

Materials Science

Degree Offered	Materials Science PhD
Website	https://www.uab.edu/engineering/mse/graduate/tri-campus-phd-program
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PhD Program

UAB participates in the tri-campus Materials Science PhD program, an interdisciplinary, interdepartmental, and intercampus doctoral program linking the three universities that comprise the University of Alabama System—the University of Alabama (Tuscaloosa), the University of Alabama at Birmingham, and the University of Alabama in Huntsville. This program is separate from the PhD in Materials Engineering offered by UAB's Materials Science and Engineering department, providing flexibility for students who may wish to study materials science while based in another department.

Admission Requirements

In addition to the general Graduate School admission requirements, requirements for admission to the Materials Science PhD program include the following:

- A baccalaureate degree in materials, metallurgical, or ceramics engineering or in a similarly named engineering program. A student with an undergraduate degree in another field of engineering or in the sciences may also be accepted into the Materials Science program.
- An undergraduate GPA of 3.0 or better on a 4.0 scale on all degree major courses attempted
- CV/Résumé
- 3 recommendations from academic or professional contacts
- Original transcripts from all colleges and universities attended since high school must be sent directly to the UAB Graduate School (detailed instructions are included during the online application process)
- International applicants must submit English proficiency scores in accordance with UAB Graduate School requirement. [Click here for details](#)

Additional Academic Policies

Special Topics (590/690/790) courses and Independent Study (591/691/791) courses are reviewed for degree applicability for each program in the School of Engineering. No more than 6 combined hours of Special Topics and/or Independent Study courses will be applied to the PhD without appeal to and approval from the Program Director.

UAB offers similar courses at the 400/500 and 600/700 levels. While the higher numbered course has more advanced content, there is a significant overlap in topics. Therefore, students are not allowed to take a 500-level or 700-level course for credit if they have previously taken the related 400-level or 600-level course, respectively.

Coursework for Students with a BS

It is expected that students entering the PhD program with a BS degree will also earn a Plan II masters degree after completing the required coursework.

For a student entering with a BS degree from an undergraduate program in engineering or the physical sciences, a minimum of 72 credit hours of graduate credit are required according to the following guidelines:

- A minimum of 48 credit hours of approved graduate coursework related to materials science or a supportive field is required
 - No more than 15 hours may be at the 500 level; all remaining credits must be at the 700-level.
 - Because of the broad and interdisciplinary nature of Materials Science, there is no set list of required courses for all students. Students must take at least two courses in each of the three topic areas below (such that the course credits sum to at least 18 credits) within the first 24 months of enrollment. Students must take courses which address the three fundamental areas:
 - i. Structure and Properties of Materials (CE 750, CH 783, CH 784, MSE 724, MSE 729, MSE 733, MSE 735, MSE 736, PH 553, PH 554, PH 586, PH 587, PH 753, PH 754)
 - ii. Characterization and Testing (BME 535, CH 550, CH 774, MSE 533, MSE 728, MSE 770, PH 732, PH 733, PH 745)
 - iii. Thermodynamics and Processing (CH 525, CH 526, MSE 501, MSE 509, MSE 703, MSE 767, MSE 768, PH 510, PH 532, PH 533, PH 635, PH 715, PH 716).
 - At least 6 credit hours must be taken outside the student's home department. This is to ensure that the student achieves an understanding of the multi-disciplinary nature of materials science and must be completed prior to the PhD Dissertation Proposal Examination.
 - Full-time students must register for seminar either in their home department or the MSE department a minimum of 4 terms.
 - GRD 717 Principles of Scientific Integrity is required for all UAB graduate students and can be counted toward the coursework requirement.
 - A student may apply 6 credit hours of non-dissertation research toward the coursework requirement.
 - Additional coursework may be required at the discretion of the dissertation committee.
- A minimum of 24 credit hours in MSE 799 Dissertation Research dissertation research after admission to candidacy.

