CIVIL ENGINEERING

Robert Liang, Department Chairperson

Deogratis Eustace, Graduate Program Director

Master of Science in Civil Engineering (CEE)

The program of study for the degree of Master of Science in Civil Engineering, developed in cooperation with an advisor assigned by the department chair, must include a minimum of 30 semester hours. The program of study must include:

1. Fifteen to eighteen semester hours of civil engineering, engineering mechanics, and/or thesis-related courses.
2. Six to nine semester hours of engineering or basic science electives.
3. Six semester hours of research on a civil engineering topic, CEE 599 Thesis. Students may elect to pursue a non-thesis option by replacing the six semester hours of thesis credit with six semester hours of coursework. The thesis option requires both an oral defense and a written thesis.

Students are strongly encouraged to identify an area of focus (Environmental, Geotechnical, Structural Transportation, Construction Management, or Water Resources) in their program of study by selecting courses from the below areas. Civil Engineering courses in addition to the offerings listed below are available.

EGR 500	Academic Integrity and Responsible Conduct of Research for Engineers	0
Choose 5 Courses from Below (can mix focus areas) [1, 2]		**15**
Environmental		
CEE 560	Biological Processes in Wastewater Engineering	
CEE 562	Physical & Chemical Water & Wastewater Treatment Processes	
CEE 563	Hazardous Waste Engineering	
CEE 564	Solid Waste Engineering	
CEE 574	Fundamentals of Air Pollution Engineering I	
CEE 575	Fundamentals of Air Pollution Engineering II	
CEE 576	Environmental Engineering Separation Processes	
Geotechnical		
CEE 520	Advanced Geotechnical Engineering	
CEE 522	Subsurface Investigations	
CEE 524	Foundation Engineering	
CEE 526	Retaining Structures & Slopes	
CEE 528	Soil Dynamics & Earthquake Engineering	
Structural		
CEE 500	Advanced Structural Analysis	
CEE 501	Structural Analysis by Computer	
CEE 502	Prestressed Concrete	
CEE 503	Introduction to Continuum Mechanics	
CEE 504	Structural Dynamics	
CEE 505	Plastic Design in Steel	
CEE 507	Masonry Design	
CEE 508	Design Timber Structures	
Engineering Mechanics		
CEE 511	Experimental Stress Analysis	
CEE 533	Theory of Elasticity	
CEE 534	Theory of Plates & Shells	
CEE 535	Advanced Mechanical Vibrations	
CEE 539	Theory of Plasticity	
CEE 540	Composites Design	
CEE 541	Mechanics of Composite Materials	
CEE 546	Finite Element Analysis I	
Transportation		
CEE 550	Highway Geometric Design	
CEE 551	Traffic Engineering	
CEE 552	Intelligent Transportation Systems	
CEE 553	Travel Demand Modeling	
CEE 554	Urban Public Transportation	
CEE 555	Highway Traffic Safety	
CEE 558	Traffic Engineering Research	
Construction Management		
CEE 514	Design & Construction Project Management	
CEE 516	Managing Construction Field Operations	
CEE 517	Management of Construction Organization	
CEE 518	Procurement & Contract Management for Construction Projects	
CEE 519	Risk Management for Construction Projects	
Water Resources		
CEE 580	Hydrology & Seepage	
CEE 582	Advanced Hydraulics	
CEE 584	Open Channel Flow	
Basic Engineering Science		**9**
Three approved graduate-level courses from Engineering, Math, or Natural Sciences (including courses from focus areas above).		
Choose one option below:		**6**
Thesis Option: work closely with your advisor when registering. See footnote. [3]		
CEE 599	Thesis [3]	
Non-Thesis Option: Six additional credits in approved Civil Engineering coursework		
Total Credit Hours:		**30**

1. See also: Master's Degree Requirements in the School of Engineering section (http://catalog.udayton.edu/graduate/schoolofengineering/mastersdegreerequirements/) in the catalog and consult with your advisor.
2. **At nine hours of completed coursework: A Graduate Program of Study** Document (found on Porches) is to be completed by the student and submitted to the advisor and graduate program director for approval. This document will outline the specific coursework required to complete the degree requirements. This document can be amended if necessary.
3. **Thesis hours** should be registered for a maximum of three hours mid-way through your program. **Consult with your advisor before registering for the final 3 credits** to determine if the Thesis is a viable option or if an alternative may be necessary, such as coursework or a project.

