MECHANICAL SCIENCES AND ENGINEERING

The Ph.D. program in Mechanical Sciences and Engineering at the University of Michigan-Dearborn educates and trains talented students who will conduct original and innovative research in the engineering field, educate future generations, and play leading roles in developing cutting edge technologies while working in industry, academia, and government. The doctoral program has a strong orientation toward the interfaces between the science of mechanical engineering and other areas. In addition to the core mechanical engineering subfields, such as mechanical and thermo-fluid sciences, the program's areas of research training include the emerging fields in which mechanical engineering intersects with the materials sciences, bioengineering, automotive engineering, optical engineering, and advanced energy technologies.

The Ph.D. program is highly selective and offers admission to exceptional students who have completed a Bachelor's or Master's degree in engineering, applied math, computer science, or physical science.

All students admitted for full-time study receive a competitive financial aid package in the form of an appointment as a graduate student instructor (GSI) or research assistant (GSRA).

All admissions are for the Fall term only.

If you have additional questions, please contact the program chair. D (https://umdearborn.edu/users/zikanov/)r. Dohoy Jung (https://umdearborn.edu/users/dohoy/).

The specific learning goals of the program is that the graduates will have:

- A strong foundation in engineering science and deep knowledge of the chosen field
- The ability to conduct high-quality original research in the broad field of Mechanical Sciences and Engineering
- The ability to communicate and disseminate their knowledge to a broader audience
- Preparedness for varied responsibilities and opportunities of careers in industrial research and academia.

Ph.D. in Mechanical Sciences and Engineering

The MSE Ph.D. degree requirements include a minimum of 36 credits of coursework and 24 credit hours of dissertation for Ph.D. students. The implementation of the requirements is, by necessity, different for the three major student profiles:

1. Direct Ph.D. students, who are admitted with a Bachelor's degree in mechanical engineering or a closely related field, but without a relevant Master's degree. Students of this group must complete no fewer than 36 credit hours of coursework, 30 of which allow them to earn an embedded MSE in mechanical engineering degree.
2. Students admitted with a relevant Master's degree (in mechanical engineering or a closely related field) from one of the Rackham school programs. These students must complete no fewer than 6 credit hours of coursework
3. Students admitted with a relevant non-Rackham (i.e., from outside the University of Michigan system) Master's degree. These students must satisfy the requirement of coursework in residence by completing no fewer than 18 credit hours of coursework.

For students entering with insufficient background in mechanical engineering and essential sciences, such as mathematics, physics, and chemistry, remedial coursework is assigned, which does not count toward the degree requirements.

The completed coursework must satisfy the minimum degree requirements specified below. Only letter-graded courses at the 500+ level will be allowed.

Each student is guided by a research advisor and a dissertation committee and must pass the following major milestones:

- Completion of required coursework
- Qualifying examination consisting of two parts:
  - Curriculum examination
  - Research fundamentals examination
- Dissertation proposal examination and advancement to candidacy
- Preparation of a written dissertation and its oral defense

Degree Requirements

For students admitted on the basis of a Master's degree, some of the requirements can be satisfied by the coursework completed during the Master's studies. This should be approved by the Ph.D. program committee and does not reduce the required total number of credits within the program.

GPA Requirement

To advance to candidacy, a student must have a cumulative GPA (Grade Point Average) of 3.5 or above on the 4.0-scale. Courses completed with a grade lower than 3.3 (B+) do not count toward the degree requirements.

Breadth Requirement

This requirement is for direct Ph.D. students only.

A student must take no fewer than two courses (6 credit hours) in each of the two major course groups.

1. Mechanical Sciences

ME 510|||||3||| ME 512|||||3||| ME 514|||||3||| ME 515|||||3||| ME 519|||||3|||
ME 540|||||3||| ME 542|||||3||| ME 543|||||3||| ME 545|||||3||| ME 547|||||3|||
ME 548|||||3||| ME 554|||||3||| ME 556|||||3||| ME 558|||||3||| ME 560|||||3|||
ME 563|||||3||| ME 565|||||3||| ME 567|||||3||| ME 570|||||3||| ME 580|||||3|||
ME 582|||||3||| ME 583|||||3||| ME 584|||||3||| ME 585|||||3||| ME 586|||||3|||
ME 587|||||3||| ME 589|||||3||| ME 591|||||3||| ME 593|||||3||| ME 595|||||3||| ME 610|||||3||| ME 640|||||3|||

2. Thermal/Fluid Sciences

ME 521|||||3||| ME 522|||||3||| ME 525|||||3||| ME 528|||||3||| ME 531|||||3|||
ME 532|||||3||| ME 535|||||3||| ME 537|||||3||| ME 538|||||3||| ME 552|||||3|||
ME 571|||||3||| ME 572|||||3||| ME 573|||||3||| ME 577|||||3||| ME 592|||||3||| ME 596|||||3||| ME 597|||||3||| ME 598|||||3||| ME 622|||||3|||

Depth Requirement

A least two courses (6 credit hours) must be in a sequence, i.e., belong to the same narrow field of studies (presumably the field of the student's research work) and include a higher-level course that continues the ideas of a lower-level course.