Coursework for Students with an MS

Students entering with a master's degree in Materials Science or a closely related field are required to successfully complete a minimum of 51 credit hours of graduate credit according to the following guidelines:

- A minimum of 27 credit hours of approved graduate coursework related to materials science or a supportive field is required
 - No more than 6 hours may be at the 500 level; all remaining credits must be at the 700-level.
 - Because of the broad and interdisciplinary nature of Materials Science, there is no set list of required courses for all students. Students must take at least two courses in each of the three topic areas below (such that the course credits sum to at least 18 credits) within the first 24 months of enrollment. Students must take courses which address the three fundamental areas:

- a. Structure and Properties of Materials (CE 750, CH 783, CH 784, MSE 724, MSE 729, MSE 733, MSE 735, MSE 736, PH 553, PH 554, PH 586, PH 587, PH 753, PH 754)
 - b. Characterization and Testing (BME 535, CH 550, CH 774, MSE 533, MSE 728, MSE 770, PH 732, PH 733, PH 745)
 - c. Thermodynamics and Processing (CH 525, CH 526, MSE 501, MSE 509, MSE 703, MSE 767, MSE 768, PH 510, PH 532, PH 533, PH 635, PH 715, PH 716).
- At least 6 credit hours must be taken outside the student's home department. This is to ensure that the student achieves an understanding of the multi-disciplinary nature of materials science and must be completed prior to the PhD Dissertation Proposal Examination.
 - Full-time students must register for seminar either in their home department or the MSE department a minimum of 4 terms
 - GRD 717 Principles of Scientific Integrity is required for all UAB graduate students and can be counted toward the coursework requirement.
 - A student may apply 6 credit hours of non-dissertation research toward the coursework requirement.
 - Additional coursework may be required at the discretion of the dissertation committee.
 - A minimum of 24 credit hours in MSE 799 Dissertation Research dissertation research after admission to candidacy.

Graduation Requirements

In addition to completing coursework requirements (above), doctoral students must form a Graduate Dissertation Committee consisting of at least five faculty members, the majority of which should be Materials Science faculty. At least one member must be Materials Science faculty from the University of Alabama (Tuscaloosa) or University of Alabama in Huntsville. Admission to candidacy must take place at least two semesters before the student may graduate. A student is eligible for admission to candidacy after successfully completing the following:

1. A written examination on topics related to the student's research
2. An oral dissertation proposal
3. A written dissertation proposal (following the NSF Proposal Preparation and Submission Guidelines),
4. Completion of GRD 717 Principles of Scientific Integrity.

A written dissertation embodying the results of the student's original research must then be publicly defended, approved by the committee, sent to a department-approved proofreader, and submitted to the Graduate School with edits incorporated.

Courses

MSE 501. Materials Processing. 3 Hours.

Processing of metals, glasses, ceramics, and composites. Powder, casting, welding, rapid solidification, and other advanced approaches.

MSE 505. Frontiers of Automotive Materials. 3 Hours.

Advanced lightweight automotive materials, manufacturing and modeling techniques. Technology advancements in cost-effective carbon, glass and related reinforcements; "green" and sustainable materials, crashworthiness and injury protection of occupants and pedestrians, metal castings, heavy truck, mass transit, fuel cell and hybrid vehicles. Students taking this class will receive a GATE certificate of training in automotive materials technologies upon successful completion.

MSE 508. Nanobiomaterials. 3 Hours.

Basic tools of nanotechnology, building blocks of nanostructured materials. Behavior of materials with nanoscale structures and their technological applications, including automotive, medical, and electronic applications. Introduction to biomaterials and nanobiomaterials, nanotoxicity and how to work safely with nanomaterials. Concepts in tissue engineering with special focus on nanoscaffolds and nanoparticles in drug delivery.

MSE 509. Principles of Metal Casting. 3 Hours.

Production and evaluation of cast ferrous metals (gray iron, ductile iron, steel) and non-ferrous metals (brass, bronze, aluminum). Design of castings and molds. Laboratory on the gating, risering and molten metal treatment, analysis and handling techniques required to produce high quality castings. It is recommended that students who register for this course have successfully completed MSE 280 Engineering Materials or an equivalent course.

MSE 509L. Principles of Metal Casting. 0 Hours.

Laboratory component of MSE 509 and must be taken concurrently.

MSE 513. Composite Materials. 3 Hours.

Processing, structure, and properties of metal-, ceramic-, and polymer-matrix composite materials. Roles of interfacial bond strength, reinforcement type and orientation and matrix selection in physical and mechanical properties of composite materials.

