

Mechanical Engineering

UNDERGRADUATE PROGRAMS

The undergraduate program in mechanical engineering is accredited by the Engineering Accreditation Commission of ABET. The curriculum has been designed to provide strong technical preparation in mechanical engineering. Students enter the junior year from either the Watson School's Division of Engineering Design or having completed the associate of science degree in engineering science or equivalent coursework at another school. The emphasis is on the application of engineering fundamentals rather than specialized areas within mechanical engineering. Care has been taken to ensure a balanced integration of theory, design and laboratory practice through the selection and sequencing of courses within the syllabus. Computer applications are an integral part of the total education program.

The emphasis on design projects in the curriculum provides an opportunity for faculty to engage in dialogue with students, thereby assisting them in learning-by-doing and developing their problem-solving and communication abilities as individuals and in teams. A progressive sequence of design courses in the junior and senior years culminates in a capstone senior design project. Additionally, the insertion of design in selective courses throughout the junior and senior years attests to how the design experience is developed and integrated throughout the curriculum.

Some degree of specialization is permitted in the senior year, but the primary goal is to prepare the mechanical engineering bachelor of science graduate for a creative engineering career, based on a thorough grounding in the fundamentals and skills used by the mechanical engineer, as well as motivation for continued self-education.

The department encourages students to earn an international studies certificate in parallel with the BSME. Students interested in this program should seek advice from the Watson School advising office prior to initial registration. Other program alternatives such as combined degrees in mechanical engineering and computer science are available to qualified students. A minor in computer science and other disciplines is also possible.

Qualified students are able to participate in engineering practice through internships of lengths from six to 15 months.

Requirements for BS Degree in Mechanical Engineering

To receive the BS degree in mechanical engineering, students must complete 66 credit hours in the upper-division program, with the distribution of credits as outlined below. Also required is an average of at least C (2.0 GPA) in mechanical engineering.

All Binghamton University freshmen and transfer students must also meet the University's General Education requirements. However, those requirements are waived for all transfers who have earned a minimum of 57 credits prior to entering the University. Any student with the associate degree in engineering science, or equivalent courses, will have this waiver. For more details, refer to the General Education section of this *Bulletin*, or consult your faculty adviser or the Watson School advising office.

<i>Junior Year/Semester I</i>	<i>credits</i>
ME 311. Mechanics of Deformable Bodies ...	3
ME 331. Thermodynamics	3
ME 322. Dynamics in Mechanical Design ...	3
MATH 471. Mathematical Methods in Science II	4
Humanities or social sciences*	4
TOTAL	17

<i>Junior Year/Semester II</i>	
ME 303. Engineering Computational Methods	3
ME 351. Fluid Mechanics	3
ME 361. Materials Processing	3
ME 372. Engineering Project Management ..	4
ME 392. Machine Design	3
TOTAL	16

<i>Senior Year/Semester III</i>	
ME 421. Mechanical Vibrations	3
ME 441. Heat Transfer	3
ME 491. Mechanical Engineering Lab	3
ME 493. Senior Project I	4
Technical elective	3
TOTAL	16

<i>Senior Year/Semester IV</i>	
ME 424. Control Systems in Mechanical Engineering	3
ME 494. Senior Project II	4
Technical elective	3
Technical elective	3
Humanities or social sciences*	4
TOTAL	17

* *Must be approved upper-division courses.*

GRADUATE PROGRAMS

The Mechanical Engineering Department conducts graduate programs in the broad field of mechanical engineering. The program leading to the master of science degree provides a balance of advanced theory and practical knowledge necessary either for practice of the profession or for advancement to a doctoral program. The master of engineering program is designed to equip graduates with the skills needed to be effective in industry. In recognition of the high concentration of industry in the Binghamton area, this program has the flexibility required by part-time students and takes advantage of the industrial experience available. The master of engineering program enables students to combine a specialization in mechanical engineering with coursework in several related disciplines.

Within the broad field of mechanical engineering, students may specialize in one of three areas: thermofluids, mechanics and design, or materials. Electronics packaging is a technical area of research concentration in the department. Specialization is achieved by selection of a set of courses and selection of the thesis topic and major professor.

The academic environment of the department is enriched by the appointment of adjunct faculty members employed in local industry. Under appropriate circumstances, thesis research activity may be carried out in industrial laboratories.

