

# ENGINEERING MECHANICS AND AEROSPACE ENGINEERING (E M A)

## E M A 1 – COOPERATIVE EDUCATION PROGRAM

1 credit.

Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career in industry.

**Requisites:** Sophomore standing only

**Course Designation:** Workplace - Workplace Experience Course

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work

Audience: Undergraduate

2. Synthesize and apply appropriate technical education to real world technical work

Audience: Undergraduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise

Audience: Undergraduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information

Audience: Undergraduate

## E M A 105 – INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS

3 credits.

Prepares students to operate Unmanned Aircraft Systems (UAS) for commercial purposes. Focuses on remote sensing, automation / artificial intelligence, data analytics and business applications / opportunities for UAS. Teaches all applicable subjects and provides hands-on experience necessary to 1) safely, legally and ethically operate UAS for commercial purposes; 2) effectively apply UAS to solve business problems and 3) manage, process and analyze data collected via UAS. Optional Federal Aviation Administration exam for a remote pilot-in-command (RPIC) certification. Group projects involving real-world drone flights to collect data and produce commercially viable products.

**Requisites:** None

**Repeatable for Credit:** No

**Learning Outcomes:** 1. Recall the following topics: UAS structure, remote sensing, automation, artificial intelligence and performance; UAS data management, processing and analytics; UAS regulations, airspace, flight planning and weather; and UAS business types, markets and opportunities

Audience: Undergraduate

2. Gain experience managing UAS-related projects to solve real-world business problems

Audience: Undergraduate

3. Apply photogrammetry techniques to process drone imagery into geo-rectified 3D models

Audience: Undergraduate

4. Apply different sensors such as visible imagery cameras, thermal cameras, multi-spectral cameras and lidar sensors to solve various engineering / business problems

Audience: Undergraduate

**E M A 200 – INTRODUCTION TO AEROSPACE ENGINEERING**

3 credits.

An introduction to the fields of aerospace engineering and mechanics. Fundamental concepts in engineering, including modeling, analysis, design, fabrication and experimental testing. Career paths, engineering ethics, shop safety, and oral and written technical communication.

**Requisites:** (Concurrent enrollment in MATH 113), MATH 114, 217, 221, or placement into MATH 221

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Use the COE makerspace and shop for prototype fabrication and as needed in future coursework

Audience: Undergraduate

2. Utilize the fundamentals of the engineering design process and apply them in a laboratory setting

Audience: Undergraduate

3. Implement individual learning and cooperative teamwork skills through independent research and collaborative problem solving

Audience: Undergraduate

4. Utilize technical written and oral communication skills including making plots and formatting figures, creating parts and technical drawings, and writing concisely and clearly to communicate ideas

Audience: Undergraduate

5. Utilize engineering software that is required in upper-level engineering courses

Audience: Undergraduate

**E M A 201 – STATICS**

3 credits.

Principles of mechanics, force systems, equilibrium, structures, distributed forces, moments of inertia of areas, and friction.

**Requisites:** (MATH 222 or concurrent enrollment) or member of Engineering Guest Students

**Course Designation:** Breadth – Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit – Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Interpret a given engineering schematic in the context of equilibrium

Audience: Undergraduate

2. Determine the need for free body diagram(s) or appropriate sketch(es)

Audience: Undergraduate

3. Draw the free body diagram(s) with appropriate annotations

Audience: Undergraduate

4. Generate the governing equations informed by the free body diagram(s)

Audience: Undergraduate

5. Solve the governing equations

Audience: Undergraduate

6. Critically review results to ensure answers are realistic

Audience: Undergraduate

**E M A 202 – DYNAMICS**

3 credits.

Kinematics, force-mass-acceleration relations, work and energy, impulse and momentum, moments of inertia and mass.

**Requisites:** E M A 201 or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Derive kinematic relationships among position, velocity and acceleration for systems of particles and rigid bodies  
Audience: Undergraduate

2. Apply and solve Newton-Euler equations to analyze the motion of systems of particles and rigid bodies  
Audience: Undergraduate

3. Apply and solve work-energy equations to analyze the motion of systems of particles and rigid bodies  
Audience: Undergraduate

4. Apply and solve momentum equations to analyze the motion of systems of particles and rigid bodies  
Audience: Undergraduate

**E M A 303 – MECHANICS OF MATERIALS**

3 credits.

Stress and strain, torsion, bending of beams, shearing stresses in beams, compound stresses, principal stresses, deflections of beams, statically indeterminate members, columns. For civil engineers.

**Requisites:** E M A 201 and MATH 222, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Compute stresses, strains, and deformations for structures experiencing tension, compression, torsion, bending, and thermal loads  
Audience: Undergraduate

2. Combine analyses for different types of loading  
Audience: Undergraduate

3. Analyze engineering structures for failure by yield and buckling  
Audience: Undergraduate

**E M A/M E 307 – MECHANICS OF MATERIALS LAB**

1 credit.

