Mechanical Engineering, Ph.D.

COLLEGE OF ENGINEERING

Learn more about the Doctor of Philosophy in Mechanical Engineering.

About the Program

The Ph.D. in Mechanical Engineering is designed to develop mechanical engineers who have a solid foundation in mechanical engineering research methods, design, and analytics. Doctoral students are prepared to identify a research area in mechanical engineering and analyze the literature, develop theory, perform experimentation, and develop their own methodologically rigorous research studies. Students complete their studies with a mastery of the fundamental critical thinking and analytic skills and competencies necessary for mechanical engineering. Graduates are well prepared to be engineers and researchers in a range of academic units, non-profit organizations, government agencies, and the private sector.

Time Limit for Degree Completion: 7 years

Campus Location: Main

Full-Time/Part-Time Status: Students are able to complete the didactic portion of the Ph.D. degree program through classes offered after 4:30 p.m.

Interdisciplinary Study: Engineering research is highly interdisciplinary and draws on collaboration with members of the faculty and students within the department, as well as with departments in other schools and colleges at Temple University, including the School of Medicine and the College of Science and Technology.

Areas of Specialization: Faculty in the Department of Mechanical Engineering are actively engaged in research in the following areas:

- Biofluidics
- Biomechanics
- Combustion
- Composite Materials
- Finite Element Analysis
- Fluid Dynamics
- Fluid Mechanics
- Heat and Mass Transfer
- Material Science
- Mechanics of Materials
- Vibration and Controls

In the first term, the student and the ME Graduate Program Director jointly initiate a Plan of Study. This form lists all required courses and the program requirement sequence for the student to follow. The Plan of Study is used to track the student's progress, with an annual annotation and update as the student completes various benchmarks in the Ph.D. program.

Job Prospects: The program is primarily intended for individuals who wish to pursue careers in industry, government, and academia in a highly creative environment. The program is dedicated to producing engineers who will contribute to advancements in mechanical engineering.

Non-Matriculated Student Policy: Up to 9 credits of graduate Engineering coursework may be taken at Temple University on a non-matriculated basis and subsequently applied to the Ph.D. degree upon admission. If the applicant's undergraduate GPA was less than 3.0, a GPA of 3.25 or better is required on this non-matriculated graduate coursework to receive an admissions exception. Consequently, the Mechanical Engineering Graduate Program Director may encourage those with an undergraduate GPA less than 3.0 to take their first three graduate courses prior to making formal application to the Ph.D. program. (See the relevant Graduate School policies on special admission procedures for non-matriculated students: 02.23.11.03 and 02.24.19.)

Financing Opportunities: Applicants for full-time study in the Mechanical Engineering Ph.D. program are automatically considered for financial aid. Three forms of financial aid are awarded to Ph.D. students on a competitive basis:

1. Teaching Assistantship (TA): TA awards are made solely by the Department and require the awardee to work 20 hours per week in support of the Department's undergraduate programs. The TA is compensated with a 9-month stipend, a basic health-insurance plan, and 9 credits per term of tuition remission.

2. Research Assistantship (RA): Individual faculty confer RA awards, using their research funds, upon students who appear well-qualified to carry out the research. Typically, this faculty member becomes the RA's doctoral advisor. The RA normally works up to 20 hours per week and is compensated with a stipend, basic health insurance, and tuition remission.
3. Fellowships: Fellowships are awarded by the University in a competitive process that is open to all Ph.D. applicants. The Mechanical Engineering Graduate Program Director nominates exceptional Ph.D. applicants for a University Fellowship. Fellows receive 9 to 12 months of stipend, depending on the award; basic health insurance; and 12 credits of tuition remission each Fall and Spring term. Fellows of the University have no work obligations with respect to either the Department, the College, or the University.

Because financial aid is awarded on a competitive basis, applicants are urged to complete the application as early as possible.

**Admission Requirements and Deadlines**

**Application Deadline:**

*Fall:* March 1  
*Spring:* November 1; August 1 international

Applications are processed on a continual basis. Ordinarily, the applicant is informed of an admissions decision within 4 to 6 weeks of receipt of all supporting application documents.

