

# COLLEGE OF ENGINEERING AND TECHNOLOGY

Richard T. Johnson,  
Dean

Robert Podlasek,  
Assistant Dean

The College of Engineering and Technology offers programs leading to: the Master of Science in Civil Engineering, Master of Science in Electrical Engineering, Master of Science in Industrial Engineering, Master of Science in Mechanical Engineering, and the Master of Science in Manufacturing Engineering. Students majoring in engineering are required to complete from 30 to 33 semester hours of coursework, depending on the program they are pursuing. Students should consult the department graduate advisor for a plan of study prior to registration.

For international graduates of a non-ABET-accredited program (unless from an English speaking country), a minimum TOEFL score of 525 is required for unconditional admission. The GRE is required by some departments and suggested for others.

A cumulative GPA of 3.0 for the entire undergraduate career or 3.0 for the last 60 credit hours is normally needed for unconditional admission. However, some programs may have other requirements for unconditional admission. Prospective graduate students who have a GPA below 3.0 or a TOEFL score below 525 may be admitted conditionally. TOEFL and GRE scores are taken into consideration for admission and when making assistantship award decisions.

## Special Academic Programs

*To participate, students must have authorization to work in the United States. Eligibility of nonimmigrant (F-1) students is defined on an individual basis according to regulations set forth by the Bureau of Citizenship and Immigration Services (BCIS) and the Bureau of Immigration and Customs Enforcement (BICE), formerly referred to as INS—the Immigration and Naturalization Service. For clarification of eligibility, contact the Multicultural Student Services Office or consult the BCIS website at [www.immigration.gov](http://www.immigration.gov).*

## Practicum

Graduate students enrolled in chemistry, civil engineering, computer science, electrical engineering, industrial engineering, manufacturing engineering, mechanical engineering, and physics may have an opportunity for employment for 10-20 hours per week in a practicum program that partners industry and the university. Generally, the practicum is on-site work in an industrial setting. Students are assigned technically challenging projects with a near-term economic significance. Participating students will be enrolled in EGT 500 for zero credit hours.

## Internship

Engineering internships provide engineering students an opportunity to participate in a full-time internship semester and/or summer away from campus providing career-related work experience. This internship is equivalent in work-time to a full-time cooperative education assignment, and interns will be monitored in the same way as EGT cooperative education students. Participating graduate students will enroll in EGT 510 for zero credit hours. While on a full-time internship assignment, students are considered to have full-time student status, making normal progress toward a

degree in a recognized University program, and are entitled to all student privileges at the University. Also while on a full-time internship assignment, students may register for additional hours of classroom study upon departmental approval.

## Course Descriptions

### EGT 500 Graduate Engineering Practicum 0 hrs.

Solving challenging problems with a near-term economic benefit. Only for students approved for practicum by the Dean's Office. Pass/fail. Prerequisite: graduate student.

### EGT 510 Graduate Engineering Internship 0 hrs.

Full-time internship away from campus for engineering & technology students to gain academic or career-related work experience in industry. May be repeated only with consent of internship coordinator and internship faculty advisor. Satisfactory/Unsatisfactory. Prerequisites: engineering and technology graduate student. Newly admitted graduate student must be unconditionally admitted and continuing student must have a minimum of 3.0 grade point average in graduate courses. Approval of internship coordinator and internship faculty advisor.

# Civil Engineering

Robert Fuessle,  
Graduate Coordinator

The Department of Civil Engineering and Construction offers an MSCE degree program that prepares graduates for thriving engineering careers characterized by continued professional growth. Our graduates are given unique opportunities to acquire the talents and skills needed in a highly technical society facing serious uncertainties and challenges in the environment and infrastructure. Our program provides you with the broad scope necessary for a fruitful and successful career in the practice of civil engineering and construction management.

To meet the needs of industry and students, the department recently acquired a multimedia laboratory and equipped it with the most sophisticated software and hardware available anywhere in the country. This recent acquisition provides a vivid example of the commitment to excellence and persistent drive that has become the hallmark of our department. The departmental goal is to provide an educational experience that is nationally and internationally recognized. Our students and faculty aspire to be leaders in their respective fields on and off campus.

**Financial Support** Research and teaching assistantships are available for qualified graduate students through the department and ongoing funded research projects. Currently more than 60% of all graduate students are being supported. The department has numerous endowed scholarships, and some of these funds provide fellowships to selected graduate students. Qualified students may also receive up to 100% tuition waiver from the University. Additionally, faculty and graduate students have received research grants from major companies, state agencies, the National Science Foundation, and other private and government sources.

Students have abundant opportunities to gain practical experience off campus either part time or full time during semester breaks and summers. For example, the Illinois Department of Transportation has hired many graduate students. Various industries have employed our graduates under a pollution prevention program sponsored by the Illinois EPA.

**Internationalization and Our Global Explorer Program** The Global Explorer program is designed to expand the professional capabilities, stimulate intellectual growth, and broaden the personal perspectives of all participants. Arrangements have been made with universities around the world to send our students either for short courses or for the entire academic year. Students with financial need have received financial support that enables them to study abroad for equal or less than what it would cost them to study at Bradley University. This program enables students to meet the challenges of tomorrow and equips them with the needed skills to compete in an international marketplace.

**Programs of Study** The graduate program can be characterized by areas of concentration: construction management, structures, and geo-environmental/water resources. New course offerings have been introduced

in multimedia, pavement and superpave, GIS/GPS, and transportation systems. Selected courses in other engineering departments, the college of business, and computer science are permissible. The program's flexibility provides graduate students with a wide variety of means to prepare for their future careers.