Data processing, tension/compression tests, creep stress concentrations, fatigue, fracture, composite materials, combined stress, beam flexure, dynamic loads, buckling.

**Requisites:** (M E 306, E M A 303 or concurrent enrollment) or member of Engineering Guest Students

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Perform a tensile test  
Audience: Undergraduate

2. Calculate material properties from tensile test data  
Audience: Undergraduate

3. Compare experimentally determined values to theoretical values  
Audience: Undergraduate

4. Plot experimental data in an efficient and effective manner  
Audience: Undergraduate

5. Identify sources of error and uncertainty in mechanical tests  
Audience: Undergraduate

**E M A/CIV ENGR 395 – MATERIALS FOR CONSTRUCTED FACILITIES**

3 credits.

Properties and tests of materials used in the initial construction or repair of facilities (including buildings, transportation systems, utility systems, and reinforced earth). Introduction to laboratory and field measurement techniques to assess material performance capabilities. Technical report preparation.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Use knowledge of construction materials behavior to select and specify materials for construction of civil engineering facilities

Audience: Undergraduate

2. Use knowledge of construction materials behavior to monitor construction of civil engineering facilities

Audience: Undergraduate

3. Conduct experiments with standardized testing protocols, interpret test results, and communicate results and interpretation in technical reports

Audience: Undergraduate

4. Design and conduct forensic studies to determine the role of material properties or construction methods in facility failures

Audience: Undergraduate

5. Use teamwork and communication skills relevant to the selection, specification, monitoring, and testing of construction materials

Audience: Undergraduate

**E M A 405 – PRACTICUM IN FINITE ELEMENTS**

3 credits.

Use of finite elements (FE) for solving practical problems in mechanics. Elementary theory of FE is discussed. A commercial computer program is used for applications. Major emphasis is on behavior of FE, modeling, and evaluation of results for correctness.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Identify the nature of an engineering problem and devise a simplified model that estimates expected behavior

Audience: Undergraduate

2. Perform various types of finite element analyses such as static structural, thermal, modal, harmonic, transient, random vibration, nonlinear materials, nonlinear contact, and buckling analyses

Audience: Undergraduate

3. Qualitatively and quantitatively verify the results using visual observations, a variety of simplified calculations, preliminary analysis, tabulated results, and numerical techniques

Audience: Undergraduate

4. Prepare and present informative reports on finite element modeling results

Audience: Undergraduate

**E M A 421 – AERODYNAMICS**

3 credits.

Potential flow theory; stream functions; vortex filaments and sheets.

Two- and three-dimensional wing theory. Doublet and panels methods.

Propeller theory. Was E M A 521 prior to Fall 2026.

**Requisites:** MATH 321, (E M A 202, M E 240, or PHYSICS 311), and (CIV ENGR 310 or M E 363), or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Solve potential flow problems in the context of aerodynamics

Audience: Undergraduate

2. Model and solve for the potential flow over airfoils using two-dimensional panel methods

Audience: Undergraduate

3. Analyze the performance characteristics of two- and three-dimensional lifting surfaces, including interpreting data and computing lift and drag polars

Audience: Undergraduate

4. Solve aerodynamics problems and interpret solutions using the appropriate non-dimensional parameters

Audience: Undergraduate

**E M A/M E 458 – INTRODUCTION TO FEEDBACK CONTROL OF AUTONOMOUS SYSTEMS**

3 credits.

Feedback control theory fundamentals; numerical optimal control algorithms underpinning autonomous systems; quadcopter kinematics dynamics; quadcopter control and trajectory planning; hands-on labs on a nano quadcopter platform.

**Requisites:** M E 340, E C E 332, 334, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Express a dynamic system into its state space form and determine its linearized model around a given operating point

Audience: Both Grad & Undergrad

2. Use Lyapunov direct and indirect methods to determine the stability of nonlinear systems

Audience: Both Grad & Undergrad

3. Explain and assess controllability, observability, and stability of linear systems

Audience: Both Grad & Undergrad

4. Solve general optimal control problems using off-the-shelf numerical software

Audience: Both Grad & Undergrad

5. Solve linear quadratic problems using linear quadratic regulator

Audience: Both Grad & Undergrad

6. Apply differential flatness for quadcopter trajectory generation, and design linear tracking controllers for quadcopters

Audience: Both Grad & Undergrad

7. Apply the maximum principle to find the optimal solution of an unconstrained optimal control problem

Audience: Graduate

**E M A 469 – DESIGN PROBLEMS IN ENGINEERING**

3 credits.

The design philosophy is presented. Students will be required to apply their knowledge of elementary mechanics, engineering and basic science to arrive at acceptable solutions to a variety of design problems.

