MASTER OF SCIENCE IN MECHANICAL ENGINEERING

The Master of Science in Mechanical Engineering program (MSME) is designed as a 30-credit course of study to provide graduate engineers with a deeper and broader understanding of the methods and skills in the area of mechanical engineering.

The program outcomes are achieved through knowledge and skills that students gain by virtue of expert curriculum design, instruction in an effective learning environment, and opportunities for inquiry and professional development.

Students will take elective courses based on their career and technical interests in the following broad domains:

- Thermal Systems: This domain includes instruction in aerospace, renewable energy, energy conversion, computational fluid dynamics, turbomachinery, combustion, electronics cooling, heat and mass transfer.
- Mechanical Systems: This domain includes courses in automation, robotics, mechatronics, applications of theory of elasticity, stability of structures, advanced dynamics, composite materials, fracture mechanics, advanced product design, and manufacturing and micro and nano manufacturing.

Students will be able to identify, formulate, and solve advanced mechanical engineering problems. They will also be able to use the techniques, skills, and modern analytical and software tools necessary for the mechanical engineering practice, such as ANSYS, FLUENT, MATLAB, MASTERCAM, and LabView. Sequences of electives, with an optional master's thesis, will assist in achieving the program's learning goals.

Program Overview

The aim of the MSME program is to achieve the following basic objectives:

- Students will be educated in methods of advanced engineering analysis, including the mathematical and computational skills required for advanced problem solving. They will be trained to develop the skills and the ability to formulate solutions to problems, to think independently and creatively, to synthesize and integrate information/data, and to work and communicate effectively.
- Students will be provided with in-depth knowledge that will allow them to apply innovative techniques to problems and utilize the tools they need to focus on new applications.
- Students will avail themselves of a breadth of knowledge that fosters an awareness of and skills for interdisciplinary approaches to engineering problems.
- Undergraduate students in mechanical, aerospace, civil, chemical, industrial, applied physics, applied mathematics and manufacturing engineering have the opportunity to pursue, upon completion of their undergraduate studies, a graduate program that would allow them broader career paths and leadership roles in the engineering area. Students outside the above engineering fields (e.g. physics, applied mathematics, etc.) will be assigned to take specific bridge courses in their area of specialization interest to meet the course prerequisite.

Students

Mechanical engineering is a highly diverse discipline that ranges from the aesthetic aspects of design to highly technical research and development. The student population for the MSME program has several origins. Typical examples are as follows:

- Engineers and scientists who, responding to the specific needs of their industry across the spectrum of special domains listed above, need to acquire skills so that they may effectively guide the development of technologies which will enhance product quality and business opportunities
- Engineers and scientists who wish to fulfill their need for personal and professional growth in the mechanical engineering domain
- Engineers who aspire to academic careers and those who wish to eventually continue their studies toward a Ph.D. degree
- Engineers aspiring to a career change
- Current undergraduate engineering students and alumni who desire an opportunity to continue their studies for an advanced engineering degree at Fairfield University

Program

Requirements

Code	Title	Credits
MEEG 5415	Engineering Applications of Numerical Methods	3
Core Concentration Courses		
Select seven courses from the following: [1]		21
Thermal Systems		
MEEG 5346	Energy Conversion	
MEEG 5353	Computational Fluid Dynamics	
MEEG 5354	Heat and Mass Transfer	
MEEG 5356	Renewable Wind Energy	
MEEG 5362	Gas Turbine Aerodynamics	
MEEG 5364	Combustion	
Mechanical Systems		
ENGR 5308	Autonomous Mobile Robots	
MEEG 5301	Feedback and Control Systems	
MEEG 5305	Design of Mechatronics Systems	
MEEG 5310L	Product Manufacturing Lab	
MEEG 5312	Advanced Product Design and Manufacturing	
MEEG 5319	Applications of Finite Element Analysis	
MEEG 5321	Theory and Applications of Robot Kinematics	
MEEG 5322	Advanced Dynamics	
MEEG 5324	Micro and Nano Manufacturing	
MEEG 5327	Fracture Mechanics	
MEEG 5330	Mechanics of Composite Materials	
MEEG 5372	Applications of Theory of Elasticity	
MEEG 5376	Stability of Structures	
Thesis		
MEEG 6971	Thesis I [2]	3

