DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers a Master of Science degree in Advanced Manufacturing and Enterprise Engineering and Master of Science and Doctor of Philosophy degrees in Mechanical Engineering.

- M.S. in Advanced Manufacturing and Enterprise Engineering (p. 1)
- M.S. in Mechanical Engineering (p. 2)
- Ph.D. in Mechanical Engineering (p. 3)

Master of Science Degree in Advanced Manufacturing and Enterprise Engineering

The Master of Science program in Advanced Manufacturing and Enterprise Engineering (M.S. in AMEE) is designed to offer an opportunity to individuals for continued study toward positions of leadership in industry and academia and for continuing technical education in a more specialized area. The graduates of this program will have the fundamental knowledge and understanding of the operational complexity of enterprises, manufacturing and business process improvement/optimization, and integrated product/process/system design. In addition, they will have the cognitive skills to critically evaluate the potential benefits of alternative manufacturing strategies, to use virtual/simulated platforms to facilitate and improve business processes, and to analyze enterprise systems as systems of interacting units, components, and subsystems. The program offers three concentration areas, namely Advanced Manufacturing, Enterprise Engineering, and Sustainable Systems Engineering.

Program Admission Requirements

A complete application package consists of the following:

- Students must meet the University-Wide Admission Requirements as outlined in the graduate catalog
- Official transcripts of all undergraduate and graduate coursework
- Official Graduate Record Examination (GRE) scores
- A statement of purpose/research experience
- Two professional and/or academic letters of recommendation
- Résumé or Curriculum Vitae (CV)

Due to the multidisciplinary nature of the program, the Graduate Advisor of Record (GAR), in consultation with the Mechanical Engineering Graduate Studies Committee and the Department Chair, will evaluate each student’s transcript and determine course deficiencies, if any, on a case-by-case basis. Applicants who have insufficient preparation for the program may be admitted on a conditional basis. Students admitted with course deficiencies will be required to take additional remedial courses. Courses taken to make up deficiencies may not be counted toward the graduate degree requirements. Other applicants who wish to continue their education in the area of Advanced Manufacturing and Enterprise Engineering, but do not intend to pursue a Master of Science degree, may seek admission as a special graduate student.

Degree Requirements

Thesis Option

The minimum number of semester credit hours required for the degree is 30 for the thesis option.

A. 15 semester credit hours of required topical courses selected from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 5213</td>
<td>Topics in Systems Modeling</td>
</tr>
<tr>
<td>EGR 5233</td>
<td>Advanced Quality Control</td>
</tr>
<tr>
<td>EGR 6033</td>
<td>Linear and Mixed Integer Optimization</td>
</tr>
<tr>
<td>ME 5503</td>
<td>Lean Manufacturing and Lean Enterprises</td>
</tr>
<tr>
<td>ME 5563</td>
<td>Computer Integrated Manufacturing</td>
</tr>
<tr>
<td>ME 5573</td>
<td>Facilities Planning and Design</td>
</tr>
<tr>
<td>ME 5583</td>
<td>Process Improvement and Variability Reduction</td>
</tr>
<tr>
<td>ME 5603</td>
<td>Advanced Manufacturing Systems Engineering</td>
</tr>
<tr>
<td>ME 5643</td>
<td>Green and Sustainable Manufacturing and Enterprise Systems</td>
</tr>
<tr>
<td>ME 5703</td>
<td>Lean Product Development and Service Systems</td>
</tr>
<tr>
<td>ME 6543</td>
<td>Machine Learning and Data Analytics</td>
</tr>
<tr>
<td>ME 6563</td>
<td>Flexible Automation and Manufacturing Systems</td>
</tr>
</tbody>
</table>

B. 9 semester credit hours of Prescribed Electives approved by student's advisor:

Electives are approved in consultation with either the student's advisory committee or the Graduate Advisor of Record.

C. Degree candidates must complete a minimum of 6 credit hours of the following course requirements for the thesis option:

<table>
<thead>
<tr>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 6983</td>
</tr>
<tr>
<td>Master's Thesis</td>
</tr>
</tbody>
</table>

Total Credit Hours 30

Non-Thesis Option

The minimum number of semester credit hours required for the degree is 33 for the non-thesis option.

A. 15 semester credit hours of required topical courses selected from the following:

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</tr>
</tbody>
</table>

B. 15 semester credit hours of Prescribed Electives approved by student's advisor:

Electives are approved in consultation with either the student's advisory committee or the Graduate Advisor of Record.