Master of Science in Mechanical Engineering PROTOCOL

Each student in the MSME program must select and obtain the consent of a full-time ME faculty member to serve as his or her adviser. The student will work with the adviser to create a study plan and fill out the *MSME Proposed Course of Study Form*. With the cooperation of the adviser, the student will form a research committee to supervise the student's work. The research committee is composed of the adviser as the chairman and two other technically qualified members, at least one of whom must be a full-time ME faculty member. An up-to-date biographical sketch must be provided to the director of graduate studies for any committee member who is to be chosen who is not a full-time ME faculty member. The student will then fill out the *MSME Research Committee Registration Form* and obtain the signed approval from the director of graduate studies and the chairman of the department.

The processes of adviser selection, study plan creation and research committee formation

should be completed by the end of the student's first semester of full-time study. (For part-time students the process of adviser selection, study plan creation and research committee formation should be completed before the student has completed three graduate courses.) Copies of both the *MSME Proposed Course of Study Form* and the *MSME Research Committee Registration Form* must be filed with the director of graduate studies (for department files) and the dean's office (for Watson School files).

Degree Requirements for the Master of Science in Mechanical Engineering

The student must complete a minimum of eight adviser-approved graduate courses, exclusive of the thesis. Six of the eight courses must be ME courses, as follows:

1. The student will select from ME offerings to satisfy a three-course core curriculum of:
 - a. an advanced mathematics course (e.g., ME 535)
 - b. a numerical analysis, computational mathematics or computational materials science course (e.g., ME 517, ME 536, ME 541, ME 609)
 - c. a continuum mechanics course (e.g., ME 510, ME 511, ME 554)
2. Three of the remaining five required courses must be ME courses, chosen in the student's area of emphasis.
3. Two adviser-approved technical electives (these courses may be taken outside the ME department).
4. The student must have adviser approval of each element in his or her course of study.

The student must maintain at least an overall B average (GPA 3.0/4.0 or better) for his or her graduate coursework to be eligible for the MSME degree.

RESEARCH

The student must complete a research thesis. The written thesis and an oral presentation defending the thesis must be approved by the student's research committee before he or she is eligible for the MSME degree.

SATISFACTORY ACADEMIC PROGRESS

All rules of the Graduate School apply regarding probation and academic jeopardy, except probation may not last more than two semesters.

FINANCIAL SUPPORT

MSME students receiving financial support in the form of a teaching assistantship or a research assistantship are normally eligible to receive a tuition scholarship. This is arranged by the student's adviser and the dean's office. All of those receiving financial support must be registered as full-time students.

Master of Engineering with Specialization in Mechanical Engineering

DEGREE REQUIREMENTS

All master of engineering students must complete the MEng *Course of Study Form* and obtain the approval of the director of graduate studies. The requirements for the degree include the completion of 10 graduate courses as follows:

1. Four graduate mechanical engineering courses in the student's chosen area of emphasis.
2. Four approved elective graduate courses. These courses must be approved by the director of graduate studies. Students may take these courses in a variety of departments such as other departments in the Watson School (EE, CS, SSIE), or in the Physics, Chemistry, Mathematics or Management departments.

3. Two-course sequence in Engineering Practice (WTSN 573 and 574).

The student must maintain at least an overall B average (GPA 3.0/4.0 or better) for his or her graduate coursework to be eligible for the MEng degree.

For more information on the MEng degree, see also the School-Wide graduate program section of the *Bulletin*.

Doctoral Program in Mechanical Engineering

The PhD in mechanical engineering is described above under "Graduate Information."

COURSE OFFERINGS/ UNDERGRADUATE

NOTE: Unless otherwise noted, undergraduate courses carry 3 credits.

ME 271. ENGINEERING MECHANICS

spring only, 5 credits

Statics; equilibrium of particles and bodies, equivalent force system, centroid, moment of inertia, trusses, friction,

kinematics of particles and rigid bodies, kinetics of particles and rigid bodies plane motion. Prerequisites: a first course in calculus-based physics.

ME 273. ENGINEERING MECHANICS/STATICS

spring only, 2 credits

Statics portion of ME 271, half-semester course. Prerequisite: a first course in calculus-based physics or permission of instructor.

ME 291. MECHANICAL PHENOMENA LABORATORY

fall only, 2 credits

Introduction to measurement of physical phenomena such as temperature, strain, fluid flow, pressure and thermal capacity. Physical properties of materials, conservation of energy and momentum examined. Prerequisite: PHYS 131.

