: CE 325 or BE 355. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 422 Hydraulic Structures Analysis and Design
3 credits
Hydraulic design and stability analysis of hydraulic structures, such as dams, weirs, spillways, stilling basins, culverts, levees, fish ladders etc. Project oriented problems. Extra design projects or different design projects for grad cr. One field trip. CE 422 is a cooperative course available to WSU degree-seeking students.
Prereq: CE 322 or Equivalent, ENGR 360, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 428 Open Channel Hydraulics
3 credits
Hydraulics of uniform and varied flow in open channels with fixed and movable beds. Recommended Preparation: CE 322. Cooperative: open to WSU degree-seeking students.

CE 431 Design of Water and Wastewater Systems I
3 credits
Joint-listed with CE 511
Application of fundamental engineering science to the design of systems for the treatment of domestic and industrial water supplies; treatment and re-use of domestic sewage and industrial wastes. Additional projects/assignments required for graduate credit.
Prereq: CE 322, CE 330, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 432 Design of Water and Wastewater Systems II
3 credits
Joint-listed with CE 532
Application of unit operations and processes to design of integrated wastewater treatment systems; critical analysis of existing designs. Additional projects/assignments required for grad credit. CE 532 is a cooperative course available to WSU degree-seeking students.
Prereq: CE 431. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 433 Water Quality Management
3 credits
Joint-listed with CE 533
Physical, chemical, and biological techniques for analysis of water quality management problems; development of design criteria for corrective systems. Additional projects/assignments required for grad credit.
Prereq: Permission.

CE 441 Reinforced Concrete Design
3 credits
Strength design method in accordance with latest ACI code. Two lectures and one 2-hour lab a week.
Prereq: CE 342. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 444 Steel Design
3 credits
Structural steel design using latest AISC specifications. Two lectures and one 2-hour lab a week.
Prereq: CE 342. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 445 Matrix Structural Analysis
3 credits
Joint-listed with CE 545
Formulation of the analysis of trusses, beams, and frames using the stiffness method of matrix structural analysis; development of element properties, coordinate transformations, and global analysis theory; special topics such as initial loads, member and joint constraints, and nonlinear analysis. Special project demonstrating mature understanding of materials reqd for grad cr.
Prereq: CE 342 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 460 Geotechnical Engineering Design
3 credits
Applications of soil mechanics in design of shallow and deep foundations, earth retaining structures, excavations, and soil exploration.
Prereq: CE 360 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 473 Highway Design
3 credits
Theory and practice in highway design, highway functional classification concepts, design controls and criteria; geometric design of highways and streets, cross section and roadside design, and highway safety manual applications.
Prereq: CE 211. A minimum grade of 'C' or better is required for all pre/coreqs.
Coreq: CE 372. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 474 Traffic Systems Design
3 credits
Analysis and design of network traffic systems; system evaluation using computer optimization and simulation; development and testing of alternative system design. Two lec and one 3-hr lab a wk; field data collection and field site visits. Cooperative: open to WSU degree-seeking students.
Prereq: CE 372 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 475 Pavement Design and Evaluation
3 credits
Pavement design processes; stress-strain analysis in multi-layer elastic system; materials selection and characterization methods; traffic loads, design methods for flexible and rigid pavements; performance evaluation of existing pavements; condition survey and ratings; introduction to pavement maintenance and rehabilitation techniques.
Prereq: CE 357 or Equivalent, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 484 Engineering Law and Contracts
3 credits
Project engineering techniques for planning, scheduling, and controlling typical engineering and construction projects. Contract law and application to engineering services agreements and construction contracts; preparing technical specifications, torts, professional liability, and alternate dispute resolution.
Prereq: Senior standing in engineering.
CE 491 Civil Engineering Professional Seminar
1 credit
Employment and technical topics; preparation and presentation of professional paper. Course to be taken in last semester before graduation. Graded P/F.
Prereq: Senior standing in Civil Engineering.