MEEG 6972	Thesis II	3
Total Credits		**30**

1 Students following the non-thesis option will select two additional courses for a total of 27 elective credits.

2 Students will select an academic advisor and secure approval of the program director.

Courses

MEEG 5301 Feedback and Control Systems **3 Credits**
This course emphasizes analysis and synthesis of closed loop control systems using both classical and state-space approaches with an emphasis on electro-mechanical systems. The mathematical requirements include the Laplace transform methods of solving differential equations, matrix algebra and basic complex variables. The discussion of classical control system design includes the modeling of dynamic systems, block diagram representation, time and frequency domain methods, transient and steady state response, stability criteria, controller action [Proportional (P), proportional and integral (PI), Proportional, integral and derivative (PID) and pseudo-derivatives feedback], root locus methods, the methods of Nyquist and Bode and dynamics compensation techniques. The discussion of state-space methods includes formulation and solution (analytical and computer-based) of the state equations and pole-placement design. The course integrates the use of computer-aided analysis and design tools (MATLAB) so as to ensure relevance to the design of real world controlled electro-mechanical systems using case studies and applications to electrical and mechanical systems. Includes hands-on lab (hardware-based) exploration of PID control systems. Undergraduate equivalent: ENGR 4301. Previously ME 0400.

MEEG 5303 Industrial Automation **3 Credits**
This hands-on course teaches students about components in automation systems and automated production lines. Students learn and practice with industrial sensors, actuators, PLCs, robot arms, pneumatics devices, and electro-pneumatic components. Students create, simulate, and assemble pneumatics, electric, electronics, and electro-pneumatic control circuits. Automation software, ladder logic programming, and robot programming are also discussed. The course comprises lectures, an automation lab, individual assignments, two group projects, and an individual project. Advanced topics are assigned. Undergraduate equivalent: ENGR 4303. Previously ME 0403.

MEEG 5305 Design of Mechatronics Systems **3 Credits**
This course covers development of mechatronics theory and applications to systems dependent upon the integration of mechanical, electrical and computer engineering. Students assemble hardware components to create a product design that fulfills a specified task in a mechatronics system. Students develop design skills in mechanisms, electrical devices, and software to create, test, and verify system function. Sessions include lab projects. Students will be challenged to develop a publication-worthy white paper as a final deliverable along with their final project. Undergraduate equivalent: ENGR 4305. Previously ME 0405.

MEEG 5310L Product Manufacturing Lab **1 Credit**
Fee: $120 Engineering Lab Fee
This laboratory provides practical concepts of machining processes, including milling, turning, and cutting. Students develop the knowledge and skills required in CNC programming, machine setup and operation, manual machining, and metrology. Students machine parts by cutting, drilling, pocketing, and contouring. This laboratory emphasizes the practical application of CNC machine tools and manual machining, involving set-ups and operation procedures. Undergraduate equivalent: MEEG 4310L. Previously ME 0410L.

MEEG 5312 Advanced Product Design and Manufacturing **3 Credits**
Corequisite: MEEG 5310L.
This hands-on course presents design principles, design for manufacturing, and assembly (DFMA) mythologies. Students learn to choose the best manufacturing process and appropriate material for a product considering shape, size, weight, production rate, and tolerances. The course also covers geometric dimensioning and tolerancing components (GD&T). The concepts of computer-aided design (CAD) and computer-aided manufacturing (CAM) are covered using SolidWorks and Mastercam software. Students are taught CNC programming (G-code, M-code) applied on CNC lathes and mills. Students apply their knowledge within the semester by designing and fabricating a product. The course comprises lectures, a computer lab, a machine tool lab, a group project, and individual assignments. Students will work on a class research project.

MEEG 5319 Applications of Finite Element Analysis **3 Credits**
This course examines applications of finite element analysis in modern engineering including structural analysis, fluid flow, heat transfer, and dynamics. Finite element formulations covering two- and three-dimensional elements as well as energy methods are reviewed. Students develop techniques for application of finite element method in structural design, dynamic system response, fluid and thermal analyses. Application of methodology to fluid flow is presented. Students solve example and design problems manually and using modern finite-element analysis software, Ansys and Fluent. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report and make a class presentation on their research. Undergraduate equivalent: MEEG 4319. Previously ME 0470.

MEEG 5321 Theory and Applications of Robot Kinematics **3 Credits**
Topics in advanced kinematics include introduction to basic concepts and definitions related to kinematics, commonly used links and joints, kinematic analysis of mechanisms, introduction to robotic mechanisms, homogeneous transformations, Euler angles, Denavit-Hartenberg representation of forward kinematics of robots, inverse kinematics solution of robots, degeneracy and dexterity, and differential motion and velocity relations. Industrial application of kinematics will also be covered and the course will include a laboratory or project component. Undergraduate equivalent: MEEG 4321. Previously ME 0411.

MEEG 5322 Advanced Dynamics **3 Credits**
The topics in the area of dynamics include degrees of freedom, generalized coordinates, constraints, physics of failure, flexures, and optomechanics. The course will focus on practical applications of advanced dynamics, including linkages, cams, and kinematics mechanisms, as well as computer applications and project design. Students will be challenged to develop a publication-worthy white paper as a final deliverable along with their final project. Undergraduate equivalent: MEEG 4322. Previously ME 0412.

