

ENCE - ENGINEERING, CIVIL

ENCE401 Statistical and Machine Learning Models for Natural Hazards Prediction (3 Credits)

Infrastructure and other engineered systems are exposed to a variety of natural hazards, such as precipitation, high winds, storm surge, and earthquake-induced ground shaking. Assessment of the risks involves the development of models to predict hazard severity. While these models may involve a range of techniques, this course centers on prediction models that involve statistical and machine-learning approaches. Specifically, this course will focus on the practical application of statistical and machine learning regression models, including data processing, model specification, model development, and model assessment within the context of natural hazard predictions. Models selected for consideration in this course are informed by present-day practices for multiple types of natural hazards.

Prerequisite: ENCE203 or experience with a programming language (e.g., Python, R, MATLAB); ENCE303 or another course that provides the relevant probability/statistics required content; and permission of the ENGR-Civil and Environmental Engineering department.

Jointly offered with: ENCE601.

Credit Only Granted for: ENCE401, ENCE489X, ENCE601, or ENCE689X.

Formerly: ENCE489X.

ENCE402 Simulation and Design of Experiments for Engineers (3 Credits)

Review of statistics and hypothesis testing, sample design and design of experiments, generation of discrete and continuous distributions and their applications. Introduction of simulation languages and simulation of discrete and continuous engineering systems. Output analysis, model validation and sensitivity and reliability analysis.

Prerequisite: ENCE303; and permission of ENGR-Civil & Environmental Engineering department.

ENCE403 Sustainability and Smart Green Cities (3 Credits)

Introduces the principles and components of smart green cities. System approach to sustainability and green city development is examined. City wide action plan components are reviewed and analysed in regards to sustainability, resilience, social and economic elements. The UN Sustainability development goals are covered as pertinent to smart green cities. Green initiatives and C40 emission reduction plans and components are reviewed. The course introduces concepts and calculations of sustainable energy and electric vehicles, sustainability assessments and rating of Smart Green Cities. Case studies on such topics are reviewed and discussed.

Prerequisite: MATH140 .

Credit Only Granted for: ENCE489C or ENCE403.

Formerly: ENCE489C.

ENCE404 Sustainable Infrastructure & Condition (3 Credits)

Introduces the principles of sustainability, sustainability metrics applied to civil infrastructure. Resiliency of civil infrastructure and rating criteria are examined as well. Condition assessment of civil infrastructure and Non-Destructive Evaluation, NDEs, principles and methods are introduced and case studies are examined. Performance modeling alternative methods are reviewed. Example and analysis of GHG mitigation strategies and carbon sequestration techniques for infrastructure materials and structures are introduced. Development of sustainable rehabilitation methods applied to civil infrastructure are covered as well.

Prerequisite: MATH140 .

Credit Only Granted for: ENCE489G or ENCE404.

Formerly: ENCE489G.

ENCE405 Sustainability, Thermal Comfort & Urban Heat Islands (3 Credits)

Sustainability principles applied to urban areas. Methods and analysis for urban heat islands. Heat balance analysis. Surface albedo assessment techniques. Thermal comfort principles and analysis methods. Alternative materials and permeable/ impermeable surface materials for GHG reduction and UHI. Safety assessment of sustainable roadways: principles and measurements.

Prerequisite: MATH140 .

Credit Only Granted for: ENCE489I or ENCE405.

Formerly: ENCE489I.

ENCE411 Environmental Engineering Science (3 Credits)

Introduces the analytical techniques available to assess performance of engineering processes as they relate to water, soil, and air treatment and quality. The basic principles of environmental management, economics of waste treatment, by-product reutilization, and energy cycles are introduced and discussed. Alternative technologies are introduced and evaluated mostly by assessing their potential to reduce waste, minimize energy use, and promote sustainability. Students' activities include, a weekly lab to provide hands-on experience with environmental quality measurements and treatment techniques; on-site visits to regional industries that undertake sustainable practices; and a final research project where experimental design and laboratory techniques are used to assess interactions between technologies and natural systems and their potential for reducing environmental impacts.

Prerequisite: ENCE205 and ENCE310; and permission of ENGR-Civil & Environmental Engineering department.

ENCE412 Environmental Engineering Unit Operations (3 Credits)

Examination of unit operations and processes encountered in environmental engineering field. Fundamental principles learned from previous classes will be applied into the design and operation of unit operations and processes, particularly in the area of water and wastewater treatment. Similar processes will be applied to air pollution control, solid waste disposal and hazardous waste treatment.

Prerequisite: ENCE305 and ENCE310; and permission of ENGR-Civil & Environmental Engineering department.

ENCE420 Selection and Utilization of Construction Equipment (3 Credits)

Learn to evaluate and select construction equipment with a focus on mechanized equipment for earthwork and building construction. Learn about the parties involved in procurement, operation and maintenance, and how to cost-effectively plan, select, and utilize equipment for earthmoving, paving, formwork, trenching, rock excavation, tunneling, site preparation, and steel and concrete construction. Explore trends in equipment design, construction automation, and robotics.

Prerequisite: Permission of ENGR-Civil & Environmental Engineering department.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management minor.