Courses

CEE 500. Advanced Structural Analysis. 3 Hours
Frames of variable cross-section; arches; flat and folded plates; elastic stability of columns, frames, and plates; cylindrical, spherical, and barrel shells; structural dynamics of beams and frames. Required background: CEE 317 or equivalent.

CEE 501. Structural Analysis by Computer. 3 Hours
Review of force and displacement methods. Introduction to direct element and substructure methods. Students write and execute computer programs to analyze plane and space trusses, grids, and frames. Required background: CEE 317 or equivalent.

CEE 502. Prestressed Concrete. 3 Hours
Discussion of the properties of concrete and prestressed steel. Theory and design of prestressed concrete beams, slabs, columns, frames, ties, and circular tanks. Prerequisites: UG CEE 412 GR/DO None.

CEE 503. Introduction to Continuum Mechanics. 3 Hours
Tensors, calculus of variations, Lagrangian and Eulerian descriptions of motion. General equations of continuum mechanics, constitutive equations of mechanics, thermodynamics of continua. Specialization to cases of solid and fluid mechanics. Required background: EGM 303 or equivalent.

CEE 504. Structural Dynamics. 3 Hours
The response of undamped and damped single and multi-degree-of-freedom structures subjected to harmonic, periodic, and general dynamic loadings. Special topics include nonlinear structural response, response spectra, shear buildings, and simple systems with distributed properties. Required background: CEE 316 or permission of instructor.

CEE 505. Plastic Design in Steel. 3 Hours
Analysis and design procedures based on ultimate load capacity applied to steel beams, frames, and their connections. Concept of the plastic hinge, necessary conditions for the existence of plastic moment, instability, deformations, repeated and reversed loading, and minimum weight design. Required background: CEE 411 or equivalent.

CEE 506. Design of Temporary Structures. 3 Hours
Design and analysis of temporary structures including loading, shoring, formwork, falsework, scaffolding, ground support systems, bracing, soldier beam and lagging, sheet piling, equipment bridges, and support of existing structures. Required background: Analysis of Structures Prerequisites: UG CEE 316, GR/DO None.

CEE 507. Masonry Design. 3 Hours
Properties and performance criteria of bricks, concrete blocks, mortar, and grout; codes and construction practices; design of masonry elements. Required background: CEE 316 or equivalent.

CEE 508. Design Timber Structures. 3 Hours
Study of basic wood properties and design considerations. Design and behavior of wood connectors, fasteners, beams, columns, and beam-columns. Introduction to plywood and glued laminated members. Analysis and design of structural diaphragms and shear walls. Required background: CEE 316 or permission of instructor.

CEE 509. Bridge Engineering. 3 Hours
Design and engineering of modern steel and concrete bridge structures; loading; analysis; design. Required background: CEE 316 or equivalent. Concurrency requirement: CEE 411 and CEE 412. Corequisites: CEE 411, CEE 412.

CEE 511. Experimental Stress Analysis. 3 Hours
A study of the experimental analysis of stress as an aid to design for strength and economy with emphasis on electrical strain gages. Also, photoelasticity, brittle coatings, analogies, structural similitude. Two hours lecture and one three-hour laboratory period per week. Required background: EGM 303 or equivalent.

CEE 512. Data Analytics for Engineering Applications. 3 Hours
This course is designed to provide students opportunities to learn how state-of-the-art data analytics technologies can generate useful information from data to improve cost, time, quality, and safety performances of engineering systems. Key topics that will be covered in this course include: probabilistic concepts, statistical learning, and machine learning. Basic programming for implementing data analytics algorithms is presented. Methodologies for identifying data analytics needs, evaluating its usefulness, and estimating its economic potential are also addressed. Required background: MTH 168 or equivalent courses.

CEE 513. Bayesian Learning and Engineering applications. 3 Hours
The goal of this course is to provide a broad introduction to the key ideas and concepts in Bayesian machine learning and uncertainty quantification and their applications in recent engineering research and design practices. It is aimed at advanced undergraduates or graduate students. The emphasis will be on some selected intuition and practical examples rather than heavy theoretical results, though some experience with probability, statistics, and linear algebra will be important. Through a variety of lecture examples, students will learn how to apply uncertainty quantification techniques to get the confidence intervals of the predictions from a machine learning model and how to use the results as a critical basis for the following decision-making in relevant engineering practices. Hands-on programming skills using Python packages will be covered as well. Prerequisites are basic linear algebra, calculus, or permission of instructor.

