Mechanical Engineering (MEC)

Chair: Fu-pen Chiang, Light Engineering Building Room 105, (631) 632-8311
Graduate Program Director: Peisen Huang, Light Engineering Building Room 163, (631) 632-8329
Graduate Secretary: Diane Van Tronk, Light Engineering Building Room 103, (631) 632-8340

Degrees awarded: M.S. in Mechanical Engineering; Ph.D. in Mechanical Engineering

The Department of Mechanical Engineering, in the College of Engineering and Applied Sciences, offers graduate work leading to the Master of Science and Doctor of Philosophy degrees. The Department offers a broad curriculum with concentrations in Design and Manufacturing, Solid Mechanics, and Thermal Sciences. Departmental brochures that provide a more detailed description of the graduate program are available upon request. Additional information is also available at the Department's Web site: *http://me.eng.sunysb.edu*

Facilities and Areas of Specialization

Design and Manufacturing

Studies include computer-integrated engineering; CAD/CAM; kinematics, robotics, and manufacturing systems; dynamics and vibration; control; design optimization; metrology; machine vision; mechatronics; microelectromechanical systems (MEMS); and micro/nano-technologies. Research topics cover the analysis and design of mechanical systems, such as high performance machinery and robotic manipulators, and mechanisms, including dynamics, motion, control, and vibration-related problems; optical metrology, 3-D machine vision, and their applications to manufacturing; manufacturing process modeling, free abrasive machining, human augmented systems, and intelligent fault detection and diagnosis. Applied courses emphasize case studies, finite element methods, and computer graphics. Also featured are an array of equipment and software for research and teaching, such as mechatronic systems, robots, computer vision systems, CAD/CAM stations, CMM, desktop rapid prototyping machine, I-DEAS, NX, and AutoCAD.

Solid Mechanics

The mechanical behavior of advanced materials and structures is studied with emphasis on mathematical modeling and simulation of deformation, failure, stability, and microstructural transformation. These issues span a wide range of interests that focus on various materials, systems, and multiple length scales. Research topics include fracture mechanisms of embedded flaws in coatings and thin films, delamination in composites, and the mechanical properties and behavior of micron-scale structures and systems, such as microelectromechanical systems (MEMS) and microelectronic components. Stability of complex shell structures is studied with emphasis on nonlinear buckling mode interactions, inelastic material behavior, and deformation localization mechanisms observed in shell collapse. Also investigated are the constitutive modeling and failure characterization of ceramics, polymers, and heterogeneous multi-component materials, and nano- and micromechanics of defect formation and motion in bulk materials and thin films.

Experimentally based research programs focus on the mechanical, thermomechanical, and failure behavior of a wide variety of materials such as metals, polymers, ceramics, hard and soft biological tissues, and composites under both static and dynamic loading conditions. Optical techniques of strain analysis including moiré methods, laser and white-light speckle methods, holographic interferometry, photoelasticity, and classical interferometry are developed and applied to solid mechanics problems such as fracture, wave propagation, metal forming, vibration, and deformation of micron-scale structures and systems such as MEMS. Characterization of micron and nano-scale materials and structures is accomplished with instrumented-indentation and scanning probe microscopy techniques for wear and harsh environment applications. Research is also conducted to characterize the failure mechanics of various engineered heterogeneous materials systems, ranging from functionally layered/graded coatings to nanocomposites under impact loading and high-temperature conditions. Specialized equipment includes high-speed digital cameras, scanning electron microscope, and split Hopkinson pressure bars, and *in situ* micromechanical high temperature fatigue testing system. Current research topics also include the characterization of mechanical properties of soft tissues and the pumping efficiency of an ischemic heart, both *in vitro* and *in vivo*.

Thermal Sciences and Fluid Mechanics

Fluid Mechanics

Current topics include advanced combustor design and flow control, and the behavior of chemically reacting species in turbulent flows. Numerical and theoretical studies include direct simulation of turbulent flows and turbulent transport at modest Reynolds numbers, stochastic modeling of the turbulent transport of temperature, and spectral closure approximations for chemically reactive flows. Other areas include microfluidics, interfacial fluid phenomena and wetting, multiphase flows, miscible flows, and complex fluids.

Heat Transfer

Current topics include measurement of thermophysical properties, laser-material interaction, materials processing, and heat transfer in advanced energy systems. Active research is also conducted on various aspects of crystal growth (e.g., modeling, simulation, material characteristics, process control, and system design), advanced sensors, photovoltaic technology, fuel cells, wind energy and biomass energy. The integrated crystal growth and wafer manufacturing research facility consists of an industry-scale high-pressure system for synthesis and growth of III-V compound semiconductor crystals. The ultra fast thermal processing and laser-based measurement laboratory has an amplified oscillator/regenerative amplifier, a femtosecond autocorrelator, and a host of optoelectronics and light sources. The thermal sciences research laboratory has a visualization and digital image processing system. The solidification and interfacial science laboratory contains several Bridgman crystal growth systems, a laboratory scale physical vapor deposition system, a surface energy analysis and measurement system, and a Labview-based data acquisition system.