ENCE421 Legal Aspects of Architectural and Engineering Practice (3 Credits)

Learn the basic structure of the US legal system and court procedures and legal principles relevant to architectural and engineering design and construction contracts including principles of ethical, legal and professional conduct of engineers and architects. Topics include: contracts for design and construction, sales and warranties, torts and product liability, business agency and government agencies, professional liability of architects and engineers, labor laws, expert testimony, mediation and arbitration, tangible property including real estate, intellectual property including trademarks, patents and copyrights, insurance and sureties.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management minor; or must be in the Project Management Minor. And permission of ENGR-Civil & Environmental Engineering department.

ENCE422 Project Cost Accounting and Economics (3 Credits)

Learn: the fundamentals of accounting; project cost accounting principles as they apply to project management; project cost accounting; and the fundamentals of engineering economics. Topics include: project feasibility analysis; reading and analyzing financial statements; cash management; cash flow analysis; depreciation and taxes; and impact on profitability; the principles of activity based costing; net present value analysis; the framework for project performance measurement, cost performance indices, and earned value analysis.

Prerequisite: Permission of ENGR-Civil & Environmental Engineering department.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management Minor; or must be in the Project Management Minor.

ENCE423 Project Planning, Estimating & Scheduling (3 Credits)

Learn the fundamentals of project planning, estimating, and scheduling. Understand the concepts of planning; to reduce uncertainty, improve efficiency of the operation, to set and meet objectives, and to provide a basis for monitoring and controlling the work. Be introduced to: the concepts of resource definition, assignment and management, and; the basics of project estimating (pricing) methods including global pricing strategies, types of estimates, pricing processes, overhead and profit, and project financing. Learn the basics of project scheduling including; bar charts, network-based methodologies, and linear scheduling techniques. Emphasis is placed on Critical Path Method (CPM) scheduling, a network based methodology. Be exposed to the use of scheduling software and will actually develop a CPM schedule for an actual construction project as part of a semester project.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management Minor; or must be in the Project Management Minor. And permission of ENGR-Civil & Environmental Engineering department.

ENCE424 Communication for Project Managers (3 Credits)

Learn the fundamentals of communications for project managers. Emphasis is on interpersonal and group communications; through voice, electronic, and written messages; project cycle and reports and presentations during this cycle; and communications for employment.

Prerequisite: Permission of ENGR-Civil & Environmental Engineering department.

Jointly offered with: ENCE614.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management minor; or must be in the Project Management minor.

Credit Only Granted for: ENCE424 or ENCE614.

ENCE426 Construction Documentation and BIM Applications in Engineering and Construction (3 Credits)

Learn the basics of construction documentation methods, with particular emphasis on Building Information Modeling (BIM). Topics include: the fundamentals of assembly, coordination, and maintenance of construction documents and implementation of BIM techniques in the design and construction processes, and; a review of Autodesk, Revit, and Navisworks and other leading BIM software. Lectures from project management faculty supplemented by guest lecturers from the construction industry.

Prerequisite: Permission of ENGR-Civil & Environmental Engineering department.

Restriction: Must be in a major in ENGR-A. James Clark School of Engineering; or must be in the Construction Project Management Minor; or must be in the Project Management Minor.

ENCE430 Introduction to Infrastructure and Resilience (3 Credits)

Develops system-level skills for the planning, design, maintenance, and operation of resilient infrastructure systems. Through this course, we will discuss a variety of infrastructure systems, both public and private, and their role in communities before and after disasters. The themes of the course will be grounded in the four phases of emergency management (mitigation, preparedness, response, and recovery) and the role that infrastructure plays in each. Through these applications areas, we will study a variety of conceptual, analytical, and computational models that support informed decision-making for these systems under uncertainty.

Prerequisite: ENCE302; or students who have taken courses with comparable content may contact the department.

Corequisite: ENCE360; or students who have taken courses with comparable content may contact the department. Jointly offered with ENCE632.

Credit Only Granted for: ENCE632, ENCE688U, ENCE430 or ENCE489U.

Formerly: ENCE489U.

ENCE431 Hydrologic Engineering (3 Credits)

An introduction to basic principles of hydrologic science including the hydrologic cycle, rainfall, surface runoff and streamflow. Special emphasis is placed on hydrologic engineering design of stormwater management and flood control facilities. Design projects are used to illustrate design practices.

Prerequisite: ENCE305; and permission of ENGR-Civil & Environmental Engineering department.

ENCE432 Ground Water Hydrology (3 Credits)

Concepts related to the development of the ground water resources, hydrology, hydrodynamics of flow through porous media, hydraulics of wells and basin-wide ground water development. Fundamentals of ground water pollution are introduced.

Prerequisite: ENCE305; and permission of ENGR-Civil & Environmental Engineering department.

ENCE436 Environment and Water II: Water Management (3 Credits)

Covers the essential principles and practices of water resources management, focusing on the sustainable design and operation of water systems. Students will examine key topics such as hydrology, stormwater management, groundwater flow, and water quality. Through hands-on projects, students will design water supply systems, flood management strategies, and stormwater management plans while considering economic, legal, and environmental factors. The course emphasizes the integration of technical and governance aspects in managing water resources to address global water challenges and prepare students for professional practice.

