The College of Engineering and Technology offers degrees leading to the Master of Science in Civil Engineering, Master of Science in Electrical Engineering, Master of Science in Industrial Engineering, and the Master of Science in Manufacturing Engineering. Students majoring in engineering are required to complete from 30 to 33 semester hours of course work, 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

Practicum

Many 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 on a practicum program which 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 payback. Participating students will be enrolled in EGT 500 for zero credit.

Internship

Engineering internships provide engineering and technology 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 Advisor

The Department of Civil Engineering and Construction offers an M.S.C.E. degree program that prepares graduates for thriving engineering careers characterized by continued professional growth. Our graduates have the talents and skills needed in a highly technical society facing serious problems in the environment and infrastructure. Our program will provide you with opportunities and challenges necessary for a fruitful and successful career in the practice of civil engineering and construction management. 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. Faculty and graduate students have received research grants from Caterpillar Inc., state agencies, the National Science Foundation, and other private and government sources.

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, they may become involved with community projects such as the Bridge Pal program that fosters engineering interest in high school seniors.

Research and teaching assistantships are available for qualified graduate students through the department and ongoing funded research projects. In addition, the department has several endowed scholarships and some of these funds provide fellowships to selected graduate or undergraduate students. The department has major laboratories with state-of-the-art equipment in geotechnical, concrete, asphalt, environmental, surveying, structural, microcomputers, CAD, experimental stress, construction, design, projects, research, and fluids. These laboratories are equipped to satisfy the educational needs of students and research objectives of graduate students and faculty.

After selecting core courses, the student may study in any one of four areas of concentration: construction management, geotechnical, structural, or 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. Both options require a minimum of 3 semester hours of mathematics and 18 semester hours in CE courses. The M.S.C.E. program requires a minimum of 30 semester hours beyond the bachelor’s degree.

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

1. A plan of study is required by the end of the first semester. This 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 M.S.C.E. degree.
2. Admission of undergraduate students into 500-level courses requires that the student has the necessary prerequisites and a minimum average of 2.5/4.00 in the major field.
3. Admission into the M.S.C.E. program requires a bachelor’s degree in civil engineering. Qualified graduates from other engineering or related fields may be admitted conditionally. The conditional status can only be changed after all deficiencies are removed.
4. Each student is required to pass a comprehensive examination during the last semester of his/her study.
5. Exceptions to departmental requirements may be made by the graduate advisor.

Course Descriptions

CON 500, 501 Special Topics I, II
1-3 hrs.
Topics of special interest in civil engineering and construction which may vary each time course is offered. Topic stated in current Academic Handbook. Prerequisite: senior or graduate standing; consent of department chair.

CE 504 Advanced Hydraulics
3 hrs.
Hydraulic transients in pipeline and open channel flow; gradually varied, spatially varied, and rapidly varied flow in open channels; sedimentation mechanics, stream channel mechanics. Computer and design applications. Prerequisite: CE 304.

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 511 Advanced Mechanics of Materials
3 hrs.
One, two, and three dimensional stresses and strains at a point; theories of elastic strength; effect of loading on the member; torsion of noncurricular sections; curved beams; unsymmetrical bending. Prerequisites: CE 301; senior or graduate standing; consent of instructor.

CE 518 Subsurface Flow in Porous Media
3 hrs.
Fundamentals of groundwater flow; theory of flow in anisotropic media; transient well testing techniques; analytical and computer solutions of flow problems; dispersion phenomena. Cross listed as GES 518. Prerequisites: MTH 224; senior or graduate standing in geology or civil engineering.

CE 530 Prestressed Concrete
3 hrs.
Theory and analysis of prestressed concrete members by various methods of prestressing; linear and circular prestressing; design of simple and continuous beams and slabs; extensive study of materials used in prestressed concrete. Prerequisites: CE 403, 359; senior or graduate standing; consent of instructor.

CE 545 Structural Dynamics
3 hrs.

CE 555 Solid and Hazardous Waste Management
3 hrs.
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; engineering processes for the chemical, biological, and physical treatment of toxic and hazardous wastes; remediation of contaminated soil and groundwater at existing disposal sites. Prerequisite: CE 360.

CE 557 Analysis of Environmental Systems
3 hrs.
Areas of environmental engineering not covered in CE 360: pollutant transport in air, surface water, and groundwater; environmental management of air and water resources. Prerequisites: senior or graduate standing; consent of instructor.

CE 558 Industrial Waste Treatment Process Design
3 hrs.
Industrial survey and treatment technologies for liquid, solid, and gaseous wastes. Mixing of wastes and stream sanitation. Applications and design of treatment processes with emphasis on the aqueous chemistry of heavy metals and organic contaminants. Applied electrochemistry and redox reactions, and interfacial phenomena. Prerequisite: CE 360.