ME 302. ENGINEERING ANALYSIS

Methods employed in engineering problem solving. Methods drawn from advanced topics in calculus, numerical methods, and probability and statistics. Case studies drawn from engineering disciplines used to apply the mathematical techniques. Prerequisite: calculus through differential equations.

ME 303. ENGINEERING COMPUTATIONAL METHODS

Engineering applications of numerical analysis covering topics in curve fitting, root solving, systems of algebraic equations and ordinary differential equations. Topics in computing practice, including programming and graphics and visualization. An introduction to computer-aided engineering (CAE) software packages. Prerequisite: ME 302 or MATH 471, or consent of department chair.

ME 311. MECHANICS OF DEFORMABLE BODIES

Basic principles of stress and strain of members subject to axial, shearing, bending, torsion and combined loads. Mohr's circle. Mechanical properties of engineering materials. Shear and moment diagrams. Deflection of beams. Introduction to energy methods. Prerequisite: engineering science statics.

ME 322. DYNAMICS IN MECHANICAL DESIGN

Velocity and acceleration of particles in moving coordinate systems. Newtonian dynamics of systems of particles. Newtonian dynamics of rigid bodies in three dimensions. Introduction to analytical dynamics, virtual work and Lagrange's equations. Prerequisite: ME 271 or equivalent.

ME 331. THERMODYNAMICS

Properties of pure substances. Concepts of work and heat, fundamental laws of thermodynamics; closed and open systems. Entropy and entropy production. Carnot and Clausius statements. Gas mixtures. Prerequisites: calculus-based physics on heat and mechanics and calculus through differential equations.

ME 351. FLUID MECHANICS

Hydrostatics, kinematics, potential flow, momentum and energy relations. Bernoulli equation. Real fluid phenomena, laminar and turbulent motion boundary layer, lift and drag. Prerequisite: ME 331 and MATH 471 or equivalent.

ME 361. MATERIALS PROCESSING

Selection and processing of materials. Analysis and design for common manufacturing processes such as casting, forging, extrusion, drawing, rolling, shearing, machining. Introduction to nontraditional machining processes such as EDM, ECM, Ultrasonic Tolerances and surface finish. Prerequisites: WTSN 272 or permission of department chair.

ME 372. ENGINEERING PROJECT MANAGEMENT

4 credits

Introduction to project selection and project control. Topics include: basic engineering economics (present worth, discounted cash flow, etc.), feasibility studies, cost estimating, risk analysis, project planning, scheduling and control. Open-ended projects with multiple alternatives strongly emphasized. Professional practice factors in management of projects. Prerequisite: junior standing or approval of department chair.

ME 392. MACHINE DESIGN

Application of fundamental principles of mechanics and strength of materials to machine design problems. Topics include fatigue, stress concentrations, failure theories, application to design of bolts, springs and other types of component design. Decision making and engineering judgment for open-ended problems are emphasized. Prerequisite: ME 311.

ME 417. INTRODUCTION TO THE FINITE ELEMENT METHOD

technical elective

Review of linear elasticity, introduction to calculus of variations and variational principles of elasticity. These techniques will be used in developing the finite element theory and analysis of plane stress/strain, plates, trusses and beams, as well as problems from other areas of mechanical engineering, such as heat transfer and vibration. Prerequisite: ME 311.

ME 421. MECHANICAL VIBRATIONS

Free vibration of mechanical systems, damping, forced harmonic vibration, support motion, vibration isolation, response due to arbitrary excitation, systems with multiple degrees of freedom, normal modes, free and forced vibrations, vibration absorber, application of matrix methods, numerical techniques, computer applications. Prerequisite: ME 271 and MATH 471 or equivalent.

ME 422. ACOUSTICS

technical elective

Propagation of sound. Acoustic wave equation. Reflection of sound waves from boundaries. Sound transmission through walls. Room acoustics, reverberation and absorption in enclosures. Sound generation, loudspeaker design. Sound radiation from complex surfaces. Bioacoustics. Prerequisite: calculus through differential equations.

ME 424. CONTROL SYSTEMS IN MECHANICAL ENGINEERING

Introduction to classical and modern control systems as they relate to mechanical engineering. Modeling, analysis and design of control systems. State space techniques are introduced. Prerequisite: ME 421 or consent of department chair.