MSE 525. Statistics and Quality. 3 Hours.

This course is arranged to reflect the sequential steps an engineer or scientist take to assess process capability and implement process improvement studies. There is a focus on connecting the theoretical equations to practical examples as well as interpreting and communicating of statistical results.

MSE 530. Polymeric Materials. 3 Hours.

Processing methods, structure/engineering/property relationships, and applications of polymeric materials.

MSE 530L. Polymeric Materials Lab. 0 Hours.

Laboratory component of MSE 530 and must be taken concurrently.

MSE 533. Nondestructive Evaluation of Materials. 3 Hours.

Principles, applications, and limitations of ultrasonic vibrations, acoustic emission, radiographic, magnetic particle, eddy current, and other nondestructive testing methods. Intelligent sensors and health monitoring of real structures.

MSE 545. The Evolution of Engineering Materials. 3 Hours.

Past, present and future of engineering materials; how new materials and processing methods have impacted human society, from the Stone Age until today. Taught as a 3-week study abroad course in Germany, with visits to universities, industrial facilities, research labs, museums and selected cultural sites.

MSE 562. Composites Manufacturing. 3 Hours.

Principles of manufacturing and processing of polymeric matrix composites. Production techniques including filament winding, pultrusion, and liquid infusion techniques combined with design, environmental and manufacturing issues of polymer matrix composites.

MSE 564. Metals and Alloys. 4 Hours.

Microstructures, properties, heat treatment, and processing of ferrous and nonferrous materials.

MSE 564L. Metals and Alloys Lab. 0 Hours.

Laboratory component of [MSE 564](#) and must be taken concurrently.

MSE 565. Characterization of Materials. 4 Hours.

Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 565L. Characterization of Materials Laboratory. 0 Hours.

Laboratory component of [MSE 565](#) and must be taken concurrently with [MSE 565](#).

MSE 570. Ceramic Materials. 4 Hours.

Structure, processing, properties, and uses of ceramic compounds and glasses. Mechanical, thermal, and electrical behavior of ceramic materials in terms of microstructure and processing variables.

MSE 570L. Ceramic Materials Laboratory. 0 Hours.

Laboratory component of [MSE 570](#) and must be taken concurrently.

MSE 574. Metals and Alloys II. 3 Hours.

Production and physical metallurgy of ferrous and non-ferrous alloys including: steel alloys, inoculation and production of ductile, gray, compacted and malleable iron; advanced heat treatments of steel and iron; conventional and ultra-high strength aluminum alloys; wrought and cast copper alloys; wrought and cast magnesium alloys.

MSE 590. Special Topics in Materials Science & Engineering. 1-3 Hour.

Special Topics in Materials Science & Engineering.

MSE 591. Individual Study in Materials Science & Engineering. 1-6 Hour.

Individual Study in Materials Science & Engineering.

MSE 601. Materials Science and Engineering Seminar. 0 Hours.

Seminar focusing on student research and guest presentations of various topics of interest to materials students.

MSE 602. Intro to Thermodynamics and Mechanics of Materials. 3 Hours.

This course is a survey of undergraduate level theory and application of the fundamental principles of mechanics of materials and thermodynamics. Understanding is based on the explanation of the physical behavior of materials under load and then modeling this behavior to develop the theory. Intended to provide the students with both the theory and application of the fundamental principles of thermodynamics of materials. Students must be graduate student in engineering, chemistry or physics.

MSE 603. Thermodynamics of Materials. 3 Hours.

Atomistic and classical approaches to the understanding of the thermodynamics of solids, phase transformations, chemical reactions, and alloy systems.

MSE 605. Introduction to Physical Materials. 3 Hours.

Overview of fundamental concepts of materials science and engineering, focusing on chemical and physical properties such as bonding, crystal structure and defects, diffusion, and phase diagrams.

MSE 606. Introduction to Manufacturing Engineering. 3 Hours.

Manufacturing is the process of transforming raw materials into products. Even the most optimized and controlled industrial processes are fraught with variability and inefficiencies, both of which can have a negative impact on profitability. This course will introduce students to the proven tools to characterize and optimize industrial processes. In addition, students will learn the statistical techniques to quantitatively assess and detect changes to a process and make data-driven decisions to improve that process.