CEE 514. Design & Construction Project Management. 3 Hours
Fundamentals of project management as they relate to the design and construction professional, and the application of project management techniques to the design and construction of major construction projects. The course provides a tour of project management knowledge areas and how they are applied to successfully develop and execute a construction project.

CEE 515. Pavement Engineering. 3 Hours
Fundamental principles of flexible and rigid highway and airport pavement design, construction, and management. Prerequisites: UG CEE 403 GR/DO None.

CEE 516. Managing Construction Field Operations. 3 Hours
This course is the first of two construction management courses and covers: life-cycle of construction management efforts from pre-construction services through to project close-out; planning and managing a construction job site each day – including health, safety and quality activities; managing technical submittals and field challenges, development of construction execution strategies reflecting decisions related to approaches for and coordination among various construction disciplines (civils, steel, mechanical/HVAC, electrical); and selection of construction equipment.

CEE 517. Management of Construction Organization. 3 Hours
This course is the second of two graduate construction management courses and covers: planning and managing construction labor productivity, construction, quality, health, safety, security, and environmental topics; organizational development (including management of labor force); administering contracts; cash flow forecasting, construction accounting principles, managing information, and communications; and effective operations reporting.

CEE 518. Procurement & Contract Management for Construction Projects. 3 Hours
This course covers the fundamentals of procurement and contracting management as they relate to the construction professional. Topics include procurement and contract strategy, use of standard contract models such as AIA, EJCDC, Consensus Docs in the United States and NEC, FIDIC, JCT outside of the United States, principles in the allocation of risks between owner and contractor, review and use of key provisions in design and construction contracts, construction contractor's use of purchase orders and subcontracts, and dealing with changes, disputes, and claims. The course will also cover use of design-build contracts and CMAR (construction management at risk) for construction projects.

CEE 519. Risk Management for Construction Projects. 3 Hours
This course covers the fundamentals of risk management for construction projects, with an emphasis on qualitative and quantitative risk analysis as well as treatment of these risks. The first portion of the course will concentrate on qualitative risk analysis and cover the development of risk management plan, identification, and prioritization of risks, development of risk registers, and probability-impact matrices. The second portion of the course will focus on quantitative risk analysis and cover the development of cost and schedule models, conducting a Monte Carlo simulation of these models, and interpreting the results. The third and last portion of the course will discuss the treatment of risks, including the development of risk mitigation strategies and risk response plans. The course will include use of risk simulation software.

CEE 520. Advanced Geotechnical Engineering. 3 Hours
Advanced study of Geotechnical engineering principles and study. Stress-strain characteristics; constitutive relationships; failure theories; dynamic soil properties; difficult soils; soil improvement; stability of earth slopes. Required background: CEE 312 or equivalent.

CEE 522. Subsurface Investigations. 3 Hours
Soil & rock classification; Geophysical methods; subsurface explorations; soil sampling; van shear, standard penetration, cone penetration, pressuremeter, dilatometer, and plate load testing; in-situ measurements; field instrumentation. Prerequisites: UG CEE 312 GR/DO None.

CEE 524. Foundation Engineering. 3 Hours
Application of Geotechnical engineering principles of analysis and design of shallow and deep foundations and earth retaining structures. Topics include site exploration and characterization, foundation types, bearing capacity, settlement analysis, shallow foundation design, earth pressures theories, design of retaining walls, flexible retaining structures and braced excavations, design of pile foundations and drilled piers. Prerequisites: UG CEE 312 GR/DO None.

CEE 525. Soil Improvement. 3 Hours
Principles of various mechanisms and technologies for improving soils in situ, design consideration and design methods, construction technologies, including construction equipment and construction process, performance specifications, quantity and cost estimate, sustainability consideration, quality assurance, and acceptance criteria, decision making, and construction optimization, case studies. Required background: CEE 312 or equivalent.

CEE 526. Retaining Structures & Slopes. 3 Hours
Earth pressure theories; design of earth retaining structures, such as rigid walls, anchored sheet pile walls, and reinforced soil structures; stability of excavation, cut, and natural slopes; slope stabilization methods. Prerequisites: UG CEE 312 GR/DO None.

CEE 528. Soil Dynamics & Earthquake Engineering. 3 Hours
Soil behavior under dynamic loading conditions; foundation design for vibratory loadings; introductory earthquake engineering; field and laboratory techniques for determining dynamic soil properties and liquefaction potential. Prerequisites: UG CEE 312 GR/DO None.