Prerequisite: Minimum grade of C- in ENCE336 and ENCE305.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

ENCE441 Foundation Design (3 Credits)

Critical review of classical lateral earth pressure theories, analysis of retaining walls and reinforced earth walls, subsurface explorations, bearing capacity and settlement of shallow foundations, design of deep foundations that includes both pile foundations and drilled shafts.

Prerequisite: ENCE340; and permission of ENGR-Civil & Environmental Engineering department.

ENCE442 Structural Analysis and Design II (3 Credits)

Introduces students to the structural design process, with a focus on decision-making using design codes and standards. Students will apply design methods to reinforced concrete, steel, and mass timber structures, considering life-cycle costs, sustainability, and environmental impacts. The course will cover design loads, load-resisting systems, and the principles of reinforced concrete and steel design.

Prerequisite: Minimum grade of C- in ENCE342; and must have completed or be concurrently enrolled in ENCE340.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

ENCE444 Experimental Methods in Geotechnical Structural Engineering (3 Credits)

In the geotechnical engineering part of the course, major soils testing and their interpretation including classification, compaction, strength, and compressibility will be undertaken. The structural engineering part of this course covers test planning, loading apparatus, instrumentation, data acquisition and data analysis, as well as basic aspects of structural testing techniques and shake-table test.

Prerequisite: ENCE353 and ENCE340; and permission of ENGR-Civil & Environmental Engineering department.

ENCE451 Design of Timber Structures (4 Credits)

Mass timber refers to a family of engineered wood products of large section size that provide the construction industry with a sustainable and viable alternative to steel and concrete. This course introduces students to the design of mass timber structures, a cutting-edge and eco-friendly building technology. Topics include the analysis and design of dimensional lumber and mass timber components such as Cross-Laminated Timber (CLT) and Glued Laminated Timber (Glulam). Specific focus areas include: Tension members; Beams (flexural members); Columns; Floor diaphragms; Shear walls; Connections; Fire-resistance design and acoustic considerations in the design. The course adopts a project-based learning approach to foster practical understanding and application.

Prerequisite: ENCE353 or another course that provides the relevant structure analysis required content; and permission of the ENGR-Civil and Environmental Engineering department.

Credit Only Granted for: ENCE689W or ENCE451.

ENCE453 Computer-Aided Structural Analysis (3 Credits)

Computer-aided analysis of structural systems. Unified matrix formulation of stiffness and flexibility methods. Slope deflection method. Evaluation of truss, frame, and grid systems. Non-prismatic and curved elements. Error analysis and determination of ill-conditions. Introduction to finite element methods; formulation of simple two-dimensional elements. In laboratory, use and development of CAD software.

Prerequisite: ENCE353; and permission of ENGR-Civil & Environmental Engineering department.

ENCE454 Design of Concrete Structures (3 Credits)

Combined bending and compression, development and anchorage of reinforcement, deflections, design of slabs including one-way and two-way, design of footings, retaining walls, introduction to prestressed concrete, design of multi-story buildings.

Prerequisite: ENCE353; and permission of ENGR-Civil & Environmental Engineering department.

Formerly: ENCE451.

ENCE455 Design of Steel Structures (3 Credits)

Behavior and design of members subjected to fatigue, and combined bending and compression; plate girders, composite beams, open-web joists and connections. Methods of allowable stress design, and load and resistance factor design. Elements of plastic analysis and design. Framing systems and loads for industrial buildings and bridges.

Prerequisite: ENCE353; and permission of ENGR-Civil & Environmental Engineering department.

ENCE464 Civil and Environmental Engineering Design I (2 Credits)

This experiential course provides structured and unstructured time for group work as part of the senior capstone design course. The course gives students a chance to practice the skills acquired throughout a student's academic career. The course provides students with hands-on experience similar to the experience encountered by new engineers in professional engineering and construction practice. The course offers students an opportunity to develop the leadership and group work skills needed to meet professional expectations.

Prerequisite: Minimum grade of C- in ENCE367, ENCE356, ENCE336, and ENCE342.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

Credit Only Granted for: ENCE465 or ENCE464.

Formerly: ENCE465.

Additional Information: Must be taken in the last year.

ENCE465 Civil and Environmental Engineering Design I (1 Credit)

Provides students an opportunity to develop their skills in project scoping and the development of design proposals. The fundamental concepts are taught using analytical and computational methods, which are necessary for designing and analyzing the sustainability of various engineering processes and technologies. The course provides the methods and skills for understanding the human-environment-infrastructure interactions needed to develop a design proposal.

Prerequisite: ENCE201 and ENCE215.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

ENCE467 Civil and Environmental Engineering Design II (2 Credits)

This experiential course provides structured and unstructured time for groupwork as part of the senior capstone design course sequence. The course builds on skills acquired throughout a student's academic career extending a project defined and scoped in ENCE465. The objective of this course is to provide students with hands on experience similar to the experience encountered by new engineers working in professional engineering and construction practice. The course offers students an opportunity to develop the leadership and groupwork skills needed to meet professional expectations.

