Mechanical Engineering Department
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Graduate Student Handbook

for the

Masters of Science in Mechanical Engineering

Introduction

This handbook is published as a guide for graduate students who are seeking a Master of Science Degree in Mechanical Engineering (MSME). The purpose of the handbook is to inform graduate students about the ME department's regulations, requirements, and procedures for the MSME degree. The handbook is intended as a supplement to the University Graduate School catalog; however, you should review the University Graduate Catalog for general rules and regulations governing the University's graduate programs. A copy of the catalog can be obtained at the University Graduate Studies Office.

Advising and Registration

All new students will meet with the Director of the Graduate Program before starting the first semester to get an orientation on the program and department, and register for classes. The director is the student's academic adviser until the student chooses a thesis or project adviser. At that time, the thesis or project adviser will become the student's academic adviser. If the student selects the course option, the director will remain as the student's adviser until graduation.

All students are required to meet their adviser a minimum of once per semester. Typically a student meets the adviser mid-semester after receiving a request from the University to register. The adviser monitors the student's progress towards completion of the course requirements and advises the student on course registration for the next semester. A tracking sheet is retained in the student's folder and is used to certify the student for graduation.

Students are encouraged to seek additional meetings with their adviser as needed.

Course Load Guidelines

Course load requirements are clearly spelled out in the University graduate catalog, "A course load of nine credits per semester is considered full-time in a graduate program. Students awarded full-time graduate assistantships may take no fewer than 6 and no more than 9 credits (including research and thesis or dissertation) per semester, unless approval is obtained in writing from the Graduate Director for the student's program. Twenty (20) hours per week of assistantship work and three (3) courses is considered a normal load. A course load of at least 7 credits is required for 3/4 time status and of at least 4 1/2 credits for half-time status."

A student who has completed their course requirements but has not completed the thesis or project may be given an in progress grade "IP," and may continue the thesis/project.

It is recommended that students who work full-time take only one course per semester.

Degree Requirements and Academic Progress

Each candidate for the MSME Degree must obtain a minimum of 30 graduate credits (Thesis or Project tracks) or 33 graduate credits (Course Work track), maintaining a grade point average of

at least 3.0 out of a 4.0 grading scale in course work with no more than two course grades below B-minus before the degree is awarded. Only courses with a C or better grade will be accepted toward fulfilling the degree requirements.

Required Core Courses (9 credits)

MNE 501	**Advanced Engineering Mathematics**	**3**
MNE 502	**Applied Numerical Methods**	**3**
MNE 503	**Continuum Mechanics**	**3**

15 credits – may be selected from any advisor-approved graduate level courses. No more than six of these credits may be in graduate courses offered outside the Mechanical Engineering Department. Any course taken outside the department must be approved by the thesis advisor or graduate program director. See ME course offerings below.

Additional Requirements — Thesis, Project, or Course Work tracks (6 or 9 credits)

Thesis Option	**MNE 580 Masters Thesis**	**6**
Project Option	**MNE 590 Masters Project**	**6**
Coursework Option	**3 additional courses**	**9**

Oral Exam (all options)

A student must remain continuously enrolled in the program (excluding summers) or receive approval for a leave of absence in order to maintain their status as a degree candidate. Failure to do this may result in dismissal from the program.

Project or Thesis Option

The thesis or project committee shall consist of at least three members, at least two must be ME faculty and one may be a senior scientist or engineer from outside the university or a faculty in another department. The principal advisor must be an ME faculty.

The members of student's thesis or project committee will be selected by the faculty advisor in consultation with the student. All Thesis or project committees must be approved by the Graduate Program Committee.

There are three (3) phases of thesis/project preparation:

1. Submit the thesis/project proposal. In this phase the committee is formed.
2. Research and writing resulting in a thesis/project document.
3. Oral Thesis/Project Defense. **Note**, the Dean of the College of Engineering must be notified of the defense two weeks in advance by the principal advisor.

Course Option

Masters degree candidates who take the course option will take a comprehensive oral exam in their final semester. Failure to pass the exam will prohibit the student from receiving a degree. A student who has failed the exam may petition the Graduate Committee for permission to take the exam again.

The exam will cover three (3) areas of study, and the student must choose the specific areas from the following list:

Robotics and Control Systems
Thermal and Fluid Sciences
Engineering Mathematics
Manufacturing
Material Science
Solid Mechanics and Dynamics

It is assumed that the candidate has taken courses in the department in the chosen areas. Based on the topics chosen by the student, the Graduate Committee will select no less than 3 professors to serve on the Graduate Oral Exam Committee for the student and recommend this committee to the chairperson for approval. The specific format of the exam will be determined by the examination committee, but will take no more than 3 hours. It is recommended that the student take the exam early in the final semester so that the student will have time to retake the exam if necessary during the same semester.