MEEG 5323 Thermal Management of Microdevices 3 Credits
This course addresses the thermal design in electronic assemblies which includes thermal characteristics, heat transfer mechanisms and thermal failure modes. Thermal design of electronic devices enables engineers to prevent heat-related failures, increase the life expectancy of the system, and reduce emitted noise and energy consumption. This course provides the required knowledge of heat transfer for such analysis and various options available for thermal management of electronics. This course also presents advanced methods of removing heat from electronic circuits, including heat pipes, liquid immersion, and forced convection. Undergraduate equivalent: MEEG 4323. Previously ME 0423.

MEEG 5324 Micro and Nano Manufacturing 3 Credits
This course will introduce students to the latest advancements in micro and nano manufacturing. The course will enable students to become familiar with advanced manufacturing techniques in light of the global emphasis on micro and nano manufacturing. Topics to be covered include lithography, mechanical micromachining, laser fabrication, polymers and nanocomposites, and nano imprinting. The important topics of metrology and process control at the micro and nano scale will also be discussed. Students will conduct a class project integrating the different processes for an application in electromechanical or biomedical field. A lab component is also present where students get a hands-on experience with material processing and characterization tools. Undergraduate equivalent: MEEG 4324. Previously ME 0424.

MEEG 5327 Fracture Mechanics 3 Credits
This course covers fracture mechanics concepts for design, materials selection, and failure analysis. The fundamental principles of fracture parameters and criteria, stress field at the tip of a crack, fracture toughness, thickness effect, plastic zone concept, and crack growth under cyclic loading and aggressive environment will be presented. Emphasis will be placed on the practical applications of fracture mechanics by incorporation of design problems and laboratory demonstrations in the course. Emphasis will be placed on the practical applications of fracture mechanics by incorporation of a failure investigation study where the students utilize the skills developed with the course to root cause a real world failure. Taking a holistic approach each student will have their own case study and learn to incorporate fracture mechanics, material science, mechanics of materials, computer simulation, and manufacturing techniques and knowledge into their project. Students select a related research topic, identify a technical paper to review, and give a class presentation. Undergraduate equivalent: MEEG 4327. Previously ME 0427.

MEEG 5330 Mechanics of Composite Materials 3 Credits
Engineered composite materials are finding increased use in many high-technology applications such as aerospace, automotive, electronics, sporting goods, and structural components as robust durable systems. This course is designed to provide a comprehensive understanding of classification, processing, properties, selection, design, and failure of polymer, metal, and ceramic based composite materials. Micro-mechanical and macro-mechanical analysis capabilities will be used to assess composite structures. Stiffness and strength evaluation, software simulation, and optimization are used in a laminated composite design application. Students select a related research topic, identify a technical paper to review, and give a class presentation. Undergraduate equivalent: MEEG 4330. Previously ME 0444.

MEEG 5346 Energy Conversion 3 Credits
This course covers selected topics in energy conversion, including fuels used in energy conversion, solar energy, gas turbine engines and applications, internal combustion engines, battery power, heat pumps, classic and novel power and refrigeration cycles, system analysis, system economics, and environmental considerations. The course includes computer simulation of power plant performance to optimize energy conversion efficiency. A research report and class presentation of an independent research on one of the emerging sources of energy is an essential part of this course. Undergraduate equivalent: MEEG 4346. Previously ME 0451.

MEEG 5353 Computational Fluid Dynamics 3 Credits
This course is an introduction to computational methods used for the solution of advanced fluid dynamics problems, using commercially available ANSYS-FLUENT software. Emphasis is placed on concepts in finite difference methods as applied to various ordinary and partial differential model equations in fluid mechanics, fundamentals of spatial discretization, numerical integration, and numerical linear algebra. There is a focus on the engineering and scientific computing environment. Topics may include waves, advanced numerical methods (like spectral, finite element, finite volume), non-uniform grids, turbulence modeling, and methods complex boundary conditions. Students will learn how to build and implement a working computational fluid dynamics code. Students will also work on a final computational project and will present findings to the class. Undergraduate equivalent: MEEG 4353. Previously ME 0428.

MEEG 5354 Heat and Mass Transfer 3 Credits
This course covers the basic concepts of conduction, convection, and radiation heat transfer. Boiling and condensation, design and performance of selected thermal systems (including heat exchangers), and laminar and turbulent flows as related to forced and free convection are all studied. Mathematical modeling of engineering systems using modern analytical and computational solution methods are also covered. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report, and make a class presentation on their research. Undergraduate equivalent: MEEG 4354. Previously ME 0452.