CE 494 Senior Design Project
3 credits
Gen Ed: Senior Experience
Comprehensive civil engineering design project. Requires integration of skills acquired in civil engineering elective courses, written reports, and oral presentations.
Prereq: Senior standing in Civil Engineering and Permission.

CE 498 (s) Internship
CE 499 (s) Directed Study
Credit arranged.
CE 500 Master's Research and Thesis
Credits arranged.
CE 501 (s) Seminar
Credit arranged
Conferences and reports on current developments.
CE 502 (s) Directed Studies
Credits arranged.
CE 503 (s) Workshop
Credit arranged.
CE 504 (s) Special Topics
Credit arranged.
CE 505 (s) Professional Development
CE 507 River Restoration
3 credits
This course focuses on the principles and practices used in river restoration. The potential assumptions and errors with common restoration methodologies and possible ways to improve such channel designs are discussed. A number of case studies are used to evaluate the success of various restoration techniques. The course includes homework sets and individual projects and has a mandatory field trip to a local restored site. Recommended classes to take prior to this include at least one of the following: CE 535, CE 322, CE 428, or CE 520.
Prereq: Engr 335 or Instructor Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 510 Advanced Mechanics of Materials
3 credits
See ME 539. Cooperative: open to WSU degree-seeking students.

CE 511 Design of Water and Wastewater Systems I
3 credits
Joint-listed with CE 431
Application of fundamental engineering science to the design of systems for the treatment of domestic and industrial water supplies; treatment and re-use of domestic sewage and industrial wastes. Additional projects/assignments required for graduate credit.
Prereq: CE 322, CE 330, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 512 Advanced Topics in Waste Management and Treatment
3 credits
Modeling, analysis, and design of advanced and emerging engineering technologies and processes for waste management/treatment and resource recovery.
Prereq: Instructor Permission.
CE 513 Bridge Design
3 credits
See CE J413/J513.
CE 519 Fluid Transients
3 credits
Same as ME 519. Development of concepts and modeling techniques for unsteady flow of liquid and gas in piping systems; extensive computer programming used to develop tools for analysis, design, and control of transients. (Alt/yr)
Prereq: Math 310 and Engr 335. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 520 Fluid Dynamics
3 credits
Same as ME J420/J520. Cr not granted for both CE 420 and CE 520.
A second fluid dynamics course featuring vector calculus and integral and differential forms of the conservation laws. Topics include fluid properties, fluid statistics, inviscid flow; conservation of mass, momentum, and energy; and turbulence. Other topics may be covered. Additional projects/assignments reqd for grad cr.
Prereq: Math 310, Math 310, or Permission.