C. Degree candidates must complete a minimum of 3 semester credit hours of the following course requirement for the non-thesis option:

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<tr>
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<tbody>
<tr>
<td>ME 6983</td>
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</table>
Graduate Studies Committee and the Department Chair, will evaluate of Record (GAR), in consultation with the Mechanical Engineering Due to the multidisciplinary nature of the program, the Graduate Advisor Engineering degree program are as follows:

**Program Admission Requirements**

The minimum requirements for admission to the Master's in Mechanical Engineering degree program are as follows:

- Students must meet the University-Wide Admission Requirements as outlined in the graduate catalog
- Official transcripts of all undergraduate and graduate coursework
- Official Graduate Record Examination (GRE) scores
- A statement of purpose/research experience, and ranking of the concentration areas based on preference
- Two professional and/or academic letters of recommendation
- Résumé or Curriculum Vitae (CV)

Due to the multidisciplinary nature of the program, the Graduate Advisor of Record (GAR), in consultation with the Mechanical Engineering Graduate Studies Committee and the Department Chair, will evaluate each student’s transcript and determine course deficiencies, if any, on a case-by-case basis. Applicants who have insufficient preparation for the program, may be admitted on a conditional basis. Students admitted with course deficiencies will be required to take additional remedial courses. Courses taken to make up deficiencies may not be counted toward the graduate degree requirements. Other applicants who wish to continue their education in an area of Mechanical Engineering but do not intend to pursue a Master of Science degree, may seek admission as special graduate students.

### Degree Requirements

#### Thesis Option

The minimum number of semester credit hours required for the degree is 30 for the thesis option.

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<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>A. Required mathematics course: EGR 6013</td>
<td>3</td>
</tr>
<tr>
<td>B. Degree candidates are required to choose a major area and take two courses (6 semester credit hours) in their major area of study listed below:</td>
<td></td>
</tr>
<tr>
<td>Thermal and Fluid Systems ME 5243</td>
<td>Advanced Thermodynamics</td>
</tr>
<tr>
<td>ME 6613</td>
<td>Advanced Fluid Mechanics</td>
</tr>
<tr>
<td>Robotics and Control ME 5493</td>
<td>Fundamentals of Robotics</td>
</tr>
<tr>
<td>ME 6123</td>
<td>Advanced Systems Dynamics and Control</td>
</tr>
<tr>
<td>Mechanics and Materials ME 5713</td>
<td>Mechanical Behavior of Materials</td>
</tr>
<tr>
<td>ME 6413</td>
<td>Elasticity</td>
</tr>
<tr>
<td>C. 15 semester credit hours of Designated electives (with approval of the student’s advisor):</td>
<td></td>
</tr>
<tr>
<td>ME 6983</td>
<td>Master's Thesis</td>
</tr>
</tbody>
</table>

### Non-Thesis Option

The minimum number of semester credit hours required for the degree is 33 for the non-thesis option.

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<td>Mechanical Behavior of Materials</td>
</tr>
<tr>
<td>ME 6413</td>
<td>Elasticity</td>
</tr>
<tr>
<td>C. 21 semester credit hours of Designated electives (with approval of the student’s advisor):</td>
<td></td>
</tr>
</tbody>
</table>
The minimum requirements for admission to the Doctor of Philosophy in Mechanical Engineering degree program are as follows:

- A statement of research experience, interests and goals
- Three professional and/or academic letters of recommendation attesting to the applicant's readiness for doctoral study

Degree Requirements

The degree requires 63 semester credit hours of course and research work beyond the bachelor's degree or 42 semester credit hours beyond the master's degree, and passing of Qualifying Examinations, Dissertation Proposal, Dissertation Defense and acceptance of the Ph.D. dissertation.

Required coursework and the timeline for expected progress are given below. In general, undergraduate courses, general education courses, and prerequisites for graduate courses do not count towards the required number of credit hours.

Students with the Master of Science degree in engineering may, with the approval of the Graduate Studies Committee, follow the 42-semester-credit-hour program of study described as follows. Students without the Master of Science degree in engineering are required to complete the 42-hour program of study as follows, and an additional 21 semester credit hours of coursework, as determined in consultation with their Advisor and the Graduate Advisor of Record.

Degree Curriculum for Students that have obtained a Master's Degree

Students that have obtained a master's degree must complete the following required 42 semester credit hours:

A. Common Core Courses (6 semester credit hours):

1. Required course:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 6113</td>
<td>Experimental Techniques in Engineering (or equivalent course with prior approval by the department)</td>
</tr>
</tbody>
</table>

2. Choose one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 6013</td>
<td>Advanced Engineering Mathematics I</td>
</tr>
<tr>
<td>EGR 6033</td>
<td>Linear and Mixed Integer Optimization</td>
</tr>
</tbody>
</table>

B. Technical Core Courses: 6

Among the three areas listed below, students are required to take two courses (6 semester credit hours) in their major area of study:

Thermal and Fluid Systems

<table>
<thead>
<tr>
<th>Course Code</th>
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</thead>
<tbody>
<tr>
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<td>Advanced Thermodynamics</td>
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<tr>
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</tr>
</tbody>
</table>