Thermodynamics

The design of heat engines, as well as most industrial processes that involve fluids, requires accurate, convenient-to-implement methods for predicting and correlating the thermodynamic properties of the fluids present in the process. This concentration is designed to provide students with the analytical tools needed to model and predict the thermophysical properties of fluids. Current studies include the development of statistical mechanical techniques to assess the relation between intermolecular forces and the thermodynamic, dielectric, optical, and transport properties of fluids, fluid mixtures, and suspensions. Research is also being conducted on combustion heat engines, aiming at achieving high efficiency and engine performance. In a different research direction, methodological issues of thermodynamic theory are being examined leading to the argument that theoretical self-consistency requires thermodynamic theory to be based on both the "descriptive is" statements of thermodynamic laws and the "prescriptive how" statements of operational principles—with a broad range of implication in technology and biological sciences and in philosophy of science following from this argument.

Admission

For admission to the M.S. and Ph.D. programs in Mechanical Engineering the following are required:

A. A bachelor's degree in mechanical engineering or a related field such as another engineering discipline, physical science, or mathematics;

B. A grade point average of at least B or equivalent in engineering, mathematics, and science courses;

C. Completion and submission of the Graduate Record Examination (GRE) General Test;

D. Acceptance by both the Department of Mechanical Engineering and the Graduate School.

Combined B.E./M.S. Degree

Undergraduate mechanical engineering majors with strong academic performance (GPA of 3.0 or above) may apply for admission to the special combined Bachelor of Engineering/Master of Science (B.E./M.S.) degree program in mechanical engineering at the end of their junior year. Once accepted into this program, students will be permitted to take up to nine graduate credits in replacement of the required technical electives. These credits will be applied towards both their bachelor's degree and master's degree, which will be awarded together at the end of the program after they have fulfilled the requirements for both degrees. More information about this program may be obtained from the graduate program director or the Department Web site.

Faculty

Distinguished Professor

Chiang, Fu-pen, *Chair,* Ph.D., 1966, University of Florida: Experimental mechanics; solid mechanics; photoelasticity; moiré and laser methods for stress analysis; mechanics of soft tissues and heart.

Professors

Ge, Q. Jeffrey, Ph.D., 1990, University of California, Irvine: Design kinematics; robotics; CAD/CAM; mechanical systems analysis and simulation.

Kao, Imin, Ph.D., 1991, Stanford University: Robotics; modeling of contact interface; stiffness control; intelligent fault detection and diagnosis; modern wiresaw manufacturing process; wafer manufacturing; smart contact surface technology using MEMS; Taguchi Methods and quality engineering.

Kincaid, John, Ph.D., 1974, Rockefeller University: Statistical mechanics and thermodynamics.

Nakamura, Toshio, Ph.D., 1986, Brown University: Solid mechanics; composite materials; computational fracture mechanics.

O'Brien, Edward E., *Emeritus,* Ph.D., 1960, Johns Hopkins University: Turbulent transport.

Sharma, Satya, Ph.D., 1975, University of Pennsylvania: Manufacturing and production.

Tasi, James, *Emeritus,* Ph.D., 1962, Columbia University: Solid mechanics; shock waves in crystal lattices.

Associate Professors

Huang, Peisen S., Ph.D., 1993, University of Michigan, Ann Arbor; Dr.Eng., 1995, Tohoku University, Japan: Optical metrology; 3-D computer and machine vision; manufacturing automation.

Kukta, Robert V., Ph.D., 1998, Brown University: Solid mechanics; mechanics of thin films; micromechanical modeling of defects in crystals; crystal growth.

Ladeinde, Foluso, Ph.D., 1988, Cornell University: Supersonic and hypersonic flows; flow control; turbulent flows; computational fluid dynamics; aircraft engines; combustion; numerical mathematics.

Longtin, Jon P., Ph.D., 1995, University of California, Berkeley: Heat transfer at fast time scales; ultrafast laser liquid- and laser-solid interactions; laser processing, measurement, and diagnostics for thermal systems; surface tension effects.

Rastegar, Jahangir, Ph.D., 1976, Stanford University: Mechanical design.

Wang, Lin-Shu, Ph.D., 1966, University of California, Berkeley: Combustion heat engines; thermodynamic theory; philosophy of science and technology; solar energy.

Zhang, Hui, Ph.D., 1994, Polytechnic University: Crystal growth, disaster simulations, process modeling, renewable energy systems, and spray coating.

Zheng, Lili, Ph.D., 1994, Cambridge University, England: Turbulent combustion, solidification, magnetohydrodynamics; bio-fluid mechanics; and materials processing.

Assistant Professors

Cubaud, Thomas, Ph.D., 2001, Paris-Sud University/ESPCI, France: microfluidics, interfacial fluid phenomena and wetting, multiphase flows, miscible flows, and complex fluids.

Korach, Chad S., Ph.D., 2004, Northwestern University: Solid mechanics; micro and nanoscale tribology; thin films for wear applications; friction and wear modeling, composite degradation, hard and soft biological material mechanics.

Lopez-Pamies, Oscar, Ph.D., 2006, University of Pennsylvania: Solid mechanics; nonlinear homogenization; instabilities; polymers; multi-functional materials.

Nearon, Michelle Denise, *Visiting Assistant Professor*, Ph.D., 2000, Stony Brook University: Turbulence and computational fluid mechanics.

Nejat, Goldie, Ph.D., 2005, University of Toronto: Autonomous systems; robotics and mechatronics.

Purwar, Anurag, *Research Assistant Professor*, Ph.D., 2005, Stony Brook University: CAD/CAM; computational kinematics; design automation; robotics.

Sesay, Juldeh, *Visiting Assistant Professor*, Ph.D., 2005, Stony Brook University: Turbulent flows; combustion; computational fluid dynamics and biothermal fluid sciences.

Zhou, Yu, Ph.D., 2004, Johns Hopkins University: Robot kinematics, dynamics planning, sensing and control, multi-robot systems, stochastic modeling, macromolecular mechanics.