**Construction Management** The construction industry is the largest industry in the United States. Its impact is felt in every area of civil engineering, both nationally and internationally. This fast-growing area provides courses that enhance the education of students by examining the most recent trends and methods in the management of the construction process. Opportunities are provided through coursework dealing with advanced cost estimating, contract administration, productivity analysis, total quality management (TQM), cutting-edge software dealing with design/build processes and multimedia presentations, and many other areas that affect the profession.

**Structural Engineering** The graduate courses in the structural program offer a wide variety of courses that provides a strong theoretical and applied background suitable for both practice and research. The structural engineering group has five faculty members with a diverse academic background. The group employs experimental, numerical, and analytical techniques in their research activities. The research interests within the group include: behavior and design of reinforced concrete, structural durability, analysis and design of bridges, finite element analysis, computational mechanics, structural stability, and seismic analysis and design of structures.

Students are given the opportunity to utilize a spectrum of computer facilities, including a networked personal computer and workstations. These computers are equipped with the state-of-the-art structural engineering and finite elements software packages. The well-equipped structures laboratory provides state-of-the-art research tools. Among them are an MTS 80 kips Cyclic Testing System, NI data acquisition system, a large number of transducers and LVDT's, Universal Testing Machine, and an ELE compression testing machine.

**Geo-Environmental Engineering** This program option meets the growing need for professionals who are well educated in the science and engineering of treatment processes and pollutant transport and impact on the environment. The program also addresses the need for more informed decision-making with respect to environmental risks and impacts. Graduates from this program are employed by governmental agencies, by consulting companies that specialize in environmental engineering and environmental planning, and by industrial manufacturing companies in pollution prevention or environmental control rules. Funded research from Caterpillar Inc. and from regional and national environmental agencies provides an opportunity for graduate students to participate in the research of hazardous waste treatment, biological wastewater treatment, physico-chemical treatment, and management models of environmental policies and systems.

**Facilities** The Department has major laboratories with state-of-the-art equipment in multimedia, Archicad, geo-technical, concrete, asphalt, environmental, surveying, structural, microcomputers, con-

struction, design, projects, research, and fluids. Our students have 24-hour access to a spectrum of computer facilities, including networked personal computers and workstations. These computers are equipped with cutting edge software packages in structural, geotechnical, environmental, and construction management. The CEC laboratories include needed instrumentation for education and research. For example, the structural laboratory includes an MTS 80 kips Cyclic Testing System, NI data acquisition, a universal testing machine, and an ELE compression testing machine. The environmental laboratory includes a gas chromatograph with purge trap, atomic absorption spectrophotometers, and FTIR. The asphalt laboratory is being updated to include Superpave testing equipment. These laboratories are well equipped to meet the educational needs of students and research objectives of graduate students and faculty.

**Career Services** Graduate students have numerous opportunities to develop through professional activities such as the student chapters of ASCE and AGC. These organizations sponsor noted speakers on a variety of topics and provide a forum for interaction between students and industry. In addition, graduate students may become involved with community projects such as the Bridge Pal program that fosters engineering interest in high school seniors.

The departmental advisory board is composed of successful civil engineers and construction leaders. Advisory board members are very active as speakers and outside professional contacts for our students. The departmental director for job placement also helps our students with their search for employment.

**Faculty Qualifications** The faculty are renowned worldwide and have published more textbooks (25) than any other civil engineering or construction department of similar size in the United States. These textbooks are used at a large number of highly regarded institutions. CEC faculty members have received numerous awards for teaching excellence and scholarship. Faculty have also conducted research for national, state, and local sponsors that have benefited our students.

**MSCE Degree Requirements** After selecting core courses, the student may study in any one of three areas of concentration: construction management, structural, or geo-environmental/water resources. The student has the opportunity of selecting a thesis or a non-thesis option. The thesis option requires 6 semester hours of CE 699 (Thesis). The non-thesis option requires a minimum of 6 semester hours in an area of concentration.

In addition to the requirements of the Graduate School, the Department of Civil Engineering and Construction has the following requirements:

1. The MSCE program requires a minimum of 30 semester hours beyond the bachelor's degree.
2. All MSCE students are required to take CE 510 to meet the mathematics requirement and a minimum of 18 semester hours from the department.
3. A plan of study is required by the end of the first semester. The plan may be changed by filing a request for amendment. This request must be filed with and approved by the graduate advisor prior to registering for courses. Courses not on the approved study plan may not be counted towards the MSCE degree.

4. Admission of undergraduate students into 500-level courses requires that the student have the necessary prerequisites and a minimum average of 2.50/4.0 in the major field.
5. Admission into the MSCE program requires a bachelor's degree in civil engineering or construction. Qualified graduates from other engineering or related fields may be admitted conditionally. The conditional status may be changed to unconditional only after all deficiencies are removed.
6. Each student is required to pass a comprehensive examination during the last semester of his/her study. Students seeking the thesis option are required to make oral defense of their thesis instead.

Exceptions to the departmental requirements listed above may be made with the approval of the department chair. Such exceptions are rare and will only be granted in cases where clear justification can be demonstrated.

## Course Descriptions

### **CE 508 Advanced Soil Mechanics** 3 hrs.

Consolidation theory and settlements, stress-path method, strength and deformation behavior of soils, failure theories, confined flow, flow nets, numerical analysis of flow, unconfined flow, seepage through earth dams. Laboratory experiments on consolidation and shear strength. Prerequisites: CE 308.

