Mechanical Engineering

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Graduate Program Coordinator

The Department of Mechanical Engineering offers opportunities for graduate study providing for advanced professional competency and leading to the degree of Master of Science in Mechanical Engineering. The main goal of the graduate program in mechanical engineering is to strengthen the ability of the student to solve complex technological problems in a creative way. To achieve this, the program of study is designed to broaden the student's knowledge, to provide for in-depth study in an area of concentration, and to complement theoretical study with relevant and significant research and/or design. The student will ordinarily concentrate in either the mechanical systems design area or in the area of energy systems/thermosciences.

To qualify for unconditional admission, applicants should have the equivalent of an undergraduate degree in mechanical engineering with an overall grade point average of 3.0/4.0. Transcripts of all prior work at the college level and two letters of recommendation should accompany the application. Students with undergraduate degrees in related fields of science and engineering or those who do not meet the minimum grade point requirement can be admitted conditionally at the discretion of the department. Requirements for removal of conditional status will be specified in the letter of admission. For students whose primary language is not English, a TOEFL score of at least 550 is required for unconditional admission.

Students with undergraduate degrees in mechanical engineering from institutions other than Bradley University may be required to take undergraduate coursework if their transcripts do not show a satisfactory level of preparation in certain areas.

New students who are planning to take their coursework at an off-campus site must submit copies of their transcripts for evaluation purposes with their first application for off-campus registration. To ensure that appropriate academic advising takes place, all continuing students, including those off-campus, will have their registration capability encumbered each semester until they have met with their advisor or appropriate faculty representative from the Department of Mechanical Engineering.

The student must file an approved plan of study with the graduate program director that describes the courses to be taken and any proposed research. It must be filed prior to registering for more than nine semester hours that will be applied toward satisfying degree requirements. The plan of study must be approved by the graduate program director and by the student's advisor.

Master's Degree Curriculum Requirements

A total of 30 graduate credit hours is required to complete the Mechanical Engineering program. The total credit hours must include:

- One advanced mathematics course is a general requirement for all MSME students and must be approved by the student's advisor. Courses in statistics, numerical methods, and engineering analysis are applicable to this requirement.
- Students must take ME 681 project(s) or thesis in order to graduate, unless the ME Department approves the student's work experience to satisfy this requirement.
- In the systems and solid mechanics specialization, the student must gain fundamental knowledge in the following three areas and must acquire basic knowledge in one of the fundamental areas in the thermal sciences. The following courses fulfill the above mentioned requirement:

Mechanical Systems Design students must take

Systems (Vibration ME 540, Systems ME 544, ***or*** Advanced Controls)
Dynamics (ME 502)
Advanced Design of Machine Elements (ME 557)
One course in thermal science chosen from three fundamental areas namely, thermodynamics, heat transfer and fluids. The student must select one of the courses outlined below.

Thermal science students must take

Thermodynamics (ME 501)
Heat Transfer (ME 515)
Fluids (ME 521)
One fundamental course in solid mechanics (one of the above mentioned)

Applied Science students must take

at least four of the following courses plus one fundamental course in either mechanical systems or energy systems as required above.
ME 503 Internal Combustion Engines
ME 509 Solar Engineering
ME 533 Propulsion Systems
ME 534 Environmental Engineering - Air Conditioning ME 535 Environmental Engineering - Refrigeration
ME 536 Industrial Pollution Prevention
ME 537 Building Energy Management
ME 547 Fluid Power Control Systems
ME 549 Microprocessor Interfacing in Mechanical Systems
ME 560 Principles of Robotic Programming
ME 604 Design of Internal Combustion Engines
ME 648 Advanced Computer Aided Design

The student's advisor must approve the program of study, including any subsequent changes.

Students opting not to do a thesis will be required to register for three but not more than nine semester hours of research (ME 681, 682) unless waived because of demonstrated experience. All students are required to pass a comprehensive examination in their respective area of concentration according to the policies outlined above.