CE 559 Management Models in Environmental Engineering
3 hrs.
Development, solution, and interpretation of management models used in environmental planning and management; mathematical programming techniques from operations research; trade-off analysis and risk assessment; management problems for conventional and toxic wastes in surface water, ground water, and air. Prerequisite: CE 360.

CE 562 Advanced Structural Design I
3 hrs.
Multi-story steel frame analysis and design; rigid frame design; plate girder design. Extensive use of computer for design and analysis. Prerequisites: CE 359, 442; senior or graduate standing; consent of instructor.

CE 580 Advanced Cost Estimating for Construction Projects
3 hrs.
Cost estimating for material, equipment, and labor for construction projects. Taking-off quantities, pricing techniques, computer estimating, and bidding strategy.
models. Prerequisites: IE 301; consent of graduate advisor.

**CE 582 Construction Project Management**
3 hrs.
Procedures, techniques, and research efforts regarding improvement of construction productivity. On-site laboratories to utilize and evaluate productivity improvement techniques. Prerequisites: IE 301; consent of graduate advisor.

**CE 584 Construction Contract Administration**
3 hrs.
Issues in the implementation of a construction contract. Coordinating and controlling the construction project under legal and ethical considerations. Prerequisites: CON 492 or consent of instructor.

**CE 615 Advanced Foundation Engineering**
3 hrs.

**CE 630 Theory of Elasticity**
3 hrs.
Elastic analysis of deformable bodies based on considerations of equilibrium, boundary conditions and compatibility. Stress-strain relations and applications to two-dimensional problems using rectangular coordinates and polar coordinates. Fundamentals and applications of the energy method. Prerequisites: CE 511; MTH 501.

**CE 674 Construction of Temporary Facilities**
3 hrs.
Temporary facilities employed by the construction industry for various projects. Design and construction: formwork, falsework, scaffolding, cofferdams, cableways, winter protection systems. Examples from recent literature. Prerequisites: CE 320, 351; consent of graduate advisor.

**CE 691, 692 Topics in Civil Engineering**
3 hrs. each
Topics of special interest which may vary each time course is offered. Topic stated in current Academic Handbook. 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.

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**Electrical Engineering**

Winfred Anakwa, Graduate Advisor

The Department of Electrical and Computer Engineering and Technology offers a graduate program leading to the degree Master of Science in Electrical Engineering. The curriculum is structured to give the graduate of the program a balanced technical background in core areas of modern electrical engineering and a significant experience in advanced design via a thesis or a project.

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, electronics and microprocessor applications, power systems, and signal processing. The ECET department has excellent computer and/or laboratory facilities to support advanced studies in these areas. Applicants from non-ABET-accredited schools of engineering are required to take the general test of the GRE.

**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**
- Graduate design seminar, 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**
- Graduate design seminar, 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

Approved technical electives are chosen from graduate courses offered by departments other than electrical engineering, such as computer science, math, physics, or mechanical engineering. The one-semester graduate design seminar introduces the student to advanced design techniques via several projects in key areas of electrical engineering, and supplies an excellent foundation for thesis or project work. Students who are unconditionally admitted may replace the graduate design seminar with a graduate electrical engineering course if they have adequate design experience in their background. Such students must petition the ECET graduate committee and supply
appropriate documentation. Students receiving a grade of less than "B" in the graduate design seminar may have to take remedial work including courses for which graduate credit cannot be earned. All students must pass a comprehensive exam in their last semester as required by Graduate School regulations.

Typically, an undergraduate electrical engineering degree is required for admission. However, 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. Further information can be obtained by contacting the ECET graduate advisor.

Course Descriptions

EE 530 Random Variables and Signals
3 hrs.
Correlation functions; power-density spectra; transmission of random signals through linear and nonlinear 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; multidimensional 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 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 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 Microprocessors
3 hrs.
Design of microprocessor based systems applied to real situations; control and data acquisition. Programming practice on several commercial microprocessors. Prerequisite: EE 201 or consent of instructor.

EE 566 Digital Systems: Memory and Interfacing
3 hrs.
Design of memory systems. Peripheral interfaces to universal bus structures. Design of selected common buses: unibus, multibus, and VME bus. Prerequisites: EE 304, 562.

EE 571 Semiconductor Electronics
3 hrs.
Qualitative and quantitative study of electronic and thermal properties of semiconductor materials and devices. Prerequisite: PHY 501.

EE 575, 576 Power Systems I, II
3 hrs. each
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 575 is prerequisite for EE 576.

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
a course is offered. Topic stated in current Academic
Handbook.
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; uncondi-
tional status.

