Mechanical Engineering, MS

Chairperson: John Borg, Ph.D., P.E.
Mechanical Engineering Graduate Programs website (https://www.marquette.edu/grad/programs-mechanical-engineering.php)

Degree Offered

Master of Science

Mission Statement

We immerse individuals in an active environment to cultivate broadly educated mechanical engineers who balance theory with practice for advancing knowledge, solving problems and serving society.

Program Description

The Department of Mechanical Engineering offers two master’s programs and a doctoral program. Course work and research in the department's programs may involve the broad fundamentals of mechanical engineering or may concentrate on one or more of the following fields: energy systems, manufacturing and materials systems, and mechanical systems. In these fields, engineering principles are applied not only to traditional equipment and methods but also to modern and emerging technologies. Typically, the engineering course work and research are augmented by laboratory studies. Although the study of advanced engineering mathematics and, often, basic science is necessary in all programs of study, the selection of subjects may vary depending upon the field of specialization and the student’s professional objectives.

Mechanical Engineering Master of Science (M.S.)

Specializations: Energy Systems, Manufacturing and Materials Systems, Mechanical Systems

Upon enrolling in the master of science program in mechanical engineering, a student selects one of three areas of specialization: energy systems, manufacturing and materials systems, or mechanical systems. During the first term, a curriculum, along with a research program, is designed with an academic adviser which is specific to the goals of the individual student. The program includes course work in engineering, mathematics and science with the following requirements:

- A minimum of 24 credit hours of course work.
- A minimum of 3 credit hours of an approved math course (MEEN 6101 Advanced Engineering Analysis 1, MEEN 6102 Advanced Engineering Analysis 2, MEEN 6103 Approximate Methods in Engineering Analysis, EECE 6010 Advanced Engineering Mathematics) or equivalent. An equivalent math requirement from another department must be approved by the student's adviser and the director of graduate studies.
- A minimum of one half of the total course work must be at the 6000 level.
- A minimum of one half of the total course work must be taken from the Department of Mechanical Engineering. No more than 12 credit hours may be taken outside the Department of Mechanical Engineering and these courses must be approved by the student's adviser and the director of graduate studies.
- At most, a maximum of 3 credit hours of an Independent Study course may be included in the course work total.
- Six (6) credit hours of thesis work, completion of an oral thesis defense/comprehensive exam and submission of an approved thesis.
- Continuous participation in the departmental graduate seminar series (MEEN 6960 Seminar in Mechanical Engineering).
- A maximum of 6 credit hours of graduate-level credit from other approved institutions may be accepted toward the requirement of the degree as long as requirements are met, and prior approval must be received from the student's adviser and director of graduate studies.

Specialization Requirements

Energy Systems

The energy systems specialization typically entails advanced study of (a) thermodynamics, fluid mechanics, heat and mass transfer and combustion; (b) the application of these principles to phenomena and devices which constitute energy-conversion systems; and (c) the analysis, simulation and design of such systems as well as plants; e.g., chemical, metallurgical, food, etc., which are energy-intensive. Current research topics include: plant optimization, cogeneration systems, fluid mechanics and heat transfer in surface mount technology, engine emissions/process effluents and jet engine propulsion systems, energy disspersive materials, and soot modeling.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>MEEN 6101</td>
<td>Advanced Engineering Analysis 1</td>
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<tr>
<td>or MEEN 6102</td>
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</table>
## Mechanical Engineering, MS

### Required specialization courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>MEEN 5325</td>
<td>Intermediate Fluid Mechanics</td>
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<tr>
<td>MEEN 5360</td>
<td>Intermediate Thermodynamics</td>
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### Additional requirements:

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<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>MEEN 6960</td>
<td>Seminar in Mechanical Engineering (taken every term)</td>
<td>0</td>
</tr>
<tr>
<td>MEEN 6999</td>
<td>Master's Thesis</td>
<td>6</td>
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### Additional course work chosen from the following:

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<tbody>
<tr>
<td>MEEN 5260</td>
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<tr>
<td>MEEN 5265</td>
<td>Intermediate Finite Element Methods</td>
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<tr>
<td>MEEN 5310</td>
<td>Combustion: Thermochemistry, Kinetics and Applications</td>
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<tr>
<td>MEEN 5320</td>
<td>Internal Combustion Engines</td>
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<tr>
<td>MEEN 5350</td>
<td>Transport Phenomena</td>
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<tr>
<td>MEEN 5410</td>
<td>Experimental Design</td>
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<td>MEEN 5931</td>
<td>Topics in Mechanical Engineering</td>
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<tr>
<td>MEEN 6102</td>
<td>Advanced Engineering Analysis 2</td>
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<tr>
<td>MEEN 6103</td>
<td>Approximate Methods in Engineering Analysis</td>
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<tr>
<td>MEEN 6260</td>
<td>Multiscale Material Modeling</td>
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<tr>
<td>MEEN 6310</td>
<td>Advanced Fluid Mechanics</td>
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<tr>
<td>MEEN 6320</td>
<td>Turbulence</td>
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<tr>
<td>MEEN 6330</td>
<td>Statistical Thermodynamics</td>
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<td>MEEN 6340</td>
<td>Thermal Radiation Heat Transfer</td>
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<tr>
<td>MEEN 6345</td>
<td>Multicomponent Mass Transfer</td>
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<tr>
<td>MEEN 6350</td>
<td>Convective Heat and Mass Transfer</td>
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<td>MEEN 6365</td>
<td>Computational Methods in Heat Transfer and Fluid Flow</td>
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<tr>
<td>MEEN 6370</td>
<td>Combustion Chemistry and Mechanisms</td>
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<tr>
<td>MEEN 6375</td>
<td>Turbulent Combustion</td>
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<td>MEEN 6931</td>
<td>Topics in Mechanical Engineering</td>
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<tr>
<td>MEEN 6995</td>
<td>Independent Study in Mechanical Engineering</td>
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### Total Credit Hours:

30

## Manufacturing and Materials Systems

The manufacturing and materials systems specialization typically entails advanced study in (a) evaluation of materials and their behavior; (b) processes for changing material shape and properties; (c) approaches to economizing complex systems; (d) material-man-machine interfaces; and (e) analysis of the manufacturing complex. Normally, each of these multi-disciplinary areas requires certain core courses along with specialized studies, which may include advanced courses in other engineering disciplines, courses in mathematics and statistics and/or courses in business administration. Current research topics include: cellular manufacturing, polishing and mass finishing processes, flexible assembly, robotic systems, production integration, ergonomics, reliability/quality estimation, human performance and safety evaluation and materials forming and joining processes.

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<tr>
<td>MEEN 5220</td>
<td>Intermediate Dynamics</td>
<td>15</td>
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</table>
Mechanical Systems

The mechanical systems specialization typically entails advanced study of (a) mechanical system design and analysis; and (b) modeling, simulation, and control. Mechanical design and analysis focuses on the use of physical and mathematical principles to understand the behavior of mechanical systems. It includes computer-aided optimal design, such as the design of multi-body, multi-degree-of-freedom mechanical systems. Modeling, simulation and control involve the study of theoretical mechanics in conjunction with computational applications including advanced dynamics, kinematics and stress analysis. Other applications include the modeling and control of manufacturing processes, including robotics and automated deformation processing. Current research areas include: composite and polymeric materials, control in automated assembly, design of compliant machine mechanisms, metal cutting/forming mechanics, finite element methods and multiscale material modeling.

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| Required specialization courses:                    |       |
| MEEN 5220 | Intermediate Dynamics                         |       |
| MEEN 5230 | Intermediate Mechanics of Materials          |       |

| Additional requirements:                           |       |
| MEEN 6960 | Seminar in Mechanical Engineering (taken every term) | 0     |
| MEEN 6999 | Master's Thesis                               | 6     |

| Additional course work chosen from the following: | 15 |
| MEEN 5260 | Introduction to Continuum Mechanics           | |
| MEEN 5265 | Intermediate Finite Element Methods          | |
| MEEN 5270 | Physical Systems Modeling                    | |
| MEEN 5275 | Mechatronics                                  | |
| MEEN 5410 | Experimental Design                           | |
| MEEN 5420 | Failure Analysis                              | |
| MEEN 5450 | Mechanical Behavior of Materials              | |
| MEEN 5570 | Biomaterials Science and Engineering          | |
| MEEN 5931 | Topics in Mechanical Engineering              | |
| MEEN 6102 | Advanced Engineering Analysis 2              | |
| MEEN 6103 | Approximate Methods in Engineering Analysis  | |
MEEN 6220  Advanced Dynamics
MEEN 6225  Advanced Vibrations
MEEN 6230  Advanced Mechanics of Materials
MEEN 6250  Industrial Robotics
MEEN 6260  Multiscale Material Modeling
MEEN 6931  Topics in Mechanical Engineering
MEEN 6995  Independent Study in Mechanical Engineering

Additional courses as approved by adviser.