ME 433. GAS DYNAMICS

technical elective

Introduction to basic equations of compressible flow. Wave propagation in compressible media. Isentropic flow, normal and oblique shock waves. Prandtl Meyer flow. Effects of friction and heat transfer. Prerequisites: ME 331 and 351.

ME 434. ENVIRONMENTAL ENGINEERING

technical elective

Mathematical modeling of chemistry and microbiology as applied to environmental engineering processes. Mass transfer and mixing. Biological waste treatment, sedimentation, filtration, membranes, disinfection, adsorption. Flow in porous media, groundwater flows. Water pollution, oil spills. Prerequisite: ME 351.

ME 435. APPLIED AERODYNAMICS

technical elective

Application of basic principles of fluid dynamics and thermodynamics to the aerodynamics of flight. The course deals with concepts of lift, drag, aerodynamic moments, dynamics of flow fields about bodies, including theory of airfoils and wings. Analytical techniques for predicting aircraft performance are presented. Prerequisites: ME 331 and 351.

ME 436. FUNDAMENTALS OF TRIBOLOGY

technical elective

Friction (phenomena, mechanisms and related topics of surface topography and temperature), wear (classification and identification, quantitative laws), and lubrication (as a remedy of friction and wear). The design of tribological machine components and the application of tribology in manufacturing processes. Prerequisites: ME 392 and WTSN 272 or equivalent.

ME 437. ENERGY ENGINEERING

technical elective

Applies the principles of thermodynamics, heat transfer, fluid flow and materials behavior in describing the design and operation of energy production and conversion facilities. Gas and vapor power cycles. Limiting factors and alternative solutions for applications such as electric power generation, transportation vehicles and industrial heat sources. Prerequisites: ME 331, 351 and 311. Prerequisite or corequisite: ME 441.

ME 441. HEAT TRANSFER

Introduction to fundamentals of heat transfer. Topics in conduction, forced and free convection, mixed modes (e.g. extended surfaces), heat exchangers, radiation. Development and use of analytic and empirical expressions in terms of dimensionless parameters. Prerequisites: ME 331 and 351 or consent of department chair.

ME 452. FUNDAMENTALS OF BIOMEDICAL ENGINEERING

technical elective

Study of the basic mechanical and electrical properties of the human body, including the dynamics of the cardiovascular system, the dynamics of limbs in locomotion and other activities; measurement of physiological parameters. Anatomy and physiology of these biological systems. Design of prosthetic devices. Prerequisite: senior standing in engineering.

ME 471. MANUFACTURING SYSTEMS DESIGN

technical elective

Basic course in competitive design and engineering of productive systems. Topics include engineering economics, product design, process design, automation, facility design, quality assurance. Prerequisite: senior standing.

ME 491. MECHANICAL ENGINEERING LAB

A modular laboratory course where the topics of controls, fluids, heat transfer, and solid mechanics are the subject for the experimental modules. Prerequisite: Senior standing in mechanical engineering.

ME 492. ASSISTIVE DEVICE DESIGN *technical elective*
Review of formal design principles. Case studies, project simulations, one major design/build project of an assistive device for an external client.

ME 493. SENIOR PROJECT I *fall, 4 credits*
Group project emphasizing definition and planning for solution of industrial problem. Achievement of prototype or interim design in preparation for final design or product/process realization in ME 494. Prerequisite: senior standing in mechanical engineering.

ME 494. SENIOR PROJECT II *spring, 4 credits*
Coordination of group project with unique industrial problem. Analysis, design, experimentation may be brought to bear on solution. Realization of results from final design of product or process with critical evaluation by judging panel. Prerequisite: ME 493.

ME 396/496. INDUSTRIAL INTERNSHIP *variable credit*
Engineering professional experience. Daily log book, memo reports, and a formal final report required. Prerequisite: permission of department chair.

ME 397/497. INDEPENDENT STUDY *variable credit*
Individual study under direct supervision of a faculty member. Prerequisites: approval of proposed subject by the faculty member and department chair.

COURSE OFFERINGS/ GRADUATE

NOTE: Unless otherwise noted, graduate courses carry 3 credits.

* Pending Graduate Council approval.