Prerequisite: ENCE465; and must have completed or be concurrently enrolled in ENCE302 and ENCE305.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

ENCE470 Highway Engineering (3 Credits)

Highway location and design, highway engineering economics, traffic engineering, traffic measurement devices and technologies. Includes discussion of technological advances in traffic flow and capacity, such as signal systems, corridor control, automatic driver information, incident detection and autonomous vehicle operation.

Prerequisite: ENCE302 and ENCE370; and permission of ENGR-Civil & Environmental Engineering department.

ENCE472 Transportation Engineering (3 Credits)

Transportation engineering concepts including transportation systems analysis, airport systems, airline and airport operations, marine transportation and urban public transportation systems.

Prerequisite: ENCE302 and ENCE370; and permission of ENGR-Civil & Environmental Engineering department.

ENCE482 Innovations in Materials and Technologies for Future Civil Infrastructure (3 Credits)

The future of civil infrastructure depends on novel materials that are stronger, smarter, and more sustainable, as well as new construction technologies that are faster, more reliable, and less labor-intensive. This course explores the latest breakthroughs in civil engineering materials and technologies. Students will explore how cutting-edge materials and construction technologies are transforming the civil engineering practice. Through lectures, assignments, hands-on demonstrations, and projects, students gain the skills to innovate, design, and implement next-generation materials and technologies that help to tackle the urgent challenges in sustainable and digital civil infrastructure.

Prerequisite: Minimum grade of C- in ENCE300; and permission of the ENGR-Civil & Environmental Engineering department.

Jointly offered with: ENCE682.

Credit Only Granted for: ENCE482 or ENCE682.

ENCE483 Transportation Systems II (3 Credits)

Introduces students to the characteristics, design, and analysis of various transportation systems, including roads, railways, urban transit, air transportation, and marine transportation. Students will explore the infrastructure and vehicles for passenger and freight transportation across different modes. The course covers topics in the geometric design of transportation systems, performance evaluation, system modeling, and optimization. Students will apply optimization, statistical, and economic analysis methods in designing and operating transportation systems.

Prerequisite: Minimum grade of C- in ENCE383.

Restriction: Permission of the ENGR-Civil & Environmental Engineering Department.

ENCE489 Special Problems in Civil Engineering (1-4 Credits)

A course arranged to meet the needs of exceptionally well prepared students for study in a particular field of civil engineering.

Prerequisite: Permission of ENGR-Civil & Environmental Engineering department.

Restriction: Senior standing.

Repeatable to: 9 credits if content differs.

ENCE601 Statistical and Machine Learning Models for Natural Hazards Prediction (3 Credits)

Infrastructure and other engineered systems are exposed to a variety of natural hazards, such as precipitation, high winds, storm surge, and earthquake-induced ground shaking. Assessment of the risks involves the development of models to predict hazard severity. While these models may involve a range of techniques, this course centers on prediction models that involve statistical and machine-learning approaches. Specifically, this course will focus on the practical application of statistical and machine learning regression models, including data processing, model specification, model development, and model assessment within the context of natural hazard predictions. Models selected for consideration in this course are informed by present-day practices for multiple types of natural hazards.

Jointly offered with: ENCE401.

Restriction: Permission of the ENGR-Civil department.

Credit Only Granted for: ENCE401, ENCE489X, ENCE601, or ENCE689X.

Formerly: ENCE689X.

Additional Information: Students must have prior coursework similar to the content offered in undergraduate courses ENCE203 and ENCE303.

ENCE602 Project Procurement Management (3 Credits)

Fundamental concepts and techniques for project acquisition and procurement are presented. Students are introduced to the PMBOK Guide six-step procurement process and expected to develop an in-depth understanding of project evaluation, planning, financing, contracting, negotiation, and procurement execution. It will also cover emerging methods, principles, and practices in infrastructure project procurement, including Public-Private Partnerships, Carbon project procurement, and Clean Development Mechanism.

ENCE603 Bayesian Data Analytics for Engineering (3 Credits)

Introduction to identifying, analyzing, assessing, and managing data inherent to engineering projects. Includes: statistical principles, concepts, and models; decision science aspects of data systems; Bayesian methods; measurement theory; subjective aspects of statistics and data appraisal. Examples are drawn from software development, systems integration, and other large engineering projects. Covers statistical basics, subjective probability, Bayesian data analysis, introduction to decision theory, Monte Carlo simulation, value of information, and risk-based decision making from data.

Recommended: ENCE627.

ENCE604 Sustainability Fundamentals for Project Managers (3 Credits)

Addresses the fundamentals of sustainability for project managers including best practices of modern sustainable construction and project management. Commercial and residential buildings consume about 40 percent of the energy used in the United States. The course therefore emphasizes the application of the sustainable development goals to the built environment, including the practical operational aspects of sustainable facility project management and sustainable construction by contractors. The course also will cover the fundamental concepts of sustainable project development and the move towards economic prosperity, environmental protection, and social equity, taking all three dimensions into account to achieve sustainability. Project managers need to take responsibility for more sustainable development of organizations, facilities, and projects.