Total Credit Hours: 30

Master's Learning Outcomes
1. Apply knowledge of specialized mechanical engineering concepts in engineering analysis and design in a chosen area of specialization.
2. Effectively communicate ideas on design and analysis to peers, clients and customers.
3. Conduct guided research in a chosen area of specialization.

Accelerated Bachelor's-Master's Degree Program
The accelerated program enables students to earn both a master of science degree and a bachelor of science degree from the College of Engineering in the span of five years. Only the thesis option is available with this program. Qualified students (3.500/4.000 GPA) who are enrolled in the Department of Mechanical Engineering at Marquette University may apply for admission to this program during their undergraduate junior year. Students must submit an application to the Graduate School, indicate their interest in the five-year program, and meet all other admission criteria as stated in the Application Requirements section on the Graduate School's ADP webpage.

Students select graduate-level courses in their senior undergraduate year as their electives; these elective courses count toward both the undergraduate and graduate degrees. However, only a maximum of 6 credit hours can apply toward the graduate degree. Upon completion of the first term as a master’s candidate, the student must petition the Graduate School to transfer courses taken as an undergraduate to the master’s degree.

Students begin their research for the thesis the summer between their junior and senior years. Their research is continued the summer between their senior and fifth years and throughout their fifth year, culminating in the preparation of a written thesis and defense.

University Policies
- Academic Censure - Graduate School (https://bulletin.marquette.edu/policies/academic-censure/graduate/)
- Academic Integrity (https://bulletin.marquette.edu/policies/academic-integrity/)
- Academic Misconduct (https://bulletin.marquette.edu/policies/academic-misconduct-policy/)
- Academic Program Definitions (https://bulletin.marquette.edu/policies/academic-programs-defined/)
- Accelerated Degree Programs (https://bulletin.marquette.edu/policies/accelerated-degree-programs/)
- Attendance - Graduate School (https://bulletin.marquette.edu/policies/attendance/graduate/)
- Awarding Diplomas and Certificates (https://bulletin.marquette.edu/policies/awarding-diplomas-certificates/)
- Background Checks, Drug Testing (https://bulletin.marquette.edu/policies/background-checks-drug-testing/)
- Class Rank (https://bulletin.marquette.edu/policies/class-rank/)
- Commencement (https://bulletin.marquette.edu/policies/commencement/)
- Course Levels (https://bulletin.marquette.edu/policies/course-levels/)
- Credit Hour (https://bulletin.marquette.edu/policies/credit/)
- Credit Load - Graduate School (https://bulletin.marquette.edu/policies/credit-load/graduate/)
- Faculty Grading (https://bulletin.marquette.edu/policies/faculty-grading/)
- Family Education Rights and Privacy Act-FERPA (https://bulletin.marquette.edu/policies/ferpa/)
- Grade Appeals (https://bulletin.marquette.edu/policies/grade-appeals/)
- Grading System - Graduate School and Graduate School of Management (https://bulletin.marquette.edu/policies/grading-system/graduate-management/)
- Graduation - Graduate School (https://bulletin.marquette.edu/policies/graduation/graduate/)
- Immunization and Tuberculosis Screening Requirements (https://bulletin.marquette.edu/policies/immunization-and-tuberculosis-screening/)
- Last Date of Attendance/Activity (https://bulletin.marquette.edu/policies/last-date-of-attendance-activity/)
- Military Call to Active Duty or Training (https://bulletin.marquette.edu/policies/military-call-active-duty-training/)
- Registration - Graduate School (https://bulletin.marquette.edu/policies/registration/graduate/)
- Repeated Courses - Graduate School (https://bulletin.marquette.edu/policies/repeated-courses/graduate/)
Graduate School Policies