Cognate Requirement

At least 4 credit hours of coursework must be outside the mechanical engineering area. The second mathematics class (see below) can be used to satisfy all or part of this requirement.

Other ways of satisfying this requirement with some restrictions are:

- Engineering courses of 500+ level in a discipline other than mechanical engineering or the discipline of the student's Master's studies
- Other 500+ level courses, if approved by the program committee
- Completion of a University of Michigan Master's degree, which includes a cognate component
- Completion of a relevant Master's degree from another university which had coursework that meets the expectations of the program cognate requirement, without transferring the credit to the transcript

No more than 6 credit hours of cognate courses can be counted towards the degree requirement.

Directed Study Requirement

At least 6 credit hours of research coursework, guided by the student's research advisor, must be completed within the first two years of enrollment in the program. ME 600 (Study or Research in Selected ME Topics), ME 601 (Experimental Research in Mechanical Engineering), ME 602 (Guided Study in Mechanical Engineering), or ME 699 (Master's Thesis*) can be used for this purpose.

ME 600|||||1-3||| ME 601|||||1-3||| ME 602|||||1-6||| ME 699|||||1-6|||
* Can be used by direct Ph.D. students only.

Elective Requirement

The remaining coursework must be in graduate-level engineering, mathematics, or natural sciences courses.

Methodology Seminar

This course must be completed within the first two semesters of enrollment in the program. The seminar includes required training in responsible conduct of research and scholarship. The seminar carries no credit hours. Passing is based on participation and attendance, with the exception of the responsible conduct of a research and scholarship training module, for which a test is required.

Ph.D. Research Seminar

Attendance at this seminar is required for all Ph.D. students, including those at the pre-candidacy level, during each semester they are enrolled in the program. The seminar carries no credit hours and is graded pass/fail based on attendance and participation.

Advanced Mathematics Requirement

ME 518 (Advanced Engineering Analysis, 3 credit hours) must be taken within the first two semesters of enrollment in the program. A second graduate-level mathematics or mathematics-related class of no fewer than 3 credit hours must also be taken.

ME 518|||||3|||
A list of approved advanced mathematics courses is presented below. It is acceptable to use advanced mathematics courses to meet the cognate course requirement.

IMSE 510|||||3||| IMSE 511|||||3||| MATH 504|||||3||| MATH 5055|||||3||| MATH 512|||||3||| MATH 514|||||3||| MATH 515|||||3||| MATH 516|||||3||| MATH 520|||||3||| MATH 525|||||3||| MATH 551|||||3||| MATH 552|||||3||| MATH 554|||||3||| MATH 555|||||3||| MATH 558|||||3||| MATH 562|||||3||| MATH 583|||||3||| MATH 584|||||3||| MATH 592|||||3||| STAT 530|||||3||| STAT 535|||||3||| STAT 545|||||3||| STAT 590|||||3|||

Qualifying Examination

The qualifying examination consists of two parts to be taken in sequence:

- Part 1 – Curriculum Examination
- Part 2 – Research Fundamentals Examination

A student must be in good standing (GPA of at least 3.5) and is given two attempts to pass each part. The time limits to complete the examination after enrollment in the program are two years for full-time students and three years for part-time students.

The examination committee consists of 3 faculty members appointed by the program committee, none of whom is the student's research advisor.

Curriculum Examination

The goal of this examination is to ensure that students have good understanding of the fundamentals of mechanical sciences and engineering in the broad area of their research. The examination must be completed within the first three semesters of enrollment in the program and has two components:

1. Good performance in three courses selected during the first semester of enrollment in the program. The courses must be passed with grades not lower than 3.7 (A-).
2. A written examination on the material of one of these courses and the underlying undergraduate material.

Research Fundamentals Examination

This oral examination follows a successfully passed curriculum examination and, as a rule, occurs in the same or following semester. The objective is to ensure that a student has the necessary educational background and skills to conduct independent research in the selected area. The examiners test such aspects of the student's preparedness as:

- Depth and clarity of understanding in the selected area
- Ability to make independent logical conclusions
- Problem solving skills and creativity
- Communication skills.