**Requisites:** Declared in Engineering Mechanics and (E M A 303 or M E 306)

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Navigate the mechanical design process through a group design project to include defining the problem, generating concepts, analyzing the design, and defining the manufacturing methods  
Audience: Undergraduate

2. Apply fundamentals from their Engineering Mechanics coursework to analyze, guide, and modify their designs  
Audience: Undergraduate

3. Gain proficiency in Computer Aided Drafting software and a familiarity with tools in the machine shop  
Audience: Undergraduate

4. Demonstrate a professional level of communication (written, graphical/drawing and verbal) and presentation skills with clients, instructors, and peers  
Audience: Undergraduate

**E M A/E P 471 – INTERMEDIATE PROBLEM SOLVING FOR ENGINEERS**

3 credits.

Use of computational tools for the solution of problems encountered in engineering physics applications. Topics covered include orbital mechanics, structural vibrations, beam and plate deformations, heat transfer, neutron diffusion, and criticality. Emphasis will be on modeling, choice of appropriate algorithms, and model validation.

**Requisites:** (E P 271 or COMP SCI 220) and (MATH 319, 320, 376 or concurrent enrollment), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Numerically solve systems of ordinary differential equations (ODEs)  
Audience: Undergraduate

2. Numerically solve 1-D boundary value problems  
Audience: Undergraduate

3. Numerically solve eigenvalue problems  
Audience: Undergraduate

4. Apply the basic techniques of Monte Carlo methods  
Audience: Undergraduate

5. Apply the basic techniques of numerically solving partial differential equations (PDEs)  
Audience: Undergraduate

6. Apply techniques from outcomes 1-5 to multi-step engineering problems  
Audience: Undergraduate

**E M A/M E 488 – HONORS IN RESEARCH I**

3 credits.

Independent work in aerospace engineering, engineering mechanics, or mechanical engineering, supervised by a qualified instructor.

**Requisites:** Consent of instructor

**Course Designation:** Honors - Honors Only Courses (H)

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Conduct independent mechanical engineering, aerospace engineering, or engineering mechanics research under the guidance of a qualified instructor  
Audience: Undergraduate

2. Independently develop researchable mechanical engineering, aerospace engineering, or engineering mechanics questions  
Audience: Undergraduate

3. Appropriately utilize online and library resources  
Audience: Undergraduate

**E M A 489 – HONORS IN RESEARCH**

1-3 credits.

Undergraduate research and senior honors thesis in engineering mechanics and astronautics.

**Requisites:** Declared in Engineering Mechanics Honors in Research

**Course Designation:** Honors - Honors Only Courses (H)

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Apply basic physical and mathematical principles to engineering research problems

Audience: Undergraduate

2. Apply basic mechanics principles to engineering research problems

Audience: Undergraduate

3. Communicate technical concepts to a diverse audience via verbal or written media

Audience: Undergraduate

**E M A 506 – ADVANCED MECHANICS OF MATERIALS I**

3 credits.

Analysis and design of load-carrying members, shear center, unsymmetrical bending, curved beams, beams on elastic foundations, energy methods, theories of failure, thick-walled cylinders, stress concentrations, design to prevent failure by excessive elastic deformation, plastic deformation and fracture.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Idealize and analyze practical problems in solid mechanics, complicated by geometric and material complexity

Audience: Undergraduate

2. Identify the assumptions required to solve a solid mechanics problem and judge whether those assumptions are reasonable

Audience: Undergraduate

3. Recognize the potential for structural and material failure and apply theories of failure appropriately for analysis and design

Audience: Undergraduate

**E M A/CIV ENGR/M E 508 – COMPOSITE MATERIALS**

3 credits.

Physical properties and mechanical behavior of polymer, metal, ceramic, cementitious, cellulosic and biological composite systems; micro- and macro-mechanics; lamination and strength analyses; static and transient loading; fabrication; recycling; design; analytical-experimental correlation; applications.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. List the different types of composite materials and describe their manufacturing processes

Audience: Both Grad & Undergrad

2. Describe the mechanical behavior of various composite materials under different types of loading conditions

Audience: Both Grad & Undergrad

3. Derive mathematical models and solve them for engineering stresses and deformations in a composite structure

Audience: Both Grad & Undergrad

4. Describe special theories for heterogeneous and non-isotropic materials and solve boundary value problems associated with composite structures

Audience: Both Grad & Undergrad

5. Use the knowledge acquired in this class to design and conduct a complex analysis, design, and/or experiment to address key challenges relevant to composite materials

Audience: Graduate

### **E M A 519 – FRACTURE MECHANICS**

3 credits.

Introduction to the mechanics of fracture of linear and nonlinear materials. Crack stress and deformation fields; stress intensity factors; crack tip plastic zone; fracture toughness testing; energy release rate; J-integral. Criteria for crack growth initiation/stability; application to design.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2025

**Learning Outcomes:** 1. Describe mechanisms for initiation and growth of flaws in materials

Audience: Both Grad & Undergrad

2. Derive the fields of stresses, strains, and displacements near a crack

Audience: Both Grad & Undergrad

3. Predict crack growth using concepts of energy release rate and stress intensity factors

Audience: Both Grad & Undergrad

4. Analyze the effects of plasticity and nonlinearity on crack propagation

Audience: Both Grad & Undergrad

5. Evaluate the use of fracture mechanics concepts and equations in a research manuscript

Audience: Graduate

### **E M A 522 – AERODYNAMICS LAB**

3 credits.