- Academic Performance (https://bulletin.marquette.edu/graduate/policies/academic-performance/)
- Advising (https://bulletin.marquette.edu/graduate/policies/advising/)
- Certificate Concurrent Enrollment (https://bulletin.marquette.edu/graduate/policies/certificate-concurrent-enrollment/)
- Conduct (https://bulletin.marquette.edu/graduate/policies/conduct/)
- Confidentiality of Proprietary Information (https://bulletin.marquette.edu/graduate/policies/confidentiality-proprietary-information/)
- Continuous Enrollment (https://bulletin.marquette.edu/graduate/policies/continuous-enrollment/)
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- Cross-listed Courses (https://bulletin.marquette.edu/graduate/policies/cross-listed-courses/)
- Deadlines (https://bulletin.marquette.edu/graduate/policies/deadlines/)
- Doctoral Degree Academic Program Overview (https://bulletin.marquette.edu/graduate/policies/doctoral-program-overview/)
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- Research Involving Humans, Animals, Radioisotopes or Recombinant DNA/Transgenic Organisms (https://bulletin.marquette.edu/graduate/policies/research-involving-humans-animals-radioisotopes-recombinant-dna-transgenic-organisms/)
- Temporary Withdrawal from Graduate Program (https://bulletin.marquette.edu/graduate/policies/temporary-withdrawal-graduate-program/)
- Time Limitations (https://bulletin.marquette.edu/graduate/policies/time-limitations/)
- Working with Minors (https://bulletin.marquette.edu/graduate/policies/working-minors/)

Mechanical Engineering Graduate Programs

- Mechanical Engineering, ME (https://bulletin.marquette.edu/graduate/mechanical-engineering-me/)
- Mechanical Engineering, MS (p. 1)
- Mechanical Engineering, PHD (https://bulletin.marquette.edu/graduate/mechanical-engineering-phd/)

MEEN 5220 Intermediate Dynamics (3 credits)
Develop an understanding of the principles of 3D rigid body kinematics (motion) and kinetics (forces and accelerations). Use these principles to analyze the dynamic behavior of mechanical systems. Learn to use analytical mechanics tools including virtual work and Lagrange's method. Develop a systematic approach for solving engineering problems.

Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205220)

MEEN 5230 Intermediate Mechanics of Materials (3 credits)
Review of beam theory; asymmetric bending, shear center, thin-walled sections; torsion of non-circular sections, open and closed thin-walled sections; energy methods, Castigliano's second theorem, statically indeterminate structures, internal static indeterminacy; curved beams.

Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2022 Fall Term, 2021 Fall Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205230)

MEEN 5260 Introduction to Continuum Mechanics (3 credits)
Introduction to tensor notation, tensor analysis and coordinate system invariance; analysis of stress, strain and rate of strain for infinitesimal and finite deformation; application of Newtonian mechanics to deformable media; mechanical constitutive equations; field equations for solid and fluid mechanics.

Level of Study: Graduate
Last four terms offered: 2017 Fall Term, 2016 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205260)
MEEN 5265 Intermediate Finite Element Method (3 credits)
Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).
Prerequisite: MEEN 3260 or equiv.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2021 Spring Term, 2018 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205265)

MEEN 5270 Physical Systems Modeling (3 credits)
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2021 Fall Term, 2019 Fall Term, 2018 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205270)

MEEN 5275 Mechatronics (3 credits)
Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electronics, control engineering, and computer science, all integrated through the design process. This course covers mechatronic system design, modeling and analysis of dynamic systems, control sensors and actuators, analog and digital control electronics, interfacing sensors and actuators to a microcomputer/microcontroller, discrete and continuous controller design, and real-time programming for control.
Level of Study: Graduate
Last four terms offered: 2018 Fall Term, 2017 Fall Term, 2015 Fall Term, 2014 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205275)

MEEN 5310 Combustion: Thermochemistry, Kinetics and Applications (3 credits)
Fundamentals of combustion and chemical kinetics, with applications to engines and combustion devices. Study of fluid flow, thermodynamics, combustion, heat transfer and friction phenomena, and fuel properties relevant to engine power, efficiency and emissions. Examination of spark-ignition, diesel, stratified charge, HCCI, mixed-cycle and gas turbine engines.
Level of Study: Graduate
Last four terms offered: 2020 Fall Term, 2019 Fall Term, 2018 Spring Term, 2018 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205310)

MEEN 5320 Internal Combustion Engines (3 credits)
Fundamental aspects of the design and operating characteristics of spark-ignition and diesel engines. Presents an overview of the thermodynamics, combustion, fluid flow and heat transfer that takes place within the engine cylinder. Discusses efficiency and emissions challenges that the engine must meet.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2022 Fall Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205320)

MEEN 5325 Intermediate Fluid Mechanics (3 credits)
Intermediate Fluid Mechanics continues to develop fluid mechanic concepts, building on a working knowledge of the Reynolds Transport Theorem. Topics include: differential analysis, irrotational flow theory, boundary layer theory and compressible flow theory. Both laminar and turbulent flows are discussed. Some working knowledge of computer programming is necessary.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2022 Fall Term, 2021 Fall Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205325)

