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.

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 (https://umdearborn.edu/cecs/departments/mechanical-engineering/graduate-programs/mse-mechanical-engineering/) or bioengineering (https://umdearborn.edu/cecs/departments/mechanical-engineering/graduate-programs/mse-bioengineering/).
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

For direct Ph.D. students, the courses must be selected so that, in addition to satisfying the Ph.D. program requirements, they satisfy the requirements of one of the two MSE degrees offered by the ME department: MSE in Mechanical Engineering (https://catalog.umd.umich.edu/graduate/college-engineering-computer-science/mechanical-engineering/#overviewtext) or MSE in Bioengineering (https://catalog.umd.umich.edu/graduate/college-engineering-computer-science/bioengineering/).

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.

Code	Title	Credit Hours
ME 600	Study or Research in Selected Mechanical Engineering Topics	1-3
ME 601	Experimental Research in Mechanical Engineering	1-3
ME 602	Guided Graduate Study in Mechanical Engineering	1-6
ME 699	Master's Thesis	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.

ENGR 700: Ph.D. Research Methodology Seminar

This course provides doctoral students with the fundamental training for conducting high-level scholarly research used in the various fields of engineering. Topics include evaluation of information resources, intellectual property, writing for journals and dissertation, effective work with scientific literature, literature review, plagiarism, publication, bibliographic management, and library resources. Students also complete the Responsible Conduct of Research (RCR) and Scholarship Training workshops. Additionally, students appointed as GSIs are required to attend the approved GSI training workshop.

The course is required for all doctoral students in the first year of enrollment and prior to taking the qualifying exam. Students must register for two semesters of ENGR 700 (one Fall semester and one Winter semester). Passing is based on participation and attendance. The seminars will carry no credit hours.

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.

Code	Title	Credit Hours
ME 518	Advanced Engineering Analysis	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.

Code	Title	Credit Hours
IMSE 510	Probability & Statistical Mod	3
IMSE 511	Design and Analysis of Exp	3
MATH 504	Dynamical Systems	3
MATH 512	Introduction to Modern Algebra	4
MATH 520	Stochastic Processes	3
MATH 523	Applied Linear Algebra	3
MATH 525	Statistical Inference	3
MATH 551	Advanced Calculus	4
MATH 554	Fourier Series and Boundary Value Problems	3
MATH 555	Functions of a Complex Variable with Applications	3
MATH 562	Mathematical Modeling	3
MATH 572	Introduction to Computational Mathematics	3
MATH 592	Introduction to Topology	4
STAT 530	Applied Regression Analysis	3
STAT 531	Machine Learning and Computational Statistics	3
STAT 535	Data Analysis and Modeling	3
STAT 590	Topics in Applied Statistics	3

Qualifying Examination

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

- Part 1 – Curriculum Examination
- Part 2 – Oral Qualifying 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.

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 committee will be selected from the graduate faculty by the program committee. The examination must be completed within the first three semesters of enrollment in the program. The examination will include the following steps:

1. A set of three mechanical engineering graduate-level courses is selected by the student during their first semester in the program. The list is then approved by the Ph.D. program committee. One course should be in the area of the student's research program (Research Area course).
2. Each course must be passed by the student with a grade no lower than 3.7 (A-).

Oral Qualifying Examination

This oral examination on the selected Research Area course will follow a successfully passed curriculum examination and, as a rule, occur in the same or following semester. The principal objective will be to ensure that a student has the necessary educational background and skills to conduct independent research in the selected area. Specifically, the examiners will 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

The examination committee will consist of 3 graduate faculty members appointed by the program committee, none of whom will be the student's research advisor. Three examiners submit the QE rubric and comments to the MSE Ph.D. Committee. The MSE Ph.D. Committee reviews the three examiners' reports and makes the final decision.

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 composition of a dissertation committee must adhere to the Rackham guidelines (see the Rackham dissertation handbook).