MEEG 5356 Renewable Wind Energy 3 Credits
This course will give students a comprehensive introduction to wind energy systems, a practical means of extracting green and renewable energy. Topics covered include a historical perspective of wind turbines, aerodynamics of wind turbines, Mechanics and dynamics, material and components, aeroelasticity and control systems, statistical wind modeling, wind energy system economics, and environmental considerations such as noise and aesthetics. Students will work on a class research project. Undergraduate equivalent: MEEG 4356.

MEEG 5358 Heating, Ventilation, and Air Conditioning Systems Design 3 Credits
Heat loss and heat gain calculations for commercial and industrial buildings using Trane Engineering software. Students will learn how to layout and design HVAC systems per given building architectural plans, using computer software, codes, standards, and owner's requirements. Students will select appropriate HVAC equipment, size duct and piping systems, and conduct economic analysis. Energy estimating methods will be studied and an analysis of an actual building conducted. Current federal, state, and local codes and ASHRAE standards will be examined. Students will work on a class research project. Undergraduate equivalent: MEEG 4358.

MEEG 5362 Gas Turbine Aerodynamics **3 Credits**
Theory and fundamentals of modern turbomachinery for aerospace (helicopter, aircraft) and power generation (marine, industrial) applications. Brayton engine cycle analysis and performance improvement are examined. Applications of the principles of fluid mechanics and thermodynamics to the design of turbines and compressors are discussed; analysis and velocity diagram for axial compressors, centrifugal compressors and axial turbines. Discussion of combustion and environmental emissions is included. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report, and make a class presentation on their research. Undergraduate equivalent: MEEG 4362. Previously ME 0453.

MEEG 5364 Combustion **3 Credits**
An introduction to combustion, this course covers the study of combustion science based on the background of thermodynamics, fluid mechanics, and heat transfer. Basic principles of combustion, including thermochemical equilibrium, flame temperature, energy of reaction, chemical kinetics, and flame structure are discussed. This course also introduces some important chemical mechanisms and combustion modifications for pollutant control. Undergraduate equivalent: MEEG 4364. Previously ME 0464.

MEEG 5372 Applications of Theory of Elasticity **3 Credits**
This course covers theory of elasticity (stress, strain, and generalized Hooke's law), strain energy methods (Castigliano's theorem), thin shells of revolution (equilibrium equations, pressure vessels), thin plates (rectangular and circular plates, moment-curvature relations), beams of elastic foundations and buckling. Students are required to complete a group project on an advanced topic covered in class and write a research report. Undergraduate equivalent: MEEG 4372. Previously ME 0472.

MEEG 5376 Stability of Structures **3 Credits**
This course will give students a comprehensive introduction to the fundamentals and principles in the stability analysis of structures. The course provides a strong foundation for understanding the stability criteria and their application in everyday practice. The topics include a comprehensive overview of different stability analysis methods and their applications in columns, beam-columns, torsional stabilities, plate elements, and cylindrical shells. Students will work on class project/research. Undergraduate equivalent: MEEG 4376.

MEEG 5410 Vibration Analysis **3 Credits**
Fundamental laws of mechanics. Free and forced vibration of discrete single and multi-degree-of-freedom systems. Periodic and harmonic motion, viscous damping, and measures of energy dissipation. Modal analysis for linear systems. Computational methods in vibration analysis. Natural frequencies and mode shapes. Analytical dynamics and Lagrange equation. Longitudinal, torsional, and flexural vibration of continuous elastic systems, (strings, rods, beams). Energy methods. Approximate methods for distributed parameter systems. Dynamic response by direct numerical integration methods. ANSYS modeling will be covered. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report and make a class presentation on their research. Previously ME 0410.

MEEG 5415 Engineering Applications of Numerical Methods **3 Credits**
This course provides students with the theoretical basis to proceed in future studies. Topics include root-finding, interpolation, linear algebraic systems, numerical integration, numerical solution of ordinary and partial differential equations, modeling, simulation, initial boundary value problems, and two point boundary value problems. Undergraduate equivalent: ENGR 4415. Crosslisted with ECEG 5415. Previously ME 0415.

MEEG 5990 Independent Study **3 Credits**
Graduate students conduct a well-planned program of individual study under the supervision of a faculty member. Enrollment by departmental approval only. Previously ME 0495.

MEEG 6971 Thesis I **3 Credits**
The master's thesis is intended to be a test of the student's ability to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis by a faculty member. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits the student to demonstrate skills that are basic to both academic and work in industry. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic. Previously ME 0550.

MEEG 6972 Thesis II **3 Credits**
The master's thesis is intended to be a test of the student's ability to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis by a faculty member. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits the student to demonstrate skills that are basic to both academic and work in industry. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic. Previously ME 0551.