MEEN 5350 Transport Phenomena (3 credits)
Includes three closely related topics: fluid dynamics, mass transfer, and heat transfer. Fluid dynamics involves the transport of momentum, mass transfer is concerned with the transport of mass of various chemical species, and heat transfer deals with the transport of energy. In practice, rarely are these phenomena acting alone. Develops a more cohesive understanding of these interrelated processes.
Level of Study: Graduate
Last four terms offered: 2017 Fall Term, 2016 Fall Term, 2015 Fall Term, 2014 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205350)

MEEN 5360 Intermediate Thermodynamics (3 credits)
Covers fundamentals of thermodynamics, including classical and statistical approaches with application to equilibrium and non-equilibrium, non-reactive and reactive systems. May cover topics relevant to micro/nanoscale and biological systems.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Spring Term, 2022 Spring Term, 2021 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205360)
MEEN 5370 Heat Exchangers Design and Analysis (3 credits)
Addresses the fundamental thermal-hydraulic equations and correlations used to design and analyze various types of heat exchangers. A systematic approach/method to the thermal-hydraulic design and analysis, or rating, of various types of heat exchanger systems through selected virtual and real problems.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205370)

MEEN 5380 Renewable Energy - Fundamentals and Applications (3 credits)
Emphasis on thermodynamics, heat transfer and fluid mechanics aspects of renewable energy systems and applications. Topics include solar, wind, hydropower, geothermal, biomass, and wave and tide. Both technical and economic analyses of renewable energy systems.
Level of Study: Graduate
Last four terms offered: 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205380)

MEEN 5410 Experimental Design (3 credits)
Application of statistical concepts to design engineering experiments to improve quality, production techniques, and reliability. Use and advantages of various models; factorial, fractional factorial, orthogonal arrays and fractional designs.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205410)

MEEN 5420 Failure Analysis (3 credits)
Methodology of failure analysis. Studies of brittle fracture, ductile fracture, fatigue, stress corrosion and electro-chemical corrosion as applied to the failure of metals. Involves some laboratory work and analyses of a variety of metallurgical failures.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2022 Fall Term, 2021 Fall Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205420)

MEEN 5430 Powder Metallurgy (3 credits)
Introduces a modern technology with growing importance. Covers the basics of powder metallurgy with main emphasis on sintered steel. The primary topics covered are powder production, die compacting, sintering theory and practice, full density processing, properties under static and dynamic loading conditions.
Level of Study: Graduate
Last four terms offered: 2017 Fall Term, 2015 Fall Term, 2013 Fall Term, 2012 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205430)

MEEN 5440 Processing and Forming of Materials (3 credits)
Solidification and microstructural development in metal casting with an overview of selected melting processes. Overview of primary and secondary working principles involved in ferrous materials processing. Stress based and finite element analyses are applied to both sheet and bulk forming to develop a fundamental understanding of deformation processing principles and technology associated with processes such as drawing, open and closed die forging and rolling.
Level of Study: Graduate
Last four terms offered: 2022 Spring Term, 2020 Fall Term, 2019 Fall Term, 2018 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205440)

MEEN 5450 Mechanical Behavior of Materials (3 credits)
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Spring Term, 2020 Fall Term, 2019 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205450)

MEEN 5470 Computer Integrated Production Systems (3 credits)
Overview of computer integrated production systems, which include computer numerical control, industrial robotics, material transport and storage systems, automated production lines, flexible manufacturing systems, quality control systems, CAD/CAM, production planning and control, just-in-time and lean manufacturing.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205470)

MEEN 5485 Welding Engineering (3 credits)
Arc welding physics, fundamentals of power supplies and welding circuits, fusion and solid-state welding processes, weld testing, analysis of welded joints, demonstrations using various processes.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2013 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205485)
MEEN 5570  Biomaterials Science and Engineering  (3 credits)
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested. Same as BIEN 4420.

Level of Study: Graduate

Last four terms offered: 2020 Spring Term, 2019 Spring Term, 2018 Spring Term, 2016 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205570)

MEEN 5931  Topics in Mechanical Engineering  (3 credits)
Topics may include energy conversion, mechanical analysis and design, and manufacturing systems.