### **CE 510 Advanced Numerical Methods with Engineering Applications** 3 hrs.

Selected numerical methods and applications chosen to meet current needs for solving problems in civil engineering. Prerequisite: CE 202 or equivalent.

### **CE 515 Advanced Foundation Engineering** 3 hrs.

Advanced pile capacity formulations, buckling, and lateral loading. Mat foundations, finite difference solutions. Foundations on difficult soils. Slope stability; stability of earth dams. Excavations; geotechnical instrumentation. Prerequisite: CE 422.

### **CE 522 Advanced CADD** 3 hrs.

Applications of CAD systems. Visualization and optimization of the processes used in construction through three-dimensional modeling and utilization in various civil engineering and construction applications. Prerequisite: CE 244 or CON 224 or consent of department chair.

### **CE 524 Multimedia Applications in Civil Engineering and Construction** 3 hrs.

Application of state-of-the-art technology in projects during various phases from inception to completion including planning, design, procurement, construction, handing over, and operation and maintenance. Investigation of different available tools and technologies in recording, storing, and sharing project information. Prerequisite: senior or graduate standing in the College of Engineering and Technology.

### **CE 526 Advanced Cost Estimating for Construction Projects** 3 hrs.

Advanced techniques in taking-off quantities, pricing techniques, computer estimating, and bidding strategy models. Prerequisite: CON 396.

### **CE 528 Advanced Scheduling** 3 hrs.

Project scheduling methods with emphasis on network scheduling techniques, work breakdown structure (WBS), resource and cost loading, scheduling under uncertainties, project time compression, resource leveling, scheduling for linear projects (LOB), time-cost trade-offs, project status, reporting and updating, schedules as tools for claims documentation. Case studies. Computer based. Prerequisite: CON 392.

### **CE 529 Construction Contract Administration** 3 hrs.

Issues in the administration and implementation of a construction contract. Coordinating and controlling the construction project under legal and ethical considerations. Prerequisites: CON 492.

### **CE 536 TQM Principles in Construction** 3 hrs.

Theory and analysis of the Total Quality Management system as applied within the construction industry. Case studies. Prerequisite: QM 262 or IME 311.

### **CE 537 Simulation in Construction** 3 hrs.

Decision making using simulation and simulation languages to model construction operations. Simulation of construction process using what-if analysis. Role of simulation and decision making in the planning and scheduling phases in the construction industry. Topics include introduction to discrete event simulation, generation of random numbers, queuing, simulation languages for construction. Prerequisites: senior or graduate standing; consent of instructor.

### **CE 541 Transport Phenomena in Environmental Systems** 3 hrs.

Phenomena that affect mass balance of contaminants in environmental systems. Advection, diffusion, dispersion, and interfacial mass transfer. Physical, chemical, and biological descriptions of these processes with mathematical models. Solutions to these models with illustrations from reactor engineering and surface water quality modeling. Application to actual process reactor. Prerequisites: senior or graduate standing; consent of instructor.

### **CE 542 Physiochemical Processes Design** 3 hrs.

Design of physical and chemical unit processes and unit operations with an emphasis on water treatment. Design of aeration systems, coagulation and flocculation processes, sedimentation tanks, filtration systems, chemical precipitation processes, ion exchange processes, and disinfection processes. Advanced purification methods including adsorption, reverse osmosis, electro-dialysis, and membrane processes. Treatment and disposal of physiochemical process sludges. Prerequisite: CE 360.

**CE 543 Biological Processes Design****3 hrs.**

Application of concepts from microbiology and biology to environmental engineering systems. Detailed integrated design of wastewater treatment. Microbiology of wastewater treatment processes and soil bioremediation processes. Interaction between biogeochemical phenomena and microbial processes in an environmental engineering context. Prerequisite: CE 360.

**CE 544 Advanced Hydraulics****3 hrs.**

Steady state closed conduit flow; flow in pipe networks. Hydraulic transients in pipelines. Open channel flow; gradually varied, spatially varied, rapidly varied flow in open channels; open channel transients. Water and wastewater treatment plant hydraulics. Sedimentation mechanics, sediment transport, design of unlined channels, bridge scour, reservoir sedimentation. Design and computer applications. Prerequisite: CE 430.

**CE 546 Groundwater Hydrology and Hydraulics****3 hrs.**

Groundwater in the hydrological cycle, fundamentals of groundwater flow; flow net analysis; steady-state and transient well testing techniques for parameter estimation; multiple well systems; leaky aquifers; sea water intrusion; groundwater investigation; artificial recharge of aquifers, design of wells; subsidence and lateral movement of land surface due to groundwater pumping. Design and computer applications. Cross listed as GES 546. Prerequisites: CE 202, 304, or consent of instructor.

**CE 550 Geoenvironmental Engineering****3 hrs.**

Soil composition and behavior. Development and movement of groundwater. Soil sampling and monitoring of contaminants in groundwater. Drilling techniques based on soil type. Land disposal of wastes. Solidification of wastes and design of landfills. Processes affecting the distribution of inorganic and organic pollutants in the environment. Exchange among soil, water, sediment, and biota. Remediation of contaminated soil and groundwater at existing sites. Prerequisites: CE 308, CE 360.

**CE 555 Environmental Regulations and Policy****3 hrs.**

Description and analyses of environmental regulations and policies for air, water, groundwater, and solid wastes. Conventional and hazardous wastes. Toxicological, risk assessment, and regulatory aspects of solid and hazardous waste management; characterization of hazardous wastes and materials; waste reduction strategies; collection, storage, and transportation methods. Environmental impact statements. Prerequisite: CE 360.