Transfer Credits

If a student wants to take a course at another university for transfer credit after they have been admitted to the department, the student must fill a Mechanical Engineering Graduate Transfer Credit Evaluation Form prior to taking a course.

A maximum of six (6) credits may be transferred from another institution upon approval by the chairperson and Dean. The transferred course must have a B- or better grade.

Repeat Courses

The ME department allows a student to repeat a specific course once if it is offered at UMD. The repeat course grade will be used to calculate the student's GPA. Both grades will remain as part of the student's record.

Mechanical Engineering Faculty and Specialization

Farhad Azadivar
PhD Purdue University, MS Asian Institute of Technology, BS Tehran University. Specialization: Computer Simulation, Modeling and Optimization of Manufacturing, Traffic, and Marine Fishery Systems. Deterministic and Stochastic Optimization.

Sankha Bhowmick
PhD University of Minnesota, MS Villanova University, BS Jadavpur University , Specialization: Heat and mass transfer, bioengineering, MEMS.

Vijay B. Chalivendra
PhD University of Rhode Island; MS and BS Sri Venkateswara University of College of Engineering. Specialization: Mechanical Behavior of Emerging Advanced Materials, Biomaterials, Nano-Composites, MEMS.

Sherif D. El Wakil
PhD Birmingham University, MS El-Azhar University, BS Cairo University. Specialization: computer-aided manufacturing, design for manufacturing, materials science.

Alex J. Fowler (Chairperson)
PhD Duke University, BA Wesleyan University. Specialization: Fluid flow in porous media, heat transfer, thermodynamics, bioengineering.

Peter D. Friedman
PhD Johns Hopkins University, MS Georgia Institute of Technology, BS Georgia Institute of Technology. Specialization: Experimental fluid mechanics and heat transfer, thermodynamics, nuclear power plant operation.

Wenzhen Huang
PhD^2 University of Wisconsin-Madison and Shanghai Jiaotong University, Specialization: Manufacturing Systems Modeling, Computer- Aided Tolerance Design, Applied Statistics, Quality Control.

Raymond N. Laoulache **(COOP Advisor)**
PhD Brown University, ScM, ScB Northeastern University. Specialization: Thermodynamics, multiphase flow, control systems, fluid mechanics, laser doppler anemometry, parallel computing.

Katja Holtta-Otto
PhD and MS Helsinki University of Technology. Specialization: Project Design and Development, Modularity, Product Platforms, Systems Engineering.

Tesfay Meressi
PhD, MS, University of California Santa Barbara, BS Addis Ababa University. Specialization: Robotics, control theory, machine design.

John M. Rice **(Graduate Program Director)**
PhD University of Rhode Island, MS Stanford University, BA Northeastern University. Specialization: Solid mechanics, computer-aided engineering, finite element analysis, composite materials.

T. K. Roy
PhD Texas Tech University, MS University of Hawaii, BS Bihar University. Specialization: Machine design, solid mechanics, shell dynamics, robotics.

K. Srinagesh
PhD, MS Indian Institute of Science, BS University of Mysore, India. Specialization: Manufacturing processes, physical metallurgy, foundry engineering.

Course Offerings

MNE 501 three credits
Advanced Engineering Mathematics
Prerequisite: EGR 301 or equivalent
Ordinary differential equations: power series .solutions; solutions to Legendre, Bessel, Hermite, associated Legendre, and Mathieu equations. Partial differential equations: separation of variables; transform methods; eigenvalues; Green's function; solutions to elliptic, parabolic and hyperbolic equations.

MNE 502 three credits
Applied Numerical Methods
Prerequisite: EGR 301 or equivalent
An introduction to the tools of numerical analysis used in all areas of engineering study. Solution of linear systems and non-linear
systems of equations. Numerical integration of functions ODE's and PDE's: differentiation, error control, stability and accuracy. Extensive programming in C is required.

MNE 503 three credits
Continuum Mechanics
Prerequisites: EGR 301 and MNE 252 or equivalents
A comprehensive study of the fundamental principles of Continuum Mechanics. The following topics are covered: stress, strain, and strain rated tensors; Lagrangian and Eulerian descriptions; conservation laws; constitutive relations; Navier-Cauchy and Navier Stokes equations; Newtonian fluids.

MNE 504 three credits
Advanced Mechanics of Fluids
Prerequisite: MNE 332 or equivalent
Integral Transformation: Divergence Theorem; Stokes Theorem. Reynolds Transport Theorem. Navier-Stokes equations. Kelvin's theorem. Vorticity Transport. Crocco's Theorem. Viscous flow: boundary layers, buoyancy-driven flows.