Dissertation Proposal and Advancement to Candidacy

The last step of advancement to candidacy is the dissertation proposal examination, the main objective of which is to ensure sufficient strength and feasibility of the proposed research topic, as well as the suitability of the student's background and skills regarding the topic. The examination must be completed within a year of passing the qualifying examination.

The examination consists of a written dissertation proposal and its open-to-the-public presentation by the student. The examination is conducted by the dissertation committee. As a rule, the dissertation committee continues overseeing the student's work to the stage of final dissertation defense.

Dissertation and Defense

Dissertation Committee

The dissertation committee consists of the chair and three members. The student's dissertation advisor serves as chair. Of the three additional members, two must hold at least a 50 percent appointment as tenured or tenure-track faculty of the mechanical engineering department, with at least one being a member of the graduate faculty. The third committee member must be from outside the ME department—a faculty member from another department or another university, or an expert from industry.

The composition of the dissertation committee must be approved by the Ph.D. program committee.

Dissertation and Final Defense

Upon completion of the dissertation work, the student initiates the last step toward the degree—the dissertation defense process. The process follows the official guidelines and consists of the following main stages:

1. Preparation of a written dissertation formatted in accordance with the guidelines
2. Pre-defense meetings with the members of the program committee
3. Written evaluations of the dissertation by the dissertation committee members presented to the Ph.D. program committee
4. Oral defense of the dissertation consisting of two parts:
   - Public seminar and open question session held by the student
   - Private examination of the student by the members of the dissertation committee
5. Final oral examination report and certificate of approval prepared by the dissertation committee and submitted to the Ph.D. program committee

Time Limit for Completing the Degree

Full-time students must achieve candidacy within three years of enrolling in the program and complete the degree within five years of achieving candidacy. The total time for completing the degree is limited to seven years after enrolling in the program. Extensions of the time limits in justified cases are handled in accordance to the program guidelines.