Experimental methods for aerodynamic measurements: wind tunnel tests with 6-component sting balance, pitot probe, hot wire anemometer; flow visualization with smoke generator and laser sheet; digital data acquisition; practical considerations for experimental design. Methods for comparing theoretical predictions to experimental measurements and computational simulations.

**Requisites:** E M A 521, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Plan a comprehensive campaign of wind tunnel testing

Audience: Both Grad & Undergrad

2. Utilize state-of-the art instrumentation to measure aerodynamic loads on 2D and 3D models

Audience: Both Grad & Undergrad

3. Perform a comprehensive uncertainty analysis of all the measurements

Audience: Both Grad & Undergrad

4. Perform numerical simulations of the flow past 2D and 3D object using state-of-the art commercially available software

Audience: Both Grad & Undergrad

5. Report the results in a professional format, using appropriate normalizations, scientific notation, graphics, and tables

Audience: Both Grad & Undergrad

6. Perform a grid resolution convergence study

Audience: Graduate

**E M A 523 – FLIGHT DYNAMICS AND CONTROL**

3 credits.

Aircraft longitudinal and lateral static stability. Aircraft equations of motion. Stability derivatives. Longitudinal and lateral dynamic stability of uncontrolled motion. Open-loop aircraft control. Closed-loop aircraft control.

**Requisites:** E M A 521 and 542, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Determine the static and dynamic stability characteristics of an aircraft based on its geometrical and inertial properties

Audience: Both Grad & Undergrad

2. Use the formalism of control theory to describe an aircraft's open-loop and closed-loop control schemes

Audience: Both Grad & Undergrad

3. Utilize appropriate software to describe an aircraft's response to basic control inputs

Audience: Both Grad & Undergrad

4. Experiment with analysis software to study "what if?" scenarios

Audience: Graduate

**E M A 524 – ROCKET PROPULSION**

3 credits.

Rocket performance. One dimensional gasdynamics. Thrust chambers, nozzle design criteria. Fundamentals of combustion. Rocket configurations.

**Requisites:** M E 363, CIV ENGR 310, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Describe the quantitative relationship between thrust and stagnation and exit conditions

Audience: Both Grad & Undergrad

2. Optimize a rocket's mass distribution

Audience: Both Grad & Undergrad

3. Apply basic one-dimensional gasdynamics and combustion fundamentals to predict a rocket's thrust

Audience: Both Grad & Undergrad

4. Report in written form their understanding of rocket-related issues not covered in class

Audience: Graduate

**E M A/M E 540 – EXPERIMENTAL VIBRATION AND DYNAMIC SYSTEM ANALYSIS**

3 credits.

Application of digital data acquisition to the investigation of mechanical components, structures and systems using time histories, transforms and response functions to characterize free, forced and transient inputs. Introduction to sensors, instrumentation and methods appropriate for dynamic system response.

**Requisites:** (M E 440, E M A 545, or concurrent enrollment) or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Apply common laboratory techniques to measure dynamic system responses

Audience: Both Grad & Undergrad

2. Demonstrate knowledge of instrumentation, data acquisition, signal processing, and results display for dynamic systems

Audience: Both Grad & Undergrad

3. Formulate analytical models with parameters identified from measured signals

Audience: Graduate

**E M A/M S & E 541 – HETEROGENEOUS AND MULTIPHASE MATERIALS**

3 credits.

Principles of the mechanics of solid multiphase systems. Role of heterogeneity and anisotropy in determining physical properties including elastic, dielectric and piezoelectric properties. Applications in lightweight structures, ultrastrong materials, materials for protection of the body, and materials for the replacement of human tissues. Materials with fibrous, lamellar, particular, and cellular structures. Heterogeneous materials of biological origin. Biomimetic and bio-inspired materials.

**Requisites:** E M A 303, M E 306, or M S & E 441, graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2022

**Learning Outcomes:** 1. Describe the fundamental concepts and classifications of heterogeneous materials

Audience: Both Grad & Undergrad

2. Apply analytical and computational methods to predict the mechanical response of heterogeneous materials

Audience: Both Grad & Undergrad

3. Interpret experimental data to determine the properties of various materials

Audience: Both Grad & Undergrad

4. Compare and contrast the structure and properties of classical and contemporary heterogeneous materials

Audience: Both Grad & Undergrad

5. Design, fabricate, and test rib and plate lattice materials, and analyze the experimental results

Audience: Both Grad & Undergrad

6. Identify and explain industrial applications of various heterogeneous materials

Audience: Undergraduate

7. Critique current research and evaluate recent developments in the field of novel heterogeneous materials

Audience: Graduate

**E M A 542 – ADVANCED DYNAMICS**

3 credits.

Kinematics and kinetics of plane and three-dimensional motion, Coriolis acceleration, general methods of linear and angular momentum, central force motion, gyro dynamics, generalized coordinates. Lagrange's equations.