ME 506. VEHICLE CONTROL AND SIMULATION
Concepts of modeling and simulation of vehicle dynamics are developed with particular emphasis on real-time simulation. The digital simulation of the continuous system is developed as a discrete dynamic system that can be filtered, tuned, stabilized, controlled, analyzed and synthesized. Also included are coordinate transformation techniques for multi-degree of freedom systems and numerical integration techniques in the context of real-time applications. A term project is included that involves the simulation of the dynamics of a vehicle such as an aircraft or a land vehicle. Prerequisite: BS degree in engineering or physics, or approval of department chair. Offered fall semester in odd-numbered years.

ME 510. CONTINUUM MECHANICS *fall*
An introductory course emphasizing basic concepts. The initial part of the course is devoted to cartesian tensor calculus. Next the study includes stress, deformation, strain, flow and the general laws of change. Constitutive laws for fluid, elastic and plastic media are formulated. An objective is to develop the student's ability to formulate mechanical problems in engineering and science. Prerequisite: undergraduate mechanical engineering curriculum or equivalent, or consent of department chair.

ME 511. ELASTICITY *fall*
Topics covered include three-dimensional analysis and representation of stress and strain, development of governing equations of elastic media, applications of these equations to two- and three-dimensional problems. Prerequisite: mechanics of materials or consent of department chair.

ME 512. ENERGY METHODS IN APPLIED MECHANICS
Energy methods lend themselves to both conceptual and computational treatment of mechanical phenomena. Variational principles constitute the basis of several numerical methods such as the Rayleigh-Ritz, which in turn nurtures finite element theory. The course ties together the principles of minimum potential energy, complementary energy, virtual work, Hamilton, etc., and applies them to structural analysis. Prerequisites: mechanics of materials or consent of department chair.

ME 513. PLATES AND SHELLS
Analysis of plates acted upon by forces in their plane. Bending theory of plates. Applications to circuit board design. Rectangular and circular planes. Approximate methods: Ritz, finite element differences. Large deflection, thermal stresses in plates. Orthotropic plates. Membrane theory of shells. Bending theory of cylindrical shells. Pressure vessels and space vehicle structures. Prerequisites: differential equations and ME 311 or equivalent, or consent of department chair.

ME 514. PLASTICITY
Fundamentals of deformation and strength concepts of isotropic materials. Plastic stress-strain relations, criteria for yielding under multiaxial stress and properties of the yield surface under loading and unloading schemes. Hardness tests and forging problems. Elasto-plastic deformation of torsional and flexural members, hollow spheres and thick-walled tubes. Slip-line analysis for indentation problems, and limit analysis for frame structures and plates. Finite element theory with applications and practical programming experience in a convenient FEM code. Dynamic plasticity experimental methods are discussed. Prerequisites: solid mechanics and calculus courses, or consent of department chair.

ME 516. MECHANICAL ASPECTS OF ELECTRONIC PACKAGING
First part of the course is devoted to general concepts: Thermal stress and its associated problems in multimaterial assemblies. Layered solids subjected to flexure and local pressure. Analytical tools: theory and experiment. Finite element methods. Mechanical behavior of solder. The second part: first-level packaging, chip bonding; the module flip chip structures; encapsulation. Second-level packaging: stresses and strains in module attachment; pin-in-hole and surface solder joints. Analysis of circuit cards and boards. Thermal, flexural and dynamic loading. Third-level packaging: attachments and connectors; shock and vibration. Introduction to thermal management. Prerequisites: calculus and mechanics of materials.

ME 517. FINITE ELEMENT ANALYSIS I *spring*
An introductory course in the finite element method dealing with the fundamental principles. Problems solved in the areas of solid mechanics, structures, fluid mechanics and heat transfer. Use of standard FE software such as ANSYS. Prerequisites: undergraduate course in mechanics or consent of department chair.

ME 518. ADVANCED MECHANICS OF MATERIALS
Review of Equilibrium, compatibility and Constitutive Laws. Bending and torsion problems. Energy methods. Variational formulations. Stability of elastic systems. Prerequisite: ME 311 or equivalent, or consent of department chair.

ME 523. ADVANCED DYNAMICS

The course deals with the fundamentals of mechanics. It is designed for students in engineering practice and students contemplating further in-depth study in mechanics. Topics included are: 1) mechanics of particles and systems of particles; 2) D'Alembert's principle and Lagrange's equations; 3) kinematics of rigid body motion; 4) multi-reference frames; 5) rigid body equations of motion—Euler equations; 6) applications. Prerequisite: ME 322 or equivalent, or consent of department chair.

