

MECHANICAL ENGINEERING (ME)

ME 123 Introduction to Mechanical Design (3 credits)

Introduction to engineering design process and analysis techniques including problem solving skills, development of software learning skills, graphical analysis, data analysis, and documentation skills. The course includes lecture and lab periods each week. (Fall only)

Coreqs: MATH 143 and MATH 144

ME 201 (s) Engineering Team Projects (2-3 credits, max arranged)

Joint-listed with ME 401

Students will be introduced to a systems approach to designing, building and delivering an interdisciplinary engineering project, with an emphasis on learning how to realize a project in an organized team environment.

Projects are chosen at the discretion of the department. Additional project duties/assignments required for 400-level credit. Prereq for ME 401: ME Certification and Permission

ME 204 (s) Special Topics (1-16 credits)

Credit arranged

ME 223 Mechanical Design Analysis (3 credits)

Use of design and problem solving methodology to model requirements, conduct project learning, develop concepts, and realize prototypes. Projects feature elements of electromechanical design, rapid prototyping, and experimentation. Typically Offered: Fall and Spring.

Prereqs: ME 123, ME 280

Coreqs: MATH 175

ME 280 Programming Essentials for Engineers (3 credits)

The course introduces fundamental principles and techniques of computing and software programming. The course aims to provide students with an understanding and ability to write small to medium-level programs that will allow them to perform computing tasks in various projects or coursework. Topics include procedural programming (methods, parameters, return values, etc.), basic controls and data structures, algorithms and problem-solving strategies, and software development tools and techniques. The course will use Python as the programming language, and is intended for students without any prior programming experience. Typically Offered: Fall and Spring.

Prereqs: MATH143, MATH144

Coreqs: ME123

ME 299 (s) Directed Study (1-16 credits)

Credit arranged

ME 301 Computer Aided Design Methods (3 credits)

Engineering drawing literacy, pre-CAD planning, part modeling, assembly modeling, drawing package formulation, culminating team project involving virtual dissection and reassembly of a complex machine.

Prereqs: ME 223

ME 307 Group Mentoring I (1 credit)

Mentoring of student groups in engineering classes where a process education environment is used; students taking this course will improve their engineering skill in the area they are mentoring as well as improving their team, communication, and leadership skills. Students must attend all classes or labs where group activities in the process education environment are done (a minimum of 2 mentoring sessions per week).

Prereqs: Permission

ME 308 Group Mentoring II (1 credit)

Mentoring of student groups in engineering classes where a process education environment is used; students taking this course will improve their engineering skill in the area they are mentoring as well as improving their team, communication, and leadership skills. Students must attend all classes or labs where group activities in the process education environment are done (a minimum of 2 mentoring sessions per week).

Prereqs: Permission

ME 313 Dynamic Modeling of Engineering Systems (3 credits)

Application of basic engineering principles to model and analyze the dynamic response of engineering systems; problem solutions will utilize transfer function methods, state variable techniques, and simulation software.

Prereqs: ME 223, ENGR 220, ENGR 240, and MATH 310

Coreqs: MATH 330

ME 322 Mechanical Engineering Thermodynamics (3 credits)

Thermodynamic properties of substances, first and second laws of thermodynamics, thermodynamic analysis of mechanical engineering thermal components and cycles, psychrometric process, and introduction to combustion systems. (Fall only)

Prereqs: CHEM 111/CHEM 111L and PHYS 211/PHYS 211L

ME 325 Machine Component Design I (3 credits)

Study of stress, deflection and stiffness, material properties, static and fatigue failure theory in the context of the analysis and design of machine components such as fasteners, welds, spring design and bearings. Significant use of solid modeling and use of equation solvers.

Prereqs: ME 341 and MSE 201

ME 330 Experimental Methods for Engineers (3 credits)

Measurement systems and their application to engineering problems; topics include generalized performance of measurement systems, measuring and control devices, data acquisition and analysis, and report writing. Two lectures and one 2-hour lab per week.

Prereqs: ENGR 240

ME 341 Intermediate Mechanics of Materials (3 credits)

Mechanics of materials approach to: three-dimensional stress and strain, unsymmetrical bending, shear centers, curved beams, thick-walled pressure vessels, non-circular torsion; energy methods and advanced strength theories. Introduction to elementary kinematics. Significant use of solid modeling and use of equation solvers.