Comprehensive Exam

The student will be eligible to take the MCE after he/she successfully completes **all** the requirements stated above. The student must report to the department by February 15 or September 15 a list of five courses (excluding math and the course from other side) to be tested on. The list must include all the three fundamental/applied required courses listed above and two additional ME courses. The department's graduate committee will combine the list of courses to be tested on by the 3rd week of February or September. A request for test questions will be issued by March 1 or October 1 by the graduate committee to the faculty members who teach the listed courses. The involved faculty will provide two (2) problems for each of their listed courses to the ME Department office by the first Friday of March or October. The student will be required to solve one of the two problems. Each problem should not take more than one-half hour to solve. All tests are open book. Faculty who request a closed-book option for their part must notify the ME Department by the first Friday of March or October and will be encouraged to proctor the exam. The students must be notified by the ME Department by the second Friday of March or October whether certain tests will be closed book. The students will be instructed to solve 5 of the 10 problems. No two problems can be on the same topic. Passing the MCE requires successful completion of 4 of the 5 submitted problems. The student must retake the topic that he/she failed during the next regularly scheduled MCE. Students who fail have only one additional opportunity for reassessment. Time allotted for the test will be three hours. Students who opt to take thesis option will not be required to take the MCE written exam, but still must abide by the degree guidelines as described above. These students will be tested on their fundamental knowledge during the oral defense of their thesis.

Course Descriptions

ME 501 Advanced Thermodynamics 3 hrs.
Laws and concepts of classical thermodynamics; real gases and equations of state; availability; irreversibility; property relations; potential functions; equilibrium; multicomponent systems. Prerequisite: ME 302.

ME 502 Problems in Advanced Dynamics 3 hrs.
Application of analytical and graphical methods to problems involving velocities, accelerations, working and inertia forces. Prerequisite: ME 341.

ME 503 Internal Combustion Engines 3 hrs.
Thermodynamic analysis, thermo-chemistry, and performance characteristics of spark ignition and compression ignition engines. Prerequisites: ME 301; ME 302 or consent of instructor.

ME 504 Experimental Stress Analysis 3 hrs.
Experimental methods of stress analysis. Strain gages and related transducers. Photoelasticity and polariscopes. Instrumentation amplifiers, integrated circuits, and other electronics used for connecting transducers with a terminating device. Analog to digital conversion. Extensive hands-on laboratory exercises are emphasized. Prerequisites: ME 303, 304 or consent of instructor.

ME 509 Solar Engineering 3 hrs.
Nature and characteristics of solar energy as a renewable energy source. Solar geometry and radiation. Thermodynamics of solar systems; emphasis on 2nd Law considerations. Performance characteristics of collectors, storage systems, house heating systems, cooling and refrigeration, and photovoltaics. Comprehensive design project. Theory and performance characteristics of solar devices and application to design of a comprehensive solar energy system. Prerequisite: ME 415 or consent of instructor.

ME 511 Heat Transfer - Conduction 3 hrs.
General conduction equation in Cartesian, cylindrical, spherical, parabolic, and paraboloidal coordinate systems solved for various boundary conditions. Inversion theorem and residue theorem used to solve Laplace transform equation. Prerequisite: ME 415.

ME 512 Heat Transfer - Convection 3 hrs.
Non-isothermal flow of fluids in Cartesian, cylindrical, spherical, and other coordinate systems: slug flow, laminar flow, flow entrance effects, property variation effects, and turbulent flow. Prerequisite: ME 415.

ME 515 Intermediate Heat Transfer 3 hrs.
In-depth treatment of the three modes of heat transfer; design applications. Development of analytical and specific numerical skills needed for solving design problems involving heat transfer. Prerequisite: ME 415.

ME 520 Gas Dynamics 3 hrs.
One dimensional flow: wave and shock motion in subsonic and supersonic flow; flow with heat transfer and friction; viscosity effects; similarity. Introduction to multidimensional flow. Prerequisite: ME 308.

ME 521 Intermediate Fluid Mechanics 3 hrs.
Analysis of statics and dynamics of non-viscous and viscous fluids. Derivation of differential equations of motion. Potential flow; vortex motion; creeping motion; introduction to boundary layer theory; turbulence. Prerequisites: MTH 224; ME 308.