ME 524. ADVANCED MECHANICAL VIBRATIONS

spring, odd-numbered years

This course deals with the fundamentals of dynamics as applied to mechanically vibrating systems. Equations of motion for systems with multiple degrees of freedom are developed in order to determine natural modes of vibration of discrete systems. Approximate methods of solution, e.g., Rayleigh-Ritz, Galerkin's method, etc., are discussed. Vibration of continuous systems, e.g., free and forced vibration of strings, bars, beams and plates are considered. Numerical approaches including the finite element method are applied to continuous systems. Prerequisite: ME 421 or equivalent, or consent of departmental chair.

ME 526. VIBRATION AND NOISE CONTROL

spring, even-numbered years

Summary of methods for controlling vibration and noise. Vibration-damping treatment design, including auxiliary mass dampers and constrained layer dampers. Fundamentals of noise radiation and propagation. Sound transmission through walls. Sound absorption and muffler design. Reverberation and room acoustics. Prerequisite: graduate standing or grade of B or higher in ME 421 or equivalent.

ME 527. MECHATRONICS

Review of classical mechanics and electromagnetics. Operation of electric motors. Mechanical response of piezoelectric materials. Review of classical control. Current research in sensors and actuators. Signal conditioning. Design of active and passive vibration damping systems. Applications. Prerequisite: graduate standing in electrical or mechanical engineering or physics, or consent of department chair.

ME 530 (also IE 530). MAN-MACHINE SYSTEMS

fall, even-numbered years

This course presents a systems engineering characterization of the human operator and his interaction with simple and complex machines, such as airplanes and ground vehicles. Topics will include human perception, information measurement, manual control and mathematical modeling of the human operator. Modern control theory will be employed to characterize the man-machine system. Prerequisite: BS in engineering or approval of department chair.

ME 534. ANALYSIS AND CONTROL OF MECHANICAL SYSTEMS

spring, 4 credits

Presents the fundamentals of control theory applied to mechanical and industrial engineering problems. The emphasis of the course is in the mathematical modeling and analysis of the dynamics of mechanical systems such as aircraft, large space structures, robots, etc. Assignments given to model these systems, analyze the dynamics and define the requirements for control of these devices. The concentration is on analysis as opposed to design. Digital simulations are a major tool for the analysis, which employs both classical and state space techniques. Prerequisite:

BS in mechanical or industrial engineering, or approval of department chair.

ME 535. ANALYTICAL METHODS

A survey and discussion of some of the most important and useful analytical methods for analyzing a wide variety of engineering and scientific problems. Topics will include solution of partial differential equations, including methods for linear equations; eigenfunction expansions and separation of variables; topics in multi-variable calculus, including vector analysis; and selected topics in linear algebra, integral transforms and functions of a complex variable. Each of the methods will be introduced in the context of real, applied problems and then illustrated with typical engineering applications. Prerequisite: Ordinary differential equations, ME 302 or equivalent.

ME 541. COMPUTATIONAL HEAT TRANSFER

fall

Fundamentals of computational heat transfer as they relate to conduction and convection. Applications oriented and designed for students in engineering practice and students contemplating further in-depth study. Prerequisites: undergraduate heat transfer, fluid mechanics and differential equations, or consent of department chair.

ME 542. HEAT TRANSFER CONVECTION

spring

Topics included in this course are: 1) conservation principles in momentum and energy; 2) differential equations of the boundary layer-momentum and energy for laminar and turbulent flows; 3) momentum transfer-external and internal flows; 4) heat transfer-external and internal flows; 5) influence of temperature-dependent fluid properties; 6) convective heat transfer at high velocities; 7) free-convection boundary layers. Prerequisite: undergraduate course in heat transfer, or consent of department chair.

ME 551. INVISCID FLOW

fall

Euler equations, vorticity dynamics, two-dimensional and three-dimensional potential theory, fundamental solutions, conformal mapping, boundary element formulations. Applications include slender bodies, wing theory, natural flight and propulsion mechanisms. Prerequisites: undergraduate fluid mechanics and ME 535 concurrently, or consent of department chair.

