

# Mechanical Engineering (MEE)

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Course information contained within the Bulletin is accurate at the time of publication in July 2024 but is subject to change. For the most up-to-date course information, please refer to the Course Catalog.

## **MEE 0843. Technology Transformations. 3 Credit Hours.**

Learn about science and technology through the history of discovery, inventions, and innovations. The course expands your knowledge of innovations in science and technology, and their inherent disruptive quality in altering society, economy, and politics. You will learn of key ingredients within a socio-political-economic milieu that is the sine qua non for innovation to germinate and flourish. The goal is to prepare you for a lifelong journey as innovators in your chosen field. The course dissects "case studies" centered around innovators and original thinkers who metamorphized scientific phenomena from a mere curiosity into key technologies (electricity, automobiles, airplanes, telephones, bridges, highways, electronics, computers, and information technology), and in the process, transformed the world around us. At the end of the course, students will become discerning citizens able to judge the pros and cons of modern technologies and surf new waves of technologies without anxiety. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core.

**Course Attributes:** GS, SI

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1001. Introduction to Mechanical Engineering. 2 Credit Hours.**

Provides an understanding of the study and practice associated with mechanical engineering and technology disciplines. Understand the importance of good communications and teamwork skills in a successful engineering and technology career. Understand the basics of problem solving and design. Discipline-specific labs.

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1019. Automotive Design I. 1 Credit Hour.**

Design of automotive chassis, suspension, and drive train for participation in Society of Automotive Engineers competitions. Grade based on participation (50%) and/or design report (50%).

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1029. Automotive Design II. 1 Credit Hour.**

Continuation of MEE 1019 (0180). Grade based on participation (50%) and/or design report (50%).

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1039. Automotive Design III. 1 Credit Hour.**

Continuation of MEE 1029 (0181). Grade based on participation (50%) and/or design report (50%).

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1117. Fundamentals of Mechanical Engineering Design. 2 Credit Hours.**

An introduction to the art of communicating design ideas in two and three dimensions with a combination of hand sketching and computer modelling. Specific topics include: isometric, orthographic and perspective hand sketching; computer-aided design (CAD) modeling - part model, assembly and mechanism synthesis; CAD drawings - orthographic, auxiliary and sectional views, dimensioning and annotations. A culminating team project will facilitate introduction of rapid prototyping techniques necessary to convert a design intent into a functional product.

**College Restrictions:** Must be enrolled in one of the following Colleges: Engineering.

**Repeatability:** This course may not be repeated for additional credits.

## **MEE 1305. Machine Shop Laboratory. 1 Credit Hour.**

This machine-shop lab experience provides practical, hands-on training on the machine-shop tools that BS ME students will use in their subsequent course work. Students will fabricate specific parts using the principal machine tools and using 3D Printing. Particular emphasis will be placed on safety procedures, on precise manufacture of parts, on using the right machine tool for a particular application, and for the judicious, least wasteful use of stock material.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 1117 or ENGR 1117)

**MEE 2011. Linear Systems. 3 Credit Hours.**

This course introduces junior-level engineering students to linear-systems analysis and numerical methods in engineering. Numerical-analysis procedures typically encountered in the upper-level mechanical-engineering curriculum are considered and include: linear matrix equations and their solutions, eigenvalue problems, numerical interpolation, differentiation and integration, and the numerical solution of differential equations.

**Field of Study Restrictions:** Must be enrolled in one of the following Fields of study: Bioengineering, Civil Engineering, Mechanical Engineering.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MATH 1042, MATH 1942, 'Y' in MATW, or 'Y' in METW), (MATH 2043 (may be taken concurrently), MATH 2943 (may be taken concurrently), or 'Y' in METW), and (MATH 3041, MATH 3941, MATH 2041, MATH 2941, or 'Y' in METW)

**MEE 2305. Instrumentation and Data Acquisition Lab. 1 Credit Hour.**

Students will learn the instrumentation of basic static and dynamic mechanical systems. Students will use data-acquisition hardware and software. Students will carry out statistical analysis of results, evaluate error propagation, and provide written lab reports.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 2332 (may be taken concurrently) or ENGT 3323 (may be taken concurrently)), ECE 2112 (may be taken concurrently), ECE 2113 (may be taken concurrently), and (ENGR 1102 or 'Y' in ENGW)