Prereqs: ME 301 and Certification

Coreqs: MSE 201

ME 345 Heat Transfer (3 credits)

Transmission by conduction of heat in steady and unsteady states, by free and forced convection, and by radiation; combined effects of conduction, convection, and radiation.

Prereqs: ME 322 and MATH 310

Coreqs: ENGR 335

ME 398 (s) Engr Coop Internship I (1-16 credits)

Credit arranged Supervised internship in professional engineering settings, integrating academic study with work experience; requires written report to be evaluated by a designated faculty member; details of coop to be arranged with ME Department before start of coop; cannot be counted as a technical elective. Graded P/F.

Prereqs: Permission

ME 401 (s) Engineering Team Projects (2-3 credits, max arranged)

Joint-listed with ME 201

Students will be introduced to a systems approach to designing, building and delivering an interdisciplinary engineering project, with an emphasis on learning how to realize a project in an organized team environment. Projects are chosen at the discretion of the department. Additional project duties/assignments required for 400-level credit. Prereq for ME 401: ME Certification and Permission

ME 403 (s) Workshop (1-16 credits)

Credit arranged

ME 404 (s) Special Topics (1-16 credits)

Credit arranged

ME 407 Group Mentoring III (1 credit)

Mentoring of student groups in engineering classes where a process education environment is used; students taking this course will improve their engineering skill in the area they are mentoring as well as improving their team, communication, and leadership skills. Student must attend all classes or labs where group activities in the process education environment are done (a minimum of 2 mentoring sessions per week).

Prereqs: Permission

ME 410 Principles of Lean Manufacturing (3 credits)

Principles of lean manufacturing are introduced that provide a systematic process for identifying and eliminating non-value activities (waste) in production processes. Students learn these principles through a series of workshops, lectures, and hands-on simulations of lean principles. Three hours of lecture and six hours of outside work per week.

Prereqs: Senior standing in an engineering discipline or Permission

ME 412 Gas Dynamics (3 credits)

t Compressible flow in ducts and nozzles, shock waves and expansion waves, and adiabatic two-dimensional compressible flow.

Prereqs: MATH 310, ME 322 or ENGR 320, and ENGR 335

ME 413 Engineering Acoustics (3 credits)

Joint-listed with ME 513 and ECE 579

Fundamentals of acoustics including wave theory; transmission through layers, generation and reception; low frequency models; application to sound measurement, transducers, loudspeaker cabinet design, and nondestructive testing; acoustic design project required. Additional projects/assignments required for graduate credit.

Prereqs: ENGR 240 or ECE 212, and MATH 310, or ME 313

ME 414 HVAC Systems (3 credits)

Joint-listed with ME 514

Application of thermodynamics, heat transfer, and fluid flow to understanding the psychrometric performance of systems and equipment; evaluating the performance characteristics, advantages, and disadvantages of the various types of HVAC systems including large tonnage refrigeration/chiller equipment, cooling coils, cooling towers, ducts, fans, and heat pump systems; economics of system and equipment selection. Cooperative: open to WSU degree seeking students.

Prereqs: ME 345

ME 415 Materials Selection and Design (3 credits)

Selection of materials for use in structural applications; consideration of environment, stress conditions, cost, and performance as guide to properties; optimization of choice of materials and fabrication methods; open-ended problems of real applications in various industries. Recommended Preparation: MSE 313 and MSE 456. (Spring only)

Prereqs: MSE 201 and ENGR 350

ME 416 FE Exam Review (1 credit)

Review of 10 essential topics on the Mechanical Engineering Fundamentals of Engineering exam, including preparation in each topic area based on online review sessions and solving sample problems.

Graded P/F

Prereqs: Senior Standing

ME 417 Turbomachinery (3 credits)

Joint-listed with ME 517

Introduction to the basic principles of modern turbomachinery. Emphasis is placed on steam, gas (combustion), wind and hydraulic turbines.

Applications of the principles of fluid mechanics, thermodynamics and aerodynamics to the design and analysis of turbines and compressors are incorporated. Additional technical research report and presentation required for graduate credit. ME 517 is cooperative: open to WSU degree-seeking students. Recommended Preparation: ENGR 320, ENGR 335.