ENCE605 Evolving as a Project Leader (3 Credits)

Projects are now used by many organizations for the implementation of strategic initiatives. This means that project managers must be able to do more than manage, organize, and control. They must be able to lead the project team and its stakeholders through change. This course explores four themes 1) Leadership theory with an emphasis on servant and situational leadership; 2) Vital leadership skills; 3) Project leadership in traditional and agile projects; and, 4) Developing your leadership skills.

ENCE606 Graduate Introduction to Project Scheduling (3 Credits)

Students are taught the basics of project scheduling and the various scheduling approaches that are currently being used in the design and construction industry. Project planning techniques will be covered and basic scheduling methods will be taught including the use of bar charts. Critical Path Method (CPM), Program Evaluation and Review (PERT) and Linear Scheduling (Line of Balance) methods.

ENCE607 Mastering Agile Project Management (3 Credits)

Learn how and why Agile project management is the fastest growing and most successful project management philosophy today. Learn the mechanics of how to design and facilitate projects using pure Agile Scrum and Lean Kanban techniques; The tradeoffs of using hybrid techniques such as Lean Startup, Scaled Agile for the Enterprise, and Disciplined Agile Development. Then go beyond these frameworks to the science beneath with the essential principles to ensure you get the best benefits of Agile project management methods.

ENCE610 Fundamentals of Structural Analysis (3 Credits)

Cartesian tensor notation. Linear forms of the general equilibrium, compatibility, and constitutive equations. The calculus of variations. The principles of virtual work and complementary virtual work. Self-adjoint problem formulations.

ENCE611 Finite Element Methods (3 Credits)

Basic principles and fundamental concepts of the finite element method. Consideration of geometric and material nonlinearities, convergence, mesh gradation and computational procedures in analysis. Applications to plane stress and plane strain, plates and shells, eigenvalue problems, axisymmetric stress analysis, and other problems in civil engineering.

Formerly: ENCE661.

ENCE613 Structural Dynamics (3 Credits)

Analysis of the dynamic response of structures and structural components subjected to impact load, transient load, and ground excitations; study of single degree-of-freedom and multi degree-of-freedom systems in classical closed form solution and approximate numerical solution; solution in the frequency domain and the use of finite element method.

Formerly: ENCE653.

ENCE620 Risk Analysis in Engineering and Economics (3 Credits)

Covers quantitative risk analysis and management using probability theory and statistics starting with system definition, hazard and scenario identification, likelihood estimation and consequence assessment, and finishes with economic valuation and microeconomics for informing decision making. Students will learn uncertainty, risk; natural and anthropogenic hazards and fundamental risk methods; analytical and empirical reliability and resilience estimation for components and systems; consequence, severity and loss analysis and accumulation including property and life; risk-cost-benefit tradeoffs and analysis; microeconomics and socioeconomics in risk analysis for informing decisions; and expert-opinion elicitation; among others.

Jointly offered with: ENCE410.

Restriction: Permission of the Civil and Environmental Engineering Department.

Credit Only Granted for: ENCE410, ENCE620, ENCE489L, ENRE648M or ENSE698R.

Formerly: ENRE648M and ENSE698R.

Additional Information: Students must have prior coursework similar to the content offered in undergraduate course ENCE303.

ENCE622 Construction Automation & Robotics (3 Credits)

Covers advanced technologies leading to redesign and partial or full automation of selected construction processes utilizing industrial robotics. Lectures and presentations will cover topics such as basic robotic technology (robot kinematics and dynamics, industrial manipulators, mobility bases, end effectors, sensors, control systems, and robot task programming), design of automated construction processes, selection of means and methods for automated construction processes, robot ergonomics and safety, calculation of costs and benefits of construction robots in selected applications, engineering and economic feasibility of automation and robotics in the construction industry.

ENCE623 Introduction to Advanced Scheduling (3 Credits)

A Combination of lecture and hands-on use of software to develop advanced knowledge and skills necessary to master advanced scheduling techniques for project management and control will be used. No software purchase is necessary.

Prerequisite: ENCE423 or ENCE662.

Credit Only Granted for: ENCE623 or ENCE688S.

ENCE625 Project Administration (3 Credits)

Principles of project administration procedures from the viewpoint of a resident project manager or project engineer on a construction or engineering project. The course specifically addresses the project administration responsibilities of the project manager or project engineer in the engineering, design, or construction industries. Students with a background in the private sector or the government sector will benefit. The course takes a project team approach for improved job efficiency, outlining a project team operation in which the office project administrator delegates to the greatest possible extent all those project administrative functions that can be done more efficiently in the field. The class also addresses the responsibilities and risks that a project administrative manager is likely to encounter. The course is suitable for students, engineering and design professionals, project managers, experienced contract administrators, and owners interested in the special administrative problems of engineering or construction.

ENCE627 Project Risk Management (3 Credits)

Introduction to identifying, analyzing, assessing, and managing risks inherent to engineering projects. Includes: probability modeling, choice and value theory, schedule and cost risk, risk mitigation and transfer, and contract considerations of project risk. Examples are drawn from construction, software development, systems integration, and other large engineering projects; and cover probability basics, subjective probability, statistical data analysis, introduction to decision theory, Monte Carlo simulation, value of information, and risk-based decision making.