Adjunct Faculty

Hodson, Donald, *Adjunct Instructor*, M.S., 1969, SUC at Buffalo: CAD; inductrial arts; desktop publishing.

Rohatgi, Upendra Singh, *Adjunct Professor, Brookhaven National Laboratory,* Ph.D., 1975, Case Western Reserve University: Fluid mechanics; heat transfer; two-phase flow; numerical analysis; and turbomachinery.

Yuan, Lifang, *Adjunct Assistant Professor*, Ph.D., 2001, Stony Brook University: Cam integrated high-speed mechanisms; smart materials; robotics; optimal machine design.

Affiliated Faculty

Adzic, Radoslav, *Senior Chemist,* Brookhaven National Laboratory, Dr.Sci., 1974, University of Belgrade: Surface electrochemistry; electrocatalysis, direct energy conversion; fuel cells.

Cess, Robert D., *Distinguished Professor and Distinguished Service Professor Emeritus, Marine Sciences Research Center,* Ph.D., 1959, University of Pittsburgh: Atmospheric sciences; climate modeling; greenhouse effect; nuclear winter theory.

Einav, Shmuel, *Professor and Associate Dean, College of Engineering and Applied Sciences,* Ph.D., 1972, Stony Brook University: Biomedical engineering, two dimensional flow systems.

Kirk, Harold G., *Physicist, Brookhaven National Laboratory,* Ph.D., 1972, University of Oklahoma: High-energy physics, accelerator and beam physics, experimental physics.

Mahajan, Devinder, *Research Professor, Department of Materials Science and Engineering*, Ph.D., 1979, University of British Columbia, Canada: Clean fuels, energy technologies.

Sampath, Sanjay, *Professor, Center for Thermal Spray Research,* Ph.D., 1989, Stony Brook University: Thermal spraying, coatings, direct write electronics, thick film sensors, multifunctional systems.

Wong, Teng-fong, *Professor, Department of Geosciences*, Ph.D., 1980, Massachusetts Institute of Technology: Experimental rock physics; fault mechanics.

Number of teaching, graduate, and research assistantships, Fall 2007: 39

Academic Advisor

Each graduate student is assigned an academic advisor in his or her area of interest before registration. The academic advisor will guide the student in course selection, research, and other areas of academic importance. Students receiving financial aid must select a thesis research advisor before the start of their second semester.

Academic Standing

An average GPA of 3.0 or higher in all coursework, exclusive of MEC 599 M.S. Thesis Research, MEC 698 Practicum in Teaching II, and MEC 699 Ph.D. Dissertation Research, is a minimum requirement for satisfactory status in the graduate program. In the doctoral program, a 3.5 grade point average is expected.

Degree Requirements

Requirements for the M.S. Degree

A minimum of 30 credits is required for the M.S. degree.

A. Course Requirements

1. M.S. with thesis: 21 approved graduate course credits and an accepted thesis, which is registered as nine credits of MEC 599 and MEC 696 Special Problems in Mechanical Engineering combined.

2. M.S. without thesis: 30 approved graduate credits. No credit for MEC 599 Master's Thesis is approved for fulfilling this requirement. No more than six credits of MEC 696 may be applied toward the course requirements.

3. All full-time graduate students are required to register for MEC 691 Mechanical Engineering Seminar each semester and obtain a satisfactory grade.

4. A minimum of 18 graduate credits, of which 15 credits are in courses other than MEC 599 and MEC 696, must be taken in the Department of Mechanical Engineering. All courses taken outside the Department for application to the graduate degree requirements are subject to approval of the student's advisor and the graduate program director.

B. Transfer Credits

A maximum of 12 graduate credits may be transferred from other programs toward the M.S. degree. These may include up to six credits from other institutions. The maximum also includes any credits received from taking Mechanical Engineering courses while having non-degree status at Stony Brook as an SPD or GSP student. Credits used to obtain any prior degrees are not eligible for transfer. All requests for transfer of credits require the approval of the graduate program director.

C. Thesis Requirements

A student choosing the thesis option must select a research advisor. Upon completion, the thesis must be defended in an oral examination before a faculty committee of at least three members of which at least two must be Mechanical Engineering faculty. A student choosing the thesis option may not switch to the non-thesis option without permission of the graduate program committee. A student who has ever been appointed as a teaching, graduate, or research assistant must choose the thesis option unless otherwise approved by the graduate program committee.

Requirements for the Ph.D. Degree

A. Course Requirements

1. Eighteen approved graduate course credits beyond the M.S. degree requirement. A minimum of nine credits, excluding MEC 599, MEC 696 and MEC 699, must be taken in the Department.

2. MEC 507. The graduate program director may waive this requirement if the student has taken sufficient applied mathematics courses elsewhere.

3. All full-time graduate students are required to register for MEC 691 each semester and obtain a satisfactory grade.

4. All courses taken outside the Department for application to the graduate degree requirements are subject to approval of the student's advisor and the graduate program director. The advisor may impose additional course requirements.

B. Transfer Credits

A student who has entered the Ph.D. program with an M.S. degree from another institution may transfer up to 12 credits; a student with a master's degree from Stony Brook may transfer up to six credits toward the Ph.D. degree. Credits used to obtain any prior degrees are not eligible for transfer. Requests for transfer of credits must be submitted to the graduate program director.