Design and Manufacturing Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 5603</td>
<td>Advanced Manufacturing Systems Engineering</td>
</tr>
<tr>
<td>ME 6543</td>
<td>Machine Learning and Data Analytics</td>
</tr>
</tbody>
</table>

Mechanics and Materials

<table>
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<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 5713</td>
<td>Mechanical Behavior of Materials</td>
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Robotics and Control

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 5493</td>
<td>Fundamentals of Robotics</td>
</tr>
<tr>
<td>ME 6123</td>
<td>Advanced Systems Dynamics and Control</td>
</tr>
</tbody>
</table>

C. Technical Elective Courses (6 semester credit hours): 6

Students are required to take at least two elective courses in consultation with their Ph.D. advisor.

D. Doctoral Research and Dissertation (24 semester credit hours): 24

1. Seminar

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 7993</td>
<td>Research Seminar (3 credit hours)</td>
</tr>
</tbody>
</table>
Department of Mechanical Engineering

2. Doctoral Research (minimum of 9 semester credit hours required):
   ME 7951 Doctoral Research
   ME 7952 Doctoral Research
   ME 7953 Doctoral Research

3. Doctoral Dissertation (after admitted for candidacy) (minimum of 12 semester credit hours required):
   ME 7981 Doctoral Dissertation
   ME 7982 Doctoral Dissertation
   ME 7983 Doctoral Dissertation

Total Credit Hours 42

Degree Curriculum for Students that have Obtained a Bachelor’s Degree

Students that have obtained a bachelor’s degree must complete the following required 63 semester credit hours:

A. Common Core Courses (6 semester credit hours):
   1. Required course:
      ME 6113 Experimental Techniques in Engineering (or equivalent course with prior approval by the department)
   2. Choose one of the following:
      EGR 6013 Advanced Engineering Mathematics I
      EGR 6033 Linear and Mixed Integer Optimization

B. Technical Core Courses (6 semester credit hours):
   Among the four areas listed below, students are required to take two courses (6 semester credit hours) in their major area of study:
   - Thermal and Fluid Systems
     ME 5243 Advanced Thermodynamics
     ME 6613 Advanced Fluid Mechanics
   - Design and Manufacturing Systems
     ME 5603 Advanced Manufacturing Systems Engineering
     ME 6543 Machine Learning and Data Analytics
   - Mechanics and Materials
     ME 5713 Mechanical Behavior of Materials
     ME 6413 Elasticity
   - Robotics and Control
     ME 5493 Fundamentals of Robotics
     ME 6123 Advanced Systems Dynamics and Control

C. Technical Elective Courses (27 semester credit hours):
   Students are required to take at least 9 elective courses in consultation with their Ph.D. advisor.

D. Doctoral Research and Dissertation (24 semester credit hours):
   1. Seminar
      ME 7993 Research Seminar (3 credit hours)
   2. Doctoral Research (minimum of 9 semester credit hours required):
      ME 7951 Doctoral Research
      ME 7952 Doctoral Research
      ME 7953 Doctoral Research
   3. Doctoral Dissertation (after admitted for candidacy) (12 semester credit hours required):
      ME 7981 Doctoral Dissertation
      ME 7982 Doctoral Dissertation
      ME 7983 Doctoral Dissertation

Total Credit Hours 63

Progression and Milestones

Ph.D. Advisor and Dissertation Committee

Students must select an advisor within the first 9 semester credit hours of coursework. The Ph.D. advisor must be a tenured or tenure-track faculty member of the Mechanical Engineering Department or have an adjoint affiliation with the Mechanical Engineering Department. The program of study, as well as the selection of core and elective courses, must be recommended by the student's Ph.D. advisor.

A Dissertation Committee must be created at least one month before dissertation proposal defense. The committee, with a minimum of four members, includes the Ph.D. advisor as the chair of the committee. At least 50 percent of the committee members must be Mechanical Engineering graduate faculty and one must be outside the Mechanical Engineering Department, whose suitability will be subject to approval of the Graduate School. Part-time faculty may serve as members of the dissertation committee, but not as chair.

Doctoral Candidacy

All students seeking a doctoral degree must be admitted to candidacy in order to become eligible to continue their research leading to the Doctoral degree. The requirement for admission to candidacy is passing the qualifying examination and the dissertation proposal defense.

Written Qualifying Examinations

The qualifying examination of the Ph.D. in Mechanical Engineering program consists of written questions in both common and major areas of research interest of the student. The purpose of the written qualifying examination is to ensure that students pursuing a doctoral degree in Mechanical Engineering have the essential depth and breadth of knowledge basis.