MNE 511 three credits
Theory of Elasticity
Prerequisite: MNE 503 or equivalent
Basic field equations. Generalized Hooke's law. General concepts of stress and strain. Equilibrium equations. Plane problems. Stress functions. Saint Venant torsion and flexure. Introduction to three-dimensional problems. Thermoelasticity. Anisotropic solutions.

MNE 512 three credits
Plasticity and Metal Forming Theory
Prerequisite: MNE 503 or equivalent
Tresca and von Mises yield criteria and their associated flow rules. Slip-line field theory and Geiringer velocity equations. Upper bound and lower bound theories. Application of the plasticity theories to rigid, perfectly-plastic bodies undergoing large plastic deformation in 110

various metal forming processes such as wire drawing, extrusion, forging, deep drawing, etc.

MNE 513 three credits
Theory of Plates and Shells
Prerequisite: EGR 242, Pre or co-requisite: MNE 503
Basic plate and shell equations; solutions of different shape plates. Application of cylindrical and spherical shell equations. Linear and nonlinear situations. Plates on elastic foundations. Numerical solutions of plates and shells. Membrane theory.

MNE 515 three credits
Finite Element Analysis
Prerequisite: MNE 485 or equivalent
A broad study of the principles of Finite Element Analysis. The following topics are covered: energy methods; variational principles; element formulation; coordinate transformation; problems in dynamics, solids, and heat transfer; non-linear problems; numerical errors and convergence; computer modeling.

MNE 518 three credits
Advanced Physical Metallurgy
Prerequisites: EGR 231, EGR 221 or equivalents
Extending understanding of the effect of structure on the properties of metals and alloys. Deviation in various forms from perfect crystallinity will be analyzed. Metallurgical processes of typical ferrous and nonferrous alloys will be explored.

MNE 519 three credits
Metal Casting Principles
Prerequisites: EGR 231, MNE 345, MNE 411 or equivalents
Advanced concepts in solidification of alloys. Mutually dependent topics are: flow of liquid metals, transient heat transfer, phase and state change. Consequence of these in the design of sound castings will be presented.

MNE 521 three credits
Classical Thermodynamics
Prerequisite: EGR 232 or equivalent
An in-depth study of the fundamental principles of classical thermodynamics. The following topics are covered: equilibrium; temperature; equations of state; fundamental equations; First Law for steady, unsteady and continuous systems; Born-Caratheodory formulation of the Second Law; Third Law.

MNE 522 three credits
Statistical Thermodynamics
Prerequisite: EGR 232 or equivalent
The principles of thermodynamics based on a microscopic approach. The following topics are covered: statistical concepts, Kinetic Theory, Gibbsian ensembles, partition function, Liouville's theorem, Boltzmann equation and the Chapman-Enskog solution, calculation of equilibrium and transport properties.

MNE 525 three credits
Bioengineering Fundamentals
Applications of thermodynamics, fluid mechanics, and transport study to biological systems. An introduction to chemical kinetics, intercellular interactions, and basic biomechanics is also included. Emphasis is on engineering with relevance to clinical and research medical applications.

MNE 530 three credits
Simulation Modeling
Prerequisites: Advanced mathematics (EGR
301) and computer programming (EGR 102) or equivalents
Concepts and principles associated with systems simulation and modeling using contemporary software such as Simulation with Arena. Topics include probability and statistics, discrete event simulation, statistical techniques in simulation modeling. Statistical analysis is integrated for the most part into the simulation modeling, reflecting the joint nature of these activities in good simulation studies, and continuous simulation of industrial and manufacturing systems using SIMAN language. The student will work in a team producing a design project relating to these topics.

MNE 531 three credits
Advanced Dynamics
Prerequisites: EGR 242, EGR 301 or equivalents
A course of study of technologically useful topics from dynamics, such as: three dimensional motion of rigid bodies; dynamics of flexible rotors and linkages; balancing of machinery and non-linear forces and stability. Variational methods and numerical techniques will be introduced.

MNE 532 three credits
Advanced Robotics
Prerequisite: MNE 482 or equivalent
Advanced course in kinematics, dynamics and control of robots. Topics covered include: trajectory generation, position and force control of open chain and closed chain manipulators, kinematic redundancy, link flexibility, artificial intelligence and integration of industrial robots in integrated manufacturing systems.

MNE 533 three credits
Manufacturing Automation
Prerequisite: MNE 345 or equivalent
A study of the different components of an automated manufacturing system. Design of the hardware and software used in the different manufacturing systems. Analysis, modeling, performance and economics of flexible manufacturing systems and flexible manufacturing cells. Design of parts to facilitate automatic assembly.