ME 552. MECHANICS OF LUBRICATION I

spring, even-numbered years

The course studies the mechanics of fluid film lubrication. Topics of discussion include the basic assumptions and derivation of Reynolds equation; the three mechanisms (wedge action, squeeze action and external pressurization) of fluid film lubrication; the analysis and design of journal and thrust bearings under static and dynamic loads; whirl instability in journal bearings; pneumatic instability in externally pressurized gas bearings; cavitation of liquid lubricant films; and thermal effects in bearings. Prerequisite: usual undergraduate mechanical engineering curriculum, or consent of department chair.

ME 553. PHYSICO-CHEMICAL HYDRODYNAMICS

spring, odd-numbered years

Diffusion, random walk, chemical thermodynamics, phase diagrams, thermocapillary phenomena, diffusive-convective flows, chemically reacting flows, interfacial stability, microhydrodynamics. Applications in materials processing, biological and chemical systems, electronics packaging. Prerequisites: undergraduate fluid mechanics, ME 535, or consent of department chair.

ME 554. VISCOUS FLOW

spring

Various topics in viscous incompressible fluid flow. Navier-Stokes equations, boundary layers, vorticity, Stokes flow, lubrication approximation, Hele-Shaw flow, capillarity, thin films, interfacial stability. Prerequisites: undergraduate fluid mechanics, ME 535, or consent of department chair.

ME 561. PHYSICAL METALLURGY OF ALLOY SYSTEMS

Course deals with the physical metallurgy of several important metallic alloy systems. Alloys discussed include: steels, aluminum, copper, titanium, refractory metals. Role of processing and microstructure on properties is emphasized. The basic concepts of phase transformations, diffusion, surfaces and interfaces, and defect structures are discussed with emphasis on applications. Prerequisite: An introductory course in materials science or materials engineering, or consent of department chair.

ME 562. MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS

A study of the response of materials to applied stresses, especially stress-induced failures. Relationship between structure and properties with emphasis on microstructural changes and failure. Macroscopic and microscopic concepts of fracture mechanics, fatigue, creep and their interactions. Emphasis on design applications and failure analysis. Prerequisites: undergraduate courses in mechanics of materials and materials science, or consent of department chair.

ME 565. CORROSION OF METALS AND ALLOYS

Fundamental aspects of metallic corrosion in aqueous environments and applications to practical engineering problems. Electrochemical thermodynamics and kinetics; application of polarization theory to uniform corrosion; mechanisms of nonuniform corrosion; metallurgical aspects of corrosion failures and prevention. Prerequisite: undergraduate course in materials engineering, or consent of department chair.

*ME 571 (also SSIE 576). MANUFACTURING PROCESSES I
Equilibrium and nonequilibrium microstructure arising from liquid-solid processing of materials. Casting of metal alloys, fusion welding of metals, injection molding of polymers and brazing/soldering of metals. Prerequisite: An introductory course in materials science/engineering, or consent of department chair. A course in strength of materials and course in heat transfer are desirable.

*ME 572 (also SSIE 577). MANUFACTURING PROCESSES II
The role of mechanical and thermal forces on the solid state fabrication of materials will be studied. Fabrication processes to be analyzed will include extrusion, forging, particulate (powder) processing, rolling, sheet forming and wire drawing. The related thermal treatments such as heat treating and sintering will be discussed. A variety of materials classes will be exemplified such as in continuous annealing of steel, ceramic powder processing and metal powder injection molding. Prerequisite: An introductory course in materials science/engineering, or consent of department chair. A course in strength of materials and course in heat transfer are desirable.

ME 574. PRINTED WIRE BOARD MANUFACTURING

Course deals with materials for printed wire boards, processes like lithography, drilling, plating, etching and test requirements and procedures for PWB testing. Prerequisite: undergraduate course in physics, chemistry and manu-

facturing processes, related experience or consent of department chair.

ME 580. SPECIAL TOPICS

Topics vary from semester to semester.

A. MECHANICS AND DESIGN

B. THERMOFLUIDS

C. MATERIALS

ME 597. INDEPENDENT STUDY

1-4 credits

Independent study supervised by a mechanical engineering faculty member. Student must obtain consent of instructor, who then determines description of program, number of credits (variable), frequency of meeting and location. Appropriate paperwork must be submitted to the advising office in order to complete registration.

ME 598. ME PROJECT

Literature review, mechanical engineering development or other projects as defined by the project committee. Formal bound report for department library.

ME 599. THESIS RESEARCH

Training in the methods of research. Varied computer modeling, hardware development and experimentation as determined by the MSME thesis committee. Oral examination required. Bound thesis goes in University library.