ME 510 Finite Element Methods 3 Credit Hours
Overview and applications of FE theory in linear static and dynamic systems. Review of matrices, strain and stress tensors. Variational and energy principles in FEA. Applications in linear stress analysis; 1D, 2D and 3D. Transient solutions; modal analysis. Modeling concepts. Use of general purpose codes like ANSYS, NISA, ARIES. Project work. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 512 Structural Dynamics 3 Credit Hours
Advanced treatment of dynamic structural theories. Topics covered include: Rayleigh and Timoshenko beams and plates; free and forced vibration response of structural components; static and dynamic stability; and impact.
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 514 Advanced Mechanics of Materials 3 Credit Hours
Stresses and deformations in mechanical and structural elements and systems; theory, analysis and applications. Topics selected from among the following in applied elasticity and advanced mechanics of materials: stress and strain transformation; plane theory of elasticity and stress functions; energy methods; thick-walled cylinders and spinning disks; torsion of non-circular and hollow sections; unsymmetric bending and shear center; curved beams; beams on elastic foundations; plates and shells; elastic stability. Graduate standing or permission of instructor. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 515 Advanced Mechanics of Solids 3 Credit Hours
A comprehensive treatment of the theory of the mechanics of deformable media. Analysis of stress and strain, stress-strain relations, and the general equations of elasticity. Formulations for large strains; small strain linearization. Applications to boundary value problems. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 516 Special Topics in Mech Eng 1 to 3 Credit Hours
Selected topics pertinent to mechanical engineering. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Class is
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 518 Advanced Engineering Analysis 3 Credit Hours
The course emphasizes the exact methods used in the solution of the partial differential equations that arise in advanced engineering problems. Examples are taken from heat transfer, fluid dynamics, solid mechanics, electromagnetic theory, vibrations, etc. Linear integral equations, time dependent boundary conditions, nonlinear boundary conditions, and other topics. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Class is
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 521 Dyn and Therm of Comp Flow 3 Credit Hours
Review of basic equations of fluid mechanics and thermodynamics in control volume form. One-dimensional, compressible flow involving area change, normal shocks, friction, heat transfer, and combined effects. Two-dimensional supersonic flow including linearization, method of characteristics, and oblique shocks. One-dimensional, constant area, unsteady flow. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 522 Advanced Fluid Mechanics 3 Credit Hours
Graduate level course of fluid mechanics. Review of fluid flow phenomena based on common principles of transfer of mass, momentum, and energy. Introduction of the fundamental concepts and methods of analysis of fluid flows in industrial and environmental settings. Navier Stokes equations; viscous and inviscid flows; laminar and turbulent flows; boundary layers; drag; thermal convection. Prerequisite: Full course of undergraduate thermodynamics, fluid dynamics, and heat transfer. Course is the equivalent of ME 520. Students who have already taken ME 520 with a grade of B or better will not receive additional credit for ME 522. (W,YR)
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 525 Computational Thermo-Fluids 3 Credit Hours
The course introduces students to the fundamentals of computational fluid dynamics and heat transfer. Classification of partial differential equations and formulation of well-posed problems. Spatial and temporal approximation techniques for partial differential equations: stability, consistency and convergence. Finite volume formulations. Survey of methods for solving hyperbolic, elliptic, and parabolic problems. Formulation of discrete boundary conditions. Application of methods to one- and two-dimensional flow and heat transfer problems. (AY).
Prerequisite(s): ME 518
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 532 Combustion Processes 3 Credit Hours
Introduction to combustion processes, equilibrium and reaction kinetics. Combustion of premixed gases, detonation and deflagration flames. Laminar and turbulent flames. Ignition, flammability, and flame quenching. Application to spark, diesel and gas turbine engines. Combustion-generated pollution. Graduate standing or special permission. (YR).
Prerequisite(s): ME 371*
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 535 Advanced Thermodynamics 3 Credit Hours
Advanced treatment of engineering thermodynamics as applied to producing mechanical power and refrigeration. Involves rigorous application of the first and second laws. Topics to be discussed are energy/entropy generation, thermodynamics relations, nonreacting mixtures, and reacting mixtures. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 537 Automotive Air Conditioning 3 Credit Hours
Applications of HVAC fundamentals to analysis and design of automotive air conditioning systems. Topics include psychometrics, thermal comfort, refrigeration cycles and system design, heating system design, air flow circuits, air space diffusion, compact heat exchanger design, and instrumentation/controls.
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 538 Vehicle Thermal Management 3 Credit Hours
This course covers fundamental thermo-fluid principles and advanced topics in thermal management of conventional and electric drive vehicles (EDVs). The topics include: principles of energy conservation, heat transfer, and fluid mechanics; vehicle thermal management system and components; electrification of vehicle thermal management system; EDV thermal management; battery thermal management in EDVs; and waste energy recovery.
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 540 Mechanical Vibrations 3 Credit Hours
A study of the linear vibrations of discrete multi-degree-of-freedom systems. Generation of equations of motion using the unit displacement, unit force, and Lagrange methods. Generalized eigenvalue problem. Modal analysis. Effects of damping. Synthesis of forced response by the unit step, unit impulse, and Fourier series methods; response to shock excitation. Numerical techniques. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 542 Advanced Dynamics 3 Credit Hours
An advanced treatment of analytical mechanics for particles, systems of particles and rigid body motions with special emphasis on three-dimensional motion. Lagrange's equation of motion will be introduced and utilized in the analysis of multiple-mass systems. Computer methods will be covered. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 543 Vehicle Dynamics 3 Credit Hours
A treatment of the response, ride, and maneuvering of motor vehicles. Road loads, suspension systems, mechanics of pneumatic tires.
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 545 Acoustics and Noise Control 3 Credit Hours
Fundamentals of acoustical waves, sound propagation and intensity, instruments for vibration and noise, HVAC system noise, automobile and aircraft noise, noise control techniques. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 547 Powertrains I 3 Credit Hours
Topics in vehicle powertrain kinematics and dynamics, engine output characteristics, vehicle road load analysis, engine-transmission matching, design and analysis of gears and gear systems, planetary gear trains, design of powertrain components, clutch design and analysis, transmission design and analysis, torque and ratio analysis of automatic transmissions. (YR).
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 548 Automotive Powertrains II 3 Credit Hours
Simulation of vehicle performance; dynamics in gear shifting; engine balance, fuel economy, and performance related to powertrains; powertrain arrangements, manual and automatic transmissions, automotive axles, four-wheel-drive systems; design and manufacturing of gearing systems.
Prerequisite(s): AENG 547 or ME 547
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 552 Sustainable Energy Systems 3 Credit Hours
The course provides an overview of energy technology from a broad perspective that encompasses technical and environmental aspects. It covers a wide range of traditional and alternative energy sources and presents assessments of their availability, sustainability, and environmental impacts as well as evaluation of their potential role in solving the global energy problem. Course work includes project.
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 554 Theory of Gearing and Applicat 3 Credit Hours
The course emphasizes the theory and methodology for the design, manufacturing and analysis of gears and other engineering surfaces. Topics include differential geometry, kinematics of conjugate motions, surface enveloping, curvatures, cutter design, machine tool settings, simulation of machining process, tooth contact analysis, geometry modeling and design of power transmissions. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Class is
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 556 Stress and Stren Cons in Desgn 3 Credit Hours
Treatment of stress and strength aspects of machine design. Analytic and experimental determination of stresses in machine members. Evaluation of strength under steady and fatigue loadings. Post-yield behavior, residual stress, temperature and corrosion effects. Graduate standing or special permission. (YR).
Restriction(s):
Can enroll if Level is Rackham or Graduate
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 558 Fracture and Fatig Cons in Des 3 Credit Hours
A comprehensive review of fracture and fatigue processes in engineering material with emphasis on mechanics instead of mechanisms of failure. Design methodology based on fracture toughness and fatigue crack propagation is presented. Laboratory test methods and data interpretations are also presented. Graduate standing or permission of instructor. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 563 Advanced Instrum and Control 3 Credit Hours
Analysis of design techniques in modern control theory are presented. State space concepts, digital control, and adaptive control methods are covered, along with information on practical implementation problems experienced with these control techniques. Graduate standing or special permission. (YR).
Restriction(s):
Can enroll if Level is Rackham or Graduate
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 564 Linear Systems Control 3 Credit Hours
This course covers fundamental properties of linear dynamic systems. Topics include linear space, linear operators, Eigen-values/vectors, canonical form, representation, solution of state equations, stability, controllability, observability, design of state feedback control and development of observers with application examples in mechanical engineering. (OC)
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate
Can enroll if Major is Mechanical Engineering