**CE 560 Advanced Structural Analysis****3 hrs.**

Direct stiffness method for the analysis of two-dimensional trusses and frames, equivalent nodal forces, thermal and settlement effects, principle of virtual work, space trusses, grid structures, static condensation, Lagrange multipliers, tapered elements. Prerequisites: CE 202, CE 359.

**CE 562 Advanced Steel Design****3 hrs.**

Structural framing systems; rigid frame design; design of bracing; design of simple rigid and moment resisting connections; torsion of steel open sections; design of beams subjected to torsion; design of steel plate girders; design of composite beams. Prerequisite: CE 442.

**CE 565 Advanced Reinforced Concrete****3 hrs.**

Advanced topics in flexural design; torsion in beams; behavior and design of slender columns; biaxial bending of columns; design of two-way slabs; behavior and design of frame-wall structural systems; inelastic analysis of flexural members; use of strut and tie analysis; yield line analysis; design of mat foundations. Prerequisite: CE 403.

**CE 567 Prestressed Concrete****3 hrs.**

Theory and analysis of prestressed concrete members by various methods of prestressing; design of simple and continuous beams and slabs; prestress losses; composite beams. Extensive study of materials used in prestressed concrete. Precast concrete systems. Prerequisites: CE 403; senior or graduate standing.

**CE 573 Advanced Mechanics of Materials****3 hrs.**

Two- and three-dimensional stress and strain at a point; two-dimensional elasticity; beams on elastic foundations; torsion of noncircular sections; curved beams; unsymmetrical bending; plastic collapse and limit analysis. Prerequisites: CE 301; senior or graduate standing.

**CE 575 Structural Dynamics****3 hrs.**

Single degree of freedom systems; multi-degree of freedom systems; lumped mass and consistent mass—MDOF beams; free and forced vibrations; earthquake loading; impact and impulsive loads; numerical procedures.

**CE 591 Special Topics I****1-3 hrs.**

Topics of special interest, which may vary each time course is offered. Topic stated in current Schedule of Classes. Prerequisite: senior or graduate standing.

**CE 592 Special Topics II****1-3 hrs.**

Topics of special interest, which may vary each time course is offered. Topic stated in current Schedule of Classes. Prerequisite: senior or graduate standing.

**CE 655 Environmental Management Modeling****3 hrs.**

Development, solution, and interpretation of management models used in environmental planning and water resource systems. Risk analysis and management. Risk and how its various aspects influence environmental regulations and policy. Decision making with risk including risk-based design. Environmental impact assessment. Water resource allocation decisions. Prerequisite: CE 360.

**CE 670 Theory of Elasticity****3 hrs.**

Stress and strain tensors; stress on arbitrary planes; principle stresses in three dimensions; equilibrium equations; strain displacement equations and compatibility conditions; transformation of stresses and strains; plane elasticity in rectangular and polar coordinates; boundary value problems; yield and failure criteria; energy principles. Prerequisites: CE 510, CE 573.

**CE 691 Advanced Topics in Civil Engineering I****3 hrs.**

Advanced topics of special interest in civil engineering and construction which may vary each time course is offered. Topic stated in current Schedule of Classes. Prerequisites: graduate standing and consent of instructor.

**CE 692 Advanced Topics in Civil Engineering II****3 hrs.**

Advanced topics of special interest in civil engineering and construction which may vary each time course is offered. Topic stated in current Schedule of Classes. Prerequisites: graduate standing and consent of instructor.

**CE 699 Thesis****3-6 hrs.**

Research on a topic selected by the student and approved by the thesis advisor. Prerequisite: graduate standing in CE.

# Electrical Engineering

Prasad Shastry,  
Program Coordinator

The Department of Electrical and Computer Engineering offers a graduate program leading to the degree Master of Science of Electrical Engineering. The goal of the program is to enhance the student's understanding of advanced concepts in core areas of modern electrical and computer engineering and to enrich the student's design and/or research skills in a specialization of his or her choice. This is done through coursework and a design project or thesis as described below.

Students work closely with a faculty advisor in tailoring an overall program best suited to their background and interests. Course sequences, design projects, and research are available in applied electromagnetics, communication theory, control theory, digital systems and computers, microprocessor applications, signal processing, and wireless components and systems. The ECE department has excellent computer and laboratory facilities to support advanced studies in these areas.

## Degree Requirements

A total of 33 semester hours is required for the degree and all students must do either a thesis (thesis option) or design project (design option). The specific requirements for each option are as follows:

### Thesis Option

- EE 501 Principles of Electrical Engineering Design, 3 hours
- Thesis, 6 hours
- 18 hours of electrical engineering courses with two 6-hour specializations
- 6 hours of EE or approved technical electives

### Design Option

- EE 501 Principles of Electrical Engineering Design, 3 hours
- Design Project, 3 hours
- 21 hours of electrical engineering courses with two 6-hour specializations
- 6 hours of EE or approved technical electives

In addition to the two six-hour specializations, at least six hours of the EE coursework must utilize advanced mathematical concepts. Examples of such courses are EE 530, EE 540, and EE 550. Technical electives can be chosen from graduate courses offered by other engineering programs or by the biology, chemistry, computer science, math, or physics departments. All the courses used to satisfy the degree requirements for the MSEE degree must be listed in the student's Graduate Program of Study. This document must be completed and approved by the student's faculty advisor and the EE graduate program coordinator before completion

of 12 hours of coursework. The student must also complete a final degree experience, normally an oral comprehensive or colloquium.