ME 609. COMPUTATIONAL FLUID DYNAMICS

Fundamentals of computational fluid mechanics as they relate to viscous, laminar and turbulent flows. Applications oriented and designed for students in engineering practice and students contemplating further in-depth study. Prerequisite: graduate fluid mechanics in heat transfer, or consent of department chair.

ME 618. FINITE ELEMENT ANALYSIS II

This is a second-level course in the understanding of the FEM. The course material covers variational formulations, nonlinear static and dynamic analysis, transient problems and other specialized features of applying the finite element method to solve engineering problems. The FE code ANSYS and/or CAEDS is used to solve the projects assigned in the course. Prerequisite: ME 517 or equivalent, or consent of department chair.

ME 627. RANDOM VIBRATIONS

fall, odd-numbered years

Methods for analyzing the response of vibrating systems with random inputs. Correlation and spectral methods for discrete and continuous vibrating structures. Analysis of nonlinear systems using equivalent linearization, Gaussian closure and the Fokker-Plank equation. Applications include flow-induced vibrations, response of distributed systems to spatially random fields, reliability analysis and high-cycle fatigue life predictions. Prerequisites: graduate course in mechanical vibration and a course in ordinary differential equations, or consent of department chair.

ME 628. ADVANCED KINEMATICS

This course is designed as an advanced course in modern kinematics and design of mechanisms with emphasis on numerical design methods. Analysis of spatial mechanisms in terms of position, motion and force are studied. Mobility, rigid body guidance, function generation, path generation and optimal synthesis of mechanisms are also covered. The above involves use of vector mechanics, computers (both writing and using software packages), and computer simulation of large displacement dynamics in two and three dimensions. Prerequisites: ME 322 or a first course in

kinematics, vector analysis, ordinary differential equations and FORTRAN, or consent of departmental chair.

ME 629. NONLINEAR SYSTEMS DYNAMICS

Introduction and examples of nonlinear systems from various branches of science and engineering. Nonlinear second-order systems, phase-plane analysis. Stability of linear and nonlinear systems; Liapunov's criteria, Popov's frequency method, limit cycles. Approximate techniques: perturbation and averaging methods. Computational methods in nonlinear analysis. Prerequisite: ME 524 or equivalent, or consent of department chair.

ME 654. TRANSPORT PHENOMENA IN MATERIALS PROCESSING *fall, odd-numbered years*

The role of transport phenomena in materials processing. Topics include chemical thermodynamics, diffusion in solids and fluids, transport, capillary phenomena, phase transformations, moving boundary problems. Applications will draw from casting of metal alloys, fusion welding of metals, injection molding of polymers and brazing/soldering of metals. Prerequisite: undergraduate fluid mechanics, ME 535 or consent of department chair.

ME 655. PERTURBATION METHODS IN MECHANICAL ENGINEERING

Application of perturbation methods to problems in engineering mechanics. Regular perturbation expansions, method of matched (and composite) expansions and method of multiple time scales are applied to problems drawn from such areas as vibrations, fluid mechanics, heat conduction and solid mechanics. Prerequisite: undergraduate course in mechanics, ME 535 or consent of department chair.

ME 658. STABILITY AND BIFURCATION THEORY

Stability and bifurcation in evolution problems. Scalar autonomous problems, classification of points, exchange of stability, isolated solutions, breaking of bifurcation. Two-dimensional autonomous problems, eigenvalue-eigenvectors. Projection methods. Bifurcation of periodic solutions, Hopf bifurcations, stability. Conservative and gradient systems. Prerequisite or corequisite: ME 535 or consent of department chair.

ME 680. ADVANCED SPECIAL TOPICS

Topics vary from semester to semester.

- A. MECHANICS AND DESIGN
- B. THERMOFLUIDS
- C. MATERIALS

ME 697. ADVANCED INDEPENDENT STUDY

ME 698. PREDISSERTATION

Research for and preparation of PhD dissertation.

ME 699. DISSERTATION

Research for and preparation of PhD dissertation.

ME 700. CONTINUOUS REGISTRATION

Required to maintain matriculation through any spring or fall semester when no other courses are taken. If the minimal one-credit registration is not maintained, student must reapply for admission.

ME 701. PRACTICUM FOR RESEARCH AND TEACHING ASSISTANTS *every semester*

Required for all funded graduate assistants. Research or teaching supervised by faculty adviser.