**Requisites:** (E M A 202, M E 240, or PHYSICS 311), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Formulate and solve problems using various coordinate systems to describe the motion of systems of particles and rigid bodies

Audience: Undergraduate

2. Formulate and solve problems using impulse-momentum principles to generate equations of motion for systems of particles and rigid bodies

Audience: Undergraduate

3. Formulate and solve problems by applying Euler's equations to gyroscopic systems

Audience: Undergraduate

4. Employ appropriate numerical methods to advance equations of motion for systems of particles and rigid bodies

Audience: Undergraduate

**E M A 545 – MECHANICAL VIBRATIONS**

3 credits.

General theory of free, forced, and transient vibrations; vibration transmission, isolation, and measurement; normal modes and generalized coordinates; method of matrix equation formulation and solution. The application of theory and methods to the analysis, measurement and design of dynamic systems.

**Requisites:** (E M A 202, M E 240, or PHYSICS 311), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Convert practical problems/systems into suitable mathematical models

Audience: Undergraduate

2. Develop the analytical vibratory response of a structure subjected to various types of excitation

Audience: Undergraduate

3. Apply computational methods to explore mathematical models of the vibratory response of structures subjected to various types of excitation

Audience: Undergraduate

**E M A/E P 547 – ENGINEERING ANALYSIS I**

3 credits.

Methods of higher mathematics; stress on problem solving rather than rigorous proofs; linear algebra, calculus of variations, Green's function.

**Requisites:** MATH 321, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Solve ordinary differential equations in the form of initial-value and boundary-value problems through substitution, integrating factors, and Laplace and Fourier transforms

Audience: Both Grad & Undergrad

2. Apply methods of undetermined coefficients, variation of parameters, and Green's functions to solve inhomogeneous ordinary differential equations

Audience: Both Grad & Undergrad

3. Identify whether linear algebraic systems have a unique solution, no solution, or an infinite number of solutions and apply methods for solving algebraic systems

Audience: Both Grad & Undergrad

4. Determine eigenvalues and eigenvectors of algebraic eigenvalue problems

Audience: Both Grad & Undergrad

5. Determine whether a function is analytic in the neighborhood of some point in the complex plane and apply contour integration to evaluate integrals

Audience: Both Grad & Undergrad

6. Identify appropriate combinations of methods for solving problems arising in engineering and scientific applications

Audience: Graduate

### **E M A/E P 548 – ENGINEERING ANALYSIS II**

3 credits.

Function of complex variable, series solution of differential equations, partial differential equations. A year of math beyond calculus

**Requisites:** (MATH 322 and 320), (MATH 322 and E P/E M A 547), or (MATH 322, 319, and 340), or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Intermediate

L&S Credit - Counts as Liberal Arts and Science credit in L&S

Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Apply local analysis and asymptotic methods to distinguish analytical and singular behavior of ordinary differential equations to approximate their solutions

Audience: Both Grad & Undergrad

2. Apply asymptotic methods to estimate the values of integrals

Audience: Both Grad & Undergrad

3. Use perturbative methods such as boundary-layer theory, WKB theory, and multi-scale analysis to analyze ordinary differential equations

Audience: Both Grad & Undergrad

4. Apply the method of characteristics and separation of variables to solve partial differential equations

Audience: Both Grad & Undergrad

5. Identify appropriate combinations of methods for solving problems arising in engineering and scientific applications

Audience: Graduate

### **E M A/ASTRON 550 – ASTRODYNAMICS**

3 credits.

Coordinate system transformations, central force motion, two body problem, three and n-body problem, theory of orbital perturbations, artificial satellites, elementary transfer orbits, and elementary rocket dynamics.

**Requisites:** (E M A 202, M E 240, or PHYSICS 311, or concurrent enrollment), or member of Engineering Guest Students

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

### **E M A 569 – SENIOR DESIGN PROJECT**

3 credits.

Students will select specific engineering design projects. These projects will be student team efforts supervised by individual faculty members.

**Requisites:** E M A 469 and (have completed or be concurrently enrolled in two of E M A 506, 519, 521, 542, 545)

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Navigate the mechanical design process through a group design project focused on the aerospace industry

Audience: Undergraduate

2. Apply fundamentals from their base Engineering Mechanics coursework to analyze, guide, and modify their designs

Audience: Undergraduate

3. Apply fundamentals from the aeronautics and astronautics coursework to a design problem

Audience: Undergraduate

4. Demonstrate a professional level of communication (written, graphical/drawing and verbal) and presentation skills with clients, instructors, and peers

Audience: Undergraduate

**E M A/M E 570 – EXPERIMENTAL MECHANICS**

3 credits.

Experimental methods for design and analysis of mechanical components, structures and materials. Electrically and optically recorded stress, strain and deformation data; computer acquisition/reduction/presentation techniques; applications to static and transient events, sensors, transducer design, NDT, fracture and residual stresses.