C. Areas of Concentration

The student selects an area of concentration in one of the following areas of Mechanical Engineering:

1. Design and Manufacturing
2. Solid Mechanics
3. Thermal Sciences and Fluid Mechanics

D. Written Qualifying Examination

The written qualifying examination is offered once every year, usually in January. Students who enter the graduate program with an M.S. degree from another institution are encouraged to take the examination the first time it is offered after they begin academic residency. Students who enter the graduate program without an M.S. degree are encouraged to take the examination the first time it is offered following three academic semesters in residence. Both categories of students who fail to take this opportunity must take the examination the next time it is offered during their residency. Part-time students should follow a rule based on graduate course credit hours (determined by the equivalence of nine credits with one semester in residence). Students are allowed to take the written qualifying examination no more than twice. Any student who fails the exam twice will be dismissed from the Ph.D. program.

The written qualifying examination consists of two parts. Part I covers applied mathematics. Part II corresponds to the student's area of concentration.

More precise information on the exam, including a list of suggested courses for each subject in the exam, is available in the Departmental office, as are samples of previous examination questions.

Each student taking the examination is required to submit a written statement to the graduate program director with a declaration of both areas chosen at least one month before the announced exam date.

E. Minor Area of Concentration

In addition to the major area of concentration, each student must select a second, minor area from the following list: Bioengineering, Biomedical Engineering, Computational Sciences (including Applied Mathematics), Design and Manufacturing, Electrical Engineering, Electronic Engineering, Environmental Sciences, Fluid Mechanics, Geological Sciences, Information Sciences, Material Science and Engineering, Solid Mechanics, and Thermodynamics and Heat Transfer. A petition to select a minor area that is not contained in this list must be approved by the Graduate Program Committee.

A student will be required to take a coherent sequence of three graduate level courses in the minor area and obtain a grade of B or better in each of the courses. However, students must submit a list of five courses from the proposed minor field no later than the time he or she applies to take the qualifying exam. The courses in the minor field must be approved by the graduate program director, with the recommendation of the student's advisor. Upon submission of the list of five courses, students must provide an explanation for the list, how the courses are related, and the rationale for the courses. Note that students are not required to have taken the courses in the minor field before taking the qualifying exam. However, the minor requirement must be satisfied before the student can be admitted to candidacy.

F. Advancement to Candidacy

A student will be advanced to candidacy for the Ph.D. degree when all formal coursework has been completed and all the requirements listed in items A through E have been satisfied. These requirements must be completed within one calendar year after passing the written qualifying examination. Advancement to candidacy must be one year before the beginning of the semester in which a student plans to defend his or her dissertation.

G. Teaching

Ph.D. students are required to take three credits of MEC 698 Practicum in Teaching II as part of the degree requirement. This requirement may be met by taking one three-credit MEC 698, or a combination of one-credit and/or two-credit MEC 698, totaling three credits. The form of this practicum may include making class presentations, teaching in recitation classes, and preparation and supervision of laboratory classes. Note that MEC 697 Practicum in Teaching I does not meet this requirement.

A faculty advisor is responsible for providing feedback and formal evaluation of MEC 698.

H. Dissertation Examining Committee and Dissertation Proposal

The student chooses a dissertation topic in consultation with his or her doctoral dissertation advisor as soon as possible after passing the written qualifying examination. Within one year after passing the written qualifying examination, a dissertation examining committee is established. The committee must include at least three members from the Department of Mechanical Engineering, including the dissertation advisor, and at least one member from another program or from outside the University. The committee must be approved by the graduate program director upon recommendation by the dissertation advisor. The official recommendation for the appointment of the dissertation examining committee is made to the dean of the Graduate School.

Dissertation research is an apprenticeship for the candidate, who, under the supervision of the dissertation advisor, independently carries out original work of significance. The dissertation examining committee provides a means of exposing the candidate's ideas to a variety of views, and helps to guide and oversee the candidate's research progress, which is reviewed by the committee each year. The chair of the committee must submit a written report to the graduate program director on the student's progress after each review.

In addition, the student is required to submit a written dissertation proposal and present it in an oral examination conducted by the dissertation examining committee. The written dissertation proposal must be distributed to the committee members at least two weeks before the oral examination. The oral examination probes the doctoral student's ability and examines the progress, direction, and methodology of the dissertation research. The student will be examined on the dissertation topic and its objective, the problem formulation, research approach, and knowledge in related areas. The majority of the dissertation examining committee must approve the student's performance.

I. Dissertation Defense

At the completion of the dissertation, approval of the dissertation involves a formal oral defense. The formal defense is open to all interested members of the University community. A candidate must fill out the Doctoral Degree Defense Form (available on the Graduate School Web page) with dissertation abstract as well as other relevant details, and submit the form to the graduate program director at least three weeks in advance of the proposed event. The form is forwarded by the graduate program director to the Dean of the Graduate School, which will be responsible for advertising the defense to the University community. Copies of the dissertation are to be distributed to the committee members at least two weeks before the dissertation defense; one copy is to be kept in the Departmental office for examination by the faculty. The final approval of the dissertation must be by a majority vote of the dissertation examining committee.