Both admissions and financial aid award decisions originate in the Department of Mechanical Engineering within the College of Engineering. Applicants who plan to matriculate full-time are automatically considered for financial aid awards so no separate application for financial aid is required. To ensure financial aid consideration for the intended term of study, however, applicants should submit a complete application by January 15 (Fall) and August 1 (Spring).

**APPLY ONLINE to this graduate program.**

**Letters of Reference:**

**Number Required:** 3

**From Whom:** Letters of recommendation should be obtained from college or research faculty who are familiar with the applicant's competency. If the applicant has an established career in engineering, one of the letters should be provided by the applicant's immediate supervisor. If the applicant has been out of school long enough that relevant academic reference letters appear impractical, s/he should contact the Mechanical Engineering Graduate Program Director to obtain a waiver of this admission requirement.

**Coursework Required for Admission Consideration:** Students not adequately prepared for advanced courses may be required to take a number of prerequisites. The Department of Mechanical Engineering identifies the needed coursework on a case-by-case basis.

**Master's Degree in Discipline/Related Discipline:** A master's degree is not required, but preferred.

**Bachelor's Degree in Discipline/Related Discipline:** A bachelor's degree is required.

University regulations stipulate that the applicant must have earned a 3.0 grade-point average on a 4.0 scale in her/his undergraduate studies, but admission exceptions are made for a variety of circumstances. (See Graduate School Policy 02.23.11.03.) The Mechanical Engineering Graduate Program Director helps the applicant navigate the admission possibilities and assists in the assessment of her/his overall educational qualifications with respect to the departmental requirements for the Ph.D. program.

**Statement of Goals:** Describe your relevant technical experiences, career goals, and specific research interests in one to two pages.

**Standardized Test Scores:**

**GRE:** Required. Scores must be no more than 5 years in advance of the application date. (See Graduate School Policy 02.23.12.) Applicants who require a waiver of the GRE should consult the Mechanical Engineering Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

Applicants who earned their baccalaureate degree from an institution where the language of instruction was other than English, with the exception of those who subsequently earned a master's degree at a U.S. institution, must report scores for a standardized test of English that meet these minimums:

- TOEFL iBT: 79
- IELTS Academic: 6.5
- PTE Academic: 53

**Resume:** Current resume required.

**Advanced Standing:** Both transfer credit for courses taken at another institution while matriculated at Temple and/or advanced standing credit for courses taken within the 5-year period prior to matriculating at Temple may be applied toward the Ph.D.-level didactic coursework requirement. Written approval is required from the student’s doctoral advisor, the College’s Associate Dean for Graduate Study, and the Graduate School. (See Graduate School Policy 02.24.21.) Up to six credits of advanced standing for courses taken within the 5-year period prior to matriculating at Temple may be used to satisfy the master's-level didactic coursework requirement. Approval of the Mechanical Engineering Graduate Program Director is required. The courses must be equivalent to courses offered at Temple in the student's area of study and research, and the grades must be 'B' or better.
Program Requirements

General Program Requirements:

Minimum Number of Credits Required Beyond the Bachelor’s: 60, including 45 credits of graduate-level didactic coursework and 15 research credits, including preliminary Ph.D. examination and dissertation research.

Minimum Number of Credits Required Beyond the Master’s: 30, including 15 credits of graduate-level didactic coursework and 15 research credits, including preliminary Ph.D. examination and dissertation research.

Required Courses:

Post-Baccalaureate (for students WITHOUT a master’s degree in Mechanical Engineering)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Didactic Courses 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research Courses 2</td>
<td></td>
</tr>
<tr>
<td>MEE 991</td>
<td>Directed Research (8 credits)</td>
<td></td>
</tr>
<tr>
<td>MEE 994</td>
<td>Preliminary Examination Preparation (1 credit)</td>
<td></td>
</tr>
<tr>
<td>MEE 998</td>
<td>Pre-Dissertation Research (3 credits)</td>
<td></td>
</tr>
<tr>
<td>MEE 999</td>
<td>Dissertation Research (3 credits)</td>
<td></td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

1 Didactic coursework is typically selected by the student’s Doctoral Advisory Committee. It may include up to, but no more than, 3 credits of MEE 9182 Independent Study I, 3 credits of MEE 9282 Independent Study II, or 3 credits of MEE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University’s other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

2 Expected distribution of the 15 credits associated with Ph.D. examinations and dissertation research is shown, although the actual distribution of credits can vary across courses depending on the student’s particular circumstances.

