CE 105 Civil Engineering Drafting
3 credits
Freehand and computer aided drawing in pictorial and orthographic projection; section and auxiliary views; descriptive geometry; graphical presentation of data; scales, dimensioning, and measurements. Two lectures and one 2-hour lab per week.

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: STAT 301. 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
This course provides an introduction to environmental engineering. Focus areas include water sources and drinking water treatment, wastewater treatment and water reuse, and solid and hazardous waste management. Quantitative aspects and engineering solutions to environmental problems are emphasized.
PreReq: CHEM 111, CE 215 and MATH 310. A minimum grade of 'C' or better is required for all pre/corequisites.

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 lectures and one 2-hour lab per wk.
PreReq: ENGR 350, MATH 275, MATH 310, and PHYS 211/PHYS 211L. A minimum grade of 'C' or better is required for all pre/corequisites.

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 lectures and two hours of lab.
PreReq: CE 215, ENGR 350, MATH 310. A minimum grade of 'C' or better is required for all pre/corequisites.
Coreq: STAT 301. A minimum grade of 'C' or better is required for all pre/corequisites.

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 per week.
PreReq: CE 215, ENGR 335, ENGR 350, and MATH 310. A minimum grade of 'C' or better is required for all pre/corequisites.

CE 372 Fundamentals of Transportation Engineering
3 credits
Intro to planning, design, and operation of highway and traffic, public transportation, and airport systems. Three lectures 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/corequisites.

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
Joint-listed with CE 513.
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/corequisites.

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 graduate credit. One field trip. Cooperative: open 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/corequisites.

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/corequisites.

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. Cooperative: open to WSU degree-seeking students.
Prereq: CE 431. A minimum grade of 'C' or better is required for all pre/corequisites.

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 graduate 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 per week.
Prereq: CE 342. A minimum grade of 'C' or better is required for all pre/corequisites.

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

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 required for graduate credit.
Prereq: CE 342 or Permission. A minimum grade of 'C' or better is required for all pre/corequisites.

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/corequisites.

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/corequisites.
Coreq: CE 372. A minimum grade of 'C' or better is required for all pre/corequisites.

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/corequisites.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 475</td>
<td>Pavement Design and Evaluation</td>
<td>3</td>
<td>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.</td>
</tr>
<tr>
<td>CE 484</td>
<td>Engineering Law and Contracts</td>
<td>3</td>
<td>Design methods for flexible and rigid pavements; performance evaluation of existing pavements; condition survey and ratings; introduction to pavement maintenance and rehabilitation techniques.</td>
</tr>
<tr>
<td>CE 491</td>
<td>Civil Engineering Professional Seminar</td>
<td>2</td>
<td>Intro to river morphology and channel responses; fluvial processes of erosion, entrainment, transportation, and deposition of sediment. Possible ways to improve such channel designs are discussed.</td>
</tr>
<tr>
<td>CE 494</td>
<td>Senior Design Project</td>
<td>3</td>
<td>Comprehensive civil engineering design project. Requires integration of skills acquired in civil engineering elective courses, written reports, and oral presentations. Permission not guaranteed if not registered before fall recess.</td>
</tr>
<tr>
<td>CE 499</td>
<td>Directed Study</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 500</td>
<td>Master's Research and Thesis</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 501</td>
<td>Seminar</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 502</td>
<td>Directed Study</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 503</td>
<td>Workshop</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 504</td>
<td>Special Topics</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 505</td>
<td>Professional Development</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 507</td>
<td>River Restoration</td>
<td></td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
<tr>
<td>CE 510</td>
<td>Advanced Mechanics of Materials</td>
<td>3</td>
<td>Cross-listed with ME 539. 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.</td>
</tr>
</tbody>
</table>
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. Cooperative: open 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/corequisites.

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 BE 355; or Permission. A minimum grade of 'C' or better is required for all pre/corequisites.

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. Cooperative: open to WSU degree-seeking students.  
Prereq: CE 431. A minimum grade of 'C' or better is required for all pre/corequisites.

CE 533 Water Quality Management  
3 credits  
Joint-listed with CE 433  
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: Permission

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/corequisites.

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/ yrs)  
Prereq: CE 428 or Permission. A minimum grade of 'C' or better is required for all pre/corequisites.

CE 541 Reliability of Engineering Systems  
3 credits  
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  
3 credits  
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/corequisites.

CE 543 Dynamics of Structures  
3 credits  
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.  
Prereq: CE 445  
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 required for graduate credit.  
Prereq: CE 342 or Permission. A minimum grade of 'C' or better is required for all pre/corequisites.

CE 546 Finite Element Analysis  
3 credits  
Cross-listed with 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/corequisites.
CE 547 Advanced Reinforced Concrete
3 credits
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/corequisites.

CE 550 Experimental Methods in Fluid Dynamics
3 credits
Cross-listed with ME 551.
The objective of this course is to develop the knowledge and skills to be able to design and perform fluid dynamics experiments (and experiments in related areas) and to interpret and report the results. Learn the words, the concepts, and experimental skills in areas including dimensional analysis and scaling of experiments, flow visualization, velocity and flow rate measurements, turbulence measurements, and sediment sizing and transport measurements. Additional projects/assignments required for graduate credit. One 1-1/2 hr lecture and one 3-hour lab per week. Recommended Preparation: ENGL 317 and ENGR 335

CE 554 Environmental Hydrodynamics
3 credits
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/corequisites.

CE 556 Properties of Highway Pavement Materials
3 credits
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-hour lectures per week and variable number of lab hours 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/corequisites.

CE 561 Engineering Properties of Soils
3 credits
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/corequisites.

CE 562 Advanced Foundation Engineering
3 credits
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/corequisites.

CE 563 Seepage and Slope Stability
3 credits
Cross-listed with 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 years, Spring only)
Prereq: CE 360 or GEOE 436; or Permission. A minimum grade of ‘C’ or better is required for all pre/corequisites.

CE 566 Geotechnical Earthquake Engineering
3 credits
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/corequisites.

CE 571 Traffic Flow Theory
3 credits
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/years)
Prereq: Permission

CE 572 Intersection Traffic Operations
3 credits
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/years)
Prereq: Permission

CE 573 Transportation Planning
3 credits
Concepts and methods of transportation planning, including network modeling, travel demand forecasting, and systems evaluation of multimodal transportation systems. Cooperative: open to WSU degree-seeking students. (Alt/years)
Prereq: Permission

CE 574 Public Transportation
3 credits
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/years)
Prereq: Permission

CE 575 Advanced Pavement Design and Analysis
3 credits
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/corequisites.
CE 576 Highway Design and Traffic Safety
3 credits
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 Preservation and Management
3 credits
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/corequisites.

CE 578 Highway Traffic Operations
3 credits
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/years)
Prereq: Permission

CE 579 Simulation of Transportation Systems
3 credits
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

CE 598 (s) Internship
Credit arranged

CE 599 (s) Non-thesis Master's Research
Credit arranged
Research not directly related to a thesis or dissertation.
Prereq: Permission

CE 600 Doctoral Research and Dissertation
Credit arranged