ME 420 Fluid Dynamics (3 credits)

Joint-listed with ME 520 and CE 520

Credit not granted for both ME 420 and ME 520. A second fluid dynamics course featuring vector calculus and integral and differential forms of the conservation laws. Topics include fluid properties, fluid statistics, inviscid flow; conservation of mass, momentum, and energy; and turbulence.

Other topics may be covered. Additional projects/assignments required for graduate credit.

Prereqs: ENGR 335, MATH 310, or Permission

ME 421 (s) Advanced Computer Aided Design (3 credits)

Use of solid modeling software for advanced component design, creation of complex multi-component assemblies, animation studies, and rendering. Course concludes with one month-long final project.

Prereqs: ME 301

Coreqs: ME 341

ME 424 Mechanical Systems Design I (3 credits)

General Education: Senior Experience

Study of production realization including project planning, concept design, detail design, and manufacturing processes with multiple realistic constraints. Concepts learned are applied to a two-semester, capstone design project. The project is continued in ME 426. (Fall only)

Prereqs: ME 301, ME 313, ME 325, ME 330, ME 345, and Certification

ME 426 Mechanical Systems Design II (3 credits)

General Education: Senior Experience

Continuation of each two-semester, capstone design project that was started in ME 424. (Spring only)

Prereqs: ME 424

ME 430 Senior Lab (3 credits)

Detailed lab investigation of engineering problem; statistical design of experiments; application of engineering principles to analyze experimental data; technical report writing; oral communication skills. One lecture and four hours of lab per week.

Prereqs: ME 313 and ME 330

ME 433 Combustion Engine Systems (3 credits)

Theory and characteristics of combustion engines; combustion process analysis; fuels, exhaust emissions and controls; system analysis and modeling.

Coreqs: ME 345 or Permission

ME 435 Thermal Energy Systems Design (3 credits)

Application of fluid mechanics, thermodynamics and heat transfer in the design of thermal energy systems; topics include thermal energy system component analysis and selection, component and system simulation, dynamic response of thermal systems, and system optimization.

Prereqs: ME 345

ME 436 Sustainable Energy Sources and Systems (3 credits)

An introduction to renewable energy conversion. Topics include: solar thermal, solar photovoltaic, and wind energy. Cooperative: open to WSU degree seeking students.

Prereqs: ME 345

ME 438 Sustainability and Green Design (3 credits)

Joint-listed with ME 538

Understanding the Concept of Sustainability, Industrial Ecology and Sustainable Engineering, Metabolic Analysis, Sustainable Engineering, Design for Environment and Sustainability, Life Cycle Assessment, Energy & Water and Industrial Ecology, The status of Resources, Sustainable Engineering and Economics Development. Cooperative: open to WSU degree seeking students.

Prereqs: MATH 310

ME 450 Fundamentals of Computational Fluid Dynamics (3 credits)

Joint-listed with CE 550 and ME 551

Governing equations of fluid flow; fundamentals of turbulence modeling; accuracy and stability of discretization schemes; verification and validation; boundary and initial conditions; grid generation; CFD post-processing. Application of CFD software (ANSYS FLUENT) through five hands-on CFD Labs including internal viscous pipe flows, external flows over a 2D airfoil and a circular cylinder, and flows in a 2D driven cavity.

Prereqs: ENGR 335 and MATH 330

ME 451 Experimental Methods in Fluid Dynamics (3 credits)

Joint-listed with ME 551

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

ME 454 Assistive Technologies for Physical Impairment (3 credits)

Introduction to assistive and rehabilitative robotics research. Topics include but not limited to: normal and pathological function in the brain and body; exoskeleton robotics; human-machine-interfaces; and development of R&D technical skills culminating in a team design project. Additional project/assignment components required for graduate credit.

Prereqs: Junior Standing or Instructor Permission

ME 455 Biomechanics: Genome to Phenome (3 credits)

Joint-listed with ME 555

The course introduces students to the history and evolution of plant biomechanics with a specific focus on grass species and crops. A multiscale understanding of biomechanical structures and features will be presented. Students will learn appropriate testing methodologies to quantify material properties of plant tissue at multiple scales. Additional work required for graduate credit. Typically Offered: Fall (Odd Years).