- Dissertation committees must have at least four members, including at least three tenure or tenure-track members (appointment as Professor, Associate Professor, or Assistant Professor) of the instructional faculty affiliated with a Rackham doctoral program.
- The chair, or one of the co-chairs in the case of co-advising, must be a member of the graduate faculty in the Mechanical Engineering (ME) Department.
- At least two of the four committee members must hold at least 50% appointment as tenured or tenure-track faculty in the ME Department, with at least one being a member of the graduate faculty.
- Committees must have a cognate member from outside the department: a faculty member with at least 50% appointment from a Rackham Doctoral program other than Ph.D MSE. The cognate member may not serve as chair or co-chair.
- A committee may have a sole chair or two co-chairs. By special arrangement, retired faculty members who were affiliated with a Rackham doctoral program or research professors may serve as sole chairs. Persons who may serve as co-chair, but not sole chair, include:
  - tenure or tenure-track members of the university's instructional faculty who are not affiliated with a Rackham doctoral program;
  - research faculty;
  - instructors and lecturers;
  - similarly qualified university faculty or staff, or person from outside the university; and
  - former university faculty members who have moved to a faculty position at another university
- Committees may include a person holding regular clinical, research professor, visiting, adjunct, instructor, or lecturer appointment. Subject to review on a case-by-case basis, a committee may include other qualified university faculty and staff, or person from outside the university who can provide expertise in the candidate's research area.
- Persons who do not have an earned doctorate, whether affiliated with a Rackham doctoral program or not, must be approved for committee service on a case-by-case basis.

For more information on the composition of the committee and roles of the members, see Guidelines for Dissertation Committee Service (https://rackham.umich.edu/downloads/oard-dissertation-committee-guidelines.pdf). The committee chair, graduate program personnel, or the graduate student may call a meeting of the dissertation committee, as needed.

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.

Specific Learning Goals

- 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.

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 Level is Rackham or Graduate or Doctorate or
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):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 513 Advanced Biomechanics 3 Credit Hours
This course covers intermediate level subject matter on structural biomechanics, analysis and design. Topics include: soft tissues biomechanics, human motion analysis including gait, orthopedic implants, fixation and reconstruction, head impact and injury, and advanced bone models. (YR) (YR).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 523 Sustainability Science and Engineering 3 Credit Hours
Sustainable development is commonly defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This course incorporates ethical and social issues into the design of products, processes and practices that will benefit the society as a whole. Specific emphasis will be given to engineering principles that will help engineers design products and services to meet societal needs with minimal impact on the global ecosystem. Using specific examples and illustrations, the course will demonstrate opportunities for sustainable engineering practices, providing students with valuable insight to applying these principles. Further, students will debate and evaluate biased and controversial opinions published in various media channels. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering, Automotive Systems Engineering, Bioengineering

ME 525 Computational Fluid Mechanics and Heat Transfer 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).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Mechanical Engineering-NCFD, , Bioengineering, Mechanical Engineering

ME 526 Microfluidics 3 Credit Hours
Microscaled systems and devices have enhanced reaction rates, predictable fluid mechanics, reduced reagent volumes, and a cheaper path to rapid prototyping. These advantages benefit many biomedical and processes engineering applications that require sensitive molecular detection and precise flow controls. In this course, a range of microsystem techniques will be discussed, including those based on microfluidics, MEMS, and optofluidics. The lectures will be accompanied by student-driven design projects that will be conducted in 3-hour laboratories. (YR).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 527 Transport in Biosystems - ME 3 Credit Hours
This course introduces the principles of transport phenomena (mass, fluid, and heat transfer) in biological and medical systems. Students will develop governing equations and learn analytical approaches to study topics that include but are not limited to biological fluid mechanics and circulation, solute transport in biological systems like cell membranes, transport phenomena in medical devices and artificial organs, and pharmacokinetic analysis. In addition to in-class lectures, the course integrates focused laboratory experiences that cover topics in biotransport phenomena like blood rheology and blood-brain barrier transport. There will also be a journal club presentation at the end of each lecture led by the students. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 530 Modeling of Automotive Systems 3 Credit Hours
This course will first introduce systems modeling approach and then develop mathematical models for ride, vibration, handling control, etc. of automobiles. The models will then be used to examine the design and performance of an automobile from a systems point of view. (YR).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (YR).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 547 Automotive 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 Level is Rackham or Graduate or Doctorate or
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):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 549 Mechanical Wave Vibrations 3 Credit Hours
Vibrations in distributed systems are analyzed using a novel wave based approach, in which vibrations are described as waves propagating along a structural waveguide. Such waves are reflected and transmitted when incident upon structural discontinuities. The propagation, reflection, and transmission relations are assembled in solving vibration problems in distributed mechanical structures. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , 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):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate
Can enroll if College is Engineering and Computer Science
Cannot enroll if Major is