Level of Study: Graduate

Last four terms offered: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%205931)

MEEN 6101  Advanced Engineering Analysis 1  (3 credits)

Level of Study: Graduate

Last four terms offered: 2024 Spring Term, 2023 Spring Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206101)

MEEN 6102  Advanced Engineering Analysis 2  (3 credits)

Level of Study: Graduate

Last four terms offered: 2017 Spring Term, 2010 Fall Term, 2009 Spring Term, 2006 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206102)

MEEN 6103  Approximate Methods in Engineering Analysis  (3 credits)
Treatment of approximate methods for solving various problems in engineering. Matrix methods, variational methods (e.g., Ritz, Galerkin, etc.), finite difference methods, finite element method.

Level of Study: Graduate

Last four terms offered: 2013 Fall Term, 2012 Fall Term, 2011 Spring Term, 2010 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206103)

MEEN 6220  Advanced Dynamics  (3 credits)
Kinematics of particles and rigid bodies. Basic principles of vector mechanics. Variational principles. Basic principles of analytical mechanics.
Prerequisite: MEEN 4220/5220 or equiv.

Level of Study: Graduate

Last four terms offered: 2019 Spring Term, 2018 Spring Term, 2017 Spring Term, 2015 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206220)

MEEN 6225  Advanced Vibrations  (3 credits)
Theory of vibration with applications. Natural modes of vibration for lumped parameter systems. Response of lumped systems with damping. Response of distributed parameter system including bars, beams, etc.

Level of Study: Graduate

Last four terms offered: 2023 Fall Term, 2021 Fall Term, 2020 Fall Term, 2018 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206225)

MEEN 6230  Advanced Mechanics of Materials  (3 credits)
Thick wall cylinders, rotating disks, initial stresses; stress concentration factors, cracks, discontinuity stresses; autofrettage, residual stresses; beams on elastic foundation, introduction to plates and shells, pressure vessel analysis.
Prerequisite: MEEN 5230; or MEEN 5250.

Level of Study: Graduate

Last four terms offered: 2019 Spring Term, 2018 Spring Term, 2016 Spring Term, 2015 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206230)
MEEN 6240 Composite Materials (3 credits)
Introduction to fiber/matrix materials systems with emphasis on continuous fiber-reinforced composites. Principles of anisotropic elasticity, classical lamination theory, and viscoelasticity. Analysis of mechanical, thermal, hygroscopic and combination loading of laminated composites. Review of manufacture/fabrication methods for advanced composites, consolidation techniques, and basic issues in the design of advanced composites.
Level of Study: Graduate
Last four terms offered: 2016 Fall Term, 2014 Fall Term, 2012 Spring Term, 2009 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206240)

MEEN 6250 Industrial Robotics (3 credits)
Fundamentals of industrial robotic systems. Covers serial and parallel manipulators, forward and inverse kinematics, differential kinematics, multi-rigid-body dynamics, trajectory planning, linear control theory, actuators and sensors, mechanism design and vision systems.
Level of Study: Graduate
Last four terms offered: 2022 Fall Term, 2019 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206250)

MEEN 6260 Multiscale Material Modeling (3 credits)
Numerical and analytical techniques for modeling the micromechanics and micro-structural evolution of complex heterogeneous materials (including granular, composite, and atomic/molecular materials); techniques for transferring information between local (micro-scale) and global (macro-scale) representations of multi-scale materials.
Prerequisite: MEEN 3260 or equiv., and MEEN 4260 or MEEN 5260 or equiv.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206260)

MEEN 6310 Advanced Fluid Mechanics (3 credits)
Further development of fluid flow theory starting with classic potential flow solutions. Numerical and analytical techniques for both inviscid and viscid fluid flows, including boundary layer theory and stability. Transition routes and chaos with an introduction to turbulence.
Prerequisite: MEEN 5325 or MEEN 5350 or equiv.; computer programming experience recommended.
Level of Study: Graduate
Last four terms offered: 2016 Spring Term, 2014 Fall Term, 2013 Fall Term, 2012 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206310)

MEEN 6320 Turbulence (3 credits)
Advanced physical and mathematical description of fluid flow systems, including the fundamentals of turbulence motion. The development of the Reynolds stress equations, processes that govern dissipation and statistical description of scales. Includes the modeling techniques associated with turbulent velocity profiles as well as the development of zero, one and two equation closure models.
Prerequisite: MEEN 5350 or equiv.; computer programming experience recommended.
Level of Study: Graduate
Last four terms offered: 2017 Spring Term, 2009 Spring Term, 2007 Spring Term, 2001 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206320)