Prereqs: Junior standing or instructor permission.

ME 458 Finite Element Applications in Engineering (3 credits)

Joint-listed with ME 558

The finite element method is an essential tool for the design and research activities performed in engineering companies and academic institutions. The goal of this course is to introduce students to the use of the finite element method by focusing on a range of engineering applications and employing an interactive commercial finite element code. Students will learn how to solve various problems from several mechanical engineering areas including solid mechanics, heat transfer and fluid mechanics. When available, analytical solutions will be compared with the finite element solutions for validation purposes. ME 558 is cooperative: open to WSU degree seeking students.

Prereqs: (ME 322 or ENGR 320) and ENGR 350

Coreqs: ME 341 or Instructor Permission

ME 461 Fatigue and Fracture Mechanics (3 credits)

Fracture mechanics approach to structural integrity, fracture control, transition temperature, microstructural and environmental effects, fatigue and failure analysis.

Prereqs: MSE 201 and ENGR 350

ME 464 Robotics: Kinematics, Dynamics, and Control (3 credits)

Mathematical analysis applied to spatial robotics including: Rigid body motion using screw theory, forward and inverse kinematics, analyses of forces and velocities using the manipulator Jacobian, serial and parallel chains, robot dynamics and simulation, nonlinear control and adaptive control, and Lyapunov stability theory. Additional projects/assignments required for graduate credit. Recommended Preparation is CS 120.

ME 472 Mechanical Vibrations (3 credits)

Free and forced vibration of single and multiple degree of freedom systems; response of mechanical systems to inputs of varying complexity, ranging from single frequency to pseudo-random; applications to mechanical design and vibration control. Cooperative: open to WSU degree-seeking students.

Prereqs: ENGR 220, MATH 310, and ME 313; or Graduate standing.

ME 480 Introduction to Programming for Engineers (3 credits)

This course will provide an introduction to the programming world. Topics covered include data types, functions, logic, conditionals, recursion, and sorting. More advanced topics are introduced, including classes, methods, and input/output. Programs are developed using modern languages (e. g. Python) and applications in engineering are explored (e. g. data acquisition, data analysis, computer vision, and artificial intelligence.)

ME 481 Control Systems (3 credits)

Cross-listed with ECE 470

Analysis and design of feedback control systems using frequency and time domain methods, and computer-aided design tools. Cooperative: open to WSU degree-seeking students.

Prereqs: MATH 330 Prereq for Electrical Engineering and Computer Engineering majors: ECE 350 Prereq for Mechanical Engineering majors: ME 313

ME 490 Solid Modeling, Simulation and Manufacturing Capstone (3 credits)

Use of solid modeling software focused on preparation for certification examinations, introduction to multi-physics numerical simulation, and computer aided manufacturing (CAM). A major final project is required. (Fall only)

Prereqs: Permission

ME 495 Mechanics in Design and Manufacturing (3 credits)

An examination of the mechanics of deformation, shaping, and forming of materials, and the manufacturing processes utilizing them. Discussion of the four main material classes, their properties and their applications. Topics include elasticity, plasticity, and continuous material flow, microstructural concerns, advanced material failure mechanisms, materials testing, and design for manufacture.

Prereqs: ME 341

ME 499 (s) Directed Study (1-16 credits)

Credit arranged Selected topics. Detailed report required.

Prereqs: Senior standing and Permission

ME 500 Master's Research and Thesis (1-16 credits)

Credit arranged

ME 501 (s) Seminar (1-16 credits)

Credit arranged

ME 502 (s) Directed Study (1-16 credits)

Credit arranged Supervised study, including critical reading of current literature.

Prereqs: Permission

ME 503 (s) Workshop (1-16 credits)

Credit arranged

ME 504 (s) Special Topics (1-16 credits)

Credit arranged

ME 505 (s) Professional Development (1-16 credits)

Credit arranged

ME 513 Engineering Acoustics (3 credits)

Cross-listed with ECE 579

Joint-listed with ME 413

Fundamentals of acoustics including wave theory; transmission through layers, generation and reception; low frequency models; application to sound measurement, transducers, loudspeaker cabinet design, and nondestructive testing; acoustic design project required. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree-seeking students.