ME 565 Mechatronics 3 Credit Hours
Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electrical engineering, control engineering, and computer science, all integrated through the design process. The course is to establish a working familiarity with the key engineering elements in the design and control of electro-mechanical systems in general and automotive systems in particular. The key engineering elements include microprocessor technology, electronics, sensors and actuators, data communication and interface, control algorithms, and mechanisms of machine elements. The course is to introduce a design methodology in an integrated system environment through case studies and design projects. (AY).
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 567 Reliability Consid in Design 3 Credit Hours
Theory and application of common statistical distributions to the analysis of both life and strength data for components. Introduction to system reliability. Emphasis on use of digital computer in reliability simulation and analysis. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 570 Powertrain NVH of Elect Veh 3 Credit Hours
This course focuses on the Noise, Vibration and Harshness (NVH) characteristics of Electric Vehicles (EV), Hybrid Electrical Vehicles (HEV), and Plug-In Electric Vehicles (PHEV). Topics include principles of mechanical vibration and acoustics, driveline induced noise/vibration from both conventional internal combustion engine and electrical motor/generator, cooling fan noise, regenerative braking system and electrical accessory noise. The potential countermeasures for typical noise/vibration sources will be presented. The course consists of classroom lectures and experimental laboratory sessions. The laboratory sessions will provide the student with hands-on experience on noise/vibration measurements and analyses. The student will be required to carry out a course project on NVH related subject of electrified vehicles.
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 571 Conduction Heat Transfer 3 Credit Hours
Conduction heat transfer in steady and transient state, including heat sources. Analytical, numerical, graphical, and analog methods of solution for steady and fluctuating boundary conditions. Thermal stresses. Dynamics of thermal instrumentation and heat exchangers. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 572 Convection Heat Transfer 3 Credit Hours
The course is primarily concerned with the determination of the rate of heat transfer due to the transport of energy to or from surfaces by both molecular conduction processes and gross fluid movement inside channels and over external surfaces. Emphasis will be placed on basic understanding of the convection heat transfer phenomena and the necessary mathematical techniques for the solution of such problems along with engineering applications. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 573 Radiative Transport of Heat 3 Credit Hours
Thermal radiation processes. Physics of monochromatic and total radiation. Emission and absorption. Exchange factors for black and gray surfaces and enclosures. Radiant exchange involving: absorbing and emitting media, including gases and flames. Properties of solar radiation. Significance of coatings on radiative interchange. Emphasis on basic understanding of the radiation heat transfer phenomena along with engineering applications and methods of solution of such problems. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 576 Battery Sys Modeling & Ctrl 3 Credit Hours
Full Course Title: Battery Systems, Modeling, and Control This course will cover modeling, control, and estimation techniques for battery systems. Students will learn how electrochemical systems work and how they can be mathematically described. A simple phenomenological electrical circuit model and a detailed physics-based model that can capture diffusion dynamics will be covered. The thermal behavior of a battery system and its modeling will be covered as well. Students will learn the basic functions of battery management systems for monitoring state-of-charge, state-of-power, and state-of-health in applications to automotive and consumer electronics. (OC).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate
Can enroll if Major is , Automotive Systems Engineering