**MEE 3011. Analysis and Computation of Linear Systems in Mechanical Engineering. 3 Credit Hours.**

Many types of mechanical-engineering situations are modeled as systems of coupled linear equations, or as systems of coupled linear differential equations. Modern computing techniques offer very powerful functionality for calculating linear-equation systems and will be used extensively in this course. Upon completion of this course students will attain: proficiency in coding, a conceptual foundation for core linear algebra and eigenfunction analysis, and insight for both numerical and exact solution strategies applicable to a wide range of problems encountered in mechanical engineering.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 2332 or BIOE 3312), (MATH 2043, MATH 2943, or 'Y' in METW), and (MATH 3041, MATH 3941, MATH 2041, MATH 2941, or 'Y' in METW)

**MEE 3117. Computer-Aided Mechanical Design. 3 Credit Hours.**

An introduction to the mathematical and computational fundamentals of finite element method and the use of an industry standard Computer Aided Design (CAD) package to analyze failure. It is expected that before taking this course, students have a fundamental understanding of concepts from statics, dynamics, solid mechanics and design of machine elements. A culminating design project will help students understand the design and assembly of complex machines by analysis of individual components and the interaction between them, from the prime mover to the load.

**Degree Restrictions:** Must be enrolled in one of the following Degrees: Bach of Science in Mech Eng.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of D- in (MEE 3011 or MEE 3421) and MEE 3301.

**MEE 3185. Mechanical Engineering Summer Work Experience. 3 Credit Hours.**

This course is for an approved, full-time, full-summer (ten weeks or more) work experience in industry or a government agency. The full-time work experience must be carried out during the summer between a full, regular spring semester and full, regular fall semester. The summer employment must entail rigorous engineering analysis at a level comparable to an approved technical elective course in the BS ME program.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 3301. Machine Theory and Design. 3 Credit Hours.**

The course includes design process and consideration of materials, reliability, stress and deflection, failure criteria from static and dynamic loadings. Topics also include analysis of mechanical components including rotating shafts, screws, welded parts, bearings, gears, and belts. There will be individual and team design projects with written reports and presentations.

**Degree Restrictions:** Must be enrolled in one of the following Degrees: Bach of Science in Mech Eng.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 1117 or MEE 1117), ENGR 2332, (ENGR 2333 or ENGR 2933), and MEE 3305 (may be taken concurrently)

**MEE 3302. Kinematics of Mechanisms. 3 Credit Hours.**

This course builds on the concepts of kinematics first presented in sophomore level Dynamics and explores its application to mechanical design. Starting with an introduction to links, joints and kinematic chains, students will learn the analysis and design of spatial mechanisms with an emphasis on position, velocity and acceleration of linkages. In addition to graphical and numerical analysis, computer aided mechanism design will be performed using SolidWorks Motion.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 2332.

**MEE 3304. Mechanical Design and Fabrication. 3 Credit Hours.**

This course builds on the theoretical foundation of MEE 3301 Machine Theory and Design and MEE 3117 Computer-Aided Mechanical Design. Students will learn to incorporate design constraints associated with the practical fabrication and assembly of a mechanism. In this machine-shop-intensive course, student teams will be trained in precision machining and assembly techniques. A significant portion of the grade will rely on the quality of workmanship and accuracy of output.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of D- (except where noted) in MEE 2305 (C- or higher), MEE 1117 (C- or higher), MEE 3301, and (MEE 3011 or MEE 3421)

**MEE 3305. Materials Laboratory. 1 Credit Hour.**

Laboratory experiments related to the nature and properties of materials, including: stress, strain, fractures, microstructure, metallography, and nondestructive testing.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 2333, ENGR 2933, or ENGT 2322) and MEE 2305.

**MEE 3421. Dynamic Systems. 3 Credit Hours.**

A study of the dynamic response of physical systems, concentrating on mechanical systems in translation, rotation, and combined motion. Mathematical models are developed using interacting elements, inter-connecting laws, and physical laws. Both the state variable and input-output analysis are considered. Solutions for the model response include using the following techniques: analytical, Laplace Transform, transfer function, matrix methods, and numerical analysis. Design project.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in MEE 3011.