**Requisites:** Senior standing and (M E 306, E M A 303 or 304) or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2022

**Learning Outcomes:** 1. Apply knowledge of experimental techniques and measurement systems for mechanical components, structures and materials

Audience: Both Grad & Undergrad

2. Work in groups in the formulation of analytical models, configuration of measurement systems, interpretation of experimental and theoretical results, and presentation of conclusions

Audience: Both Grad & Undergrad

3. Use digital data acquisition systems, computer aided data reduction and display, and commercial software packages for modeling and data analysis

Audience: Both Grad & Undergrad

4. Evaluate clarity and/or accuracy of written work

Audience: Graduate

**E M A 599 – INDEPENDENT STUDY**

1-3 credits.

Directed study projects as arranged with instructor.

**Requisites:** Consent of instructor

**Course Designation:** Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Apply physical and mathematical principles to engineering research problems

Audience: Undergraduate

2. Apply mechanics principles to engineering research problems

Audience: Undergraduate

3. Communicate technical concepts to a diverse audience via verbal or written media

Audience: Undergraduate

**E M A 601 – SPECIAL TOPICS IN ENGINEERING MECHANICS**

1-3 credits.

Selected topics in such areas as structural mechanics, dynamics, experimental mechanics, vibrations, engineering materials, soil mechanics, engineering analysis, rheology, etc.

**Requisites:** Graduate/professional standing or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Identify and describe key theories, concepts, and methods in a special topic of Engineering Mechanics

Audience: Both Grad & Undergrad

2. Apply key theories, concepts, and methods in a special topic of Engineering Mechanics, using appropriate tools, processes, and/or software

Audience: Both Grad & Undergrad

3. Apply, Analyze or evaluate advanced theories, concepts, or methods in a special topic of Engineering Mechanics

Audience: Graduate

**E M A 605 – INTRODUCTION TO FINITE ELEMENTS**

3 credits.

A first course in finite elements, with theory and applications in stress analysis and in areas related to structural mechanics. Practice in the use and/or development of computer programs.

**Requisites:** (E M A 303 or M E 306), graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Motivate variational treatment of free energy to obtain governing equations

Audience: Both Grad & Undergrad

2. Formulate finite element approximations to linear partial differential equations

Audience: Both Grad & Undergrad

3. Choose appropriate approximation space (mesh, basis, quadrature) for a given application

Audience: Both Grad & Undergrad

4. Assess stability and accuracy of linear finite element computations

Audience: Graduate

### **E M A 610 – STRUCTURAL FINITE ELEMENT MODEL VALIDATION**

3 credits.

An introduction to test-based validation of finite element models for the design and analysis of dynamic structures.

**Requisites:** E M A 545 or M E 440, or graduate/professional standing or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2022

**Learning Outcomes:** 1. Demonstrate knowledge of the use and limitations of finite element models in structural analysis

Audience: Both Grad & Undergrad

2. Formulate and document results using common dissemination methods such as technical report writing and/or oral presentations

Audience: Both Grad & Undergrad

3. Apply common methods of finite element validation including vibration test design, test and analysis correlation, and model calibration

Audience: Graduate

### **E M A 611 – ADVANCED MECHANICAL TESTING OF MATERIALS**

3 credits.

Theory and use of servo-controlled, electro-hydraulic equipment for research of mechanical properties of engineering materials. Measurement of stress, strain, hysteresis energy, and material properties during deformation and at fracture. Analysis of four significant components of total strain.

**Requisites:** (E M A/M E 307 or M E/E M A 307) and (E M A 506 or concurrent enrollment), or graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Perform experiments to measure mechanics quantities of interest

Audience: Both Grad & Undergrad

2. Measure mechanical properties of materials

Audience: Both Grad & Undergrad

3. Analyze experimental data in the context of theoretical solutions and experimental error

Audience: Both Grad & Undergrad

4. Communicate methods, results, and analysis through written reports and/or oral presentations

Audience: Both Grad & Undergrad

5. Evaluate clarity and/or accuracy of written work

Audience: Graduate

### **E M A/E P 615 – MICRO- AND NANOSCALE MECHANICS**

3 credits.

An introduction to micro- and nanoscale science and engineering with a focus on the role of mechanics. A variety of micro- and nanoscale phenomena and applications covered, drawing connections to both established and new mechanics approaches.

**Requisites:** Graduate/professional standing or E M A 303 or M E 306

**Course Designation:** Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2021

**Learning Outcomes:** 1. Describe the current state and potential future impact of micro and nanotechnology

Audience: Both Grad & Undergrad

2. Explain how mechanics enters a new regime at the micro and nano scales where surfaces, interfaces, defects, material property variations, and quantum effects play more dominant roles

Audience: Both Grad & Undergrad

3. Use or adapt engineering mechanics concepts to describe behavior at the micro and nano scale

Audience: Both Grad & Undergrad

4. Describe cross-disciplinary intersections and how mechanics is integrated with the fields of materials science, chemistry, physics, and biology at the micro/nano scale

Audience: Graduate

**E M A 630 – VISCOELASTIC SOLIDS**

3 credits.