MSE 607. Measurement Systems Analysis. 3 Hours.

Whether in a manufacturing process, research & development lab or quality control, assessment and analysis of data used for decision making has roots in the equipment and procedures that make up a measurement system. Students will learn to critically assess the capability of measurements systems, gauges and analytical equipment used to collect data. Students will learn metrology, best practices, and statistical tools to quantitatively assess, as well as procedures to implement a Gage R&R study to improve a measurement system. In addition, students will learn effective communication strategies for presenting the results of statistical analysis.

MSE 608. Process Characterization and Advanced Statistical Analysis. 3 Hours.

This course centers on manufacturing processes and the inherent variability of all products. Product variability has origins at all input points in a process; raw materials, energy, time, human, etc. This course will expose engineers to the statistics to quantify and assess variability. In addition to statistical tools, we will delve deep into all phases of the DMAIC (Define, Measure, Analysis, Improve, and Control) methodology and the Lean/Six Sigma tools to identify, implement and document process improvements. An emphasis will be placed on the communication of these often-complicated statistics in an industrial setting. We will put these concepts into practice through completion of a final term paper. Students will be required to choose an industrial process and apply and communicate the concepts learned in this course.

MSE 610. Advanced Materials, Manufacturing and Applications Development. 3 Hours.

Introduction to advanced materials by design, near net-shape cost-effective manufacturing, synergistic knowledge of material properties, durability and function. Hands on activities related to extrusion-compression, fiber spinning, thermoset/thermoplastic materials, medical grade materials, intermediate forms and hybrid manufacturing. Integrated process and product development methodology. Student projects will involve manufacturing processes associated with mass production.

MSE 613. Mechanical Behavior of Materials. 3 Hours.

Microstructural effects on the deformation mechanisms responsible for mechanical behavior of engineering materials.

MSE 614. Process Quality Engineering. 3 Hours.

Application of the concepts and tools of total quality to develop, implement, and maintain an effective quality assurance system in a materials processing and manufacturing environment. Students will be exposed to probability models, statistical tools, linear and multiple regression, DOE, TQM and six sigma.

MSE 624. Physical Metallurgy. 3 Hours.

Course will consider the fundamental thermodynamic and kinetic principles governing the behavior of metals and alloys, particularly with respect to their influence the formation and evolution of microstructure. Topics will include liquid-solid and solid-state phase transformations, nucleation, growth, solidification and diffusion.

MSE 628. Thermal Characterization. 3 Hours.

This lab-oriented course will be focused to give graduate students the theory and hands-on experience in operation, data acquisition and interpretation of widely used thermal characterization techniques such as differential scanning calorimeter (DSC), thermo gravimetric analyzer (TGA), Simultaneous TGA-DTA, Thermo mechanical analyzer (TMA), Dynamic mechanical analyzer (DMA) and rheological and viscosity analyses of polymeric resins and composite materials. Exposure to the surface characterizations techniques such as contact angle goniometer for wettability, Fourier Transform infrared spectrometer (FT-IR).

MSE 628L. Thermal Characterization Lab. 0 Hours.

Laboratory component of [MSE 628](#) and must be taken concurrently.

MSE 629. Polymer Structure and Morphology. 3 Hours.

Polymer structures and morphology and its relationships with applications, multicomponent polymer systems (polymer blends, copolymers, micro and nanocomposites), liquid crystalline polymers, polymer crystals, oriented polymers, morphological aspects of deformation and advances in polymers (biomimetic and bioinspired polymer systems).

MSE 633. Advanced Mechanics of Deformation. 3 Hours.

Basics and intermediate mechanics of deflection of beams and columns, mechanics of impact, failure theories, plastic deformation of materials, fracture mechanics, fatigue, creep and vibration. The topics will be supported by industry relevant case studies. Suggested prerequisites included Mechanics of Solids ([CE 220](#)) and Mechanical Behavior ([MSE 382](#)).

MSE 635. Advanced Mechanics of Composites. 3 Hours.

Classical lamination theory, analysis and failure of reinforced composite material systems, anisotropic elasticity, stress analysis and design of laminated composites including 3D effects, stress concentrations, free-edge effects, hygrothermal behavior, adhesive and mechanical connections.