The one-semester EE 501 Principles of Electrical Engineering Design introduces the student to design techniques via several projects in key areas of electrical engineering, and supplies an excellent foundation for thesis or project work. Students receiving a grade of less than "B" in EE 501 may have to take remedial work including courses for which graduate credit cannot be earned. Students, though, with considerable design experience in their background may seek to waive EE 501. To do so, a student must send a letter requesting the waiver and documentation of design experience to the graduate advisor. If the waiver is granted, the student must then satisfy the requirements under either the Thesis Option or Design Option except for EE 501, yielding a total of 30 hours to complete the MSEE program.

## Admission

Successful completion of an undergraduate electrical or computer engineering program is required for admission. In addition to the material described in the general admission section of this catalog, applicants to the MSEE program must also submit their scores from the GRE general test or new test #2 when available. Undergraduate GPA, number of repeated undergraduate courses (if any), and GRE scores are the primary factors considered in admission decisions. International students must also submit material and information described in the general admission section of this catalog.

Plans of study are available for those with non-electrical engineering or non-engineering undergraduate degrees. These plans require a number of undergraduate foundation courses to be successfully completed before admission to the MSEE program. Further information can be obtained by contacting the ECE graduate program coordinator.

## Course Descriptions

### **EE 501 Principles of Electrical Engineering Design** **3 hrs.**

Analog, digital, and software design experiments: use of instrumentation transistor amplifiers and switches, operational amplifiers, active and passive filters, digital logic, microcontrollers, and signal processing circuits. Use of computer-aided design and simulation tools for system analysis and design. (Cannot be used to satisfy MSEE elective.) Prerequisite: BSEE degree or consent of the department chair.

### **EE 530 Random Variables and Signals** **3 hrs.**

Correlation functions; power-density spectra; transmission of random signals through linear and non-linear systems; linear mean square estimation. Prerequisite: EE 302 or graduate standing.

### **EE 531 Communication Theory** **3 hrs.**

Optimum filtering; analogue and digital communication; detection theory. Prerequisite: EE 530.

### **EE 532 Information Theory** **3 hrs.**

Coding theory; memory and memoryless systems. Prerequisite: EE 530.

### **EE 533 Digital Image Processing** **3 hrs.**

Design of computer-based imaging systems; multi-dimensional filtering and quantization methods for image enhancement, restoration, and pattern recognition. Prerequisite: EE 302 or MTH 325.

### **EE 534 Digital Signal Processing** **3 hrs.**

Representation and analysis of discrete time signals and systems. Finite and infinite impulse response filter design; computer-aided-design; Fast Fourier Transform; implementation of digital filters. Prerequisites: EE 302.

### **EE 535 Engineering Applications of Neural Networks** **3 hrs.**

Provides a working knowledge of the theory, design, and engineering applications of artificial neural networks. Emphasis will be directed to low-level implementation such as embedded microcontrollers and integrated circuits. Specific architectures such as correlation matrix memory, perceptron, adaline, multilayer networks, radial-basis function networks, and Hopfield networks will be examined as well as their corresponding learning rules. Prerequisite: EE 302 or graduate standing.

### **EE 540 Dynamic Systems Analysis** **3 hrs.**

Advanced techniques for analysis of electrical, mechanical, and electromechanical systems. State function concepts are emphasized with methods for determining state equations, system stability, and control. Prerequisite: EE 302 or graduate standing.

### **EE 550 Electromagnetic Theory** **3 hrs.**

Time-varying electric and magnetic fields; Maxwell's equations; plane waves in conducting and dielectric media; transmission lines; wave guides; antennas. Prerequisite: EE 381.

### **EE 551 Radio Frequency Circuits and Systems** **3 hrs.**

Review of transmission lines, impedance matching and transformations, S-parameters, passive R.F. junctions, R.F. amplifier design, R.F. systems, and front end design. Prerequisites: EE 205, 206.

### **EE 555 Optical Fiber Communication** **3 hrs.**

EM wave propagation in silica glass and step index optical fibers, LP modes, multimode and singlemode fibers, optical transmitters and receivers, design of optical fiber communication systems meeting industry standards. Prerequisite: EE 381 or consent of instructor.

### **EE 561 Digital Systems: Logic Design** **3 hrs.**

Boolean algebra; logical design; storing and switching phenomena. Prerequisite: EE 304 or graduate standing.

**EE 562 Digital Systems: Computer Structures**  
**3 hrs.**

Use of hardware programming language to design a small computer or other digital system; busing; control units; interfacing; transfer design. Prerequisite: EE 201.

**EE 563 Advanced Electronics - VLSI System Design**  
**3 hrs.**

Design and implementation of very-large-scale integrated systems (VLSI). Integrated circuit devices, subsystems, and architecture. Computer-aided-design (CAD) and design testing. Prerequisites: EE 304 or graduate standing.

**EE 565 Digital Systems: Microprocessor and PC Architecture**  
**3 hrs.**

Architecture of PC-compatible computers; 32-bit processor architecture and assembly language programming; standard buses. Design of peripheral cards to interface with the standard PC bus architectures. Prerequisites: EE 365 or consent of instructor.

**EE 566 Digital Systems: Memory and Interfacing**  
**3 hrs.**

Design of single-board computers using 32-bit processors; processor architecture and assembly language programming. Introduction to RISC processors. Prerequisites: EE 365 or consent of instructor.

**EE 567 Advanced VLSI Design**  
**3 hrs.**

Addresses the testability of integrated systems, using very large scale integration or VLSI, which includes topics on devices, circuits, and digital subsystems in CMOS technology. Includes the concept and methodology for the design for testability of digital integrated systems. Prerequisite: EE 563.