Prereqs: ENGR 240 or ECE 212, and MATH 310, or ME 313

ME 514 HVAC Systems (3 credits)

Joint-listed with ME 414

Application of thermodynamics, heat transfer, and fluid flow to understanding the psychrometric performance of systems and equipment; evaluating the performance characteristics, advantages, and disadvantages of the various types of HVAC systems including large tonnage refrigeration/chiller equipment, cooling coils, cooling towers, ducts, fans, and heat pump systems; economics of system and equipment selection. Cooperative: open to WSU degree seeking students.

Prereqs: ME 345

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ME 520 Fluid Dynamics (3 credits)

Cross-listed with CE 520

Joint-listed with ME 420

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Other topics may be covered. Additional projects/assignments required for graduate credit.

Prereqs: ENGR 335, MATH 310, or Permission

ME 527 Thermodynamics (3 credits)

Thermodynamic laws for design and optimization of thermodynamic systems, equations of state, properties of ideal and real fluids and fluid mixtures, stability, phase equilibrium, chemical equilibrium, applications of thermodynamic principles. Cooperative: open to WSU degree-seeking students.

Prereqs: ME 322 or ENGR 320 or Permission

ME 529 Combustion and Air Pollution (3 credits)

Formation of pollutants during combustion processes and their subsequent transformations in the atmosphere; emphasis on the effects of design and operating parameters of combustion devices on the nature and composition of exhaust gases, improvements, post-combustion treatment of effluent gases, atmospheric chemistry, transport of pollutants, smog formation, acid rain, ozone formation and destruction.

Prereqs: ENGR 320 and ENGR 335, ME 345 or Permission

ME 538 Sustainability and Green Design (3 credits)

Joint-listed with ME 438

Understanding the Concept of Sustainability, Industrial Ecology and Sustainable Engineering, Metabolic Analysis, Sustainable Engineering, Design for Environment and Sustainability, Life Cycle Assessment, Energy & Water and Industrial Ecology, The status of Resources, Sustainable Engineering and Economics Development. Cooperative: open to WSU degree seeking students.

Prereqs: MATH 310

ME 539 Advanced Mechanics of Materials (3 credits)

Cross-listed with CE 510

Limitations of results of elementary mechanics of materials, complex situations of loading and structural geometry, applications to design of machines and structure, introduction to elasticity. Cooperative: open to WSU degree-seeking students.

Prereqs: ME 341 or CE 342

ME 540 Continuum Mechanics (3 credits)

Stress and deformation of continua using tensor analysis; relationship between stress, strain, and strain rates in fluids and solids; applications. Cooperative: open to WSU degree seeking students.

Prereqs: Permission

ME 541 Mechanical Engineering Analysis (3 credits)

Mathematical modeling and solutions to mechanical engineering problems; analytical solutions to linear heat and mass diffusion, waves and vibrations; introduction to approximate techniques. Cooperative: open to WSU degree-seeking students.

Prereqs: MATH 330 and MATH 310 or Equivalent

ME 544 Conduction Heat Transfer (3 credits)

Formulation of steady-state and transient one- and multi-dimensional heat conduction problems; analytical solution techniques for linear problems including separation of variables, integral transforms, and Laplace transforms.

Prereqs: ME 345 or equivalent, or Permission

ME 546 Convective Heat Transfer (3 credits)

Energy conservation equations; laminar and turbulent forced convective heat transfer; internal and external flow; free convection. Cooperative: open to WSU degree-seeking students.

Prereqs: ME 345 or Permission

ME 547 Thermal Radiation Processes (3 credits)

Thermal radiation; radiation interchange among surfaces; radiation in absorbing-emitting gases; combined modes of heat transfer.

Prereqs: ME 345 or Permission

ME 549 Finite Element Analysis (3 credits)

Cross-listed with CE 546

Formulation of theory from basic consideration of mechanics; applications to structural engineering, solid mechanics, soil and rock mechanics; fluid flow. Cooperative: open to WSU degree seeking students.