Post-Master’s (for students WITH a master’s degree in Mechanical Engineering)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Didactic Courses 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research Courses 2</td>
<td></td>
</tr>
<tr>
<td>MEE 991</td>
<td>Directed Research (8 credits)</td>
<td></td>
</tr>
<tr>
<td>MEE 994</td>
<td>Preliminary Examination Preparation (1 credit)</td>
<td></td>
</tr>
<tr>
<td>MEE 998</td>
<td>Pre-Dissertation Research (3 credits)</td>
<td></td>
</tr>
<tr>
<td>MEE 999</td>
<td>Dissertation Research (3 credits)</td>
<td></td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>

1 Didactic coursework is typically selected by the student’s Doctoral Advisory Committee. It may include up to, but no more than, 3 credits of MEE 9182 Independent Study I, 3 credits of MEE 9282 Independent Study II, or 3 credits of MEE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University’s other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

2 Expected distribution of the 15 credits associated with Ph.D. examinations and dissertation research is shown, although the actual distribution of credits can vary across courses depending on the student’s particular circumstances.

Culminating Events:

Formation of the Doctoral Advisory Committee:

Selection of a research advisor and formation of a Doctoral Advisory Committee constitute the first steps toward achieving a Ph.D. Selection of a doctoral advisor depends on the student’s level of preparation upon entering the Ph.D. program. The Doctoral Advisory Committee selects the required coursework and guides the progress of the student’s dissertation research:

- Students entering the Ph.D. program with a master’s degree, i.e., those who must complete 30 credits to earn the degree, form their Doctoral Advisory Committee before the end of their second regular term of study.
- Students entering the program with a bachelor’s degree, i.e., those who must complete 60 credits to earn the Ph.D. degree, generally complete most of their coursework before forming their Doctoral Advisory Committee by the end of their fourth regular term in the program.
See Graduate School Policy 02.28.11 for clarification on the composition of the Doctoral Advisory Committee.

Preliminary Examination:
All students generally complete their didactic coursework prior to taking the preliminary examination. (See Graduate School Policy 02.27.11.) Students in the 30-credit cohort ordinarily take the exam in their third or fourth term. Students in the 60-credit cohort typically take the exam no later than the eighth regular term. Students should register for one credit of MEE 9994 Preliminary Examination Preparation in the term when the exam will be taken.

The preliminary exam tests both the student’s core knowledge in Mechanical Engineering and her/his capacity to synthesize and interpret research communications. The student coordinates the scheduling of the preliminary exam with the ME Graduate Program Director. The ME Graduate Program Director supervises the specific form, content, and frequency of the Mechanical Engineering preliminary exam. A maximum of two opportunities to pass the preliminary exam are available to the student. In each term when the exam is attempted, the student registers for one credit of MEE 9994. Students are dismissed upon the second failure.

Dissertation Proposal:
Within a year of passing the preliminary exam, the student must develop a written research proposal and present it in an open College seminar. Ten business days prior to the presentation seminar, the student must schedule the proposal and post an announcement. Immediately following the seminar, the Doctoral Advisory Committee questions the student about the details and strategy of her/his proposed research.

Approval is granted for the proposed dissertation research when the ‘Dissertation Proposal Transmittal for Elevation to Candidacy’ form (found in TU portal under the Tools tab within “University Forms”) has been signed off by the entire Doctoral Advisory Committee. After the dissertation proposal has been accepted by the Doctoral Advisory Committee and the Graduate School has received the form, the student is considered to be a doctoral candidate. (See Graduate School Policy 02.28.12 for more information.)

Research Credits:
Students carry out research throughout their studies and register for the corresponding research credits while in the Ph.D. program. However, the type of research credits that a student registers for depends on the student’s progress in the program:

- Prior to passing the preliminary exam, credit hours associated with the student’s research should be registered under MEE 9991 Directed Research.
- After the preliminary exam is passed, but before elevation to candidacy, credit hours associated with the student’s research should be registered under MEE 9998 Pre-Dissertation Research.
- After elevation to candidacy, the student’s research credits should be registered under MEE 9999 Dissertation Research. Students are required to register for at least three credits of MEE 9999 following their elevation to candidacy. (See Graduate School Policy 02.28.15.)