Courses

MEC 500 Introduction to Computer Integrated Design and Manufacturing

Topics include part design specification; Computer Aided Design (CAD); CAD-driven engineering analysis; Computer Aided Manufacturing (CAM); integration of CAD/CAM; computer integrated manufacturing industrial robotics; CAD-driven inspection and measurement; concurrent engineering; Internet-based design and manufacturing.
Prerequisite: B.S. in engineering
Fall, 3 credits, ABCF grading

MEC 501 Convective Heat Transfer and Heat Exchange

Differential and integral formulation. Exact and approximate solutions. Topics include parallel and boundary layer flows, similarity solutions, external and internal flows, laminar and turbulent convection, and forced and free convection.
Spring, 3 credits, ABCF grading

MEC 502 Conduction and Radiation Heat Transfer

Heat conduction and conservation laws; formulation of conduction equations in differential and integral forms; analytical solution techniques including Laplace transforms and separation of variables; scaling analysis; black body radiation, Kirchoff's law, analysis of heat conduction problems; analysis of radiative exchange between surfaces and radiative transport through absorbing, emitting, and scattering media
Fall, 3 credits, ABCF grading

MEC 504 Thermal Analysis and Design of Electronic Systems

Thermal characteristics of electronic components and systems, reliability considerations, design concepts, basic modes of heat transfer and fluid flow. Topics of applied heat transfer: heat exchanger, boiling and condensation, cooling techniques, cooling at various packaging levels, thermal elastic effects, computations for electronic systems.
Fall, alternate years, 3 credits, ABCF grading

MEC 505 Modeling and Simulation for Materials Processing and Manufacturing

Importance of modeling and simulation; interface between computer models and actual processes; microscopic versus macroscopic models; continuum models; thermo-fluid models, chemical transport, magnetic and electrical effects, and stress field; simulation schemes: finite difference versus finite element methods; software development; post-processing: graphical representation, video animation; case studies; melting/solidification bulk crystal growth; thin film deposition.
Spring, alternate years, 3 credits, ABCF grading

MEC 506 Energy Management in Commercial Buildings

Topics include basic heating, ventilating, and air-conditioning (HVAC) system design and selection for commercial buildings (includes both low-rise and high-rise buildings); selection of central plant components and equipment; calculation of space heating and cooling load; computer techniques for estimating annual energy consumption; design tools for reducing energy consumption; ASHRAE codes; building controls; BACnet.
Prerequisite: B.S. in mechanical engineering or related fields
Fall, alternate years, 3 credits, ABCF grading

MEC 507 Mathematical Methods in Engineering Analysis I

An introduction to the use of mathematical analysis techniques for the solution of engineering analysis problems and the simulation of engineering systems. Both continuous and discrete methods are covered. Initial and boundary value problems for ordinary and partial differential equations are treated.
Fall, 3 credits, ABCF grading

MEC 508 Mathematical Methods in Engineering Analysis II

A continuation of the material covered in MEC 507. Introduction to and application of numerical analysis techniques used in engineering such as finite elements and fast Fourier transforms. Determination of response characteristics of dynamic systems. Combinatoric methods and techniques for optimization of engineering design and systems/process analysis problems.
Prerequisite: MEC 507
Spring, alternate years, 3 credits, ABCF grading

MEC 510 Object-Oriented Programming for Scientists and Engineers

Practical introduction to C++ and object-oriented programming for a first programming course for scientists and engineers. Covers basics of application software development such as problem decomposition, structure charts, object modeling, class diagrams, incremental code building, and testing at a beginner's level. Features the concepts of abstract data types (ADT), encapsulation, inheritance, composition, polymorphism, operator and function overloading besides studying UML (Unified Modeling Language) as a graphical representational design technique. The course follows the evolution of programming ideas from the use of a single function to the use of structural charts and functions to modularize and finally to the use of object-oriented programming.
Prerequisite: B.S. in science or engineering
Spring, 3 credits, ABCF grading

MEC 511 Mechanics of Perfect Fluids

Lagrangian and Eulerian frames. Dynamical equations of momentum and energy transfer. Two-dimensional dynamics of incompressible and barotropic perfect fluids and of the compressible perfect gas. Conformal mapping applied to two-dimensional fluid dynamics. Jets and cavities. Surface waves, internal waves. Perfect shear flows.
Summer, 3 credits, ABCF grading

MEC 512 Mechanics of Viscous Fluids

The role of viscosity in the dynamics of fluid flow. The Navier-Stokes equations, low Reynolds number behavior including lubrication theory, percolation through porous media, and flow due to moving bodies. High Reynolds number behavior including steady, unsteady, and detached boundary layers, jets, free shear layers, and wakes. Phenomenological theories of turbulent shear flows are introduced.
Fall, 3 credits, ABCF grading

MEC 514 Advanced Fluid Mechanics: Introduction to Turbulence

Introductory concepts and statistical descriptions: kinematics of random velocity fields; equations of motion; experimental techniques: isotropic turbulence, closure problem; transport processes.
Prerequisite: MEC 512
Spring, alternate years, 3 credits, ABCF grading

MEC 521 Thermodynamics

This course begins with a review of the fundamental concepts and laws of classical thermodynamics. Then the thermostatic theory of equilibrium states and phase transitions is treated, followed by the thermodynamic theory of processes and cycles of simple and composite systems, including heat engines. Special topics may include statistical thermodynamics, irreversible thermodynamics, radiation and photovoltaic energy conversion, biological thermodynamic processes, and other topics of current interest.
Spring, 3 credits, ABCF grading

MEC 524 Computational Methods for Fluid Mechanics and Heat Transfer

Introduction of finite difference, finite volume, and finite element methods for incompressible flows and heat transfer. Topics include explicit and implicit schemes, accuracy, stability and convergence, derived and primitive-variables formulation, orthogonal and non-orthogonal coordinate systems. Selected computer assignments from heat conduction, incompressible flows, forced and free convection.
Prerequisite: MEC 507
Fall, alternate years, 3 credits, ABCF grading

MEC 525 Product Design Concept Development and Optimization

This graduate course will concentrate on the design concept development of the product development cycle, from the creative phase of solution development to preliminary concept evaluation and selection. The course will then cover methods for mathematical modeling, computer simulation, and optimization. The concept development component of the course will also cover intellectual property and patent issues. The course will not concentrate on the development of any particular class of products, but the focus will be mainly on mechanical and electromechanical devices and systems. As part of the course, each participant will select an appropriate project to practice the application of the material covered in the course and prepare a final report.