**EE 568 VHDL: Digital System Design**  
**3 hrs.**

A structured guide to the modeling of the design of digital systems, using VHDL, a hardware description language. VHDL is designed to fill a number of needs in the design process. It allows description of the structure of a system, and the specification of the function using familiar programming language forms. As a result it allows the design of a system to be simulated and synthesized.

**EE 575 Power Systems**  
**3 hrs.**

Analysis of electric power systems; fault studies; load flow; economic loading; stability; relaying; high voltage DC transmission; lightning and switching transients. Prerequisite: senior or graduate standing in EE.

**EE 631 Advanced Communication Theory**  
**3 hrs.**

Continuation of Electrical Engineering 531. Prerequisites: EE 531, 540.

**EE 642 Advanced Control Systems**  
**3 hrs.**

Continuation of EE 540. Prerequisite: EE 540.

**EE 643 Optimal Control Systems**  
**3 hrs.**

Analysis and design of multivariable control systems: stability, observability and controllability, deterministic/stochastic linear optimal regulator and observers, and multivariable stability robustness. Prerequisite: EE 540 or permission of instructor.

**EE 651 Advanced Electrodynamics**  
**3 hrs.**

Continuation of EE 550. Special theory of relativity; plasma dynamics. Prerequisites: EE 540, 550.

**EE 681, 682 Research**  
**3-6 hrs. each**

Graduate research on a project selected by student and advisor.

**EE 691, 692 Topics in Electrical Engineering**  
**1-3 hrs. each**

Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes.

**EE 699 Thesis**  
**3-6 hrs.**

Advanced electrical engineering research or design under the guidance of a faculty advisor. Required of students choosing thesis option. Total of 6 semester hours to be taken in one or two semesters. Prerequisites: consent of Department Chair; unconditional status.

# Industrial & Manufacturing Engineering & Technology

The Department of Industrial & Manufacturing Engineering & Technology offers two graduate programs leading to the Master of Science degree: M.S.I.E. in industrial engineering and M.S.Mf.E. in manufacturing engineering.

These degree programs respond to a wide range of manufacturing and service industry needs.

Each program has a graduate advisor. The admission requirements for each are stated in the following program statements.

## Industrial Engineering

Fariborz Tayyari,  
Graduate Advisor

The Department of Industrial & Manufacturing Engineering & Technology offers a graduate program leading to the M.S.I.E. degree stressing the role of industrial engineers as problem solvers at managerial and staff levels in both manufacturing and service industries. The program offers students the opportunity to customize a plan of study, beyond an IE core, based on the student's educational background and career objectives. Courses will be drawn from such disciplines as engineering, science, mathematics, and business administration.

Admission is selective and is open to holders of an undergraduate degree in engineering, science or mathematics who meet Graduate School admission requirements. Students without an IE undergraduate degree may be required to make up undergraduate deficiencies. Those who do not have an engineering degree should have worked in an engineering environment for at least three years. International graduates of a non-ABET accredited program should have a TOEFL score of 550 for unconditional admission and a score of 52 on part 1 of the test. Both part-time and full-time students are welcome.

## Degree Requirements

The total program is 30 semester hours of graduate level work of which a minimum of 18 hours must be taken from IME designated courses, including 3 semester hours of a project course to demonstrate ability to identify, define and solve unstructured IE related problems. Most entering students who do not have the undergraduate degree in IE must complete IME 500, Engineering Economy and Costs, and IME 503, Engineering Quantitative Analysis. Neither will count towards graduate credit. A 36-hour, non-project program is also available.

A course of study must be prepared by each student in consultation with the academic advisor and must be approved by the department as early as possible but not later than the beginning of the second semester of study at Bradley.

## Manufacturing Engineering

Saeed Saboury,  
Graduate Advisor

The Department of Industrial and Manufacturing Engineering and Technology offers a graduate program leading to the Master of Science in Manufacturing Engineering. The objective of the program is to educate professionals who will design, build, operate, and control world-class manufacturing systems with enhanced productivity and competitiveness.

The program is structured with five interrelated areas: design, materials, processes, systems, and automation and integration.

Students applying for admission to the program must have a baccalaureate degree in engineering or science and must meet the grade point requirements of the Graduate School. Transcripts of all prior work at the college level and two letters of recommendation must accompany the application. All applicants will be considered on an individual basis. Successful applicants will have a background in the areas of processes, materials, mathematics, mechanics, computer science, and manufacturing systems. If a candidate does not have the required level or breadth of preparation in the areas specified above, the candidate may be admitted conditionally and will be advised of appropriate preparatory courses or conditions for full unconditional entrance to the program.

A total of 33 graduate credit hours is required to complete the program. Of the total credit hours:

- A. A minimum of 15 semester hours must be taken from the list entitled Manufacturing Engineering Areas. At least one course must be taken from each of the five manufacturing engineering areas. Selected topic courses and professional projects do not fulfill this requirement.
- B. Six semester hours should be devoted to thesis work. If a student elects not to undertake a thesis, a minimum of 3 semester hours must be devoted to project work.
- C. A minimum of 3 semester hours will be taken in advanced mathematics.
- D. A minimum of 6 semester hours must be taken outside of the program. A list of suggested courses is available from the graduate advisor.

The student must file and secure approval for a plan of study with the manufacturing graduate advisory committee prior to completing 9 semester hours. Such a plan will specify the courses to be taken and the proposed thesis or project topic. In the event that a change in the plan is desired, such a change can be accomplished by filing a request for amendment with the advisory committee. This amendment must be approved prior to taking the alternative course. Candidates will be expected to demonstrate their capacity to draw upon and integrate their knowledge from all courses presented for their degree in a written comprehensive examination. Scheduling, grade reporting, and retakes will conform to the rules of the Graduate School.