The written qualifying examination is offered twice a year, generally in January and June. Upon approval by their Ph.D. advisor, students wishing to take the examination must submit their request using the designated form to the Graduate Advisor of Record. Normally, students who have completed the coursework listed under sections A and B of the degree curriculum are able to take the examination. The written qualifying examination includes the Common Core and Technical Core based on their fields of study.

1. Common Core (select one):
   a. Advanced Engineering Mathematics
   b. Linear and Mixed Integer Optimization

2. Technical Core (select one area):
   b. Design and Manufacturing Systems: Advanced Manufacturing Systems Engineering, Advanced Data Analytics
   c. Mechanics and Materials: Elasticity, Mechanical Behavior of Materials

Retaking the Written Qualifying Examination

A student who failed the first attempt may be allowed to take the examination a second time. However, no more than two attempts are permitted. Should a student fail the qualifying exam for a second time, he or she will be dismissed from the doctoral program. The dismissed
student may apply for the Master's degree in Mechanical Engineering by transferring the credits earned from the doctoral program upon the approval of the Graduate Studies Committee of the department.

**Doctoral Dissertation Proposal**
The student should first consider research topics for his/her dissertation under the supervision of his/her advisor, and then write and defend a dissertation proposal based on his/her preliminary studies. Students must pass the doctoral dissertation proposal defense before being permitted to register for doctoral dissertation.

For more information, please see the online Ph.D./ME Handbook (http://engineering.utsa.edu/mechanical/joint-graduate-program).

**Final Dissertation Defense and Graduation**
Candidates must demonstrate their ability to conduct independent research by completing an original dissertation. The Dissertation Committee guides, critiques and finally approves the candidate's dissertation. All coursework in the final program of study must have been taken within eight years to include successful completion and defense of the dissertation. The format of the dissertation must follow University regulations.

**Academic Probation and Dismissal**
- To receive the doctoral degree, students must follow the University-wide Requirements of Doctoral Degree Regulations in the UTSA Graduate Catalog. University-wide regulations of academic probation and dismissal are defined in the Academic Standing section of the General Academic Regulations in Student Policies.
- Students who fail the qualifying exam for a second time will be dismissed from the doctoral program.

**ME 5013. Topics in Mechanical Engineering. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Current topics in mechanical engineering, such as advanced fracture mechanics, lean manufacturing, advanced manufacturing engineering and advanced energy systems. May be repeated for credit with consent of Graduate Committee as topics vary. Differential Tuition: $165.

**ME 5143. Advanced Dynamics. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Review of Newtonian mechanics, 3-D particle kinematics, dynamics of a system of particles, analytical mechanics, Lagrange's equations, kinematics and rigid-body dynamics, Eulerian angles, computational analysis using a symbolic language. Differential Tuition: $165.

**ME 5183. Advanced Mechanical Vibration. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Free and forced vibration of single and multi-degree-of-freedom systems; response to harmonic, periodic, and nonperiodic excitations; continuous systems; computational techniques for the response. Differential Tuition: $165.

**ME 5243. Advanced Thermodynamics. (3-0) 3 Credit Hours.**
Prerequisite: ME 3293. Concepts and postulates of macroscopic thermodynamics; formulation of thermodynamic principles; exergy stability of thermodynamic systems, principles of irreversible thermodynamics, chemical equilibria. Differential Tuition: $165.

**ME 5263. Combustion. (3-0) 3 Credit Hours.**
Prerequisite: ME 4293. Thermochemistry and transport theory applied to combustion; gas phase equilibrium; energy balances; reaction kinetics; flame temperatures, speed, ignition, and extinction; premixed and diffusion flames; combustion aerodynamics; mechanisms of air pollution. Differential Tuition: $165.

**ME 5273. Alternative Energy Sources. (3-0) 3 Credit Hours.**
Prerequisite: ME 3293. Solar, nuclear, wind, hydrogen, and geothermal energy sources. Resources, production, utilization, economics, sustainability, and environmental considerations. (Same as CE 5643. Credit cannot be earned for both ME 5273 and CE 5643.) Differential Tuition: $165.

**ME 5283. Power Plant System Design. (3-0) 3 Credit Hours.**
Prerequisites: ME 4293 and ME 4313. Application of thermodynamics and fluid mechanics to the design of vapor and gas-turbine power plant systems including boilers, condensers, turbines, pumps, compressors, cooling towers, and alternative energy power plants. Differential Tuition: $165.

**ME 5303. Advanced Heat and Mass Transfer. (3-0) 3 Credit Hours.**

**ME 5343. Convection. (3-0) 3 Credit Hours.**
Prerequisite: ME 4313. Derivation of equations of convection of mass, momentum, and energy; scale analysis; boundary layer solutions; classical, laminar convection problems; turbulent convection; natural convection. Differential Tuition: $165.