CE 521 Sedimentation Engineering
3 credits
Intro to river morphology and channel responses; fluvial processes of erosion, entrainment, transportation, and deposition of sediment. Cooperative: open to WSU degree-seeking students.
Prereq: CE 428 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 522 Hydraulic Structures Analysis and Design
3 credits
Hydraulic design and stability analysis of hydraulic structures, such as dams, weirs, spillways, stilling basins, culverts, levees, fish ladders etc. Project oriented problems. Extra design projects or different design projects for grad cr. One field trip. CE 422 is a cooperative course available to WSU degree-seeking students.
Prereq: CE 428 or Equivalent, Engr 360, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 526 Aquatic Habitat Modeling
3 credits
The course objective is to learn the underlying principles of all components required for aquatic habitat modeling, to be able to perform such projects in riverine ecosystems including project design, data collection, data analysis and interpretation of the results and to learn the use of computational aquatic habitat models. Students will be working on their own modeling projects using the simulation model CASiMiR.
Prereq: CE 322 and CE 325 or BAE 355; or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 531 Environmental Engineering Unit Operations
3 credits
Analysis and design of physical and chemical operations of water and waste treatment; flow models, sedimentation, flocculation, filtration, and water conditioning. Cooperative: open to WSU degree-seeking students.
Prereq: Permission.
CE 532 Design of Water and Wastewater Systems II
3 credits
Joint-listed with CE 432
Application of unit operations and processes to design of integrated wastewater treatment systems; critical analysis of existing designs. Additional projects/assignments required for grad credit. CE 532 is a cooperative course available to WSU degree-seeking students.
Prereq: CE 431. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 533 Water Quality Management
3 credits
Joint-listed with CE 533
Physical, chemical, and biological techniques for analysis of water quality management problems; development of design criteria for corrective systems. Additional projects/assignments required for graduate credit.
Prereq: CE 431 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 534 Environmental Engineering Unit Processes
3 credits
Aeration system design, biological oxidations, growth kinetics, process design of suspended growth and fixed film aerobic and anaerobic systems, biological nutrient removal, land treatment systems. Cooperative: open to WSU degree-seeking students.
Prereq: CE 431 or Permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 535 Fluvial Geomorphology and River Mechanics
3 credits
Hydraulic and morphologic processes of rivers. Drainage network development, channel hydraulics and shear stress partitioning via boundary layer theory, hydraulic geometry and cross-sectional form, sediment transport and bed material sampling, reach-scale morphologies and processes from headwater streams to lowland rivers, physical processes of forest rivers, sediment budgets, and river valley evolution. Field exercises emphasize quantitative analysis of fluvial processes and channel form, acquisition of field skills (measuring hydraulic and geomorphic variables, topographic surveying), and scientific writing. (Alt/yr)
Prereq: CE 428 or Permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 541 Reliability of Engineering Systems
3 credits
Same as ME 583. Fundamentals of reliability theory, system reliability analysis including common-mode failures and fault tree and event tree analysis, time-dependent reliability including testing and maintenance, propagation of uncertainty, human reliability analysis, practical applications in component and system design throughout the semester. Cooperative: open to WSU degree-seeking students.
Prereq: Permission.

CE 542 Advanced Design of Steel Structures
CE 542 Advanced Design of Steel Structures (3 cr)
Plate girder design; local and global buckling; plastic collapse analysis; shear and moment-resisting connections; eccentrically-loaded connections. Cooperative: open to WSU degree-seeking students.
Prereq: CE 444 or Permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 543 Dynamics of Structures
CE 543 Dynamics of Structures (3 cr)
Equations of motion, free vibration, damping mechanisms, harmonic, impulse, and seismic loading; shock and seismic response spectra, time and frequency domain analysis, modal analysis, structural dynamics in building codes. Cooperative: open to WSU degree-seeking students.

CE 545 Matrix Structural Analysis
3 credits
Joint-listed with CE 445
Formulation of the analysis of trusses, beams, and frames using the stiffness method of matrix structural analysis; development of element properties, coordinate transformations, and global analysis theory; special topics such as initial loads, member and joint constraints, and nonlinear analysis. Special project demonstrating mature understanding of materials reqd for grad cr.
Prereq: CE 342 or Permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 546 Finite Element Analysis
CE 546 Finite Element Analysis (3 cr)
Same as ME 549. Formulation of theory from basic consideration of mechanics; applications to structural engineering, solid mechanics, soil and rock mechanics; fluid flow. Cooperative: open to WSU degree-seeking students.
Prereq: ME 341 or CE 342. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 547 Advanced Reinforced Concrete
CE 547 Advanced Reinforced Concrete (3 cr)
Composite design; slab design; limit state design; footings; retaining walls; deep beams; brackets and corbels; torsion; seismic design; shear walls. Cooperative: open to WSU degree-seeking students.
Prereq: CE 441. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 550 Experimental Methods in Fluid Dynamics
CE 550 Experimental Methods in Fluid Dynamics (3 cr)
See ME J451/J551.