MSE 636. Engineering Fibers. 3 Hours.

Processing-microstructure-properties of different fibrous materials: natural polymeric fibers (jute, sisal, silk, etc.), synthetic polymeric fibers (aramid and polyethylene, etc.), metallic fibers, and high performance ceramic fibers (alumina and silicon carbide). Application of Weibull statistics to strength of fibrous materials, techniques of mechanical testing of fibers and applications of fibers in various fields.

MSE 638. Degradation of Materials. 3 Hours.

Basics of materials degradation- thermodynamics and kinetics - Pourbaix diagram, chemical and electrochemical reactions; Degradation types and mechanisms; Degradation of different material systems: Metals, alloys, ceramics and glasses, polymers and composites for versatile applications- structural, functional, energy and biomedical; Impact on materials properties; Investigation for materials degradation; Protection from degradation and materials design; Environmental and biological aspects; Societal impact.

MSE 667. Process Modeling/Simulation. 3 Hours.

Theory and practice of analytical methods and computational modeling for manufacturing processes of metals, ceramics, polymers and composites. Applications on processes such as metal cutting, welding, casting, massive forming, solidification, rapid prototyping, injection molding and resin transfer molding.

MSE 668. Applied Finite Element Analysis. 3 Hours.

Finite Element Analysis (FEA) is used widely for design optimization and failure prediction in automobile, energy, aerospace, and other industries. This course primarily looks at how practically to set up static structural models and get meaningful results. The focus will be on applying loading and boundary conditions, good meshes, convergence of results, and correct interpretation of results. Students will learn how to set up models using programs such as Pro/Engineer and ANSYS.

MSE 670. Physical Characterization. 3 Hours.

Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 670L. Physical Characterization Lab. 0 Hours.

Laboratory component of [MSE 670](#) and must be taken concurrently.

MSE 690. Special Topics In (Area). 1-6 Hour.

Special Topics in (Area).

MSE 690L. Special Topics in (Area) Laboratory. 0 Hours.

Special Topics in (Area) laboratory.

MSE 691. Individual Study in (Area). 1-6 Hour.

Individual Study in (Area).

MSE 698. Non-Thesis Research. 1-12 Hour.**MSE 699. Thesis Research. 1-12 Hour.**

Prerequisites: GAC M

MSE 701. Materials Science and Engineering Seminar. 0 Hours.

Seminar focusing on student research and guest presentations of various topics of interest to materials students.

MSE 702. Intro to Thermodynamics and Mechanics of Materials. 3 Hours.

This course is a survey of undergraduate level theory and application of the fundamental principles of mechanics of materials and thermodynamics. Understanding is based on the explanation of the physical behavior of materials under load and then modeling this behavior to develop the theory. Intended to provide the students with both the theory and application of the fundamental principles of thermodynamics of materials. Students must be graduate student in engineering, chemistry or physics.

MSE 703. Thermodynamics of Materials. 3 Hours.

Atomistic and classical approaches to the understanding of the thermodynamics of solids, phase transformations, chemical reactions, and alloy systems.

MSE 705. Introduction to Physical Materials. 3 Hours.

Overview of fundamental concepts of materials science and engineering, focusing on chemical and physical properties such as bonding, crystal structure and defects, diffusion, and phase diagrams.

MSE 710. Advanced Materials, Manufacturing and Applications Development. 3 Hours.

Introduction to advanced materials by design, near net-shape cost-effective manufacturing, synergistic knowledge of material properties, durability and function. Hands on activities related to extrusion-compression, fiber spinning, thermoset/thermoplastic materials, medical grade materials, intermediate forms and hybrid manufacturing. Integrated process and product development methodology. Student projects will involve manufacturing processes associated with mass production.

MSE 714. Process Quality Engineering. 3 Hours.

Application of the concepts and tools of total quality to develop, implement, and maintain an effective quality assurance system in a materials processing and manufacturing environment. Students will be exposed to probability models, statistical tools, linear and multiple regression, DOE, TQM and six sigma.

MSE 724. Physical Metallurgy. 3 Hours.