Linear theory of viscoelasticity; non-aging materials; Boltzmann superposition principle; time-temperature superposition boundary value problems. Applications: vibration damping, relaxation of stress, creep, droop, and sag in structural members, sound absorption, creep buckling, settlement of foundations, tire mechanics, and shock attenuation.

**Requisites:** M E 306 or E M A 303, or graduate/professional standing, or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Fall 2025

**Learning Outcomes:** 1. Describe, qualitatively and quantitatively, the response of viscoelastic materials in creep, relaxation, and cyclic loading  
Audience: Both Grad & Undergrad

2. Demonstrate proficiency in solving problems related to viscoelasticity  
Audience: Both Grad & Undergrad

3. Describe underlying mechanisms for viscoelastic behavior  
Audience: Both Grad & Undergrad

4. Apply concepts of viscoelasticity in an open-ended project  
Audience: Graduate

**E M A 642 – SATELLITE DYNAMICS**

3 credits.

Review of Euler's equations, torque-free motion, stability of rotation, energy dissipation effects, gyroscopic instruments, gyrodynamic of the Earth, gravity gradient stabilized satellites, spin stabilized satellites, dual spin satellites, tethered satellites, mass movement techniques, space vehicle motion and rocket dynamics.

**Requisites:** E M A 542 or PHYSICS 311, or graduate/professional standing or member of Engineering Guest Students

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2025

**Learning Outcomes:** 1. Formulate and solve problems using attitude parameterizations to describe the motion of aerospace systems  
Audience: Both Grad & Undergrad

2. Formulate and solve problems using linear and angular momentum to generate equations of motion for spacecraft  
Audience: Both Grad & Undergrad

3. Formulate and solve problems using energy methods to predict the attitude motion of spacecraft  
Audience: Both Grad & Undergrad

4. Demonstrate knowledge of spacecraft stability and control theory to assess and enforce spacecraft attitude  
Audience: Graduate

**E M A 700 – THEORY OF ELASTICITY**

3 credits.

Equations of elasticity in curvilinear and rectangular coordinates; two dimensional problems; problems of prismatic bars; variational methods and energy principles; complex variable and numerical methods; thermal stress problems. Knowledge of advanced mechanics of materials [such as E M A 506] and vector calculus [such as MATH 321] strongly encouraged.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2025

**E M A 702 – GRADUATE COOPERATIVE EDUCATION PROGRAM**

1-2 credits.

Work experience that combines classroom theory with practical knowledge of operations to provide students with a background on which to develop and enhance a professional career. The work experience is tailored for MS students from within the U.S. as well as eligible international students.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Summer 2025

**Learning Outcomes:** 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work  
Audience: Graduate

2. Synthesize and apply appropriate technical education to real world technical work  
Audience: Graduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise  
Audience: Graduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information  
Audience: Graduate

**E M A/M E 703 – PLASTICITY THEORY AND PHYSICS**

3 credits.

Physical foundations of plasticity as a basis for choices made in the formulation of theories representing plastic deformation and their limitation. Motion of dislocations and formation and growth of deformation twins. Experimental results in the context of plasticity models. Traditional and research topics of plasticity and theories for rate-independent, rate-dependent, single and polycrystal descriptions. Numerical solution of equations and computational plasticity. Knowledge of mechanics of materials [such as E M A 303 or M E 306] and continuum mechanics [such as E M A 622] required.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Identify the physical sources of plastic deformation in materials

Audience: Graduate

2. Explain and apply traditional and advanced theories of plasticity

Audience: Graduate

3. Execute a computational study of plasticity with a common engineering material

Audience: Graduate

4. Given a material model, know how to evaluate the material parameters in the model

Audience: Graduate

5. Provide critical assessment of seminal and modern plasticity literature

Audience: Graduate

**E M A 705 – ADVANCED TOPICS IN FINITE ELEMENTS**

3 credits.

Finite element methods for problems with linear and nonlinear media. Stress analysis, heat transfer, and fluid dynamics. Vibration and transient analysis. Weighted residual methods. Material and geometric nonlinearity. Nonlinear iteration methods. Instructor may also select additional material. Knowledge of finite element theory [such as E M A 605] strongly encouraged.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2026

**Learning Outcomes:** 1. Identify the principal attributes of the finite element method

Audience: Graduate

2. Explain and apply all components of the finite element method including strengths and weaknesses of approaches

Audience: Graduate

3. Execute a computational development project by deriving a method and coding within a solver

Audience: Graduate

4. Derive finite element formulations of general order

Audience: Graduate

5. Demonstrate clear proficiency in all aspects of the finite element method

Audience: Graduate

**E M A/M E 708 – ADVANCED COMPOSITE MATERIALS**

3 credits.