**ME 5353. Radiation. (3-0) 3 Credit Hours.**
Prerequisite: ME 4313. Thermal radiation laws, geometric factors, black bodies, gray enclosures, nongray systems, combined conduction, convection, and radiation. Differential Tuition: $165.

**ME 5453. Advanced Strength of Materials. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Failure theories, energy methods, advanced topics in bending, torsion, and stress concentration. (Formerly EGR 5553. Credit cannot be earned for both ME 5453 and EGR 5553.) Differential Tuition: $165.

**ME 5463. Fracture Mechanics. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Introduction to failure and fracture of engineering materials, Griffith's energy balance, stress intensity and strain energy release rate approaches to brittle fracture, Dugdale and Irwin approaches to ductile fracture. Application to modern engineering materials. (Formerly EGR 5313. Credit cannot be earned for both ME 5463 and EGR 5313.) Differential Tuition: $165.

**ME 5473. Viscoelasticity. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Principle of fading memory, integro-differential constitutive laws, mechanical models, time and temperature superposition, and linear and nonlinear methods. Applications to polymers, composites, and adhesives. (Formerly EGR 5323. Credit cannot be earned for both ME 5473 and EGR 5323.) Differential Tuition: $165.

**ME 5483. Finite Element Methods. (3-0) 3 Credit Hours.**
Prerequisite: Graduate standing in engineering or consent of instructor. Derivation and computer implementation of the finite element method for the solution of boundary value problems. (Same as CE 5023 and CE 5193. Credit cannot be earned for more than one of the following: ME 5483, CE 5023 and CE 5193.) Differential Tuition: $165.
ME 5493. Fundamentals of Robotics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Theoretical and analytic developments, Denavit-Hartenberg parameters, quaternions, state-space, linear and nonlinear analysis, classical and modern methods of mechanics, serial manipulators, parallel manipulators, and controls. Differential Tuition: $165.

ME 5503. Lean Manufacturing and Lean Enterprises. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Methodologies for transforming an enterprise into a lean enterprise. Topics include Lean Manufacturing basics and tools; Lean Implementation Guidelines; Lean Metrics and Performance Measures; Lean Extended Enterprise; and Lean Supply Chain Design and Management. Hands-on Value Stream Mapping project is required. Differential Tuition: $165.

ME 5513. Advanced Mechanism Design. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Advanced topics in kinematic synthesis of linkage, static and dynamic force analyses, and computer-aided design of mechanisms. Differential Tuition: $165.

ME 5533. Advanced Machine Design. (3-0) 3 Credit Hours.
Prerequisite: ME 3823 or an equivalent. Advanced problems in machine design, including bearings, brakes, clutches, gears, shafts, springs, and advanced stress analysis. Differential Tuition: $165.

ME 5543. Probabilistic Engineering Design. (3-0) 3 Credit Hours.
Prerequisite: STA 2303 or an equivalent. Development and application of probabilistic methods in engineering: random variable definitions, probability distributions, distribution selection, functions of random variables, numerical methods including Monte Carlo sampling, First Order Reliability Methods, and component and systems reliability. (Same as BME 6333. Credit cannot be earned for both BME 6333 and ME 5543.) Differential Tuition: $165.

ME 5553. Advanced Design of Cams and Gears. (3-0) 3 Credit Hours.
Prerequisites: ME 3823 and ME 4543, or their equivalents. Advanced problems in design of cam follower systems, gear trains and spur, helical, bevel, and worm gears. Differential Tuition: $165.

ME 5563. Computer Integrated Manufacturing. (3-1) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Advanced concepts and models related to computer-aided design, manufacturing, process planning, production planning and scheduling, and manufacturing execution systems. Laboratory work includes computer-based manufacturing applications and programming of automated production equipment. Differential Tuition: $165.

ME 5573. Facilities Planning and Design. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Advanced concepts and fundamentals essential to understand, analyze, and solve problems related to manufacturing plant layout and material handling system selection. Topics include Product, Process, and Schedule Design; Flow, Space, and Activity Relationships; Material Handling; Layout Planning Models and Design Algorithms; and Warehouse Operations. The subjects included in this course are organized around integrated product, process, and manufacturing system design principles. Differential Tuition: $165.

ME 5583. Process Improvement and Variability Reduction. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Concepts, methodologies, and tools for the design, engineering and continuous improvement of manufacturing systems and enterprise operations. Topics include Six Sigma for Process Improvement and Design, Lean Systems, Performance Evaluation, and other contemporary enterprise process engineering approaches. (Formerly titled “Advanced Enterprise Process Engineering.”) Differential Tuition: $165.

ME 5603. Advanced Manufacturing Systems Engineering. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Design, planning, scheduling, and control of manufacturing systems with emphasis on information flow and decision-making. After introducing students to system simulation, simulation models of manufacturing systems are developed and evaluated in terms of system performance under different production planning and control policies. Contemporary manufacturing topics and research areas are emphasized. Differential Tuition: $165.