MNE 534 three credits
Advanced Vibrations
Prerequisites: EGR 242, EGR 301, or equivalent
Vibration of structures and machine components, Free and Forced Vibrations, Damped Vibrations, National Modes, Critical speeds, non-linear systems techniques, phase plane and function description methods.

MNE 536 three credits
Advanced Control Theory
Prerequisite: MNE 466 or equivalent
Advanced course in design of control systems. Topics covered include: input-output and state space description; controllability and observability of multi-input multi-output systems; pole placement; observer design and separation principle; linear quadratic optimal control; non-linear systems and linearization; Lyapunov stability theory; application to electromechnical systems.

MNE 537 three credits
Manufacturing Systems Design
Prerequisite: MNE 345 or equivalent
Advanced topics in manufacturing systems design and analysis with emphasis on modeling and integration methodologies. Specific topics include production flow analysis, group technology, manufacturing cell design, facilities location and work design, material handling systems and automated guided vehicles, flexible manufacturing systems, and systems evaluation. Term design projects are required using computer and software tools.

MNE 538 three credits
Manufacturing Planning and Control
Prerequisite: EGR 301 or equivalent
Advanced topics in manufacturing production planning and control with emphasis on design and resource utilization. Specific topics include operations planning and control, linear programming, capacity planning, resource material planning, inventory control, project scheduling, and manufacturing cost analysis. Term design projects are required using computer and software tools.

MNE 539 three credits
Engineering Optimization
Prerequisite: EGR 301 or equivalent
Advanced topics in engineering optimization with emphasis on the algorithm and applications. Specific topics include linear and 111 nonlinear optimization, mathematical modeling, constrained optimality criteria, transformation methods, constrained direct search, quadratic approximation methods for constrained problems, and comparison of constrained optimization methods. Term design projects are required using computer and software tools.

MNE 541 three credits
Heat Conduction
Prerequisite: MNE 411 or equivalent
Basic heat transfer modes. Steady one dimensional problems with or without heat sources, constant or variable properties. Concepts of thermal resistance. Multidimensional heat conduction problems. Transient problems. Numerical treatment of heat conduction problems. Special applications in heat conduction field.

MNE 542 three credits
Convective Heat Transfer
Prerequisite: MNE 411 or equivalent
Boundary layer flow problems: laminar and turbulent plows. Thermal boundary layer plows. Dimensional analysis. Forced convection problems. Free convection problems. Duct flows. Boiling and Condensation. Special convection problems. Heat Exchange Design. Applications.

MNE 543 three credits
Radiation Heat Transfer
Prerequisite: MNE 411 or equivalent
Basic concepts and fundamental relations of thermal radiation. Radiation field; Kirchoff's laws. Radiation density. Radiation pressure. Blackbody radiation. Graybody radiation. Radiative heat exchanges among surfaces, in enclosures. Radiation through weakly absorbing media.

MNE 551 three credits
Compressible Fluid Flow
Prerequisite: MNE 431 or equivalent
Conservation laws. Wave propagation in compressible media. Isentropic flow. Normal and oblique shock waves. Prandt-Meyer flow. Converging-diverging nozzles and supersonic diffuses. Supersonic oblique shock diffuses. Exit flow for underexpanded and overexpanded supersonic nozzles. Fanne line flow. Rayleigh line flow.

MNE 552 three credits
Computational Fluid Mechanics
Prerequisite: MNE 504
Solutions to Navier-Stokes equations. Finite difference methods: Lax-Wendroff, MacCormack, Rusanov, implicit, forward-time and centered-method, leap-frog/Dufort-Frankel, ADI, predictor-corrector methods. Grid generation. Accuracy and convergence.

MNE 560 three credits
Methods of Experimental Research
Prerequisite: Graduate standing
The need and subject matter of research. Laws, truths, analogy and hypothesis. Identifying and clustering parameters. Use of models. Experimental setup. Induction, deduction, statistics, and conclusions. Presentation and use of finding.

MNE 570 three credits
Reading and Research
Prerequisite: Graduate standing and approval of student's graduate committee Independent study under faculty supervision. Intensive literature search culminating in a technical report. Oral presentation at the option of the faculty.

MNE 580 six credits
Masters Thesis
Prerequisites: Graduate standing, Thesis Option, and approval of the student's Graduate Committee Thesis research on an experimental or theoretical project in mechanical engineering under a faculty advisor. A formal thesis must be submitted to fulfill the course requirements.

MNE 590 six credits
Masters Project
Prerequisites: Graduate standing, Project
Option, and approval of the student's Graduate Committee
Project research in conjunction with industry under a faculty advisor. A formal report must be submitted to fulfill the course requirements.