**MEE 3422. Modeling and Control of Electromechanical Systems. 3 Credit Hours.**

Control systems are integral parts of our modern life. This course introduces the control of electromechanical systems with an emphasis on linear systems. Analyzing systems using transfer functions and Laplace transforms is studied, and the stability of control systems and their transient response is covered. In addition, frequency-domain techniques and the design of feedback-control systems will be discussed.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011 or MEE 3421)

**MEE 3506. Fluid Mechanics Laboratory. 1 Credit Hour.**

This laboratory aims to familiarize the students with different data acquisition techniques and devices to measure and control the behavior of various fluid systems. Experiments will include pressure and velocity measurements as well as modern transducers and pressure/flow regulators.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- (except where noted) in (ENGR 3553 (may be taken concurrently) or ENGT 2521 (D- or higher; may be taken concurrently))

**MEE 4040. Special Topics. 1 to 4 Credit Hour.**

A course designed to present new and emerging areas of engineering. The course may also be used to present areas not normally taught in the College. Course requirements vary with the topic and instructor. Offered as needed or as appropriate.

**Class Restrictions:** Must be enrolled in one of the following Classes: Junior 60 to 89 Credits, Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

**Repeatability:** This course may be repeated for additional credit.

**MEE 4172. High-Speed Imaging and Analysis for Engineering Applications. 3 Credit Hours.**

This course will introduce students to high-speed imaging and analysis techniques widely used in academia, industry, and government to solve complex engineering problems. Students will first learn key digital imaging concepts, followed by the fundamentals of optics, lensing and lighting. Then, they will learn how to process images to track and quantify the motion of points. This will naturally evolve into discussions on techniques including 3D point tracking, Digital Image Correlation (DIC), and Particle Image Velocity (PIV). Students will also be introduced to non-invasive imaging techniques for characterizing transparent flows, namely shadowgraphy and schlieren imaging. Finally, students will utilize software packages to perform digital processing steps such as filtering, pyrometry, correlations, tracking and more.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011 or MEE 3421)

**MEE 4173. Data Acquisition and Analysis for Engineers. 3 Credit Hours.**

Course content includes the use of microcomputers for automated data acquisition, process control, and data analysis. The principles and applications of sensors, transducers, recording instruments, signal conditioning, and control instrumentation, and sampling theory. Data analysis using Fourier transform and least squares method. Computer software development for interfacing and graphics. Hands-on lab and design project required.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011 or MEE 3421), MEE 2305, and (ECE 2112, ECE 2332, or ECE 2312)

**MEE 4177. Design and Realization of a Mechanical System. 2 Credit Hours.**

In this project-based course, student teams will design, fabricate, and test a mechanical assemblage that achieves a specific performance goal. Each student team will consider the same design problem, which may be either thermal-fluid or mechanical in nature depending on the course-section instructor. A significant portion of the grade will rely on the quality of workmanship and the team's success in achieving the design objectives.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- (except where noted) in MEE 1305 (may be taken concurrently), MEE 2305, (ENGR 2196 or ENGR 2996), ENGR 3001 (D- or higher), ENGR 3571, (ENGR 3553 or ENGR 3953), MEE 3301 (D- or higher), and MEE 3117 (D- or higher; may be taken concurrently)

**MEE 4191. Independent Research in Mechanical Engineering. 2 to 5 Credit Hours.**

Arranged each semester, please consult with the instructor.

**Repeatability:** This course may be repeated for additional credit.

**MEE 4212. Tribology and Surface Engineering. 3 Credit Hours.**

Tribology encompasses the interdisciplinary science and engineering of interacting surfaces in relative motion. Tribology is in every aspect of our lives and has a tremendous impact on manufacturing, energy production and use, transportation vehicles, health care, mining safety and reliability, and space exploration. This course introduces the nature of engineering surfaces, methods of surface characterization, modes of friction and wear, theories of contacts, and lubrication.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of D- in ENGR 3201.

**MEE 4311. Mechanics of Composite Materials. 3 Credit Hours.**

Introduction to the behavior of composite materials and their use in engineering structures: behavior and properties of the constituent fibers and matrices, micromechanical predictions of composite properties, anisotropic elasticity, behavior of composite laminae, classical lamination theory; fracture mechanisms, failure theories; behavior of composite plates and beams.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- (except where noted) in (ENGR 2333 or ENGR 2933), ENGR 3201 (D- or higher), and (MEE 3011 or MEE 3421)

**MEE 4314. Impact and Crashworthiness. 3 Credit Hours.**

This course is an advanced course on impact mechanics, impact biomechanics, as well as vehicle crashworthiness standards and accident data analysis. Students will learn about FMVSS and NCAP crash tests, FARS and NASS real world accident databases, and methods to analyze crash and accident data.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 2332 and (ENGR 2333 or ENGR 2933)

**MEE 4382. Independent Study in Mechanical Engineering. 1 to 6 Credit Hour.**

Arranged each semester, please consult with the instructor.