ME 5633. Gas Dynamics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Integral and differential forms of the conservation equations, one-dimensional flow, oblique shock and expansion waves, and supersonic, transonic, and hypersonic flows. Differential Tuition: $165.

ME 5643. Green and Sustainable Manufacturing and Enterprise Systems. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, ME 5503, or consent of instructor. Advanced concepts, tools and topics in eliminating wastes from the processes and operations of manufacturing firms via the perspective of the environment. Topics include identifying, measuring, and minimizing environmental wastes related to energy, water, materials, garbage, transportation, emissions, and biodiversity, as well as ways to totally eliminate these environmental wastes from green value stream mapping techniques. Readings and survey of contemporary technologies and tools enabling green and sustainable manufacturing and enterprise systems are also required. (Formerly titled “Advanced Topics in Manufacturing and Enterprise Engineering.”) Differential Tuition: $165.

ME 5653. Computational Fluid Dynamics. (3-0) 3 Credit Hours.
Prerequisite: ME 3663 or an equivalent. The mathematical models for fluid-flow simulations at various levels of approximation, basic description techniques, and the nature of flow equations and their boundary conditions. Differential Tuition: $165.

ME 5703. Lean Product Development and Service Systems. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Theory and applications of lean manufacturing and six-sigma to enterprise functions beyond production shop floor, with focus on lean product and process development, lean costing, and integration of IT and ERP systems to sustain continuous improvement. (Credit cannot be earned for both ME 5703 and ME 5583 taken prior to Fall 2011.) (Formerly titled “Advanced Enterprise Systems Engineering.”) Differential Tuition: $165.

ME 5713. Mechanical Behavior of Materials. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Mechanical behavior of engineering materials (metals, alloys, ceramics, and polymers) elasticity, dislocation theory, strengthening mechanism, fracture, fatigue, creep, and oxidation. Differential Tuition: $165.
ME 5733. Advanced Medical Device Design. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor.
Topics include classification of medical devices, the design process, implementation, and evaluation, IP protection, FDA approval process, and human factors in medical device design. Differential Tuition: $165.

ME 5743. Composite Materials. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Introduction to mechanics of composites, micromechanics, macromechanics, lamination theory, design, and applications of fiber-reinforced composites and particulate composites. (Formerly EGR 5413. Credit cannot be earned for both ME 5743 and EGR 5413.) Differential Tuition: $165.

ME 5753. Fluid Dynamics in Natural Systems. (3-0) 3 Credit Hours.
Prerequisite: ME 5613 or consent of instructor. Fundamental principles of turbulent fluid flows in natural systems with a focus on atmospheric flows, coastal flows, wind energy and physiological flows. Topics include classical and statistical theory of turbulence and energy cascading, spectral analysis of turbulence, atmospheric boundary layer, aerodynamics of wind turbines, flow dynamics in diseased and normal coronary artery. Differential Tuition: $165.

ME 5803. Principles of Microfabrication. (1-6) 3 Credit Hours.
Prerequisite: EGR 3323 or consent of instructor. Photolithography, thin film deposition, doping, wet patterning, plasma etching, thin film characterization. Students will fabricate simple microstructures such as coplanar waveguides, micro-fluidic devices and nano-powder silica films. (Same as EE 5413. Credit cannot be earned for both ME 5803 and EE 5413.) Differential Tuition: $165.

ME 5883. Introduction to Micro and Nanotechnology. (2-3) 3 Credit Hours.
Prerequisite: Graduate standing or completion of or concurrent enrollment in EE 3323. Survey of micro-fabrication techniques, scaling laws, mechanical, optical and thermal transducers, micro-fluidic applications, and nanostructures. (Same as EE 5503. Credit cannot be earned for both ME 5883 and EE 5503.) Differential Tuition: $165.

ME 5963. Topics in Bioengineering. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Topics may include: biomechanics, biological systems, biosolid and biofluid, transport phenomena, biomaterials, medical devices, and medical imaging. May be repeated for credit as topics vary. Differential Tuition: $165.

ME 5971. Special Project. (0-0) 1 Credit Hour.
Prerequisites: Permission in writing (form available) from the instructor and the Graduate Advisor of Record. The directed research course is offered only for nonthesis option students and may involve either a laboratory or a theoretical problem. The course requires an oral presentation of the work done at the end of the semester. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: $55.

ME 5973. Special Project. (0-0) 3 Credit Hours.
Prerequisites: Permission in writing (form available) from the instructor and the Graduate Advisor of Record. The directed research course is offered only for nonthesis option students and may involve either a laboratory or a theoretical problem. The course requires an oral presentation of the work done at the end of the semester. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: $165.