Prerequisites: Undergraduate electrical or mechanical engineering and/or science training
Fall, 3 credits, ABCF grading

MEC 528 Introduction to Experimental Stress Analysis
The concepts of three-dimensional stress and strain, their transformation laws, and their mutual relationships are discussed in detail. Results from theory of elasticity as pertinent to experimental stress analysis are also presented. Experimental techniques studied include two-dimensional photoelasticity, resistance strain gauge, moire methods, holographic interferometry, and speckle photography. The application of different techniques to the measurement of stress and strain in models as well as actual structures is demonstrated. Students form small groups and each group is assigned different laboratory projects to gain experience in various experimental stress analysis methods.
Prerequisite: MEC 362 or equivalent
3 credits, ABCF grading

MEC 529 Introduction to Robotics: Theory and Applications
Topics: robot components and mechanatronic aspects of robotics (sensors, actuators, and effectors, system integration); rotation, translation, rigid-body transform; robotics foundations in kinematics and inverse kinematics, dynamics, serial and parallel manipulators and their duality, introduction to mobile robots and LEGO Robotics, control theories, motion planning, trajectory generation, grasping and manipulation, robotic programming language, industrial robotics, manufacturing automation, and societal impacts. Include hands-on projects.
Spring, 3 credits, ABCF grading

MEC 530 Applied Stress Analysis
A study of linear elastic solids with emphasis on internal stress analysis. Simple boundary value problems at plane structures are analyzed with various solution techniques. Major topics are stress and strain tensors, linear elasticity, principle of virtual work, torsion, stress functions, stress concentration, elementary fracture, and plasticity.
3 credits, OPT

MEC 532 Vibration and Control
Fundamentals of vibrations and control of vibrations of structures and dynamic systems. Topics include one dof systems and responses, multiple dof systems and responses, classical feedback control theory, modern state-space feedback control theory, application of control methodology in structure and systems under vibration and dynamics; introduction of optimal control theory; feedforward control; and distributed transducers for active control of vibration.
Fall, every year, 3 credits, ABCF grading

MEC 535 Engineering Stress Analysis
Provides an overview of stress analysis for practicing engineers and scientists.
Spring, 3 credits, ABCF grading

MEC 536 Mechanics of Solids
A unified introduction to the fundamental principles, equations, and notation used in finite deformation of solids, with emphasis on the physical aspects of the subject. Cartesian tensor representation of stress, principal values, finite strain, and deformation. Conservation of mass, momentum, and energy. Formulation of stress-strain relations in elasticity, and compatibility relations. The use of general orthogonal coordinate systems in the equations governing solids. Principles of virtual displacement and virtual work.
Fall, 3 credits, ABCF grading

MEC 539 Introduction to Finite Element Methods
(Formerly Finite Element Methods in Structural Analyses.) Theory of finite element methods and their application to structural analysis problems. Matrix operations, force and displacement methods. Derivation of matrices for bars, beams, shear panels, membranes, plates, and solids. Use of these elements to model actual structural problems. Weighted residual techniques and extension of the finite element method into other areas such as heat flow and fluid flow. Laboratory sessions introduce use of the computer in solving finite element problems. Programs for the solution of force and displacement method problems are configured. A computer project consisting of the solution and evaluation of a structural problem is required.
Spring, alternate years, 3 credits, ABCF grading

MEC 540 Mechanics of Engineering Structures
An introduction to variational principles of mechanics and the development of approximation methods for the solution of structural mechanics problems. Linear and nonlinear theories of beams and thin plates are developed along with their framework for numerical solutions. An introduction of the general theory of structural stability is presented along with its application to the buckling and initial postbuckling behavior of beams and plates.
3 credits, ABCF grading

MEC 541 Elasticity
Formulation of boundary value problems. Compatibility equations and reciprocal theorem. Torsion of noncircular cross-sections. Fundamental solutions for two- and three-dimensional domains. Potential function formulations. Use of integral transforms and complex variable approaches. Formulation and solution of problems in thermoelasticity.
Prerequisite: MEC 536
Spring, 3 credits, ABCF grading

MEC 543 Plasticity
Stress and deformation of solids: yield criteria and flow rules for plasticity deforming solids; the notion of a stable inelastic material; static and dynamic analysis of plastic bodies under mechanical and thermal loading; use of load bounding theorems and the calculation of collapse loads of structures; the theory of the slip-line field.
Prerequisite: MEC 541
Fall, alternate years, 3 credits, ABCF grading

MEC 550 Mechatronics
An introduction to the design, modeling, analysis, and control of mechatronic systems (smart systems comprising mechanical, electrical, and software components). Fundamentals of the basic components needed for the design and control of mechatronic systems, including sensors, actuators, data acquisition systems, microprocessors, programmable logic controllers, and I/O systems, are covered. Hands-on experience in designing and building practical mechatronic systems are provided through integrated lab activities.
Fall, every year, 3 credits, ABCF grading