**Repeatability:** This course may be repeated for additional credit.

**MEE 4405. Vibrations Laboratory. 1 Credit Hour.**

This course covers instrumentation and data acquisition of single degree of freedom, multi-degree of freedom, and continuous vibratory systems. It also covers data analysis software in time domain and frequency domain, simulation of basic vibratory systems, and statistical analysis of results.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of D- (except where noted) in MEE 4422 (may be taken concurrently) and MEE 2305 (C- or higher)

**MEE 4411. Introduction to Mobile Robotics. 3 Credit Hours.**

Introduction to Mobile Robotics will teach you, through the use of project-based learning, fundamental concepts in mapping, planning, control, and dynamics that are used in mobile robotics. By the end of this course you will be able to program both a ground and aerial robot to autonomously and safely navigate through an obstacle-filled environment. You will work with both simulated and real robots and use both off-the-shelf software and write code from scratch using ROS.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in MEE 3011.

**MEE 4412. Modern Dynamics for Robotics. 3 Credit Hours.**

This course focuses on the algebraic and differential equations governing the static and dynamic 3D motion of rigid bodies, including vectors, vector differentiation, and dyads. The equations of motion for multibody systems will be derived using Newton-Euler, Lagrange, and Kane's methods. Computational tools for 3D force and motion analysis will be used to simulate physical systems.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011, MEE 3421, or Complete the following: ENGR 2332, MEE 2011, and (MATH 3041, MATH 3941, MATH 2041, MATH 2941, or 'Y' in METW))

**MEE 4413. Robotic Manipulation. 3 Credit Hours.**

This course is an introduction to the design, modeling and control of robot manipulators, using modern dynamic formulations for multi-degree of freedom, 3D rigid body systems. This course covers 3D spatial transformations, forward and inverse kinematics, Jacobians, joint space and operational space control, and force control. This course also introduces ROS for communication and control of 2 6 axis robotic arms.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in MEE 3011.

**MEE 4414. Optimization and Control of Mechanical Systems. 3 Credit Hours.**

From the everyday commute to flight control, optimization and optimal control play an important role. This course covers topics related to optimization and designing optimal controllers for mechanical systems. Topics include optimization, introduction to calculus of variations, finding optimal paths and route planning for autonomous vehicles, dynamic programming, linear optimal control, and model predictive control. Applications of the course concepts in robotics and modern mechanical systems will be discussed through several examples.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3422 or ECE 3412)

**MEE 4422. Mechanical Vibrations. 3 Credit Hours.**

The study of single degree, two degrees, and multi-degrees of freedom systems, harmonic and non-harmonic excitation, damped and undamped response, free, forced, transient, and random vibrations, resonance beating, force transmission, isolation, base, and self excitation. Term design project. Computer numerical methods.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011 or MEE 3421)

**MEE 4506. Energy Conversion Laboratory. 1 Credit Hour.**

This laboratory will emphasize advanced measurement techniques in energy systems. Computer based data acquisition and statistics are integral parts of the course. Experiments will include: gas and liquid measurements, heat and mass transfer, and engine measurements.

**Course Attributes:** SE, SF

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- (except where noted) in (ENGR 3553 or ENGR 3953), ENGR 3571, MEE 2305, MEE 3506, MEE 4571 (D- or higher; may be taken concurrently), and MEE 4572 (D- or higher; may be taken concurrently)

**MEE 4512. Compressible Fluid Dynamics. 3 Credit Hours.**

This course will introduce students to the subject of high speed gas dynamics. Compressible flows exhibit fundamentally different behavior from that observed in low speed, constant density fluids. Such flows are found in aerodynamics, combustors, turbines, jets, gas pipelines, and wind tunnel test facilities. Students will study phenomena associated with supersonic flows, including normal and oblique shocks, expansion fans, and compressible flows with friction and/or heat transfer. An introduction to high temperature and rarefied gas dynamics will also be included.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 3553 or ENGR 3953) and ENGR 3571.