ME 533 Propulsion Systems 3 hrs.
Gas turbine analysis; stationary power plants; turboprop, turbojet, and ramjet engines; rocket propulsion; applications of thermodynamics. Prerequisite: ME 308.

ME 534 Environmental Engineering - Air Conditioning 3 hrs.
Heating and cooling of moist air; solar radiation; computation of heating and cooling loads; study of heating, ventilating, and cooling systems and equipment; design project. Prerequisite: ME 301.

ME 535 Environmental Engineering - Refrigeration 3 hrs.
Mechanical vapor compression refrigeration cycles; refrigerants; absorption refrigeration; miscellaneous refrigeration processes; cryogenics; semester design project. Prerequisite: ME 301.

ME 536 Industrial Pollution Prevention 3 hrs.
Industrial pollution prevention for small quantity generators such as foundries, metal fabrication, electroplating, electronics, soldering, wood products, cleaning, degreasing, and coating. Study of emerging technologies for pollution prevention. Relationships among energy consumption, waste production, and productivity enhancement. Actual plant assessments. Prerequisite: consent of instructor.

ME 537 Building Energy Management 3 hrs.
The energy problem. Energy consumption patterns in existing and new buildings. Analysis of energy saving strategies for existing buildings; developing designs for new, energy efficient buildings, including reliability, comfort, and economic considerations. Formal oral presentations.

ME 540 Advanced Mechanical Vibrations 3 hrs.
Principles of vibration in one or more degrees of freedom; application to machine members. Prerequisite: ME 341; MTH 224.

ME 544 Mechanical Systems Analysis 3 hrs.
Mathematical modeling of mechanical, electrical, pneumatic, hydraulic, and hybrid physical systems emphasizing a unified approach such as the Bond graph technique. LaPlace, state-variable, and matrix formulation of models. Systems response characteristics, prediction, and analysis. Prerequisite: ME 341.

ME 547 Fluid Power Control Systems 3 hrs.
Definition and scope of fluid power control systems. Fluid properties. Continuity and power balance equations. Components function, operation, and dynamic performance. Use of perturbation theory for developing linearized transfer functions. Application of conventional control theory. Prerequisite: ME 301, 308.

ME 548 Optimization of Mechanical Systems 3 hrs.
Development and application of optimization techniques in design of engineering systems and elements; mathematical modeling and formulation of design problems for optimization; different optimization methods including linear, non-linear, geometric and dynamic programming; shape optimization. Emphasis on development and choice of appropriate search methods, sensitivity analysis, and programming. Prerequisite: senior standing in engineering or consent of department.

ME 549 Microprocessor Interfacing in Mechanical Systems 3 hrs.
Principles of microprocessor hardware and software; integration of microprocessor hardware and software in mechanical systems for data acquisition and control purposes (e.g., robotics, internal combustion engine monitoring systems, and pneumatic controls). Intensive hands-on laboratory exercises and practical problem solving. Introduction of "mechatronics." Prerequisites: ME 303; EE 328; proficiency in at least one computer language; or consent of instructor.

ME 554 Fracture of Solids 3 hrs.
Mechanical failure caused by the stresses, strains, and energy transfers in mechanical parts: conventional design concepts relationship to occurrence of fracture; mechanics of fracture; fracture toughness; macroscopic and microscopic aspects of fracture; high and low cycle fatigue failures; creep; stress rupture; brittle fracture; wear; case studies of failure analysis. Emphasis on time-dependent failures. Prerequisites: ME 354 and CE 301.

ME 556 Mechanics of Composite Materials 3 hrs.
Mechanical behavior, analysis, and design of various advanced composite materials: introduction to composite materials and their applications; elasticity of anisotropic solids; micromechanics of fiber reinforced composites and particulate composites; short fiber composites; macromechanics of laminated composites; thermal stresses; failure criteria; fracture and fatigue, reliability, testing, and design of composite materials. Emphasis on developing simple microcomputer programs for analysis. Projects involve curing and testing composites. Prerequisite: CE 301.