ME 577 Energy Conversion 3 Credit Hours
This course covers fundamental engineering principles for converting available energy sources, renewable and nonrenewable, into other energy forms of direct utility. It may include such topics as steam and gas based power plants as well as devices for solar, wind, and hydraulic energy conversion.
Restriction(s):
Cannot enroll if Class is
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 580 Advanced Engineering Materials 3 Credit Hours
A second course in materials which expands the philosophy that all materials possess common traits which allow: (1) interchange of classes of materials to perform the same function, e.g., metals, polymers, ceramics, composites, etc.; and (2) understanding of the mechanisms of property controls in new materials. There is an attempt to provide equal representation of the science and the phenomena of engineering materials. Greater emphasis is placed on thermodynamics, stress-strain relations, multicomponent phase equilibria, and such other areas as received minimal exposure in the first course in materials. As a result of present technology trends, more time is spent on composites and achievement of design specifications through synthesis. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 582 Injection Molding 3 Credit Hours
This is an in-depth course on injection molding processes, which include the conventional injection molding process, low pressure injection molding, structural sandwich molding, gas assisted injection molding etc. Material, process and tool design parameters are emphasized. The roles of rheology and flow modeling are discussed. Design issues for injection molded products are also discussed. Injection molding applied to other materials, such as ceramics, is also described. (YR).
Restriction(s):
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 583 Mechanical Behav of Materials 3 Credit Hours
Mechanical behavior of materials are covered in relation to their structures, deformation characteristics and failure mechanisms. Means of improving strength, fracture toughness and other mechanical properties are discussed. Environmental effects on mechanical behavior are also included. The emphasis is on metals; however, polymers and ceramics are also covered. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 584 Mechanical Behavior of Polymer 3 Credit Hours
Mechanical behavior of polymers and ceramics are considered in relation to their structures, processing and applications. Emphasis is given on their deformation, fatigue and fracture characteristics. Strengthening mechanisms for both materials are discussed. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 585 Cast Metals in Eng Design 3 Credit Hours
An understanding of the properties of the most important cast metals is obtained by melting, casting, and testing. In addition to measurement of mechanical properties, resistance to heat, wear, and corrosion is discussed. The application of these properties in the design of critical parts in the aircraft, automotive, chemical, mining, and railroad industries is presented by case histories and examination of castings. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 586 Materials Consid in Manufactur 3 Credit Hours
Manufacturability of materials and influence of processing variables on the properties of manufactured products are important considerations in materials selection and product design. These issues are addressed on the basis of mechanical deformation and thermal characteristics of materials during processing. Test methods to measure formability, castability, machinability, etc., are critically discussed. Defects in manufactured products including their origin and detection are also discussed. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 587 Automotive Composites 3 Credit Hours
The emphasis in this course is on automotive composites, such as SMC, SRIM and RTM. In addition to properties and applications of these materials, this course covers manufacturing processes, design considerations, test methods and quality control techniques used for automotive composites. The use of continuous fiber composites in automotive applications, such as leaf springs, drive shafts and energy absorbing structures, are also discussed. (YR).
Restriction(s):
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 589 Composite Materials 3 Credit Hours
This course will consider four different aspects of composite materials; namely, materials, mechanics, manufacturing and design. Recent developments on fiber reinforced plastics and metals will be covered. Fundamental analytical concepts on micro and macro mechanics will be emphasized to create a better understanding of the design principles of composite materials. Graduate standing or special permission. (YR).
Restriction(s):
Cannot enroll if Class is
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 591 Degradation of Materials 3 Credit Hours
The course will introduce students to the fundamentals of corrosion and degradation behavior of materials. The degradation of metals, polymers and composites will be discussed. Monitoring and life prediction techniques will be covered. Preventive measures such a materials selection and design, protective coating, surface treatments, inhibitors, and electrochemical techniques are applied, when they should be used, and how various techniques can be integrated to solve complex problems. (AY).
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 592 Fuel Cells 3 Credit Hours
This course covers fundamentals of fuel cell systems for both automotive and distributed power applications. Detailed descriptions of the principles and component designs of various types of fuel cells including proton exchange membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), solid oxide fuel cell (SOFC), and molten carbonate fuel cell (MCFC). Discussions on water and thermal management, and balance of power plant. Review of hydrogen storage and safety consideration. Challenges and future opportunities.
Restriction(s):
Cannot enroll if Class is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 593 Powder Materials & Processing 3 Credit Hours
A lecture course that provides a comprehensive understanding of the theory and principles, the associated synthesis, processing, and characterization techniques; and the applications of powder and particulate materials. The students will gain knowledge of the following: fundamentals of powder and particulate materials (metals and ceramics), various metallic and non-metallic powder synthesis/production techniques, diverse techniques of powder characterization, and the principles and methods of homogenization, compaction, and sintering. Students will be exposed to the relevant criteria for designing parts/components based on powder and particulate materials and, will familiarize themselves with a wide range of applications-as structual, functional, and biomedical components made of metallic, ceramic, and composite powders-in various industries. (OC)
Restriction(s):
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 595 Digital Manufacturing 3 Credit Hours
This combined lecture and hands on project course aims to train students to optimize the interplay of materials, people, machines and profitability. The course introduces methods to identify product concepts with commercial potential. Student teams will perform market analysis and explore the intellectual property space around their ideas and rapidly iterate them into a final prototype via direct digital manufacturing (e.g., 3D CAD/CAM files manifested via digital printing or machining). Advanced instruction on direct digital manufacturing tools will be given, and customer response will be used as feedback. Early stage prototypes will progress into more sophisticated designs, scaling up (cost, pricing, tooling, process flow and automation) scenario planning for mass manufacturing as well as Failure Mode Effect Analysis (FMEA) will be discussed. (W,YR)
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 596 Internal Combustion Engines I 3 Credit Hours
Comparison of several forms of internal combustion engines including Otto and Diesel type piston engines; performance parameters and testing; thermodynamic cycles and fuel-air cycles; combustion in SI and Diesel engines; charge formation and handling; ignition; elements of exhaust emissions. (Not available to students with ME 496 or equivalent background.)
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 597 Internal Combustion Engines II 3 Credit Hours
Fuel flow and air flow measurements and techniques; engine maps; fuel and ignition control and control strategies; combustion and burn rate considerations in engine design; intake and exhaust systems; emissions and control strategies; emission test procedures.
Prerequisite(s): AENG 596 or ME 596
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 598 Engine Emissions 3 Credit Hours
This course introduces students to the fundamentals of engine exhaust emissions, including their formation mechanisms and abatement techniques. The students will be familiarized with the present emission control technologies and future challenges. The topics covered include: engine emissions and air pollution; review of emission regulations; catalyst fundamentals; catalyst aftertreatment techniques for gasoline, diesel, and lead-burn engines; discussion of cold start emission control and breakthrough catalytic technologies. (AY).
Restriction(s):
Cannot enroll if Level is
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 600 Study or Res in Sel Mech Eng 1 to 3 Credit Hours
Individual or group study or design in an area of Mechanical Engineering under the supervision of a member of the graduate faculty. The student will submit a report on the project and give an oral presentation to a panel of faculty members at the close of the term. Graduate standing or special permission. (YR).
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate

