305 Introduction to Structural Analysis
Fall, Spring. 3(3-0) P: ME 222 and (CE 273 or concurrently) and (CE 274 or concurrently) R: Open to juniors or seniors in the Department of Civil and Environmental Engineering and open to juniors or seniors in the Biosystems Engineering major.

312 Soil Mechanics
Fall, Spring. 4(3-3) P: ME 222 and (CE 273 or concurrently) and (CE 274 or concurrently) R: Open to juniors or seniors in the Department of Civil and Environmental Engineering and open to juniors or seniors in the Biosystems Engineering major.

321 Introduction to Fluid Mechanics
Fall, Spring. 4(3-2) P: (MTH 235) and CE 221 and Completion of Tier I Writing Requirement R: Open to juniors or seniors in the Department of Civil and Environmental Engineering or in the Biosystems Engineering Major. Not open to students with credit in ME 332.

337 Civil Engineering Materials
Fall, Spring. 3(3-3) P: (ME 222 or concurrently) and (CE 273 or concurrently) and (CE 274 or concurrently) R: Open to juniors or seniors in the Department of Civil and Environmental Engineering.
Common civil engineering construction and paving materials: aggregates, inorganic cements, asphalts, concretes, wood, and steel. Composition, structure, physical and mechanical properties, tests, and production mix design.

341 Transportation Engineering
Fall, Spring. 3(3-0) P: (MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently) and (CE 273 or concurrently) and (CE 274 or concurrently) and completion of Tier I writing requirement R: Open to juniors or seniors in the Department of Civil and Environmental Engineering or in the Urban and Regional Planning major. SA: CE 346
Overview of transportation system issues and problems. Fundamentals of highway design and operations. Planning and evaluation of transportation system alternatives.

371 Sustainable Civil and Environmental Engineering Systems
Fall, Spring. 3(3-0) P: (MTH 234 or concurrently) or (LB 220 or concurrently) or (MTH 254H or concurrently) and ENE 280 R: Open to juniors or seniors in the Civil Engineering Major or in the Environmental Engineering Major. SA: CE 272
Principles and tools of sustainable design and engineering economics in Civil and Environmental Engineering.

372 Risk Analysis in Civil and Environmental Engineering
Fall, Spring. 2(2-0) P: (MTH 234 or concurrently) or (LB 220 or concurrently) or (MTH 254H or concurrently) R: Open to juniors in the Civil Engineering Major or in the Environmental Engineering Major and open to seniors in the Civil Engineering Major or in the Environmental Engineering Major. SA: CE 272
Applications of probability, statistics, uncertainty and risk analysis to topics in civil and environmental engineering, characterization of system safety, and comparison tests for engineering quality control and environmental analyses.

400 Structural Mechanics
Spring. 3(3-0) P: CE 305 R: Open to juniors or seniors or graduate students in the College of Engineering.

405 Design of Steel Structures
Spring. 3(3-0) P: CE 305 and CE 337 R: Open to juniors or seniors or graduate students in the Department of Civil and Environmental Engineering or in the College of Engineering.
Design of steel beams, columns, tension members and connections. Stability and plastic strength.

406 Design of Concrete Structures
Fall. 3(3-0) P: CE 305 and CE 337 R: Open to seniors in the Department of Civil and Environmental Engineering or in the College of Engineering.
Design of reinforced concrete beams, slabs, columns and footings.

407 Materials Engineering: Properties, Selection and Processing
Spring. 3(3-0) P: CE 221 and ME 222 RB: MSE 250 R: Open to juniors or seniors in the Chemical Engineering Major or in the Mechanical Engineering Major or in the Civil Engineering Major.
General families of materials, materials design process for civil and environmental engineering problems, structural materials properties, processing methods and environment, microstructure of materials, structural materials selection by utilizing bubble charts.

418 Geotechnical Engineering
Fall. 3(3-0) P: CE 312 and (GLG 201 or GLG 301) R: Open to juniors or seniors or graduate students in the College of Engineering.
Civil Engineering—CE

421 Engineering Hydrology
Fall, 3(3-0) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: CE 321 and (GLG 201 or GLG 301) and (CE 372 or SIT 351) R: Open to juniors or seniors or graduate students in the College of Engineering or in the Department of Plant, Soil and Microbial Sciences. Hydrologic design of storm water systems. Equilibrium hydrograph analysis, unit hydrographs, infiltration, hydrograph synthesis, and reservoir routing. Groundwater: Darcy's law, flow nets, well hydraulics, design of capture wells.