ME 557 Advanced Design of Machine Elements 3 hrs.
Review of mechanical testing, 3-D stress-strain relationship, complex and principal states of stress, yielding and fracture under combined stresses, fracture of cracked members, stress and strain based approaches to fatigue, creep damage analysis, and plastic damage analysis as applied to the design of machine elements. Prerequisites: ME 342, ME 351, ME 354 with a minimum grade of C or graduate standing in ME. Requires consent of instructor if non-ME student.

ME 560 Principles of Robotic Programming 3 hrs.
Programming of industrial robotic manipulators with external inputs, tactile sensing and vision sensing. A design project is required. Cross-listed as IME 560. Prerequisites: graduate or senior standing in engineering or computer science.

ME 562 Analysis & Design of Robotic Systems 3 hrs.
Underlying theories of robotic systems; implications for engineering design. Kinematic, dynamic, and control analysis of robotic arms; robotic systems design. Plant visits to observe robots in action; hands-on experience using open-loop and closed-loop robots. Prerequisites: ME 344, 304, 441; EE 328; or consent of department.

ME 573 Methods of Engineering Analysis 3 hrs.
Application of principles of analog and digital computers and numerical methods to solve mechanical engineering problems. Prerequisites: ME 341; MTH 202, 224.

ME 577 Finite Element Methods in Engineering 3 hrs.
Theory of finite element methods and applications in mechanical engineering; review of matrix algebra and basic theorem of elasticity. Direct formulation of plane truss element and variational formulations of plane stress/strain, axisymmetric solids, flexural beam, and flat plate elements. Element analysis and isoparametric formulation. Applications to problems of stability, vibrations, thermal stress analysis, and fluid mechanics. Computer programming techniques. Prerequisite: senior standing in ME or consent of instructor.

ME 580 Fundamentals of Bio-Medical Engineering 3 hrs.
Human body as a thermal and mechanical system. Mathematical modeling. Thermodynamics aspects of biological systems. Energy balance of a human body as a closed and open thermodynamic system. Static and dynamic analysis of a human body as a mechanical system. Principles of instrumentation used in the medical field. Interfacing of microprocessors with rehabilitative devices. Demonstrative laboratory exercises. Field trips. Prerequisites: ME 301, 302, 303; BIO 200.

ME 582 Medical Imaging 3 hrs.
Introduction to the common methods and devices employed for medical imaging, including conventional x-ray imaging, x-ray computed tomography (CT), nuclear medicine (single photon planar imaging), single photon emission computed tomography (SPECT), and positron emission tomography (PET), magnetic resonance imaging (MRI), and ultra-sound imaging. The physics and design of systems, typical clinical applications, medical image processing, and tomographic reconstruction. Cross-listed as EE 582. Prerequisites: Senior standing in engineering or consent of instructor.

ME 591 Topics in Mechanical Engineering 1-3 hrs. each
Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes. Graduate students may repeat the course up to a maximum of 9 credits. Prerequisite: consent of instructor.

ME 604 Design of Internal Combustion Engines 3 hrs.
Detailed study of design of internal combustion engines. Gas-pressure and inertia-force diagrams; determination of bearing loads; torsional vibration analysis; stress analysis and design of components, including piston, connecting rod, crankshaft, flywheel, valve mechanism, and cam layout. Prerequisites: undergraduate courses in dynamics of machines, internal combustion engines, and machine design, or consent of instructor.

ME 648 Advanced Computer Aided Design 3 hrs.
Augmentation of mechanical design through application of computer graphics. Hardware/software characteristics; elements of geometric/solid modeling. Emphasis on integration in the application of the design process through packages for geometric/solid modeling, finite element analysis, and mechanisms and system simulation. Prerequisites: BSME; or background in mechanical and thermal systems and consent of department chair. Students without a BSME degree may take ME 342, ME 344, ME 415, and ME 411 to help develop an appropriate background for the course.

ME 681, 682 Research 1-6 hrs. each
Research on a project selected by student and advisor.

ME 691 Topics in Mechanical Engineering 3 hrs.
Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes. Prerequisite: consent of instructor.

ME 699 Thesis 3-6 hrs.
Maximum of 6 semester hours total of research and/or thesis may be applied toward the master's degree. Prerequisite: consent of department.