## Manufacturing Engineering Areas

### Design

IME 590 Geometric Modeling  
IME 591 Design for Manufacturability  
IME 592 Tribology

### Materials

IME 531 Nonmetallic Materials  
IME 533 Composite Materials

### Processes

IME 541 Forming Processes  
IME 543 Materials Removal Processes  
IME 545 Joining and Fabrication

### Systems

IME 563 Process Engineering  
IME 568 Introduction to Expert Systems and Artificial Intelligence  
IME 583 Production Planning and Control

### Automation and Integration

IME 553 Advanced Computer Aided Manufacturing  
IME 555 Computer Integrated Manufacturing

## Course Descriptions

### IME 500 Engineering Economy and Costs 3 hrs.

Analysis of the economic aspects of engineering decisions including the time value of money and the techniques of obtaining cost data. Does not count toward MSIE. Prerequisite: graduate standing in engineering or consent of instructor.

### IME 503 Engineering Quantitative Analysis 3 hrs.

Probability, random variables, distributions, inference, regression, linear programming, simulation. Does not count towards MSIE. Prerequisite: graduate standing in engineering or consent of instructor.

### IME 511 Engineering Statistical Analysis 3 hrs.

Concepts in probability and statistics from practical and theoretical angles. Definition of probability, random variable, distribution, important discrete and continuous distributions, sampling distribution of X-bar, Central Limit Theorem, t, chi-squared and F distributions, estimation, hypothesis testing, regression analysis, and analysis of variance. Prerequisite: IME 503 or consent of instructor.

### IME 512 Design and Analysis of Experiments 3 hrs.

Design and analysis of experiments in research, development, and production activities. Experimental designs for evaluating significance of main effects and interactions of several variables. Treatment of problems of measurement, planning, and evaluating programs. Prerequisite: two semesters of statistics or consent of instructor.

### IME 514 Introduction to Operations Research 3 hrs.

Mathematical model building and use of deterministic and non-deterministic tools in problem solving. Problem solving structure, linear programming, transportation and assignment algorithms, game theory, networks, branch and bound algorithms, dynamic programming, deterministic and stochastic inventory models, markov chains, queueing theory and simulation. Prerequisite: IME 503 or consent of instructor.

### IME 515 Linear Programming and Network Analysis 3 hrs.

Theoretical and computational aspects of linear programming; application to practical problems. Prerequisite: MTH 202; IME 117; consent of instructor.

### IME 522 Manufacturing Quality Control 3 hrs.

Analysis of factors affecting product quality during manufacturing; process control charts; process capability studies; error of measurement; sampling plans; motivation programs; quality audit; organization. Prerequisite: one semester of statistics or consent of instructor.

### IME 524 Advanced Quality Control 3 hrs.

Comparative study of philosophies of using quality as a business management tool, with special reference to Deming's Theory of control charts and a study of their strengths and weaknesses. Special control charts such as CUSUM chart, median chart, moving average chart, and their application. The latest published articles used to keep up-to-date in quality technology. Prerequisite: IME 522 or consent of instructor.

### IME 526 Reliability Engineering 3 hrs.

Specification, prediction, and evaluation of product reliability and maintainability. Use of models for failure distribution—exponential, Weibull, lognormal—and analytical and graphical methods for failure data analysis. Test plans and accelerated testing models. Design methods for increasing reliability and maintainability. Prerequisite: IME 511 or consent of instructor.

### IME 531 Non-metallic Materials 3 hrs.

Recent developments and applications of polymeric and ceramic materials. Selection and design criteria, material properties, process engineering, quality considerations, and failure prevention. Prerequisite: IME 331.

### IME 533 Composite Materials 3 hrs.

Science and technology of modern composite materials: properties, design, toughening mechanisms, fabrication methods, evaluation, mechanisms of failure and quality assurance. Prerequisite: IME 331.

### IME 541 Forming Processes 3 hrs.

Analytical methods in metal forming processes including slab approach, upper bound techniques, slip-line field and visio-plasticity methods. Forging, rolling, extrusion, drawing, sheet forming, near net-shape processes, and CAD/CAM. Prerequisite: IME 441.

**IME 543 Material Removal Processes****3 hrs.**

Current and future trends in: mechanics of chip generation; forces and energies in cutting and dynamometry; thermal aspects of machining; cutting tool materials; friction, wear, vibrations and tool life; applications of engineering fundamentals to design and analysis of machining operations with emphasis on computer control. Prerequisites: IME 441; IME 341.

**IME 545 Joining and Fabrication****3 hrs.**

Principles of advances in joining and fabrication of engineering materials including metallic, nonmetallic, and electronic materials. Process science and technology with emphasis on casting, welding, and microjoining of electronic components. Physical and mathematical modeling of various processes. Prerequisite: IME 331.

**IME 553 Advanced Computer Aided Manufacturing****3 hrs.**

Computer Aided Manufacturing (CAM) within the CAD/CAM and CIM contents. Computer Assisted Process Planning (CAPP), Computer Assisted Tool Design, Computer Assisted NC Programming (APT), Interactive Graphics, NC Programming, and the elements of computer control of manufacturing equipment (CNC). A semester project. Prerequisite: IME 445.

**IME 555 Computer Integrated Manufacturing****3 hrs.**

Computer Integrated Manufacturing (CIM); elements of hardware and software within the manufacturing automation environment. Islands of factory automation and their interactions, information flow and Local Area Networks within the CIM architecture, standardization of electronic data and interfaces. Prerequisite: IME 386.