422 Applied Hydraulics
Spring, 3(2-2) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: CE 321 or ME 332 R: Open to juniors or seniors or graduate students in the College of Engineering. Fundamentals of open-channel flow. Rapidly and gradually varied nonuniform flow analysis. Confined flows past submerged bodies, in pipe networks, and in turbo machinery. Design applications.

431 Pavement Design and Analysis
Fall, 3(3-0) P: CE 337 R: Open to juniors or seniors or graduate students in the College of Engineering. Highway and airfield pavement structural design. Performance measures. Failure mechanisms. Pavement thickness design procedures. Design considerations for surface friction, pavement joints, and drainage.

432 Pavement Rehabilitation
Spring, 3(3-0) P: CE 337 R: Open to seniors or graduate students in the College of Engineering. Engineering concepts and information needed to rehabilitate pavements. Network and project survey and evaluation; design of rigid and flexible overlays, other methods of rehabilitation, selection of rehabilitation alternatives. Initial and life cycle cost analysis of various rehabilitation alternatives.

441 Principles of Traffic Engineering
Fall, 3(3-0) P: CE 341 R: Open to juniors or seniors or graduate students in the Civil Engineering Major. Driver and vehicle characteristics affecting traffic flow and safety. Speed, density, capacity relationships. Signal control in street networks. Freeway management systems. Risk management and liability.

448 Transportation Planning
Spring, 3(3-0) P: CE 341 Transportation planning process and procedures. Estimation of travel demand using traditional models of trip generation, trip distribution, modal split, and traffic assignment. Use of "quick-response" procedures. Traffic impact of new facilities.

449 Highway Design
Fall, 3(3-0) P: CE 341 R: Open to juniors or seniors or graduate students in the College of Engineering. Geometric design of highways. Operation, capacity, safety, and geometric features. Alignment, drainage and pavement design. Use of CAD systems in preparing contract plans.

461 Computational Methods in Civil Engineering
Spring, 3(3-2) P: (EGR 102 and CE 221) and (MTH 235 or MTH 340 or MTH 474) R: Open to juniors or seniors or graduate students in the Civil Engineering Major. SA: CE 390 Not open to students with credit in ME 361. Theoretical, numerical, and computational methods for civil engineering problems. Physical modeling, numerical techniques, and programming methods. Focus on civil engineering dynamics, solving systems of differential equations, and visualizing the results.

471 Construction Engineering—Equipment, Methods and Planning
Spring, 3(3-0) P: (CE 305 and CE 312 and CE 337) or (CMP 305 and CMP 322) R: Open to juniors or seniors or graduate students in the College of Engineering or in the Department of Management or in the Construction Management major. Engineering and construction fundamentals of earthwork operations, moving of materials, concrete construction, formwork, false work, and other temporary structures. Relationship to a construction project's constructability, cost, and schedule.

480 Environmental Measurements
Laboratory Fall, 1(0-3) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: (CEM 161 or CEM 185H or LB 171L) and ENE 280 and (CEM 142 or CEM 152 or CEM 182H or LB 172) and (ENE 483 or concurrently) or (ENE 483 or concurrently) and Completion of Tier I Writing Requirement R: Open to juniors or seniors or graduate students in the College of Engineering. Basic chemical and microbiological methods used in the analysis of environmental media. Laboratory safety, quality assurance, quality control, and statistics used in laboratory analysis. Related technical communication, laboratory report writing.

481 Environmental Chemistry: Equilibrium Concepts
Fall, 3(3-0) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: (CEM 141 and CEM 142) or (CEM 151 and CEM 152) or (CEM 181H and CEM 182H) or (LB 171 and LB 172) and (ENE 280 or BE 230 or GLG 230 or GLG 301 or approval of department) Chemistry of natural environmental systems and pollutants. Equilibrium concepts and calculations for acid-base, solubility, complexation, redox and phase partitioning reactions and processes. Applications to ecosystem analysis, pollutant fate and transport, and environmental protection.

483 Water and Wastewater Engineering
Fall, 4(3-2) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: (ENE 280 or BE 230) and (CE 321 or CHE 311) R: Open to juniors or seniors or graduate students in the College of Engineering. Engineering and scientific basis and design of physical, chemical and biological methods for the treatment of drinking water and wastewater. Operation process selection and design. Field trips required.

485 Landfill Design
Spring, 3(3-0) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: ENE 280 and CE 312 Geotechnical and environmental design of solid waste landfills.

487 Microbiology for Environmental Science and Engineering
Spring, 3(3-0) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: ENE 280 Fundamentals of microbiology. Application of these concepts to environmental processes such as wastewater treatment, human health and bioremediation.