Prereqs: ME 341 or CE 342

ME 550 Advanced Computational Fluid Dynamics (3 credits)

Introduction to CFD OpenFoam and CFD techniques for heat transfer, free-surface flows, fluid-structure interactions, and dynamic mesh method. Application of CFD through hands-on CFD Labs including OpenFoam solutions to the five canonical flows studied in ME 450 and ANSYS Multiphysics or OpenFoam solutions to 2D wave generated by a submerged foil, heat transfer through a 2D insulated box, dynamic meshes for two cars crossing each other, and fluid-structure interaction simulation for a flapping membrane. Typically Offered: Spring (Odd Years).

Prereqs: ME 450. Cooperative: open to WSU degree-seeking students.

ME 551 Experimental Methods in Fluid Dynamics (3 credits)

Cross-listed with CE 550

, Joint-listed ME 450. Governing equations of fluid flow; fundamentals of turbulence modeling; accuracy and stability of discretization schemes; verification and validation; boundary and initial conditions; grid generation; CFD post-processing. Application of CFD software (ANSYS FLUENT) through five hands-on CFD Labs including internal viscous pipe flows, external flows over a 2D airfoil and a circular cylinder, and flows in a 2D driven cavity. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree seeking students.

Prereqs: ENGR 335 and MATH 330

ME 554 Assistive Technologies for Physical Impairment (3 credits)

Introduction to assistive and rehabilitative robotics research. Topics include but not limited to: normal and pathological function in the brain and body; exoskeleton robotics; human-machine-interfaces; and development of R&D technical skills culminating in a team design project. Additional project/assignment components required for graduate credit.

Prereqs: Junior Standing or Instructor Permission

ME 555 Biomechanics: Genome to Phenome (3 credits)

Joint-listed with ME 455

The course introduces students to the history and evolution of plant biomechanics with a specific focus on grass species and crops. A multiscale understanding of biomechanical structures and features will be presented. Students will learn appropriate testing methodologies to quantify material properties of plant tissue at multiple scales. Additional work required for graduate credit. Typically Offered: Fall (Odd Years).

ME 558 Finite Element Applications (3 credits)

Joint-listed with ME 458

The finite element method is an essential tool for the design and research activities performed in engineering companies and academic institutions. The goal of this course is to introduce students to the use of the finite element method by focusing on a range of engineering applications and employing an interactive commercial finite element code. Students will learn how to solve various problems from several mechanical engineering areas including solid mechanics, heat transfer and fluid mechanics. When available, analytical solutions will be compared with the finite element solutions for validation purposes. Cooperative: open to WSU degree seeking students (ME 558 only).

Prereqs: ME 322 (or ENGR 320) and ENGR 350

Coreqs: ME 341 or instructor permission

ME 564 Robotics: Kinematics, Dynamics, and Control (3 credits)

Mathematical analysis applied to spatial robotics including: Rigid body motion using screw theory, forward and inverse kinematics, analyses of forces and velocities using the manipulator Jacobian, serial and parallel chains, robot dynamics and simulation, nonlinear control and adaptive control, and Lyapunov stability theory. Additional projects/assignments required for graduate credit. Recommended Preparation is CS 120.

ME 571 Building Performance Simulation for Integrated Design (3 credits)

Cross-listed with ARCH 574

This course focuses on design decisions that impact energy, thermal, visual and acoustic comfort with a strong emphasis on building simulation tools. This course provides students with the understanding of the nature of building thermal comfort, building envelope behavior, ventilation requirements, indoor air quality, passive cooling systems, energy conservation, and the importance of iterative building simulation in achieving high performance buildings.

ME 583 Reliability of Engineering Systems (3 credits)

Cross-listed with CE 541

Fundamentals of reliability theory, system reliability analysis including common-mode failures and fault tree and event tree analysis, time-dependent reliability including testing and maintenance, propagation of uncertainty, human reliability analysis, practical applications in component and system design throughout the semester. Cooperative: open to WSU degree-seeking students.

Prereqs: Permission

ME 598 (s) Internship (1-16 credits)

Credits arranged

ME 599 (s) Non-thesis Master's Research (1-16 credits)

Credit arranged Research not directly related to a thesis or dissertation.

Prereqs: Permission

ME 600 Doctoral Research and Dissertation (1-45 credits)

Credit arranged