MEC 552 Mechanics of Composite Materials
The course is concerned with the analysis of layered composite materials subject to mechanical loads. Cartesian tensor calculus is used. Homogeneous anisotropic media are studied first. The effect of layering is then analyzed. Applications to plates and shell are studied and analytical methods of solution are given. Numerical analysis of composite solids is also considered using finite difference and finite element methods.
Prerequisite: MEC 536
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 560 Advanced Control Systems
Analytical methods applied to the design of multivariable linear control systems. Introduction to linear system theory: linearization, solution of linear matrix differential equations, stability, controllability, observability, transformations to canonical forms. Formulation of control objectives. Deterministic state observer. Full-state feedback control based on pole assignment and linear quadratic optimization theory. Linear systems with stochastic inputs and measurement noise. The response of linear systems to random input; stochastic state estimator (Kalman filter); separation principle of stochastic control and estimation; system robustness.
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 567 Kinematic Analysis and Synthesis of Mechanisms
Introduction, mechanism structure, basic concepts of mechanisms, canonical representation of motion. Kinematic analysis, algebraic method, vector-loop method, complex number method, spherical and spatial polygon method, matrix method, dual-number quaternion method, screw coordinate method, line coordinate method, motor algebra method, type synthesis, number synthesis, coupler curves, curvature theory path generation, finite displacement theory, rigid body guidance, function generation, computer-aided mechanisms analysis and synthesis.
Prerequisite: Permission of instructor
Spring, 3 credits, ABCF grading

MEC 568 Advanced Dynamics
Newtonian and Lagrangian mechanics of rigid bodies; kinematics, inertia tensor, principle of momentum, principle of virtual work, potential and kinetic energy, equations of motion, extraction of information from the equations of motion, and application to engineering problems.
Fall, 3 credits, ABCF grading

MEC 570 Introduction to Engineering Tribology
Focus is on the fundamentals of tribology, the science of surfaces in relative motion, with an introduction to friction, lubrication, and wear. The basics of tribology science: engineering surfaces, contact mechanics, lubrication theory, wear processes and modeling, wear properties of materials, and tribology test methods will be covered. Analysis of tribological aspects of machine components and bearings. Industrial case studies will be presented to place the topics in context to industry and society.
Spring, every year, 3 credits, ABCF grading

MEC 571 Analysis and Design of Robotic Manipulators
Introduction to robot manipulators from the mechanical viewpoint, emphasizing fundamentals of various mechanisms and design considerations. Kinematics on 2D and 3D manipulators; statics and dynamics; motion planning; control fundamentals; algorithms development; computer-graphics simulation of manipulators; current applications.
Prerequisite: Permission of instructor
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 572 Geometric Modeling for CAD, CAM
The de Casteljau algorithm, Bernstein polynomials, and Bezier curves. Spline curves. Polynomial interpolation and cubic spline interpolation. Rational Bezier and B-spline curves. Parametric surface patches. Parametric line constructs. Geometric continuity and geometric splines. Applications of geometric modeling methods in CNC machining, motion animation, and robotics.
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 575 Introduction to Micro Electro-Mechanical Systems (MEMS)
An introduction to the fundamental knowledge and experience in the design and manufacture of microsystems. Emphasis will be placed on the methodologies for design, fabrication, and packaging of microsystems. An overview on fabrication and manufacturing technologies for producing microsystems will also be covered. Interdisciplinary nature of MEMS will be emphasized via various engineering principles ranging from mechanical and electrical to materials and chemical engineering. Introduction of the working principles of micro actuators, sensors, and transducers.
Prerequisite: Permission of instructor
Spring, 3 credits, ABCF grading

MEC 576 Microfluidics and Microscale Heat Transfer
Topics: flow/control of liquids/gases at small length scales; deviation from classical fluid behavior; boundary conditions/scaling laws at small scales; microscopic flow of heat at small length- and time-scales; application to MEMS devices, heat transfer in microelectronics devices, ultra-fast laser processing.
Prerequisite: B.S. in engineering or Department approval
Fall, alternate years, 3 credits, ABCF grading

MEC 578 Reliability and Life Prediction of Electromechanical Systems
The modes of failure and the factors that play a role in the failure of mechanical components are presented. Failure modes and failure theories for brittle and ductile materials are introduced; special emphasis will be placed on the fatigue and fracture of materials. Distinctions will be drawn between the behavior of single crystal versus polycrystalline materials, and versus ductile and brittle materials. Reliability issues will be discussed regarding the design of series versus parallel systems.
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 579 Optical Measurement
Introduction to optical measurement and its applications to the fields of solid mechanics, design and manufacturing, and thermal and fluid systems. Topics include fundamentals of optics, lasers, and detectors, dimensional and surface metrology, machine vision, measurement of temperature, concentration, and density, and optical techniques for stress analysis and nondestructive testing.
3 credits, ABCF grading

MEC 580 Manufacturing Processes
The relationship between product design and manufacturing. Materials properties and influence. Introduces traditional and nontraditional manufacturing processes and their capabilities and limitations. Measurement inspection, reliability, and quality engineering. Economic impact of modern process engineering. Hands-on experience in the fundamentals of machining including, metrology tools, saw, sheet metal working, drilling, reaming, taping, turning, boring, milling, welding, and rapid prototyping.
Spring, 3 credits, ABCF grading

MEC 584 Quality Engineering
3 credits, ABCF grading

MEC 585 Total Quality Management
Concepts of TQM and quality improvement methods to attain world-class performance in business operations. Topics include policy deployment, process improvement methodology, daily work management, quality story methodology, six sigma, poka-yoke, ISO, Deming and Baldridge Awards criteria.
Spring, 3 credits, ABCF grading