CEE 533. Theory of Elasticity. 3 Hours
Three-dimensional stress and strain at a point; equations of elasticity in Cartesian and curvilinear coordinates; methods of formulation of equations for a solution, plane stress, and plane strain, energy formulations, numerical solution procedures. Required background: EGM 303 or equivalent. Corequisites: EGM 503.

CEE 534. Theory of Plates & Shells. 3 Hours
Theory of plates; small and large displacement theories of thin plates; shear deformation; buckling; sandwich plate theory. Thin shell theory; theory of surfaces; thin shell equations in orthogonal curvilinear coordinates; bending, membrane, and shallow shell theories. Required background: EGM 533 or equivalent.

CEE 535. Advanced Mechanical Vibrations. 3 Hours
Review of undamped, damped, natural, and forced vibrations of one and two degrees of freedom systems. Lagrange's equation, eigenvalue/eigenvector problem, modal analysis for discrete and continuous systems. Computer application for multi-degree of freedom, nonlinear problems. Required background: MEE 319 or equivalent; computer programming.

CEE 539. Theory of Plasticity. 3 Hours
Fundamentals of plasticity theory including elastic, viscoelastic, and elastic-plastic constitutive models; plastic deformation on the macroscopic and microscopic levels; stress-strain relations in the plastic regime; strain hardening; limit analysis; numerical procedures. Required background: EGM 503 or EGM 533 or equivalent.

CEE 540. Composites Design. 3 Hours
Design with fiber-reinforced composite materials. Fiber and resin selection, laminate design, bending and torsion of stiffening elements, open and filled holes, joining methods, fatigue, damage tolerance, building-block approach, design allowables. Required background: EGM 303 or equivalent.

CEE 541. Mechanics of Composite Materials. 3 Hours
Introduction to the mechanical response of fiber-reinforced composite materials with emphasis on the development of experimental methodology. Analytical topics include stress-strain behavior of anisotropic materials, laminate mechanics, and strength analysis. Theoretical models are applied to the analysis of experimental techniques used for characterizing composite materials. Lectures are supplemented by laboratory sessions in which characterization tests are performed on contemporary composite materials. Required background: EGM 303 or equivalent.

CEE 543. Analytical Mechanics Composite Materials. 3 Hours
Analytical models are developed for predicting the mechanical and thermal behavior of fiber-reinforced composite materials as a function of constituent material properties. Both continuous and discontinuous fiber-reinforced systems are considered. Specific topics include basic mechanics of anisotropic materials, micro-mechanics and lamination theory, free-edge effects, and failure criteria. Required background: EGM 303 or equivalent.

CEE 546. Finite Element Analysis I. 3 Hours
Fundamental development of the Finite Element Method (FEM), and solution of field problems and comprehensive structural problems. Variational principles and weak, forms; finite element discretization; shape functions; finite elements for field problems; bar, beam, plate, and shell elements; isoparametric finite elements, stiffness, nodal force, and mass matrices; matrix assembly procedures; computer coding techniques; modeling decisions; program output interpretation. Emphasis on a thorough understanding of FEM theory and modeling techniques. Required background: CEE 503 or CEE 533 or equivalent.

CEE 550. Highway Geometric Design. 3 Hours
Advanced topics in horizontal and vertical alignment design controls and criteria, sight distance, intersection, and interchange design. Prerequisites: UG CEE 403 GR/DO None.

CEE 551. Traffic Engineering. 3 Hours
Characteristics of traffic, including the road user, vehicle, traffic control devices, accident analysis, signal operations, and design and the fundamentals of signal system progression. Prerequisites: UG CEE 403 GR/DO None.

CEE 552. Intelligent Transportation Systems. 3 Hours
Fundamentals of planning, design, deployment, and operations of ITS. Integrated application of ITS architecture, traffic flow principles, advanced equipment, communications technologies, and management strategies to provide traveler information and increase the safety and efficiency of the surface transportation system. Prerequisites: UG CEE 403 GR/DO None.

CEE 553. Travel Demand Modeling. 3 Hours
Introduction to the theory, concepts, and methods underlying the practice of urban travel demand modeling. The course involves model data inputs, model development, forecasting applications, and model evaluation techniques. Prerequisites: UG CEE 403, GR/DO None.

CEE 554. Urban Public Transportation. 3 Hours
Planning and analysis of urban public transportation service and operations with a focus on bus and rail modes. Provides fundamental knowledge and methods for route and network planning, service planning and analysis, performance monitoring, operations control, and frequency and headway determination. Prerequisites: UG CEE 403, GR/DO None.