ME 6043. Continuum Mechanics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. The general purpose of the class is to introduce continuum mechanics, the equations of motion, various reference frames, and constitutive modeling. Topics covered in the class include the stress and strain tensors, equations of motion, finite elasticity, shock waves, plasticity theory, virtual displacements and nonlocal formulations. Differential Tuition: $165.

ME 6113. Experimental Techniques in Engineering. (2-3) 3 Credit Hours.
Prerequisites: Graduate standing and consent of instructor. Laboratory-based course focused on experimental testing, accounting for sources of errors, and analysis including uncertainty, graphing, and curve fitting. Modern transducers and measurement and data acquisition techniques will be discussed and utilized in the context of engineering laboratories and a course project. Differential Tuition: $165.

ME 6123. Advanced Systems Dynamics and Control. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Dynamic modeling of mechanical and multi-energy domain systems; state-space and frequency-domain analysis of dynamic systems; feedback control systems; multivariable state-feedback control; principles of controllability, observability, stability; computer-based simulation system dynamics. (Formerly ME 5113. Credit cannot be earned for both ME 6123 and ME 5113.) Differential Tuition: $165.

ME 6133. Advanced Control of Mechanical Systems. (2-3) 3 Credit Hours.
Prerequisite: Graduate standing in engineering. Input-output and state space representation of discrete time mechanical systems; controllability, observability, and stability; design and analysis of digital control systems in transform and time domain; state observer; linear quadratic optimal control, stochastic state estimation, linear quadratic Gaussian problem, loop transfer recovery, adaptive control and model reference adaptive systems, self-tuning regulators, repetitive control, application to mechanical systems including hard disk drives, intelligent vehicle, motor drives, etc. Differential Tuition: $165.

ME 6253. Bioheat Transfer. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Principles and applications of heat transfer in soft tissue. Topics may include fundamental conservation laws and governing equations of heat transfer, coupling of fluid and mass transport, and thermal activated nanoparticle transvascular transport. (Same as BME 6253. Credit can be earned for both ME 6253 and BME 6253.) Differential Tuition: $165.

ME 6333. Advanced Conduction. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. This course covers methods to calculate the distribution of temperature and heat transfer in objects. Class topics include steady-state conduction in one or more dimensions, unsteady-state conduction in one or more dimensions, exact analytic methods, approximate analytic methods, numerical techniques, nonlinear conduction in one dimension, and inverse conduction in one dimension. Differential Tuition: $165.

ME 6413. Elasticity. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Strain and stress, constitutive relations for linear elastic solids, plane problems, variational principles. (Formerly ME 5413. Credit cannot be earned for both ME 6413 and ME 5413.) Differential Tuition: $165.

ME 6543. Machine Learning and Data Analytics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Introduction to discovery and communication of meaningful patterns in data, including data description (descriptive/visualization techniques), prediction (predictive modeling using machine learning), improve performance (optimization/decision making). Differential Tuition: $165.
ME 6563. Flexible Automation and Manufacturing Systems. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. This course focuses on major integration issues related with flexible manufacturing systems and their components. Introduces mathematical models related to design, planning, scheduling, and control of flexible manufacturing systems. Contemporary manufacturing topics and research areas are emphasized. Differential Tuition: $165.

ME 6573. Robotics Design and Analysis. (3-0) 3 Credit Hours.
Prerequisites: ME 5113 and ME 5143. Serial manipulator design and controls; electromechanical issues at the actuator level; analytic modeling and synthesis techniques with emphasis on the influence of sensors, machine vision, and control at the actuator-level and robot system designs. Differential Tuition: $165.

ME 6613. Advanced Fluid Mechanics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Dynamics of incompressible fluid mechanics viscous flow, Navier-Stokes equations, boundary layer theory, and numerical operations for incompressible fluid flow. (Formerly ME 5613. Credit cannot be earned for both ME 6613 and ME 5613.) Differential Tuition: $165.

ME 6663. Advanced Fatigue and Fracture. (3-0) 3 Credit Hours.
Prerequisites: ME 5463 and graduate standing in engineering or consent of instructor. Application of engineering concepts in fatigue and fracture mechanics to actual structural failure issues faced by various industries, such as aerospace, powerplant, oil/gas, and others. Review of concepts in fatigue, damage tolerance, and probabilistic fracture mechanics. Application of concepts to modern engineering problems. Differential Tuition: $165.

ME 6813. Biomaterials. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Fundamentals in applications of material science and engineering principles and concepts to repairing, replacing, and protecting human tissues and organs. (Formerly ME 5813 and ME 6013. Same as BME 6903. Credit can be earned for only one of the following: ME 6813, ME 6013, ME 5813 or BME 6903.) Differential Tuition: $165.