489 Air Pollution: Science and Engineering
Spring, 3(3-0) Interdepartmental with Environmental Engineering. Administered by Environmental Engineering. P: (CEM 141 or CEM 151 or LB 171) and (MTH 132 or MTH 133 or MTH 155H) and (ENE 280 or BE 230) and (CE 321 or CHE 311) R: Open to juniors or seniors or graduate students in the College of Engineering. Basic physical and chemical principles governing indoor and atmospheric air pollution. Elements of air pollution meteorology, climate change, atmospheric transformations and transport. Air pollution sources and methods for their control. The role of local, state and federal government in air pollution control.

490 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open to seniors in the College of Engineering. Approval of department. Civil engineering problem of specific interest to the student and a faculty member. May be analysis or design.

492 Selected Topics in Civil Engineering
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department. Selected topics related to construction engineering, fluid mechanics, geotechnical engineering, hydrology, pavements, structural engineering, or transportation engineering.

495 Senior Design in Civil and Environmental Engineering
Fall, Spring. 4(2-3) P: (CE 274 and CE 371 and CE 372) and (ENE 421 or ENE 422 or ENE 483 or ENE 489 or ENE 418 or CE 431 or CE 405 or CE 406 or CE 444 or CE 449) and (ENE 421 or ENE 489 or ENE 483 or ENE 489 or CE 405 or CE 406 or CE 418 or CE 431 or CE 434 or CE 449) and (ENE 421 or ENE 449 or ENE 483 or ENE 489 or CE 405 or CE 406 or CE 418 or CE 431 or CE 434 or CE 449) R: Open to seniors in the Civil Engineering Major or in the Environmental Engineering Major. Preliminary design. Application of design concepts in civil engineering. Integrated design solutions using geotechnical, hydrological, pavement, structural, environmental, and transportation considerations. Planning the design process. Design Specifications. Cost. Written and oral presentations. Issues of professional practice.
847 Traffic Analysis and Control
Spring of odd years. 3(3-0) P: CE 444
RB: Graduate student in transportation engineering
Modern traffic control and traffic modeling using state-of-the-art algorithms and computer models.
Practical implications.

849 Transportation Research Methods
Spring. 3(3-0)
Application and interpretation of quantitative methods and design of experiments for transportation research; ANOVA, non-parametric, discriminant analysis, factor analysis, multivariate regression, SPSS.

850 Intelligent Transportation Systems (ITS)
Fall of odd years. 3(3-0) RB: Traffic and Transportation engineering
Technical and policy aspects emerging from the application of advanced technologies to transportation problems. Intelligent Transportation Systems (ITS) user services requirements, available and emerging technologies, case studies of ongoing operational tests, legal institutional and planning issues related to ITS development and deployment.

851 Transportation and the Environment
Spring of even years. 3(3-0) RB: B.S. in Civil Engineering with emphasis on transportation or environmental engineering R: Open only to graduate students in the College of Engineering.

872 Finite Element Method
Fall, Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. SA: AE 809, MSM 809
Theory and application of the finite element method to the solution of continuum type problems in heat transfer, fluid mechanics, and stress analysis.

878 Autonomous Futures: Self-driving Vehicles, Domotics, and Artificial Intelligence in Smart Cities
Fall. 3(3-0) Interdepartmental with Urban Planning. Administered by Urban Planning.
Characteristics of autonomous systems and emerging technology. Perceptions of people on future transport, mobility, housing, and living. International perspectives on ethics and transitions towards autonomous futures. Implications for engineering, policy, business, and planning.

880 Civil Engineering Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course. RB: Graduate student or undergraduate at senior level with a GPA of 3.0 or higher
Current research in civil engineering.

891 Selected Topics in Civil Engineering
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course.
Selected topics in new or developing areas of civil engineering.

892 Master's Research Project
Fall, Summer. 1 to 5 credits. A student may earn a maximum of 5 credits in all enrollments for this course. R: Open only to master's students in the Civil Engineering major. Approval of department.
Master's degree Plan B individual student research project. Original research, research replication, or survey and reporting on a research topic.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course.
Master's thesis research.

900 Research Strategies and Methods in Civil Engineering
Spring. 1(1-0) R: Open to graduate students in the Department of Civil and Environmental Engineering. Not open to students with credit in ENE 900.
Criteria for quality research, scientific method, scientific arguments, statistical testing, critical thinking skills, reviewing journal articles, literature synthesis, writing proposals and papers, giving presentations, responsible conduct of research.

990 Independent Study in Civil Engineering
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to doctoral students in the Civil Engineering major.
Research problems of limited scope not pertaining to thesis accomplished under CE 999.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 36 credits in all enrollments for this course.
Doctoral dissertation research.