Restriction: Must not have completed ENCE627.

ENCE631 Hydrologic Analysis and Nonpoint Pollution Models (3 Credits)

A detailed analysis of the physical processes controlling the spatial distribution of runoff and constituent transport during rainfall and snowmelt events. Emphasis is on developing an understanding of the processes and translating this understanding into practical models that can be used for runoff simulation, stormwater management, and environmental impact assessment.

ENCE632 Introduction to Infrastructure and Resilience (3 Credits)

Develops system-level skills for the planning, design, maintenance, and operation of resilient infrastructure systems. Through this course, we will discuss a variety of infrastructure systems, both public and private, and their role in communities before and after disasters. The themes of the course will be grounded in the four phases of emergency management (mitigation, preparedness, response, and recovery) and the role that infrastructure plays in each. Through these applications areas, we will study a variety of conceptual, analytical, and computational models that support informed decision-making for these systems under uncertainty.

Prerequisite: ENCE302; and ENCE360. Or students who have taken courses with comparable content may contact the department.

Credit Only Granted for: ENCE688U, ENCE632, ENCE489U or ENCE430.

Formerly: ENCE688U.

ENCE633 Assessment of Natural Hazards for Engineering Applications (3 Credits)

Ensuring the resilience of infrastructure and other engineered systems requires an assessment of the natural hazards to which the systems are exposed. Probabilistic natural hazard assessment evaluates how likely a location is to experience hazard events (e.g., hurricanes or earthquakes) and how likely those events are to cause various impacts (e.g., large surges, intense rainfall, high winds, or ground shaking). This course will review the basic science of natural hazards and provide the foundational concepts of probability and statistics required for developing models to assess the frequency and severity of natural hazards. This course will present methodologies for assessment of multiple types of natural hazards (e.g., seismic, precipitation, riverine, coastal, and wind hazards).

Prerequisite: ENCE302.

Jointly offered with: ENCE433.

Credit Only Granted for: ENCE633 or ENCE433.

ENCE635 Geographic Information Systems for Watershed Analysis (3 Credits)

Emphasis is on the use of GIS to support the analysis and modeling tasks associated with watershed planning and management. This course familiarizes the student with fundamentals of GIS data models, projections, and coordinate systems. Students develop a set of GIS-based algorithms solving common engineering problems in hydrology. Internet data sources and GPS technology are also covered.

Credit Only Granted for: ENCE524 or ENCE688Z.

Formerly: ENCE688Z.

ENCE640 Advanced Soil Mechanics (3 Credits)

Introduction to the use of elastic theory in stress and displacement solutions to geotechnical engineering (soil and rock mechanics). The effect of soil moisture (at rest) relative to effective stress principles, capillary and frost. Exact and numeric techniques for the analysis for soil seepage under isotropic and anisotropic conditions. Classical settlement (consolidation) and compressibility theories, including finite difference solution for vertical and radial drainage.

Prerequisite: ENCE340; or students who have taken courses with comparable content may contact the department.

ENCE641 Advanced Foundations Systems (3 Credits)

Review of soil properties and subsurface exploration, evaluation and design of shallow foundations, including settlement and bearing capacity of spread footings and mats. Discussion of methods of soil improvement. Analysis and design of deep foundations including single pile, pile load testing, pile group actions, and drilled shaft foundations for both vertical and horizontal loads. Load and resistance factor design concepts will be presented.

Prerequisite: ENCE340; or students who have taken courses with comparable content may contact the department.

ENCE645 Geotechnics of Waste Disposal (3 Credits)

Fundamental aspects of geotechnical engineering that apply to problems of waste containment and remediation, basic principles of containment systems, compacted clay liners and clay mineralogy, hydraulic conductivity of compacted soils, methods of laboratory and field hydraulic conductivity measurements, design of waste containment systems, landfill stability and settlement, geosynthetic liners, waste compatibility, contaminant transport through liners, leachate collection systems, gas collection systems, covers and caps.

Credit Only Granted for: ENCE489X, ENCE645, or ENCE688X.

Formerly: ENCE688X.

ENCE647 Slope Stability and Seepage (3 Credits)

Theoretical and practical aspects of seepage effects, and groundwater flow, review of shear strength principles, flow through porous media, hydraulic conductivity, flow nets, determination of water pressure, seepage forces and quantity of seepage, laboratory and field tests for shear strength, infinite slopes, block analysis, method of slices, seismic analysis of slopes, effective and total stress analysis, computer program for slope stability analysis, slope stability problems in waste disposal, construction excavations, reinforced embankments, embankments on soft ground.

Prerequisite: ENCE340.

Credit Only Granted for: ENCE489A, ENCE647, or ENCE688A.

Formerly: ENCE688A.

ENCE650 Process Dynamics in Environmental Systems (3 Credits)

The fundamentals of heterogeneous equilibria, rates of environmental reactions, and flow and material transport or presented. Applications of these principles will be presented to small and large scale environmental problems involving liquid, gas, and solid phases. Both natural and engineered environmental systems will be examined.

Formerly: ENCE636.