ME 553 Structural Design and CAE Analysis for Electric Vehicle Batteries 3 Credit Hours
The course aim is to provide the knowledge on Electric Vehicle (EV) battery structural design, development, and validation using CAE analysis. Discussion is centered on the intertwined relationship between EV and batteries during the entire phase of their design, development, and validation. Topics include the discussion on structural analysis for battery module/pack and cells as well as battery components, module/pack sizing, PSD profile development for shaker table, shaker table analysis, and thermal cyclic analysis. Battery manufacturing variations are discussed as well. Finite element techniques for batteries in vehicle validation are also covered. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 555 Computational Uncertainty Quantification for Engineering Applications 3 Credit Hours
This course focuses on a probabilistic (Bayesian) treatment of uncertainties in modeling a system's behavior, specifically adapted to mechanical engineering and bioengineering problems. This treatment extends to both making predictions under uncertainty (predictive modeling) as well as updating our knowledge about the system model using data/measurements (Bayesian inference). The course will emphasize both (i) applications with physical models as well as (ii) applications with statistical models build entirely based on data/inference. The course will start by briefly reviewing the foundations of probability as a multi-valued logic that quantifies all our available knowledge about a real system and its environment. This leads to a rigorous meaning for the probabilistic model for a system. The main part of the course focuses on computational tools for (i) predictive analysis (i.e., uncertainty propagation) and (b) Bayesian system estimation/identification (i.e., model updating based on experimental observations). (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Bioengineering, Mechanical Engineering

ME 5561 Vehicle Structure Design with CAE 3 Credit Hours
This course provides a comprehensive introduction to key design principles related to the stress and strength of machines and structures under both monotonic and cyclic loadings. Students will explore both analytical and numerical methods for stress analysis and structural strength evaluation, addressing steady-state and fatigue conditions. Emphasis is placed on vehicle structure design. By the end of the course, students will be able to apply analytical techniques to calculate stress and strain in vehicle structures subjected to mechanical loads. They will also gain proficiency in using commercial software to analyze stress and strain for both linear and nonlinear materials. Either ME 556 or ME 5561 may be applied to degree, but not both. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 557 Sustainable Fuels for Transportation 3 Credit Hours
This course will cover the fundamentals of combustion relevant to transportation fuels and the working principles of combustion-based energy conversion devices. We will explore various forms of sustainable fuels, such as biodiesel, bioethanol, hydrogen, e-fuels, and advanced biomass-derived fuels. Additionally, methods for life cycle analysis will be taught to quantify the true impact of sustainable fuels on carbon and pollutant emissions. The course will also discuss the practical implications of integrating sustainable fuels into the current transportation infrastructure. This course includes hands-on projects using computational tools. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 558 Fracture and Fatigue Considerations in Design 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 559 Battery Materials, Manufacturing and Recycling 3 Credit Hours
This course will provide a comprehensive review of electrode and electrolyte materials used in batteries and their relationship with the battery energy density, power density, voltage, etc. Various manufacturing methods of electrodes and electrolytes and their pros and cons in terms of manufacturing cost, energy, speed, scalability, and environmental impact will be presented. Battery cell types and the structures and materials of battery modules and packs will be introduced. How to calculate module and pack-level energy density and other characteristics will be presented. Finally, various battery recycling methods will be presented. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering, Manufacturing System Engin, Automotive Systems Engineering, Industrial & Systems Engin

ME 562 Energy Management of Electrified Vehicles 3 Credit Hours
This course covers the longitudinal dynamics of electrified vehicles and optimization of energy consumption. Mathematical models are developed for analyzing the energy consumption of vehicle systems. Fundamentals of optimization and optimal control are studied for developing energy management strategies for energy-efficient ground vehicle propulsion. The topics include: vehicle longitudinal dynamics, modeling powertrain components, optimization and optimal control. (OC).
Restriction(s):
Can enroll if Level is Graduate or Doctorate or
Can enroll if Major is , 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 Doctorate or Rackham or Graduate or
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. (OC).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 566 Materials Thermodynamics and Kinetics 3 Credit Hours
A lecture course that provides an understanding of thermodynamics and kinetics in materials and materials processing. Students will develop skills to evaluate the stability of materials under various external conditions, design processes to produce desired materials structures (microstructure and nanostructure), and predict the evolution of materials structures under different operating conditions. Topics will include laws of thermodynamics, equilibrium of single and multiphase systems, chemical thermodynamics, statistical thermodynamics of solid-solutions, equilibrium phase diagrams (unary, binary, and ternary), chemical kinetics, diffusion in solids, nucleation and growth processes, coarsening, glass transition, and phase transformations. Students will be exposed to various software commonly used in industries to evaluate materials thermodynamics and kinetics: Thermo-Calc, CALPHAD, and JMatPro. (YR).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Mechanical Engineering