**MEE 4513. Aerodynamics. 3 Credit Hours.**

The forces and moments exerted by moving fluids on solid bodies are of concern in numerous applications. While the performance of flight vehicles is of particular interest, aerodynamics is also a subject of importance in passenger and race car design, wind turbines, structures, sea vessels, etc. Students will study various topics in low speed aerodynamics, including thin airfoil theory and airfoil nomenclature, finite wing theory, high lift and drag reduction devices, separated and vortical flows, and rotating blades. An introduction to transonic flows and computational aerodynamics will also be included.

**Field of Study Restrictions:** Must be enrolled in one of the following Fields of study: Civil Engineering, Mechanical Engineering.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 3553 or ENGR 3953)

**MEE 4571. Advanced Thermodynamics and Combustion. 3 Credit Hours.**

Review of basic concepts, first and second laws, entropy (statistical and classical), power and refrigeration cycles, thermodynamic relationships, mixtures, chemical reactions and equilibrium, introduction to combustion process. Term design project.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 3571.

**MEE 4572. Heat and Mass Transfer. 3 Credit Hours.**

Principles and applications of heat transfer by conduction, convection, and radiation processes. Combined modes of heat transfer. Graphic and numerical solutions. Steady and unsteady as well as multi-dimensional conduction heat transfer. Forced and free convection. Heat exchanger theory. Introduction to radiation. Term design project. Computer Numerical methods.

**Class Restrictions:** Must be enrolled in one of the following Classes: Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (MEE 3011 or MEE 3421), ENGR 3571, and (ENGR 3553 or ENGR 3953)

**MEE 4573. Internal Combustion Engines. 1 Credit Hour.**

Types of engines, design considerations, combustion, friction, emission.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of D- in MEE 4571 (may be taken concurrently)

**MEE 4574. Heating, Ventilating, and Air Conditioning. 3 Credit Hours.**

Course content includes human comfort criteria, heating and cooling loads, HVAC system types, room air distribution, terminal unit selection, fans and ducts, pumps and piping, computer-aided design; term design project.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 3571 and (ENGR 3553 or ENGR 3953)

**MEE 4575. Renewable and Alternative Energy. 3 Credit Hours.**

This survey course considers current technologies for renewable and alternative energy, including: different scenarios of producing energy, mechanical heat engines, ocean thermal energy converters, thermoelectricity, solar radiation, biomass, photovoltaic converters, wind energy, and ocean engines. The course will also consider the design of hydrogen-powered systems and of polymer electrolyte-membrane fuel cells.

**Course Attributes:** SE, SF

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 3571 and (ENGR 3553 or ENGR 3953)

**MEE 4577. Power Generation and Storage Technologies. 3 Credit Hours.**

This course will give an overview of electric power generation technologies including coal, gas, and nuclear power plants, as well as some emerging technologies such as photovoltaic. This course will also discuss technologies used in power transmission and distribution such as overhead power line conductors. Power storage technologies will also be introduced, including compressed air, flywheel, hydrogen, and batteries.

**Course Attributes:** SE, SF

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 3571, ENGR 3201 (may be taken concurrently), and (ENGR 3553 or ENGR 3953)

**MEE 4578. Fundamentals of Combustion. 3 Credit Hours.**

This course is focused on concepts and applications of chemically reacting systems. Topics include heat of reaction, chemical equilibrium, chemical kinetics, chemical mechanisms, coupling chemical and thermal analyses of reacting systems, laminar premixed and diffusion flames, turbulent flames and pollutant emissions.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- (except where noted) in ENGR 3571, (ENGR 3553 or ENGR 3953), and MEE 4572 (D- or higher; may be taken concurrently)

**MEE 4643. Manufacturing Engineering. 3 Credit Hours.**

This course will provide an overview of existing and emerging manufacturing technologies in the modern society. Topics include state-of-the-art processing methods for metals and alloys, ceramics and powder metallurgy, polymers and composites, additive manufacturing of a wide range of solid materials, as well as micro- and nano- fabrications.

**Field of Study Restrictions:** Must be enrolled in one of the following Fields of study: Mechanical Engineering.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in MEE 3301 and ENGR 3201.