ME 601 Exper Research in Mech Eng 1 to 3 Credit Hours
Laboratory investigation in an area of Mechanical Engineering under the supervision of a member of the graduate faculty. The student will submit a report on the project and give an oral presentation to a panel of faculty members at the close of the term. Graduate standing or special permission. (YR).
Restriction(s):
Can enroll if Class is Graduate

ME 602 Guided Study in Mech Eng 1 to 6 Credit Hours
Independent Study of specified material in an area of Mechanical Engineering under the guidance of a member of the graduate faculty. The student will submit a report on the project and give an oral presentation to a panel of faculty members at the close of the term.
Restriction(s):
Can enroll if Class is Graduate

ME 607 Adv Mechanical Engin Problems 3 Credit Hours
A graduate-level analytical study of selected topics in mechanical engineering. The subjects of study in each term usually depend on student and instructor interest. Typical areas of study include vibrations of continuous or lumped systems, fluid mechanics, devices, thermodynamics, heat transfer, mechanics of solids, materials, or processing, etc. The course can be organized to meet the subject needs of a group of students with mutual interests.
Restriction(s):
Can enroll if Class is Graduate

ME 610 Finite Elem Methods--Nonlinear 3 Credit Hours
Review of FE theory in linear static. FEA in dynamics. FEA in heat transfer. FEA in fluid mechanics. FEA in nonlinear problems; material and geometrical nonlinearities, total and updated Lagrangian formulations, solution techniques. Use of FE codes. Graduate standing or special permission. (YR).
Prerequisite(s): ME 510
Restriction(s):
Can enroll if Class is Graduate