ME 568 Computational Materials Design 3 Credit Hours
The course introduces the fundamentals of modeling and simulations in materials engineering. It covers atomic scale molecular dynamics simulations, mesoscale phase-field simulations, and data-driven machine learning modeling. Software tools including LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator), VMD (Visual Molecular Dynamics), MATLAB, and ParaView will be introduced. Students are expected to develop models across different scales, run programs, and analyze the results. (YR).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Mechanical Engineering

ME 569 Introduction to Materials Characterization 3 Credit Hours
Designed for graduate students to gain an in-depth understanding of principal methods in materials characterization and analysis. This course will survey bulk as well as nanoscale structural characterization, such as identity, chemical composition and hierarchical arrangement. Analysis techniques such as optical microscopy, X-ray diffraction, electron microscopy, scanning probes and spectroscopy will all be reviewed. Students will learn principles of image formation and interpretation, resolution, contrast and chemical analysis. Focuses on fundamental concepts of different methods as well as practical applications.
The intent is to allow the student to make an educated selection of characterization techniques, or critical analysis of data, for materials and defect analysis. (YR).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Mechanical Engineering

ME 570 Powertrain NVH of Electrified Vehicles 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. (YR).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 574 Advanced Heat Transfer 3 Credit Hours
The course is a comprehensive graduate-level introduction into three modes of heat transfer: conduction, convection, and radiation. Topics include principles, governing equations, and applications of heat transfer; multidimensional steady-state and unsteady heat conduction; forced and natural heat convection in external and internal flows; analysis and design of heat exchangers; fundamentals and analysis of radiative heat transfer; methods of computational solution of heat transfer problems; applications to engineering problems. (OC).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , 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 Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical 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 578 Advanced Vehicle Energy Systems 3 Credit Hours
Sustainability is an increasingly important topic for the automotive industry. This course discusses sustainable vehicle technology with focus on energy-related aspects, such as resources, consumption, environmental impacts, and regulations. It reviews sustainable technologies employed in automotive systems to reduce emissions in an energy-efficient manner and discusses their impacts on the industry. The course covers the fundamentals, characteristics, and design considerations of the vehicle energy systems. Students have a hands-on practice using numerical simulation tools. Specific technical topics include advanced internal combustion engines, alternative fuels with the focus on biofuels, hybrid, electric, and fuel cell vehicles, waste energy recovery systems, and smart grid system. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Mechanical Engineering

ME 579 Aerodynamics of Road Vehicles 3 Credit Hours
This course covers the fundamental principles, numerical modeling, and experimental analysis of the aerodynamics of road vehicles. Practical applications to the design and operation of cars, vans, trucks, buses, and motorcycles are also discussed. The course includes hands-on projects using computational fluid dynamics software. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 583 Mechanical Behavior 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 585 Cast Metals in Engineering 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 586 Materials Consideration in Manufacturing 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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
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 Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 592 Fundamentals of 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. (OC).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
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 Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 595 Digital Manufacturing and Product Innovation 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):
Can enroll if Level is Rackham or Graduate or Doctorate or
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.)
Prerequisite(s): ME 330 or ME 325
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Automotive Systems 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. (OC).
Prerequisite(s): AENG 596 or ME 596
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
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. (OC).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering-NCFD, Mechanical Engineering

ME 600 Study or Research in Selected Mechanical Engineering Topics 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):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or

ME 601 Experimental Research in Mechanical Engineering 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):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or

ME 602 Guided Graduate Study in Mechanical Engineering 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):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or

ME 607 Advanced Mechanical Engineering 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):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 610 Finite Element 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. (OC).
Prerequisite(s): ME 510
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Mechanical Engineering

ME 611 Modeling of Engineering Materials 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 Rackham or Graduate or Doctorate or
Can enroll if Program is

ME 622 Advanced 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):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Program is

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. (OC).
Prerequisite(s): ME 540
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or

ME 674 Advanced Topics in Heat Transfer 3 Credit Hours
The course presents selected topics of contemporary advanced heat transfer, including, but not limited to radiation in participating media, heat transfer at nanoscales, heat transfer in the presence of phase change, cooling of electronic components, liquid-metal heat exchangers, heat transfer in biological systems, etc. (OC).
Prerequisite(s): ME 572 or ME 574
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Mechanical Engineering

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
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

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 Advanced 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

ME 798 Doctoral Seminar 0 Credit Hours
Every Ph.D. student is required to attend and actively participate in research seminars given by the CECS Dean's office or individual departments in CECS. A student gets a satisfactory grade if they attend 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-Candidate 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 12 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