Publications:
Paper writing and presentation at a conference are considered integral to the student's training. Also, peer review, in part, offers an indication of the quality and novelty of the student's research. All doctoral students must publish at least two technical papers in refereed journals or refereed conferences. The papers must be based on the student's dissertation research with the student as the first author.

Dissertation:
The dissertation defense is an open University seminar in which the student presents the concepts and results of her/his research.

The student must coordinate the formation of the Dissertation Examining Committee in the term that s/he intends to defend her/his dissertation. This committee consists of the original Doctoral Advisory Committee plus one additional “external” member who is not faculty in the College of Engineering. If the external examiner is not a member of Temple University’s Graduate Faculty, the person must be approved by the Graduate School at least four weeks prior to the dissertation defense.

The dissertation defense is to take place during a regular academic term (i.e., not scheduled during study days, final exams, or the breaks between terms). If the student is to graduate in the same term as the dissertation defense is held, then the defense should take place at least 30 days prior to the end of the term to allow for document revisions.

Three weeks prior to the defense, the members of the committee elect a Chair of the Dissertation Examining Committee. The Chair cannot be the student’s doctoral advisor. The Associate Dean of Research and Graduate Studies must approve the selection. The Chair is identified to the Graduate School in the student’s official request for permission to schedule the defense. (See Graduate School Policy 02.28.15.) The Chair’s role includes coordination of the proceedings of the defense and completion of all relevant College and Graduate School forms concerning the defense.

The dissertation document should be prepared in a format compliant with University standards. (See Graduate School Policy 02.28.18.) A copy of the completed dissertation must be provided to the committee at least three weeks before the date of the dissertation defense. Note that any Graduate Faculty may request a copy of the dissertation in advance of the defense and may participate in the defense.

A minimum of two weeks prior to the defense, a public announcement of the defense must be posted. Prior to posting, this announcement must be approved in writing by the Graduate School. (See Graduate School Policy 02.28.16.)

Immediately following the presentation, the Dissertation Examining Committee closely examines the student’s performance and her/his research. External attendees may participate in this closed portion of the defense with the permission of the Dissertation Examining Committee Chair. However, only members of the Dissertation Examining Committee may actually vote on the decision to accept the dissertation as prepared, accept the dissertation
with revisions, or not accept the dissertation. If the dissertation is accepted with revisions, a revised copy of the dissertation must be submitted and approved by the Committee within 30 days of the original defense date.

Contacts

Program Web Address:
https://www.temple.edu/academics/degree-programs/mechanical-engineering-phd-en-me-phd

Department Information:
College of Engineering
ATTN: ME Programs
1947 N. 12th Street
Philadelphia, PA 19122-6077
gradengr@temple.edu
215-204-7800

Submission Address for Application Materials:
https://apply.temple.edu/Engineering/

Department Contacts:
Admissions:
Colleen P. Baillie, Ed.D.
colleenb@temple.edu
215-204-7800

Graduate Program Director, ME:
Kurosh Darvish, Ph.D.
kurosh.darvish@temple.edu
215-204-4307

Interim Chairperson, ME:
Shih-Jiun (Jim) Chen, Ph.D.
jsjchen@temple.edu
215-204-4305

Courses

MEE 5110. Special Topics. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

MEE 5117. Finite Element Analysis. 3 Credit Hours.
Concepts and techniques of finite element and finite difference methods; mesh generation techniques; computer graphics presentation methods. Application to solids, liquids, and gases in the areas of stress, strain, deflection elasticity, heat transfer, fluid flow, and combustion.

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

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

MEE 5201. Thermodynamics of Materials. 3 Credit Hours.
An introductory master's level course that explores materials from a thermodynamic perspective: Includes the laws of thermodynamics, free energy, chemical potential, stability, etc. A detailed analysis of phase diagrams is presented in the second half of the course.

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

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

MEE 5203. Advanced Materials Science. 3 Credit Hours.
Chemical bonding, crystallography, defects and their effects on material properties, nucleation, growth, and microstructure development.