CE 554 Environmental Hydrodynamics
CE 554 Environmental Hydrodynamics (3 cr)
The course analyzes solute transport and mixing in rivers. It provides the derivation and analysis of the equations governing solute mixing and transport and shows the connection between mixing and flow field. It presents molecular and turbulent diffusion, dispersion, vertical, lateral, and longitudinal mixing, and the effects of river irregularities and curved channels. The course includes individual projects.
Prereq: CE 428 or permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.

CE 556 Properties of Highway Pavement Materials
CE 556 Properties of Highway Pavement Materials (3 cr)
Physical and mechanical properties of asphalt and Portland cement concrete materials; design of asphalt concrete mixes; introduction to viscoelastic theory; characterization methods, emphasizing fatigue, rutting and thermal cracking; modification and upgrading techniques. Three 1-hr lec a wk and variable number of lab hrs for demonstration. Cooperative: open to WSU degree-seeking students.
Prereq: CE 357 or Equivalent, or Permission. A minimum grade of ‘C’ or better is required for all pre/coreqs.
CE 561 Engineering Properties of Soils
CE 561 Engineering Properties of Soils (3 cr)
Physical properties, compressibility and consolidation, shear strength, compaction, saturated and unsaturated soils, laboratory and field methods of measurement, relations of physical and engineering properties, introduction to critical-state soil mechanics. Cooperative: open to WSU degree-seeking students. **Prereq:** CE 360. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 562 Advanced Foundation Engineering
CE 562 Advanced Foundation Engineering (3 cr)
Interpretation of in-situ tests for foundation design parameters, bearing capacity and settlement of axially loaded piles, pile groups, and drilled shafts, pile dynamics, laterally loaded deep foundations, downdrag and uplift of deep foundations, foundation load and integrity testing methods and data interpretation, mat foundations. Cooperative: open to WSU degree-seeking students. **Prereq:** CE 360 or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 563 Seepage and Slope Stability
CE 563 Seepage and Slope Stability (3 cr)
Same as GeoE 535. Principles governing the flow of water through soils; mechanics of stability analysis of slopes, landslides, and embankments for soil and rock masses; probabilistic analyses; stabilization methods. Cooperative: open to WSU degree-seeking students. (Alt/even yrs, Spring only) **Prereq:** CE 360 or GeoE 436; or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 566 Geotechnical Earthquake Engineering
CE 566 Geotechnical Earthquake Engineering (3 cr)
Faulting and seismicity; site response analysis; probabilistic seismic hazard assessment; dynamic soil properties; influence of soil on ground shaking; response spectra; soil liquefaction; seismic earth pressures; seismic slope stability; earthquake resistant design. Cooperative: open to WSU degree-seeking students. **Prereq:** CE 360 or Equivalent, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 571 Traffic Flow Theory
CE 571 Traffic Flow Theory (3 cr)
Introduction to elements of traffic flow theory including principles of traffic stream characteristics, capacity, queuing theory, and shock waves; application of traffic flow theory to freeway and arterial traffic flow problems. Cooperative: open to WSU degree-seeking students. (Alt/ yrs) **Prereq:** Permission.

CE 572 Intersection Traffic Operations
CE 572 Intersection Traffic Operations (3 cr)
Application of traffic simulation models to the design and operations of traffic facilities, including intersection, arterials; assessment and design of traffic signal timing strategies. Cooperative: open to WSU degree-seeking students. (Alt/ yrs) **Prereq:** Permission.

CE 573 Transportation Planning
CE 573 Transportation Planning (3 cr)
Concepts and methods of transportation planning, including network modeling, travel demand forecasting, and systems evaluation of multimodal transportation systems. This is a cooperative course available to WSU degree-seeking students. (Alt/ yrs) **Prereq:** Permission.

CE 574 Public Transportation
CE 574 Public Transportation (3 cr)
Concepts and principles of planning and operations of public transportation systems, including bus transit, rail transit, and paratransit modes. Cooperative: open to WSU degree-seeking students. (Alt/ yrs) **Prereq:** Permission.