**IME 561 Simulation of Human/Machine Systems****3 hrs.**

Procedures and rationale for planning, designing, and implementing computer simulation experiments used to analyze human-machine systems in engineering, business, and social sciences. Prerequisite: MTH 202, IME 117, IME 311.

**IME 563 Process Engineering****3 hrs.**

The process design function interaction with product design, and the responsibilities within a manufacturing organization. Selection and design of machinery, tools, and methods. Computer aided process design and interactive accessing of machining data and tooling element of group technology and expert systems. Prerequisites: IME 395; IME 343.

**IME 566 Advanced Facility Planning****3 hrs.**

Extension of IME 466. Facility design consideration of internal and external service functions; logistic concerns; design flexibility. Prerequisites: IME 383 or IME 386 or IME 500.

**IME 568 Introduction to Expert Systems and Artificial Intelligence****3 hrs.**

Knowledge-based systems design and implementation; expert system shells and programming environments; validation and implementation of expert systems; case studies/laboratories. Cross-listed as CIS 588. Prerequisites: two semesters of computer programming and one semester of statistics, or consent of instructor.

**IME 570 Selected Topics in Industrial and Manufacturing Engineering****1-3 hrs.**

Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes. May be repeated up to a maximum of 6 hrs. Prerequisite: consent of instructor. Combined credit for IME 590 and IME 570 may not exceed 6 hours.

**IME 583 Production Planning and Control****3 hrs.**

Analysis of production-inventory systems using common planning and scheduling techniques. Mathematical models for project planning, aggregate planning, master scheduling, and inventory analysis. Interface with quality control and computer systems. Prerequisites: IME 386; minimum grade of C in IME 311 and IME 313; or consent of instructor.

**IME 584 Advanced Production Planning****3 hrs.**

Planning methods for converting to or creating Just-in-Time and/or group technology systems. Analytical and behavioral aspects. Prerequisite: IME 564; consent of instructor.

**IME 585 Human Factors Engineering****3 hrs.**

Functional anatomy and physiology of muscle and skeletal systems and their relationship to work design. Work physiology, kinesiology, and anthropometry in relation to their application in work-place design and hand tool design. Utilization of physical work capacity and job demands for job design, personnel assignment, and assessment of work-rest scheduling. Prerequisites: IME 311, IME 386, CE 150.

**IME 587 Occupational Safety and Health****3 hrs.**

Occupational safety and health standards and regulations. Injury and illness statistics. Employer's responsibilities and bookkeeping requirements. Hazard analysis and systems safety, occupational and environmental hazards and controls. Prerequisite: consent of instructor.

**IME 590 Geometric Modeling****3 hrs.**

Computer-based representations of the shape and spatially dependent attributes of real or conceived physical objects. Techniques and concepts needed to couple the digital computer with the techniques of geometric modeling and graphics display for analysis and viewing. Prerequisite: IME 395; MTH 223.

**IME 591 Design for Manufacturability**  
**3 hrs.**

The design process; interaction of materials, processes, and design; economic considerations; design considerations for machining, casting, forging, extrusion, forming, powder metallurgy; designing with plastics; design for assembly; projects and case studies. Prerequisites: IME 395; IME 341.

**IME 592 Tribology**  
**3 hrs.**

An introduction to systems approach to tribology, surface topography, physical, chemical, and geometric nature of surfaces. Mechanics of contact between surfaces. Various theories of friction and wear, hydrodynamic, elasto-hydrodynamic, and boundary lubrication. Frictional instabilities. Rolling contact problems. Application of system methodology to tribological problems in engineering design and manufacturing. Prerequisites: IME 331 or ME 351 or consent of instructor.

**IME 670 Independent Study**  
**3 hrs.**

Critical investigation and analysis in management systems design, facilities and/or process design, material selection, or industrial economics. Prerequisites: consent of instructor.

**IME 691, 692 Research**  
**0-3 hrs. (each)**

Research project or professional problem to be selected by student and advisor. May be repeated to a maximum of 3 hours credit. Beyond initial enrollment the student must register for 0 hours. Prerequisite: unconditional graduate status; consent of instructor.

**IME 699 Thesis**  
**0-6 hrs.**

Required of students choosing thesis option. Total of six hours to be taken; any semester after six hours, the student must register for zero hours to maintain progress. Prerequisites: unconditional status, consent of graduate advisor.

# Mechanical Engineering

D. Paul Mehta,  
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. All applicants must submit GRE general test scores by the end of their first regular semester in attendance.

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.

## Masters Degree Curriculum Requirements

- 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 Structures Design

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 to 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 office by the 2nd Friday of March or October. Each problem should not take more than 1/2 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 2nd Friday of March or October and will be encouraged to proctor the exam. The students must be notified by the ME Department by the 3rd 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. If the student fails the retake exam, the matter will be referred to the graduate committee, which will make final recommendations to the department chair. 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; turbo-prop; 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 542 Kinematic Synthesis of Linkages****3 hrs.**

Design of planar and spatial linkage mechanisms to satisfy input-output motion requirements: rigid-body motion of the coupler for finitely-separated positions; coordination of shaft rotations; coupler-point path problems. Prerequisite: MTH 202, 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 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 and 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 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 621 Boundary Layer Theory****3 hrs.**

Fundamentals of vector and tensor notation; derivation of Navier-Stokes equations; exact solutions; laminar boundary layer flow; similarity solutions; numerical solutions; integral solutions; fundamental transformations; thermal boundary layers; introduction to turbulent boundary layers. Prerequisite: ME 521.

**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.