MEEN 6330 Statistical Thermodynamics (3 credits)
Level of Study: Graduate
Last four terms offered: 2013 Spring Term, 2011 Fall Term, 2010 Spring Term, 2008 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206330)

MEEN 6340 Thermal Radiation Heat Transfer (3 credits)
Level of Study: Graduate
Last four terms offered: 2019 Fall Term, 2017 Fall Term, 2016 Fall Term, 2007 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206340)

MEEN 6345 Multicomponent Mass Transfer (3 credits)
Fundamentals of Multicomponent Mass Transfer, including Maxwell-Stefan diffusion, Generalized Fick’s Law, ideal and non-ideal mixtures, interphase mass transfer and film theory and multicomponent mass transfer in porous media.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206345)
MEEN 6350 Convective Heat and Mass Transfer (3 credits)
Principles and mechanisms of convective transports of energy and of chemical species associated with laminar and turbulent flows, including condensation and boiling. Calculation of heat and mass transport coefficients. Mathematical modeling, with applications to engineering devices involving several of these processes, with and without phenomenological coupling.
Prerequisite: MEEN 6310.
Level of Study: Graduate
Last four terms offered: 2022 Spring Term, 2019 Spring Term, 2008 Fall Term, 2006 Fall Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206350))

MEEN 6360 Computational Fluid Mechanics (3 credits)
Review of the fundamental thermofluids science, mathematical and computational principles underlying modern CFD software. Utilization of software for representative applications. Individual student project devoted to a new application.
Prerequisite: MEEN 6101 and MEEN 6320; or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2010 Spring Term, 1999 Fall Term, 1998 Fall Term, 1997 Fall Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206360))

MEEN 6365 Computational Methods in Heat Transfer and Fluid Flow (3 credits)
Prerequisite: Intermediate knowledge of heat transfer and fluid flow. Knowledge of computer programming.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2022 Fall Term, 2021 Fall Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206365))

MEEN 6366 Computational Methods for Solids and Structures (3 credits)
A theoretical development of the finite element method for analysis of solids and structures with geometric and materials nonlinearities. Topics include the formulation of both Updated and Total Lagrangian 3D finite elements, solutions to quasi-static and time-dependent solid mechanics problems, non-linear materials modeling, solution methods, and stability issues often encountered in complex finite element analysis. Reviews linear elastic finite element theory and non-linear continuum mechanics. Emphasizes programming of the finite element method.
Level of Study: Graduate
Last four terms offered: 2022 Spring Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206366))

MEEN 6370 Combustion Chemistry and Mechanisms (3 credits)
Advanced theoretical, experimental and numerical techniques for studying the chemistry and kinetic mechanisms of combustion. The technical content for includes theories of gas phase chemical kinetics, a discussion of experimental and theoretical techniques for evaluating kinetic rate coefficients, and strategies for the development and reduction of kinetic mechanisms intended for modeling combustion reactions. Topics relevant to statistical thermodynamics and the physical dynamics of technical flames may be covered.
Prerequisite: MEEN 4310 or MEEN 5310 or equiv.
Level of Study: Graduate
Last four terms offered: 2017 Spring Term, 2016 Spring Term, 2007 Fall Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206370))

MEEN 6375 Turbulent Combustion (3 credits)
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2021 Spring Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206375))

MEEN 6470 Statistical Methods in Engineering (3 credits)
Level of Study: Graduate
Last four terms offered: 2006 Spring Term, 2004 Spring Term, 2002 Spring Term, 1986 Fall Term
Schedule of Classes ([link](https://bulletin.marquette.edu/class-search/?details&code=MEEN%206470))
MEEN 6473  Computer Integrated Manufacturing (3 credits)
Primary objectives include the validation of the underlying philosophy behind computer integrated manufacturing and the definition of characteristics of various components which constitute a C.I.M. environment. Describes the benefits of C.I.M. and how to upgrade conventional plants to a C.I.M. operation.
Level of Study: Graduate
Last four terms offered: 2017 Spring Term, 2016 Spring Term, 2014 Spring Term, 2008 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206473)