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

Repeatability: This course may not be repeated for additional credits.
MEE 5205. Microscopy and Microanalysis of Materials. 3 Credit Hours.
This course will cover various Microscopy and Microanalysis techniques which are widely used in research labs and in industries to characterize micro and nano structure and chemical composition of solid matter. Among them are visual light, scanning probe and electron beam microscopy and associated spectroscopy. The primary focus will be on fundamental aspects and experimental methods of Scanning Electron Microscopy (SEM) and associated spectroscopy. The SEM facility will be used for individual student projects. Particular attention will be given to the selection criteria used for choosing the appropriate technique for materials characterization.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Repeatability: This course may not be repeated for additional credits.

MEE 5211. Frontiers in Mechanical Engineering. 3 Credit Hours.
This is a survey course designed to introduce graduate students to cutting-edge research in the mechanical-engineering sciences. Topics will be taken from active research areas in the Mechanical Engineering Department, including (but not limited to) biomechanics, multifunctional materials, materials processing and/or manufacturing, acoustic sensors, nano/micro-technologies, and robotics. The course will have a coordinator, but the lectures will be given by a variety of mechanical-engineering faculty selected for their research expertise.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering, Science & Technology.
Repeatability: This course may not be repeated for additional credits.

MEE 5312. Mechanics of Composite Materials. 3 Credit Hours.
Introduction to the behavior of composite materials and their use in engineering structures: behavior and properties of the constituent fibers and matrices, micromechanical predictions of composite properties, anisotropic elasticity, behavior of composite laminae, classical lamination theory; fracture mechanisms, failure theories; behavior of composite plates and beams.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Repeatability: This course may not be repeated for additional credits.

MEE 5411. Introduction to Mobile Robotics. 3 Credit Hours.
How can one create mobile robots that operate autonomously in cluttered indoor and outdoor environments? How do robots determine their state and properties from noisy sensor data to accomplish navigation and manipulation tasks? The Introduction to Mobile Robotics course will address motion planning, control, sensing and estimation for mobile robots. The goal of the class is to train students to develop real-time planning and control software modules for robotic systems. Students taking this course are expected to be familiar with differential equations, linear algebra, and multi-variable calculus. Experience with programming in Matlab or Octave is recommended (and Matlab will be used in the course).

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Repeatability: This course may not be repeated for additional credits.

MEE 5412. Modern Dynamics for Robotics. 3 Credit Hours.
This course focuses on the algebraic and differential equations governing the static and dynamic 3D motion of rigid bodies, including vectors, vector differentiation, and dyads. The equations of motion for multibody systems will be derived using Newton-Euler, Lagrange, and Kane's methods. Computational tools for 3D force and motion analysis will be used to simulate physical systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Repeatability: This course may not be repeated for additional credits.

MEE 5413. Robotic Manipulation. 3 Credit Hours.
This course is an introduction to the design, modeling and control of robot manipulators, using modern dynamic formulations for multi-degree of freedom, 3D rigid body systems. This course covers 3D spatial transformations, forward and inverse kinematics, Jacobians, joint space and operational space control, and force control. This course also introduces ROS for communication and control of 2 6 axis robotic arms.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MEE 5412|Minimum Grade of C-|May not be taken concurrently
OR ENGR 5334|Minimum Grade of C-|May not be taken concurrently.
MEE 5423. Engineering Acoustics. 3 Credit Hours.
This graduate level course introduces the fundamentals of engineering acoustics and will help students establish a deep understanding of the physics of acoustic-wave propagation. Students will also be able to acquire knowledge on computational tools used to study acoustic systems, and explore emerging areas in acoustics including acoustic metamaterial and bio-inspired acoustic sensors.

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

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

**Pre-requisites:**
ENGR 5012|Minimum Grade of C|May be taken concurrently.

MEE 5511. Thermodynamic Properties. 3 Credit Hours.
Review of quantum mechanics and introduction to statistical mechanics. Statistical thermodynamics and various models of matter. Accuracy and trends of the predicted properties of various materials.

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

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

MEE 5512. Compressible Fluid Dynamics. 3 Credit Hours.
This course introduces students to the subject of high speed gas dynamics. Compressible flows exhibit fundamentally different behavior from those in low speed, constant density fluids. Such flows are found in aerodynamics, combustors, turbines, jets, gas pipelines, and wind tunnel facilities. Students study phenomena associated with supersonic flows, including normal and oblique shocks, expansion fans, and compressible flows with friction and/or heat transfer. An introduction to high temperature and rarified gas dynamics is also included.