ENCE651 Chemistry of Natural Waters (3 Credits)

Application of principles from chemical thermodynamics and kinetics to the study and interpretation of the chemical composition of natural waters is rationalized by considering metal ion solubility controls, pH, carbonate equilibria, adsorption reactions, redox reactions and the kinetics of oxygenation reactions which occur in natural water environments.

Credit Only Granted for: ENCE633 or ENCE651.

Formerly: ENCE633.

ENCE652 Microbiological Principles of Environmental Engineering (3 Credits)

An examination of microbiological principles directly affecting humans and the surrounding environment. Special emphasis is given to the understanding of microbial physiology and in environmental engineering related to water and land systems including aerobic and anaerobic treatment processes involved in nutrient/waste recycling as well as impact of xenobiotic compounds on processes water, soil and sediment.

Credit Only Granted for: ENCE637 or ENCE652.

Formerly: ENCE637.

ENCE655 Environmental Behavior of Organic Pollutants (3 Credits)

Introduction to the scientific data needed and methods currently available to assess the environmental risk of organic chemicals. Applications of principles from chemical thermodynamics will be used to study phase-transfer processes of organic pollutants in the environment (solid/water, solid/air, water/air). Physical-chemical properties of organic pollutants will be used to estimate partitioning.

Prerequisite: ENCE651.

ENCE661 Project Cost Accounting and Finance (3 Credits)

This course reviews the fundamentals of accounting; examines project cost accounting principles, applications, and impact on profitability; examines the principles of activity based costing; covers the elements involved in cash management; introduces the framework for how projects are financed and the potential impact financing has on the projects; and a framework for evaluating PC based systems and what resources are needed for an effective project cost system.

ENCE662 Introduction to Project Management (3 Credits)

Introduction to project management including: overview and concepts of project management (principles, body of knowledge, strategies); planning successful projects (defining, specifying, delivery options, scheduling, budgeting); implementing (organizing the team, work assignments, team building, effective leadership); executing (performance measurement, maintaining the schedule, adjustments/mid-course corrections, record keeping, status reporting, communications, managing conflict, time management); and closeout (performance measurement, maintaining the schedule, adjustments/mid-course corrections, record keeping, status reporting, communications, managing conflict, time management).

ENCE664 Legal Aspects of Engineering Design and Construction (3 Credits)

Examines ways in which the legal system affects the design and construction process. Focuses on contract types and the relationships between the parties in different delivery systems. Covers basics of procurement protocols along with negotiating techniques and strategies. Topics include contract law, the relationships between the parties, tort and negligence law, and the statutory principles affecting construction.

ENCE665 Management of Project Teams (3 Credits)

Experience has shown that really excellent project managers are not only technically competent but that they have above average skills in human relations and communications. The course will prepare project managers to optimize the utilization of their most important resource: people. Relying primarily on a wide range of research and experience in the Project Team, this course will help guide project managers in building the other skills needed to be truly successful in the competitive Project Team.

ENCE666 Cost Engineering and Control (3 Credits)

Analytical techniques to estimate and control project costs, including site investigation, quantity takeoff, work analysis, and bid preparation. Systematic cost control as related to job production and historical data. Includes the fundamentals of different types of cost estimating, the appropriate use of each, and examination of popular software. This course is designed to help students develop the ability to utilize techniques of cost estimating, cost and schedule control and project management as they apply to engineering and construction work. Students will understand why it is crucial to understand the various types of cost estimating and the appropriate use of each, activity-based costing, conceptual estimating and budgeting, unit cost estimating, parametric estimating, detailed estimating, learning curves and progress functions.

ENCE670 Highway Traffic Characteristics and Measurements (3 Credits)

The study of the fundamental traits and behavior patterns of road users and their vehicles in traffic. The basic characteristics of the pedestrian, the driver, the vehicle, traffic volume and speed, stream flow and intersection operation, parking, and accidents.

ENCE672 Regional Transportation Planning (3 Credits)

Factors involved and the components of the process for planning statewide and regional transportation systems, encompassing all modes. Transportation planning studies, statewide traffic models, investment models, programming and scheduling.

ENCE673 Urban Transportation (3 Credits)

The contemporary methodology of urban transportation planning. The urban transportation planning process, interdependence between the urban transportation system and the activity system, urban travel demand models, evaluation of urban transportation alternatives and their implementation.

ENCE674 Urban Transit Planning and Rail Transportation Engineering (3 Credits)

Basic engineering components of conventional and high speed railroads and of air cushion and other high speed new technology. The study of urban rail and bus transit. The characteristics of the vehicle, the supporting way, and the terminal requirements will be evaluated with respect to system performance, capacity, cost, and level of service.

ENCE675 Airport Planning and Design (3 Credits)

The planning and design of airports including site selection, runway configuration, geometric and structural design of the landing area, and terminal facilities. Methods of financing airports, estimates of aeronautical demand, air traffic control, and airport lighting are also studied.

ENCE676 Highway Traffic Flow Theory (3 Credits)

An examination of physical and statistical laws that are used to represent traffic flow phenomena. Deterministic models including heat flow, fluid flow, and energy-momentum analogies, car following models, and acceleration noise. Stochastic approaches using independent and Markov processes, Queuing models, and probability distributions.