**MEE 4731. Cardiovascular Fluid Dynamics. 3 Credit Hours.**

Mechanics of blood circulation, fluid mechanics of the heart, blood flow in arteries, unsteady flow in veins, current concepts in circulatory assist devices, biofluidics, and other selected topics.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in (ENGR 3553 or ENGR 3953)

**MEE 5110. Special Topics. 3 Credit Hours.**

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 5117. Finite Element Analysis. 3 Credit Hours.**

Concepts and techniques of finite element and finite difference methods; mesh generation techniques; computer graphics presentation methods. Application to solids, liquids, and gases in the areas of stress, strain, deflection elasticity, heat transfer, fluid flow, and combustion.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5172. High-Speed Imaging and Analysis for Engineering Applications. 3 Credit Hours.**

This course will introduce students to high-speed imaging and analysis techniques widely used in academia, industry, and government to solve complex engineering problems. Students will first learn key digital imaging concepts, followed by the fundamentals of optics, lensing and lighting. Then, they will learn how to process images to track and quantify the motion of points. This will naturally evolve into discussions on techniques including 3D point tracking, Digital Image Correlation (DIC), and Particle Image Velocity (PIV). Students will also be introduced to non-invasive imaging techniques for characterizing transparent flows, namely shadowgraphy and schlieren imaging. Finally, students will utilize software packages to perform digital processing steps such as filtering, pyrometry, correlations, tracking and more.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5201. Thermodynamics of Materials. 3 Credit Hours.**

An introductory master's level course that explores materials from a thermodynamic perspective: Includes the laws of thermodynamics, free energy, chemical potential, stability, etc. A detailed analysis of phase diagrams is presented in the second half of the course.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5203. Advanced Materials Science. 3 Credit Hours.**

Chemical bonding, crystallography, defects and their effects on material properties, nucleation, growth, and microstructure development.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5205. Microscopy and Microanalysis of Materials. 3 Credit Hours.**

This course will cover various Microscopy and Microanalysis techniques which are widely used in research labs and in industries to characterize micro and nano structure and chemical composition of solid matter. Among them are visual light, scanning probe and electron beam microscopy and associated spectroscopy. The primary focus will be on fundamental aspects and experimental methods of Scanning Electron Microscopy (SEM) and associated spectroscopy. The SEM facility will be used for individual student projects. Particular attention will be given to the selection criteria used for choosing the appropriate technique for materials characterization.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5211. Frontiers in Mechanical Engineering. 3 Credit Hours.**

This is a survey course designed to introduce graduate students to cutting-edge research in the mechanical-engineering sciences. Topics will be taken from active research areas in the Mechanical Engineering Department, including (but not limited to) biomechanics, multifunctional materials, materials processing and/or manufacturing, acoustic sensors, nano/micro-technologies, and robotics. The course will have a coordinator, but the lectures will be given by a variety of mechanical-engineering faculty selected for their research expertise.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**College Restrictions:** Must be enrolled in one of the following Colleges: Engineering, Science & Technology.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5212. Tribology and Surface Engineering. 3 Credit Hours.**

Tribology encompasses the interdisciplinary science and engineering of interacting surfaces in relative motion. Tribology is in every aspect of our lives and has a tremendous impact on manufacturing, energy production and use, transportation vehicles, health care, mining safety and reliability, and space exploration. This course introduces the nature of engineering surfaces, methods of surface characterization, modes of friction and wear, theories of contacts, and lubrication.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.



**MEE 5312. Mechanics of Composite Materials. 3 Credit Hours.**

Introduction to the behavior of composite materials and their use in engineering structures: behavior and properties of the constituent fibers and matrices, micromechanical predictions of composite properties, anisotropic elasticity, behavior of composite laminae, classical lamination theory; fracture mechanisms, failure theories; behavior of composite plates and beams.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5314. Impact and Crashworthiness. 3 Credit Hours.**

This course is an advanced course on impact mechanics, impact biomechanics, as well as vehicle crashworthiness standards and accident data analysis. Students will learn about FMVSS and NCAP crash tests, FARS and NASS real world accident databases, and methods to analyze crash and accident data.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5411. Introduction to Mobile Robotics. 3 Credit Hours.**