MEEN 6475  Advanced Ergonomics/Human Factors Engineering (3 credits)
Fundamentals of ergonomics/human factors engineering (HFE) with emphasis on the application of basic principles to advances in engineering applications, research, and development. Topics include: engineering anthropometry, cumulative trauma disorders, low back disorders, electromyography, biomechanical modeling, and ergonomic guidelines. Requires research papers in the above areas or in a related ergonomics/HFE field.
Prerequisite: Cons. of instr.
Level of Study: Graduate
Last four terms offered: 2015 Spring Term, 2010 Fall Term, 2008 Fall Term, 2006 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206475)

MEEN 6480  Metal Forming (3 credits)
Elements of von Mises plasticity theory-stress and deformation states, constitutive equations, and flow rules; plane and axisymmetric behavior. Solution techniques - exact, slipline theory, upper and lower bounds, finite bending, deep drawing.
Prerequisite: MEEN 5440 or equiv.; or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2020 Fall Term, 2015 Fall Term, 2013 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206480)

MEEN 6931  Topics in Mechanical Engineering (3 credits)
Topics may include thermofluid science, mechanical analysis and design, and manufacturing systems.
Level of Study: Graduate
Last four terms offered: 2024 Summer Term, 2024 Spring Term, 2023 Spring Term, 2023 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206931)

MEEN 6960  Seminar in Mechanical Engineering (0 credits)
Scholarly presentations on current topics in mechanical engineering and related areas by visiting and resident investigators. Required of all full-time graduate students. SNC/UNC grade assessment.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206960)

MEEN 6995  Independent Study in Mechanical Engineering (1-3 credits)
Faculty-supervised, independent study/research of a specific area or topic in Mechanical Engineering.
Prerequisite: Cons. of instr. and cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2023 Spring Term, 2022 Fall Term, 2022 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206995)

MEEN 6999  Master's Thesis (1-6 credits)
S/U grade assessment.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%206999)

MEEN 8986  Cooperative Education in Mechanical Engineering (1-3 credits)
Offers an additional educational experience for graduate students in mechanical engineering, intended to increase student professional development and growth as an independent engineer and/or researcher. Provides the opportunity to work on-site with engineers from industry.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Summer Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%208986)
MEEN 8995  Independent Study in Mechanical Engineering  (1-3 credits)
Faculty-supervised, independent study/research of a specific area or topic in Mechanical Engineering.
Prerequisite: Cons. of instr. and cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%208995)

MEEN 8999  Doctoral Dissertation  (1-12 credits)
S/U grade assessment.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%208999)

MEEN 9970  Graduate Standing Continuation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Designated as less than half-time status only, cannot be used in conjunction with other courses, and does not qualify students for financial aid or loan deferment.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Spring Term, 2022 Spring Term, 2019 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209970)

MEEN 9974  Graduate Fellowship: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2021 Spring Term, 2020 Spring Term, 2018 Summer Term, 2013 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209974)

MEEN 9975  Graduate Assistant Teaching: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2018 Spring Term, 2017 Fall Term, 2017 Spring Term, 2016 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209975)

MEEN 9976  Graduate Assistant Research: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2021 Fall Term, 2021 Spring Term, 2020 Fall Term, 2020 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209976)

MEEN 9984  Master's Comprehensive Examination Preparation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week toward their master's comprehensive exam.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209984)

MEEN 9985  Master's Comprehensive Examination Preparation: Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week toward their master's comprehensive exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209985)
MEEN 9986  Master's Comprehensive Examination Preparation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week toward their master's comprehensive exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2016 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209986)

MEEN 9987 Doctoral Qualifying Examination Preparation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week toward their doctoral qualifying exam.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209987)

MEEN 9988 Doctoral Qualifying Examination Preparation: Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209988)

MEEN 9989 Doctoral Qualifying Examination Preparation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209989)

MEEN 9994 Master's Thesis Continuation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2023 Summer Term, 2023 Spring Term, 2022 Summer Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209994)

MEEN 9995 Master's Thesis Continuation: Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2023 Fall Term, 2023 Summer Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209995)

MEEN 9996 Master's Thesis Continuation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Summer Term, 2024 Spring Term, 2023 Fall Term, 2023 Summer Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209996)
MEEN 9997  Doctoral Dissertation Continuation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2021 Spring Term, 2020 Fall Term, 2019 Spring Term, 2018 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209997)

MEEN 9998  Doctoral Dissertation Continuation: Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2018 Summer Term, 2015 Spring Term, 2014 Fall Term, 2013 Summer Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209998)

MEEN 9999  Doctoral Dissertation Continuation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2024 Spring Term, 2023 Fall Term, 2023 Summer Term, 2023 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%209999)