ENCE677 OR Models for Transportation Systems Analysis (3 Credits)

Fundamental skills and concepts of the quantitative techniques of operations research including: mathematical modeling, linear programming, integer programming, network optimization (shortest paths, minimum spanning trees, minimum cost network flows, maximum flows), heuristics, and basics of probabilistic modeling. Emphasis on the application of these techniques to problems arising in transportation.

ENCE681 Freight Transportation Analysis (3 Credits)

Application of operations research and system analysis methods to freight transportation systems. Cost and output analysis, terminal location, freight transportation demand models, freight transportation network equilibrium models and analytic models for analyzing the operations of rail, motor carrier, water carrier and air cargo systems.

ENCE682 Innovations in Materials and Technologies for Future Civil Infrastructure (3 Credits)

The future of civil infrastructure depends on novel materials that are stronger, smarter, and more sustainable, as well as new construction technologies that are faster, more reliable, and less labor-intensive. This course explores the latest breakthroughs in civil engineering materials and technologies. Students will explore how cutting-edge materials and construction technologies are transforming the civil engineering practice. Through lectures, assignments, hands-on demonstrations, and projects, students gain the skills to innovate, design, and implement next-generation materials and technologies that help to tackle the urgent challenges in sustainable and digital civil infrastructure.

Jointly offered with: ENCE482.

Restriction: Permission of the ENGR-Civil and Environmental Engineering department.

Credit Only Granted for: ENCE482 or ENCE682.

Additional Information: Students must have prior coursework similar to the content offered in undergraduate course ENCE300.

ENCE688 Advanced Topics in Civil Engineering (1-3 Credits)

Advanced topics selected by the faculty from the current literature of civil engineering to suit the needs and background of students. May be taken for repeated credit when identified by topic title.

ENCE689 Seminar (1-16 Credits)**ENCE710 Steel Structures I (3 Credits)**

Moment connections of beams and columns. Wind bracing connections. Plate girders. Floor systems for buildings. Strengthening of beams and trusses. Corrosion control. Fatigue and fracture.

Formerly: ENCE656.

ENCE713 Concrete Structures I (3 Credits)

The behavior and strength of reinforced concrete members under combined loadings, including the effects of creep, shrinkage and temperature. Mechanisms of shear resistance and design procedures for bond, shear and diagonal tension. Elastic and ultimate strength analysis and design of slabs. Columns in multistory frames. Applications to reinforced concrete structures.

Formerly: ENCE753.

ENCE715 Earthquake Engineering (3 Credits)

Review of SDOF and MDOF structural dynamics; characteristics of earthquakes; philosophies of seismic design; elastic and inelastic response spectra; design for ductility; principles of capacity design; design of structural systems requiring special performance criteria.

Restriction: Permission of instructor.

Formerly: ENCE755.

ENCE717 Bridge Structures (3 Credits)

The design and rating of bridge structures in accordance with the AASHTO WSD, LFD, ALFD, and LRFD specifications. Development of the basic strength and performance requirements as defined within AASHTO, area and various foreign codes. Projects requiring the design, rating and ultimate strength evaluations will be assigned for all of the predominate construction types including: simple and continuous span, straight and horizontally curved, non-composite and composite w and box section superstructure elements.

Formerly: ENCE751.

ENCE721 Investment Theory for Project Engineers (3 Credits)

An introductory course covering investment theory and its application to project evaluation and selection. Selected topics include: basic theory of interest and fixed income securities; portfolio selection and modification; capital asset pricing; asset price dynamics; derivative securities; and project evaluation using real options.

Credit Only Granted for: ENCE652 or ENCE721.

Formerly: ENCE652.

ENCE741 Earth Retaining Structures (3 Credits)

Introduction to types and uses of earth retaining structures, and lateral earth pressure concepts and theories. Analysis and design of retaining walls and shoring structures and their bracing systems. These include conventional retaining walls, mechanically stabilized earth walls, cantilever and anchored sheet piling, cellular cofferdams, braced cuts, soil nailing, and the design of tiebacks and anchors. Load and resistance factor design concept will be presented.

ENCE743 Soil Dynamics and Earthquake Engineering (3 Credits)

Review of theory of vibration and wave propagation in elastic media. Field and laboratory methods for determining dynamic soil properties. Analysis and design of soil-foundation systems subjected to machinery generated vibrations and methods of foundation isolation. Earthquake causes, magnitude and intensity, seismic hazard evaluation, NEHRP site classification, site response analyses and ground motion amplification, liquefaction and response of earth structures.

Credit Only Granted for: ENCE642 or ENCE743.

Formerly: ENCE642.

ENCE751 Chemistry of Natural Waters II (3 Credits)

A continuation of ENCE651, introducing aquatic chemical kinetics and chemistry of the solid-water interface.

Prerequisite: ENCE650 and ENCE651.

ENCE799 Master's Thesis Research (1-6 Credits)**ENCE898 Pre-Candidacy Research (1-8 Credits)****ENCE899 Doctoral Dissertation Research (1-8 Credits)**