CE 575 Advanced Pavement Design and Analysis
CE 575 Advanced Pavement Design and Analysis (3 cr)
Design of new and rehabilitated asphalt and Portland cement concrete pavements; mechanistic-empirical design procedures; performance models; deflection-based structural analysis, overlay design, environmental effects; long-term pavement performance (LTPP), and introduction to research topics in pavement engineering. Cooperative: open to WSU degree-seeking students. **Prereq:** CE 475 or Equivalent, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 576 Highway Design and Traffic Safety
CE 576 Highway Design and Traffic Safety (3 cr)
Geometric design of highways as related to operation and safety. Analysis of highway design alternatives and control strategies with respect to accident probabilities. Statistical models for safety analysis. Accident countermeasure selection and evaluation methodology. Risk management. **Prereq:** Permission.

CE 577 Pavement Management and Rehabilitation
CE 577 Pavement Preservation and Management (3 cr)
This course addresses several aspects of pavement evaluation, preservation, rehabilitation, and management. The primary objective of this course is to provide the civil engineering graduate students with state-of-the-art knowledge needed to maintain our roadways in serviceable condition. The course covers different methods used to evaluate the performance of pavements, distresses in flexible and rigid pavements, project and network level pavement management, various preservation and rehabilitation techniques and selection of the appropriate approaches for preservation and rehabilitation. **Prereq:** CE 475 or Equivalent, or Permission. A minimum grade of 'C' or better is required for all pre/coreqs.

CE 578 Highway Traffic Operations
CE 578 Highway Traffic Operations (3 cr)
Theory of two-lane highway and freeway operations, application of traffic simulation models for the design and operations of highway, development and assessment of freeway management and control strategies including Intelligent Transportation Systems applications, field data collection and analysis. (Alt/ yrs) **Prereq:** Permission.

CE 579 Simulation of Transportation Systems
CE 579 Simulation of Transportation Systems (3 cr)
This course introduces students to the simulation of transportation systems, including the algorithms that constitute most traffic simulation models and how the models are applied to the study of real transportation problems. The course considers the fundamental issues that the transportation engineer must consider when developing and applying simulation models, the core algorithms that constitute transportation simulation models, how to build and test a simulation network, the process for validating and calibrating a simulation model, how model results should be analyzed and presented, and the process for using and the value of hardware-in-the-loop simulation. **Prereq:** Permission.
Geological Engineering

GEOE 200 (s) Seminar

GEOE 398 (s) Internship

GEOE 403 (s) Workshop
Credit arranged.

GEOE 404 (s) Special Topics
Credit arranged.

GEOE 407 Rock Mechanics
3 credit
Mechanical properties of rocks and rock masses; lab and insitu techniques to estimate strength, stress distribution, and deformation behavior in rock masses; application of analytical tools such as the finite element method to design stable excavations and support systems in rock.
Prereq: Engr 350.

GEOE 428 Geostatistics
3 credits
Cross-listed with STAT 428
Applications of random variables and probability in geologic and engineering studies; regression, regionalized variables, spatial correlation, variograms, kriging, and simulation. Recommended Preparation: STAT 301. Cooperative: open to WSU degree-seeking students.

GEOE 436 Geological Engineering Analysis and Design
3 credits
Geological engineering analysis and design methods, including data collection, stability analysis, and ground reinforcement techniques; individual and teamwork approaches to formulation and solving geological engineering problems. One 1-day field trip.
Prereq: CE 360 or graduate standing.

GEOE 465 Excavation and Materials Handling
3 credits
Principles of excavation design and handling of earth materials related to construction projects, quarries, and mines; blasting, excavation planning and scheduling, equipment selection and replacement, cost estimating, geographic information and management information systems. Computerized design using Gemcom and/or other appropriate software.
Prereq: CE 211 or Permission.

GEOE 499 (s) Directed Study
Credit arranged.

GEOE 500 Master's Research and Thesis
Credit arranged.

GEOE 501 (s) Seminar
Credit arranged.

GEOE 502 (s) Directed Study
Credit arranged.