ME 6833. Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of instructor. Fundamentals in applications of engineering mechanics to modeling structures and functions of tissues, organs, joints, and human body. (Formerly ME 5833 and ME 6033. Same as BME 6803. Credit can be earned for only one of the following: ME 6833, ME 6033, ME 5833 or BME 6803.) Differential Tuition: $165.

ME 6853. Advanced CFD and Heat Transfer. (3-0) 3 Credit Hours.
Prerequisite: ME 5613 or consent of instructor. Topics include large-scale simulation tools for turbulent flows including large-eddy-simulation (LES), direct numerical simulation (DNS) and turbulence modeling for range of incompressible, buoyancy driven and compressible flows. Generalized numerical framework for numerical solution of Navier-Stokes equations. Differential Tuition: $165.

ME 6893. Topics in Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: ME 6833 or BME 6803 or an equivalent. The biomechanics of biological tissues and organs. Topics may include constitutive equations, stress, and adaptation of hard and soft tissues. (Formerly ME 6023. Same as BME 6893. Credit cannot be earned for both ME 6893 and ME 6023. Credit cannot be earned for both ME 6893 and BME 6893 when the topic is the same.) Differential Tuition: $165.

ME 6951. Independent Study. (0-0) 1 Credit Hour.
Prerequisites: Graduate standing and permission in writing (form available) of the instructor, the student's advisor, and the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: $55.

ME 6953. Independent Study. (0-0) 3 Credit Hours.
Prerequisites: Graduate standing and permission in writing (form available) of the instructor, the student's advisor, and the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: $165.

ME 6961. Comprehensive Examination. (0-0) 1 Credit Hour.
Prerequisite: Approval of the Mechanical Engineering Graduate Program Committee to take the Comprehensive Examination. Independent study for the purpose of taking the Comprehensive Examination. May be repeated for credit as many times as approved by the Mechanical Engineering Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). Differential Tuition: $55.

ME 6973. Special Problems. (3-0) 3 Credit Hours.
Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized studies not normally available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, may be applied to the Master's degree. Differential Tuition: $165.

ME 6981. Master's Thesis. (0-0) 1 Credit Hour.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: $55.

ME 6982. Master's Thesis. (0-0) 2 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: $110.

ME 6983. Master's Thesis. (0-0) 3 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: $165.
ME 7941. Independent Doctoral Study. (0-0) 1 Credit Hour.
Prerequisites: Graduate standing in Ph.D. in Mechanical Engineering program and permission in writing (form available) of the student’s advisor. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For Ph.D. students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Doctoral degree. Differential Tuition: $55.

ME 7942. Independent Doctoral Study. (0-0) 2 Credit Hours.
Prerequisites: Graduate standing in Ph.D. in Mechanical Engineering program and permission in writing (form available) of the student’s advisor. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For Ph.D. students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Doctoral degree. Differential Tuition: $110.

ME 7943. Independent Doctoral Study. (0-0) 3 Credit Hours.
Prerequisites: Graduate standing in Ph.D. in Mechanical Engineering program and permission in writing (form available) of the student’s advisor. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For Ph.D. students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Doctoral degree. Differential Tuition: $165.

ME 7951. Doctoral Research. (0-0) 1 Credit Hour.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $55.

ME 7952. Doctoral Research. (0-0) 2 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $110.

ME 7953. Doctoral Research. (0-0) 3 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $165.

ME 7954. Doctoral Research. (0-0) 4 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $220.

ME 7955. Doctoral Research. (0-0) 5 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $275.

ME 7956. Doctoral Research. (0-0) 6 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $330.

ME 7958. Doctoral Research. (0-0) 8 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor. May be repeated for credit. A minimum of 18 credit hours of Doctoral Research is required. Differential Tuition: $440.

ME 7981. Doctoral Dissertation. (0-0) 1 Credit Hour.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor, after being admitted for Ph.D. candidacy. May be repeated for credit. A minimum of 15 credit hours of Doctoral Dissertation is required. (Formerly ME 7993-8.) Differential Tuition: $55.

ME 7982. Doctoral Dissertation. (0-0) 2 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor, after being admitted for Ph.D. candidacy. May be repeated for credit. A minimum of 15 credit hours of Doctoral Dissertation is required. (Formerly ME 7993-8.) Differential Tuition: $110.

ME 7983. Doctoral Dissertation. (0-0) 3 Credit Hours.
Prerequisites: Consent of the Graduate Advisor of Record and primary thesis advisor, after being admitted for Ph.D. candidacy. May be repeated for credit. A minimum of 15 credit hours of Doctoral Dissertation is required. (Formerly ME 7993-8.) Differential Tuition: $165.

ME 7993. Research Seminar. (3-0) 3 Credit Hours.
Organized lectures and seminar presentations to facilitate the development of doctoral students’ research skills and knowledge of current and emerging research. Required for all Ph.D. students in Mechanical Engineering. Differential Tuition: $165.