Introduction to Mobile Robotics will teach you, through the use of project-based learning, fundamental concepts in mapping, planning, control, and dynamics that are used in mobile robotics. By the end of this course you will be able to program both a ground and aerial robot to autonomously and safely navigate through an obstacle-filled environment. You will work with both simulated and real robots and use both off-the-shelf software and write code from scratch using ROS.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5412. Modern Dynamics for Robotics. 3 Credit Hours.**

This course focuses on the algebraic and differential equations governing the static and dynamic 3D motion of rigid bodies, including vectors, vector differentiation, and dyads. The equations of motion for multibody systems will be derived using Newton-Euler, Lagrange, and Kane's methods. Computational tools for 3D force and motion analysis will be used to simulate physical systems.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5413. Robotic Manipulation. 3 Credit Hours.**

This course is an introduction to the design, modeling and control of robot manipulators, using modern dynamic formulations for multi-degree of freedom, 3D rigid body systems. This course covers 3D spatial transformations, forward and inverse kinematics, Jacobians, joint space and operational space control, and force control. This course also introduces ROS for communication and control of 2-6 axis robotic arms.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5414. Optimization and Control of Mechanical Systems. 3 Credit Hours.**

This course focuses on designing optimal controllers for constrained and unconstrained dynamical systems. Topics include optimization, calculus of variations, dynamic programming, linear optimal control, trajectory optimization, optimal estimation, and model predictive control. Applications of the course concepts in classical problems as well as in modern systems will be discussed through several examples.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5423. Engineering Acoustics and Continuum-System Vibration. 3 Credit Hours.**

This graduate level course introduces the fundamentals of engineering acoustics and will help students establish a deep understanding of the physics of acoustic-wave propagation. Students will also be able to acquire knowledge on computational tools used to study acoustic systems, and explore emerging areas in acoustics including acoustic metamaterial and bio-inspired acoustic sensors.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C in ENGR 5012 (may be taken concurrently)

**MEE 5511. Thermodynamic Properties. 3 Credit Hours.**

Review of quantum mechanics and introduction to statistical mechanics. Statistical thermodynamics and various models of matter. Accuracy and trends of the predicted properties of various materials.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5512. Compressible Fluid Dynamics. 3 Credit Hours.**

This course introduces students to the subject of high speed gas dynamics. Compressible flows exhibit fundamentally different behavior from those in low speed, constant density fluids. Such flows are found in aerodynamics, combustors, turbines, jets, gas pipelines, and wind tunnel facilities. Students study phenomena associated with supersonic flows, including normal and oblique shocks, expansion fans, and compressible flows with friction and/or heat transfer. An introduction to high temperature and rarified gas dynamics is also included.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5513. Aerodynamics. 3 Credit Hours.**

The forces and moments exerted by moving fluids on solid bodies are of concern in numerous applications. While the performance of flight vehicles is of particular interest, aerodynamics is also a subject of importance in passenger and race car design, wind turbines, structures, sea vessels, etc. Students will study various topics in low speed aerodynamics, including thin airfoil theory and airfoil nomenclature, finite wing theory, high lift and drag reduction devices, separated and vortical flows, and rotating blades. An introduction to transonic flows and computational aerodynamics will also be included. Students will explore Joukowski transformations, the Blasius solution, and vortex lattice methods for lift prediction.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5574. Heating, Ventilation and Air Conditioning. 3 Credit Hours.**

Overview of psychrometric and air conditioning processes, preparation of the energy balance, heat losses due to transmission and ventilation, the effect of solar radiation, heat gains, load calculations and simulations, design of heating, cooling, ventilating, and air conditioning (HVAC) systems, building energy system design, simulation, and control, duct, and piping system design, room air distribution and the air diffuser performance index, ADPI, including CFD analysis.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Course Attributes:** SI

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5575. Renewable and Alternative Energy. 3 Credit Hours.**

This survey course considers current technologies for renewable and alternative energy, including: different scenarios of producing energy; mechanical heat engines; ocean thermal energy converters; thermoelectricity; solar radiation; biomass; photovoltaic converters; wind energy; and ocean engines. The course will also consider the design of hydrogen-powered systems and of polymer electrolyte-membrane fuel cells.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Course Attributes:** SF

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5577. Power Generation and Storage Technologies. 3 Credit Hours.**

This course will give an overview of electric power generation technologies including coal, gas, and nuclear power plants, as well as some emerging technologies such as photovoltaic. This course will also discuss technologies used in power transmission and distribution such as overhead power line conductors. Power storage technologies will also be introduced including compressed air, flywheel, hydrogen, and batteries.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Course Attributes:** SI