CEE 555. Highway Traffic Safety. 3 Hours
Issues involved in transportation safety, strategic highway safety planning at state and local levels. The extent of the highway safety problem, elements of traffic accidents, common accident countermeasures, collection and analysis of accident data, evaluation of safety-related projects and programs, and litigation issues. Prerequisites: UG CEE 403, GR/DO None.

CEE 558. Traffic Engineering Research. 3 Hours
Practical problems in control or capacity restraints based on studies of actual local situations. Prerequisites: UG CEE 403, GR/DO None.

CEE 560. Biological Processes in Wastewater Engineering. 3 Hours
Measuring the characteristics of wastewater produced from domestic and industrial sources. Principles of designing and operating microbiological processes for the treatment of wastewater. Mechanisms and kinetics of biological reactions are emphasized. Prerequisites: UG College level general chemistry, GR/DO None.

CEE 562. Physical & Chemical Water & Wastewater Treatment Processes. 3 Hours
Principles and design of physical and chemical unit processes to treat water and wastewater. Industry pretreatment technologies and the basis for their development. Prerequisites: UG CHM 124; CEE 434 or CME 406, GR/DO None.

CEE 563. Hazardous Waste Engineering. 3 Hours
The fundamental principles of the design and operation of hazardous waste control and hazardous substances remediation processes. Hazardous waste regulations, risk assessment, and management. Prerequisites: UG College level chemistry, GR/DO None.

CEE 564. Solid Waste Engineering. 3 Hours
Characterizing solid waste. Managing solid waste collection, transport, minimization, and recycling. The design of solid waste disposal and resource recovery facilities.

CEE 574. Fundamentals of Air Pollution Engineering I. 3 Hours
Air pollution, combustion fundamentals, pollutant formation and control in combustion, pollutant formation and control methods in internal combustion engines, particle formation in combustion. Required background: CME 311 or MEE 301 or equivalent; CME 324 or MEE 410 or equivalent or permission of instructor.

CEE 575. Fundamentals of Air Pollution Engineering II. 3 Hours
Review of the concepts of air pollution engineering; aerosols; removal of gaseous pollutants from effluent streams; optimal air pollution control strategies. Required background: CME 574 or equivalent or permission of instructor.

CEE 576. Environmental Engineering Separation Processes. 3 Hours
Discussion of the unit operations associated with environmental engineering separation processes of solid-liquid, liquid-liquid, and gas-liquid systems; general use, principles of operation, and design procedures for specific types of equipment. Instructor permission is required.

CEE 580. Hydrology & Seepage. 3 Hours
A detailed study of the hydrologic cycle with a focus on rainfall/runoff generation techniques. The practical application of hydrologic fundamentals is demonstrated through the design of urban stormwater systems. Introduction to sub-surface hydrology and groundwater modeling. Prerequisites: UG CEE 312; CEE 333 GR/DO None.

CEE 582. Advanced Hydraulics. 3 Hours
Detailed examination of unsteady flow in closed conduits and open channels. Practical methods for solving water hammer and flood routing problems are presented. Physical modeling integrated with dimensional analysis and similitude is presented. Prerequisites: UG CEE 313; CEE 333 GR/DO none.

CEE 584. Open Channel Flow. 3 Hours
Open channel flow in its various forms will be studied. Major topics to be covered include energy and momentum principles, uniform and gradually varied flow. This course will concentrate on one-dimensional steady-state flow with an emphasis on the use of widely-used computer simulation models to determine water surface profiles and to examine flooding in urban areas. Erodible and non-erodible channel design is also covered. Prerequisites: UG CEE 313; CEE 333 GR/DO None.

CEE 585. Advanced Open Channel Flow. 3 Hours
This course builds upon concepts presented in CEE 584 with a special emphasis on one-dimensional and two-dimensional unsteady flow in open channels. Other topics to be covered include modeling hydraulic structures including bridges, culverts, in-line structures, and lateral structures. Widely used computer simulation models will be used to solve practical problems associated with advanced open channel flow. Required background: CEE 584 or equivalent. Prerequisites: CEE 584.

CEE 590. Selected Readings in Civil Engineering. 3 Hours
Directed readings in a designated area arranged and approved by the student's faculty advisor and the department chair. May be repeated.

CEE 595. Special Problems in Civil Engineering. 0-3 Hours
Special assignments in civil engineering subject matter to be arranged and approved by the student's advisor and the department chair.

CEE 598. Project. 3 Hours
Project in Civil and Environmental Engineering.

CEE 599. Thesis. 1-6 Hours
Thesis in Civil and Environmental Engineering.