MEC 591 Industrial Project in Opto Electro Mechanical Systems Engineering
A student carries out a detailed design of an industrial project in OEMS engineering. A comprehensive technical report of the project and an oral presentation are required.
Fall, 3 credits, ABCF grading

MEC 597 Graduate Research and Study in Manufacturing
Independent research or project in the area of manufacturing processes or systems.
Prerequisite: Students specializing in Manufacturing
1-6 credits, ABCF grading

MEC 599 Research
Fall, spring, and summer, 1-12 credits, S/U grading
May be repeated for credit

MEC 630 Special Topics in Fluid Mechanics
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 631 Special Topics in Heat Transfer
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 632 Special Topics in Statistical Mechanics
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 633 Special Topics in Thermodynamics
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 634 Advanced Topics in Kinematics and Dynamics of Machines
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 635 Advanced Topics in Nonlinear Dynamic Systems
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 636 Advanced Topics in Mechanical Vibration
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.

3 credits, ABCF grading
May be repeated for credit

MEC 637 Special Topics in Precision Engineering
The subject matter of each special topics course varies from semester to semester, depending on the interests of students and staff. Advanced topics and specialized topics will be discussed, particularly those of current interest.
3 credits, ABCF grading
May be repeated for credit

MEC 641 Fracture Mechanics
The mechanics of brittle and ductile fracture in engineering materials are studied. Major subjects are linear elastic fracture, elastic-plastic fracture, and fatigue crack analysis. Topics also include stress intensity factor, energy release rate, J-integ.
Prerequisite: MEC 536
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 651 Advanced Finite Element Analysis
Finite element method for the analysis of continuous media. In-depth discussion of penalty method, integration techniques, and differential equation solvers. Computer implementation of finite element code in nonlinear elastic, elastic-plastic materials, and dynamic problems. Major topics are 2-D and 3D element formulations, stress update algorithms, Newton-Raphson iterative technique, and explicit/implicit time integration schemes.
Prerequisites: MEC 541, MEC 539
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 662 Advanced Vibration and Analysis
Principle and techniques of vibration analysis of structures and machines. Includes free and forced vibration responses of linear limped-parameter, multiple dof systems; model analysis of distributed, continuous systems; non-linear vibration analysis; random vibrations.
Prerequisite: Permission of instructor
3 credits, ABCF grading

MEC 671 Optical Methods for Experimental Stress Analysis
Theory and applications of moire methods (in-plane, shadow, reflection, projection, and refraction moire techniques) for measuring static and dynamic deformation of 2D and 3D models, bending of plates and shells, and temperature distribution or refraction index change in fluids. Other topics: holographic interferometry, laser speckle interferometry, digital speckle photography, and current research activities of the field.
Fall or spring, alternate years, 3 credits, ABCF grading

MEC 691 Mechanical Engineering Seminar
This course is designed to expose students to cutting-edge research and development activities in mechanical engineering. Speakers are invited from both on and off campus.
Fall and spring, 0 credit, S/U grading
May be repeated

MEC 695 Mechanical Engineering Internship
Partipation in off-campus engineering practice in private corporations, public agencies, or non-profit institutions. Students will be required to have faculty coordinator as well as a contact in outside organization, to participate with them in regular consultations on the project, and to submit a final report to both. A maximum of three credits can be accepted toward the M.S. degree.
Fall, spring, and summer, 1 credit, S/U grading
May be repeated for up to three credits

MEC 696 Special Problems in Mechanical Engineering
Conducted jointly by graduate students and one or more members of the faculty.
Prerequisite: Advisor's permission
1-6 credits, ABCF grading
May be repeated for credit

MEC 697 Practicum in Teaching I
Every T.A. must register for this course.
Fall, spring, 0 credit, S/U grading
May be repeated

MEC 698 Practicum in Teaching II
Practicum in teaching under faculty supervision.
1-3 credits, S/U grading
May be repeated for credit

MEC 699 Dissertation Research On Campus
Prerequisite: Advancement to candidacy (G5); major portion of research must take place on SB campus, at Cold Spring Harbor, or at Brookhaven National Lab
Fall, spring, and summer, 1-12 credits, S/U grading
May be repeated for credit

MEC 700 Dissertation Research Off Campus–Domestic
Prerequisite: Must be advanced to candidacy (G5); major portion of research will take place off campus, but in the U.S. and/or U.S. provinces (Brookhaven National Lab and Cold Spring Harbor Lab are considered on campus); all international students must enroll in one of the graduate student insurance plans and should be advised by an International Advisor
Fall, spring, and summer, 1-9 credits, S/U grading
May be repeated for credit

MEC 701 Dissertation Research Off Campus–International
Prerequisite: Must be advanced to candidacy (G5); major portion of research will take place outside the U.S. and/or U.S. provinces; domestic students have the option of the health plan and may also enroll in MEDEX; international students who are in their home country are not covered by mandatory health plan and must contact the Insurance Office for the insurance charge to be removed; international students who are not in their home country are charged for the mandatory health insurance (if they are to be covered by another insurance plan, they must file a waiver by the second week of classes; the charge will only be removed if the other plan is deemed comparable); all international students must receive clearance from an International Advisor
Fall, spring, and summer, 1-9 credits, S/U grading
May be repeated for credit

MEC 800 Full Time Summer Research
0 credit, S/U grading
May be repeated

249