Course will consider the fundamental thermodynamic and kinetic principles governing the behavior of metals and alloys, particularly with respect to their influence the formation and evolution of microstructure. Topics will include liquid-solid and solid-state phase transformations, nucleation, growth, solidification and diffusion.

MSE 728. Thermal Characterization. 3 Hours.

This lab-oriented course will be focused to give graduate students the theory and hands-on experience in operation, data acquisition and interpretation of widely used thermal characterization techniques such as differential scanning calorimeter (DSC), thermo gravimetric analyzer (TGA) , Simultaneous TGA-DTA, Thermo mechanical analyzer (TMA), Dynamic mechanic analyzer (DMA) and rheological and viscosity analyses of polymeric resins and composite materials. Exposure to the surface characterizations techniques such as contact angle goniometer for wettability, and Fourier Transform infrared spectrometer (FT-IR).

MSE 728L. Thermal Characterization Lab. 0 Hours.

Laboratory component of [MSE 728](#) and must be taken concurrently.

MSE 729. Polymer Structure and Morphology. 3 Hours.

Polymer structures and morphology and it's relationships with applications, multicomponent polymer systems (polymer blends, copolymers, micro and nanocomposites), liquid crystalline polymers, polymer crystals, oriented polymers, morphological aspects of deformation and advances in polymers (biomimetic and bioinspired polymer systems).

MSE 733. Advanced Mechanics of Deformation. 3 Hours.

Basics and intermediate mechanics of deflection of beams and columns, mechanics of impact, failure theories, plastic deformation of materials, fracture mechanics, fatigue, creep and vibration. The topics will be supported by industry relevant case studies. Suggested prerequisites included Mechanics of Solids ([CE 220](#)) and Mechanical Behavior ([MSE 382](#)).

MSE 735. Advanced Mechanics of Composites. 3 Hours.

Classical lamination theory, analysis and failure of reinforced composite material systems, anisotropic elasticity, stress analysis and design of laminated composites including 3D effects, stress concentrations, free-edge effects, hygrothermal behavior, adhesive and mechanical connections.

MSE 736. Engineering Fibers. 3 Hours.

Processing-microstructure-properties of different fibrous materials: natural polymeric fibers (jute, sisal, silk, etc.) synthetic polymeric fibers (aramid and polyethylene, etc.), metallic fibers, and high performance ceramic fibers (alumina and silicon carbide). Application of Weibull statistics to strength of fibrous materials, techniques of mechanical testing of fibers and applications of fibers in various fields.

MSE 738. Degradation of Materials. 3 Hours.

Basics of materials degradation- thermodynamics and kinetics - Pourbaix diagram, chemical and electrochemical reactions; Degradation types and mechanisms; Degradation of different material systems: Metals, alloys, ceramics and glasses, polymers and composites for versatile applications- structural, functional, energy and biomedical; Impact on materials properties; Investigation for materials degradation; Protection from degradation and materials design; Environmental and biological aspects; Societal impact.

MSE 767. Process Modeling/Simulation. 3 Hours.

Theory and practice of analytical methods and computation modeling for manufacturing processes of metals, ceramics, polymers and composites. Applications on processes such as metal cutting, welding, casting, massive forming, solidification, rapid prototyping, injection molding, and resin transfer molding.

MSE 768. Applied Finite Element Analysis. 3 Hours.

Finite Element Analysis (FEA) is used widely for design optimization and failure prediction in automobile, energy, aerospace, and other industries. This course primarily looks at how practically to set up static structural models and get meaningful results. The focus will be on applying loading and boundary conditions, material properties, meshing, convergence, and correct interpretation of results. Students will learn how to set up models using programs such as Solidworks and ANSYS.

MSE 770. Physical Characterization. 3 Hours.

Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 770L. Physical Characterization Lab. 0 Hours.

Laboratory component of [MSE 770](#) and must be taken concurrently.

MSE 790. Special Topics in (Area). 1-6 Hour.

Special Topics In (Area).

MSE 790L. Special Topics in (Area) Laboratory. 0 Hours.

Special Topics in (Area) Laboratory.

MSE 791. Individual Study in (Area). 1-6 Hour.

Individual Study in (Area).

MSE 798. Non-Dissertation Research. 1-12 Hour.**MSE 799. Dissertation Research. 1-12 Hour.**

Prerequisites: GAC Z