ME 611 Modeling of Engr Matls 3 Credit Hours
Full Course Title: Modeling of Engineering Materials This course will present the mathematical models and constitutive behavior of engineering materials subjected to mechanical and non-mechanical loads. It will consider both linear and non-linear models to describe elastic, plastic, viscoelastic, viscoplastic, hypo-and hyper-elastic response of materials to mechanical loads. Non-mechanical loads will include thermal and electro-mechanical fields. Micro-scale and multi-scale mechanical modeling will also be introduced. (OC)
Prerequisite(s): ME 518
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate
Can enroll if Program is

ME 622 Adv Topics in Fluid Mechanics 3 Credit Hours
The course presents selected topics of contemporary advanced fluid mechanics, such as the hydrodynamic stability theory, turbulence, multi-phase flows, magnetohydrodynamics, interfacial flows, flows of non-newtonian fluids, micro- and nano-fluid mechanics, biofluid mechanics, etc.
Prerequisite(s): ME 522
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate or or Doctorate
Can enroll if Program is PHD-Automotive Engineering, MSE-Mechanical Engineering, MSE-Automotive Engineering

ME 640 Advanced Vibration Theory 3 Credit Hours
The course will emphasize the similarities between various types of continuous systems as well as common features of continuous and discrete systems. Variational principle will be introduced as a notion of natural modes of vibration for discrete systems is reviewed. Natural modes of vibration for continuous systems will be discussed using the boundary value formulation, the general formulation of the eigenvalue problem and orthogonality. These concepts will be applied to bars, rods, membranes, and plates. Approximate methods will be introduced to determine the natural modes of vibration for complex continuous systems. A few methods to be considered include the Rayleigh-Ritz, Galerkin, Collocation, Myklestad, and Lumped-parameter methods. All the approximate methods presented will allow expedient numerical solution by means of high-speed computers. The damped and undamped response to deterministic excitations will be considered for various systems. Graduate standing or special permission. (YR).
Prerequisite(s): ME 540
Restriction(s):
Can enroll if Level is Rackham or Graduate

ME 642 Simulation of Mechanic Systems 3 Credit Hours
Analysis, synthesis, and optimization of linear, multilinear and nonlinear mechanical systems with the electronic analog computer. Graduate standing or special permission. (YR).
Prerequisite(s): ECE 365
Restriction(s):
Can enroll if Level is Rackham or Graduate

ME 675 Predictive Control of Dynamic Systems 3 Credit Hours
This course covers predictive control of dynamic systems to students working on controls. The topics will include unconstrained and constrained optimization, discrete-time optimal control problems, dynamic programming, stability, invariance, reachability, and linear predictive control problems with application examples in mechanical engineering. (OC).
Prerequisite(s): ME 564 or ECE 560

ME 699 Master's Thesis 1 to 6 Credit Hours
Graduate students electing the course, while working under the general supervision of a member of the department faculty, are expected to plan and carry out the work themselves and submit a thesis for review and approval, and also present an oral defense of the thesis. Students must satisfactorily complete 6 credit hours in ME 699, but these hours may be spread over more than one term. Graduate standing or special permission. (YR).
Restriction(s):
Can enroll if Class is Graduate

ME 791 Adv Guided Research 1 to 6 Credit Hours
Independent study and research work on the material related to the doctoral research project under the guidance of the faculty advisor. The course is for doctoral students who have not completed the PhD program's coursework requirements. A report and an oral presentation are required. (F,W,S)
Restriction(s):
Can enroll if Level is or Doctorate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Mechanical Engineering

ME 798 Doctoral Seminar 0 Credit Hours
After attaining candidacy, every Ph.D. students is required to attend and actively participate in research seminars given by CECS Dean's office or individual departments in CECS. A student gets a satisfactory grade if he/she attends at least two research seminars during the course period. (F,W,S)
Restriction(s):
Can enroll if Level is or Doctorate
Can enroll if Major is

ME 980 Pre-Cand Dissertation Research 1 to 9 Credit Hours
Full Title: Pre-Candidate Dissertation Research Dissertation work by a pre-candidate student in Mechanical Sciences and Engineering program conducted under guidance of the faculty advisor. (F,W,S)
Restriction(s):
Can enroll if Level is Doctorate or
Can enroll if Major is

ME 990 Doctoral Dissertation 1 to 9 Credit Hours
Dissertation work by a student of the Ph.D. in Mechanical Sciences and Engineering Program conducted under guidance of the faculty advisor. The student must be admitted to the Ph.D. candidacy status.
Restriction(s):
Can enroll if Level is Doctorate or
Can enroll if Major is