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

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

MEE 5575. Renewable and Alternative Energy. 3 Credit Hours.
This survey course considers current technologies for renewable and alternative energy, including: different scenarios of producing energy; mechanical heat engines; ocean thermal energy converters; thermoelectricity; solar radiation; biomass; photovoltaic converters; wind energy; and ocean engines. The course will also consider the design of hydrogen-powered systems and of polymer electrolyte-membrane fuel cells.

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

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

MEE 5577. Power Generation and Storage Technologies. 3 Credit Hours.
This course will give an overview of electric power generation technologies including coal, gas, and nuclear power plants, as well as some emerging technologies such as photovoltaic. This course will also discuss technologies used in power transmission and distribution such as overhead power line conductors. Power storage technologies will also be introduced including compressed air, flywheel, hydrogen, and batteries.

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

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

MEE 5578. Fundamentals of Combustion. 3 Credit Hours.
This course is focused on concepts and applications of chemically reacting systems. Topics include heat of reaction, chemical equilibrium, chemical kinetics, chemical mechanisms, coupling chemical and thermal analyses of reacting systems, laminar premixed and diffusion flames, turbulent flames and pollutant emissions.

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

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

MEE 5643. Manufacturing Engineering. 3 Credit Hours.
This course will provide an overview of existing and emerging manufacturing technologies in the modern society. Topics include state-of-the-art processing methods for metals and alloys, ceramics and powder metallurgy, polymers and composites, additive manufacturing of a wide range of solid materials, as well as micro- and nano- fabrications.

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

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

**Repeatability:** This course may not be repeated for additional credits.
MEE 5731. Cardiovascular Fluid Dynamics. 3 Credit Hours.
Mechanics of blood circulation, fluid mechanics of the heart, blood flow in arteries, unsteady flow in veins, current concepts in circulatory assist devices, biofluidics, and other selected topics.

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

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

MEE 5732. Tissue Biomechanics. 3 Credit Hours.
Tissue Biomechanics course is an introductory course about the mechanical properties of living tissues. The emphasis of the course is on the meaning of constitutive models for bio-solids and bio-fluids. Topics include a review of elastic, viscous, and viscoelastic constitutive models; bioviscoelastic solids; mechanical properties of blood vessels; mechanics of skeletal and heart muscles.

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

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

MEE 5733. Viscoelasticity. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

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

MEE 8110. Special Topics. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

MEE 8315. Fracture Mechanics. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

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

MEE 9182. Independent Study I. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by MS/MSE students and once by Ph.D. students.

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

Repeatability: This course may be repeated for additional credit.

MEE 9282. Independent Study II. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by Ph.D. students.

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

Repeatability: This course may be repeated for additional credit.

MEE 9991. Directed Research. 1 to 6 Credit Hours.
Under the guidance of a faculty member, the student will conduct independent research on a selected topic in engineering.

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

Repeatability: This course may be repeated for additional credit.

MEE 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have completed their coursework but who have not yet passed both the Ph.D. Preliminary Examination.

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

Repeatability: This course may be repeated for additional credit.
MEE 9995. Project. 1 to 3 Credit Hour.
A project assigned with the approval of the Mechanical Engineering Graduate Committee and conducted under the supervision of a graduate faculty advisor. An oral presentation in an open seminar and a written report are required to complete the independent project. Projects related to industrial applications are encouraged. For non-thesis students only.

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

Repeatability: This course may be repeated for additional credit.

MEE 9996. Thesis. 1 to 3 Credit Hour.
Master's thesis. May be taken twice.

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

Repeatability: This course may be repeated for additional credit.

MEE 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have passed both the Preliminary and Qualifying Examinations but who have not been elevated to candidacy.

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

Repeatability: This course may be repeated for additional credit.

MEE 9999. Dissertation Research. 1 to 6 Credit Hour.
This course is intended only for those students who have achieved Ph.D. Candidacy status. A minimum of 6 semester hours is required for graduation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Student Attribute Restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student.

Repeatability: This course may be repeated for additional credit.