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5578. Fundamentals of Combustion. 3 Credit Hours.**

This course is focused on concepts and applications of chemically reacting systems. Topics include heat of reaction, chemical equilibrium, chemical kinetics, chemical mechanisms, coupling chemical and thermal analyses of reacting systems, laminar premixed and diffusion flames, turbulent flames and pollutant emissions.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5643. Manufacturing Engineering. 3 Credit Hours.**

This course will provide an overview of existing and emerging manufacturing technologies in the modern society. Topics include state-of-the-art processing methods for metals and alloys, ceramics and powder metallurgy, polymers and composites, additive manufacturing of a wide range of solid materials, as well as micro- and nano- fabrications.

**Field of Study Restrictions:** Must be enrolled in one of the following Fields of study: Mechanical Engineering.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5731. Cardiovascular Fluid Dynamics. 3 Credit Hours.**

Mechanics of blood circulation, fluid mechanics of the heart, blood flow in arteries, unsteady flow in veins, current concepts in circulatory assist devices, biofluidics, and other selected topics.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5732. Tissue Biomechanics. 3 Credit Hours.**

Tissue Biomechanics course is an introductory course about the mechanical properties of living tissues. The emphasis of the course is on the meaning of constitutive models for bio-solids and bio-fluids. Topics include a review of elastic, viscous, and viscoelastic constitutive models; bioviscoelastic solids; mechanical properties of blood vessels; mechanics of skeletal and heart muscles.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 5733. Viscoelasticity. 3 Credit Hours.**

Rate dependent deformation of materials, creep and relaxation, viscoelastic constitutive models, large deformations, and other selected topics.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**MEE 8110. Special Topics. 3 Credit Hours.**

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 8315. Fracture Mechanics. 3 Credit Hours.**

This course will cover essential topics of fracture mechanics such as elastic stress intensity factor and Griffith energy balance, determination of the elastic field at a sharp crack tip via eigenfunction expansion methods, elastic-plastic crack tip fields, J integrals analysis, fatigue crack growth, and experimental determination of fracture toughness. Emphasis will be given to calculation of stress intensity factors using modern numerical methods, determination of critical crack sizes, and prediction of fatigue crack propagation rate.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of C- in ENGR 5314 and MEE 5203.

**MEE 8411. Probabilistic Robotics. 3 Credit Hours.**

This course will introduce students to various techniques for probabilistic state estimation and discuss their application to problems such as robot localization, navigation, mapping, and multi-object tracking. The course will provide students with a problem-oriented introduction to the material, and it may also cover related material from machine learning and computer vision. Students will conduct a final project on a subject of their choice.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may not be repeated for additional credits.

**Pre-requisites:** Minimum grade of B- in (MEE 5411, ECE 5033, or CIS 5526)

**MEE 9182. Independent Study I. 3 Credit Hours.**

Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by MS/MSE students and once by Ph.D. students.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9282. Independent Study II. 3 Credit Hours.**

Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by Ph.D. students.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9991. Directed Research. 1 to 6 Credit Hour.**

Under the guidance of a faculty member, the student will conduct independent research on a selected topic in engineering.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.**

This course is intended for Ph.D. students who have completed their coursework but who have not yet passed both the Ph.D. Preliminary Examination.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9995. Project. 1 to 3 Credit Hour.**

A project assigned with the approval of the Mechanical Engineering Graduate Committee and conducted under the supervision of a graduate faculty advisor. An oral presentation in an open seminar and a written report are required to complete the independent project. Projects related to industrial applications are encouraged. For non-thesis students only.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9996. Thesis. 1 to 3 Credit Hour.**

Master's thesis. May be taken twice.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.**

This course is intended for Ph.D. students who have passed both the Preliminary and Qualifying Examinations but who have not been elevated to candidacy.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Repeatability:** This course may be repeated for additional credit.

**MEE 9999. Dissertation Research. 1 to 6 Credit Hour.**

This course is intended only for those students who have achieved Ph.D. Candidacy status. A minimum of 6 semester hours is required for graduation.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate.

**Student Attribute Restrictions:** Must be enrolled in one of the following Student Attributes: Dissertation Writing Student.

**Repeatability:** This course may be repeated for additional credit.