Contemporary topics in composite materials, including innovations in sandwich structures, textile composites, and architected materials; fracture mechanics; durability and damage tolerance; experimental techniques; transient, micro, nonlinear, inelastic and environmental effects; advanced manufacturing methods: repair and applications. Knowledge of basic composite materials [such as CIV ENGR/E M A/M E 508] is strongly encouraged.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Fall 2016

**Learning Outcomes:** 1. Describe different types of advanced composites and manufacturing processes  
Audience: Graduate

2. Describe the mechanical behavior of various composite materials under different types of loading conditions  
Audience: Graduate

3. Mathematically model and solve for engineering stresses and deformations in a composite structure  
Audience: Graduate

4. Assess the key challenges and impact of technical work being conducted in the area of composite materials  
Audience: Graduate

**E M A 710 – MECHANICS OF CONTINUA**

3 credits.

Tensor analysis; analysis of stress, strain and rate of strain; application of Newtonian mechanics to deformable media; mechanical constitutive equations; field equations of fluid mechanics and elasticity. Knowledge of linear algebra [such as MATH 340] required.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Fall 2024

**Learning Outcomes:** 1. Recall many important identities used in vector and tensor algebra  
Audience: Graduate

2. Understand and use basic kinematics principles used in many fields of study  
Audience: Graduate

3. Describe the breadth of conservation principles commonly employed for use in more advanced applications  
Audience: Graduate

4. Employ thermodynamic relationships readily with fundamentals of continuum mechanics  
Audience: Graduate

5. Acquire skills in rigorous continuum mechanics principles  
Audience: Graduate

**E M A/M E 722 – INTRODUCTION TO POLYMER RHEOLOGY**

3 credits.

Formulation of constitutive equations using embedded base vectors. Viscosity, normal stress differences, stress relaxation, elastic recoil. Polymer rheology; homogeneous strain history. Knowledge of differential equations [such as MATH 320] strongly encouraged.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Summer 2023

**E M A 745 – ADVANCED METHODS IN STRUCTURAL DYNAMICS**

3 credits.

Emphasis is placed on techniques used to analyze aerospace structures. Variational principles, Hamilton's extended principle, Lagrange's equations, mathematical models for continuous systems, natural modes of vibrations, dynamic response using mode superposition, mode acceleration, residual flexibility, vibration analysis using finite element methods, advanced substructure representations, component mode synthesis, systems with rigid body modes for aeronautical and astronautical systems. Knowledge of vibrations [such as E M A 545 or M E 440] strongly encouraged.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Spring 2022**E M A 747 – NONLINEAR AND RANDOM MECHANICAL VIBRATIONS**

3 credits.

Exact solutions and sectorial linearization; free and forced vibration of mechanical systems with nonlinear restoring force; self-excited mechanical vibrations and relaxation vibrations; subharmonic responses; nonlinear vibration of mechanical systems with more than one degree of freedom; nonlinear vibration of bounded continuous media; random excitation and random response, random vibrations of mechanical systems and structures; random vibrations of nonlinear mechanical systems; failure of materials under random vibrations.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Fall 2025**E M A/COMP SCI/E C E/E P/M E 759 – HIGH PERFORMANCE COMPUTING FOR APPLICATIONS IN ENGINEERING**

3 credits.

An overview of hardware and software solutions that enable the use of advanced computing in tackling computationally intensive Engineering problems. Hands-on learning promoted through programming assignments that leverage emerging hardware architectures and use parallel computing programming languages. Students are strongly encourage to have completed COMP SCI 367 or COMP SCI 400 or to have equivalent experience.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Spring 2026**E M A/CIV ENGR/M E 775 – TURBULENT HEAT AND MOMENTUM TRANSFER**

3 credits.

Stochastic methods in turbulent heat and momentum transfer; fully developed turbulence; numerical methods including model applications to boundary layers, reacting flows, mass transfer, and unsteady flows; linear and non-linear stability and transition; emphasis on applications of interest to Mechanical, Aerospace, and Environmental Engineers. Knowledge of fluid mechanics [such as M E 363 or CBE 320] strongly encouraged.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** No**Last Taught:** Spring 2026**Learning Outcomes:** 1. Describe the physics and mathematics of turbulence theory and modeling  
Audience: Graduate

2. Describe general features of turbulence

Audience: Graduate

3. Use analysis tools to solve problems and process data related to turbulence

Audience: Graduate

4. Use turbulence concepts to understand and explain turbulent behavior in more complex systems

Audience: Graduate

**E M A 790 – MASTER'S RESEARCH AND THESIS**

1-9 credits.

Directed study projects as arranged with instructor.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** Yes, unlimited number of completions**Last Taught:** Spring 2026**E M A 890 – PRE-DISSERTATOR RESEARCH**

1-9 credits.

Directed study projects as arranged with instructor.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** Yes, unlimited number of completions**Last Taught:** Spring 2026**E M A 990 – RESEARCH AND THESIS**

1-12 credits.

Directed study projects as arranged with instructor.

**Requisites:** Graduate/professional standing**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement**Repeatable for Credit:** Yes, unlimited number of completions**Last Taught:** Spring 2026