Industrial and Manufacturing Engineering and Technology

The Department of Industrial and Manufacturing
Engineering and 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 industrial & manufacturing engineering and
technology department 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 the opportunity to tailor-
make a plan of study, beyond an IE core, for each
student based on his/her 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. Interna-
tional 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 IE 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 IE 500,
Engineering Economy and Costs, and IE 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.

Course Descriptions

IE 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.

IE 503 Engineering Quantitative Analysis
3 hrs.
Probability, random variables, distributions, inference, regression, linear programming, simulation. Does not count towards MSIE. Prerequisites: graduate standing in engineering or consent of instructor.

IE 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: IE 503 or consent of instructor.

IE 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.

IE 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, queuing theory and simulation. Prerequisite: IE 503 or consent of instructor.

IE 515 Linear Programming
3 hrs.
Theoretical and computational aspects of linear programming; application to practical problems. Prerequisite: MTH 202; consent of instructor.

IE 516 Simulation of Man/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, IE 311 or equivalent.

IE 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. Prerequisites: one semester of statistics or consent of instructor.

IE 528 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 workplace 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: IE 306, 312; CE 240; or consent of instructor.

IE 530 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: IE 511 or consent of instructor.

IE 564 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. Prerequisite: IE 306; minimum grade of C in IE 312 and IE 314.

IE 582 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: IE 522 or consent of instructor.

IE 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: IE 564 or consent of instructor.

IE 588 Introduction to Expert Systems
3 hrs.
Knowledge-based systems 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.

IE 590 Topics in Industrial Engineering
1-3 hrs.
Topics of special interest which may vary each time course is offered. Topic stated in current Academic Handbook. May be repeated up to a maximum of 6 hrs. Prerequisite: consent of instructor.
IE 605 Advanced Industrial Engineering Problems 3 hrs.
Critical investigation and analysis in management systems design, facilities design, or industrial economics. Prerequisites: previous courses in the area of concentration; consent of instructor.

IE 681 Research 0-6 hrs.
Research on a project selected by student and advisor; to maintain progress, student must register for zero hours. Prerequisite: unconditional graduate status.

IE 699 Thesis 0-6 hrs.
Required of students choosing thesis option. Total of six hours to be taken; any semester after six hours requires student to register for zero hours to maintain progress. Prerequisites: unconditional status, consent of graduate advisor.

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. 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.

E. All students must enroll in MFE 690 Manufacturing Seminar course (for zero credit) each fall and spring term they are enrolled at the University. A student must receive at least two satisfactory grades in MFE 690.

The student must file and secure approval for a plan of study with the departmental 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 necessary, 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
MFE 520 Geometric Modeling
MFE 525 Design for Manufacturability

Materials
MFE 531 Nonmetallic Materials
MFE 533 Composite Materials

Processes
MFE 541 Forming Processes
MFE 543 Material Removal Processes
MFE 545 Joining and Fabrication

Systems
MFE 550 Just-in-Time Manufacturing
MFE 551 Process Engineering
MFE 555 Artificial Intelligence in Manufacturing

Automation and Integration
MFE 563 Advanced Computer Aided Manufacturing
MFE 565 Computer Integrated Manufacturing
MFE 667 Industrial Machine Vision

Course Descriptions

MFE 520 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: MFE 272; MTH 223.

MFE 525 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: MFE 272; MTH 223.

MFE 531 Nonmetallic 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: MFE 371.

MFE 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: MFE 371.
and their interactions, information flow and Local Area Networks within the CIM architecture, standardization of electronic data and interfaces. Prerequisite: MFE 370.

**MFE 581  Selected Topics in Manufacturing Engineering**  
1-3 hrs.  
Topics of special interest which may vary each time course is offered. Topic stated in current Academic Handbook: advances in manufacturing processes, materials, design, computer applications, manufacturing productivity, etc. Course may be repeated to a maximum of 6 hours credit. Prerequisite: senior or graduate standing.

**MFE 667  Industrial Machine Vision**  
3 hrs.  
Fundamental concepts of image gathering, processing, and analysis for industrial applications; artificial vision; basic concepts of computer vision appropriate to the manufacturing environment; strategies for image processing to guide a robot; description of the required hardwares and softwares; highlights of research and development trends in the area of robot-vision. Prerequisites: MTH 324; CE 301.

**MFE 681, 682  Professional Projects**  
1-3 (each)  
Research project or professional problem to be selected by student and advisor. May be repeated to a maximum of 3 hours credit each. Prerequisite: consent of instructor.

**MFE 690  Manufacturing Seminar**  
0 hrs.  
Reports on current research by visiting scholars and departmental faculty and students. All graduate students are required to register and attend each semester. Prerequisite: consent of graduate advisor.

**MFE 699  Thesis**  
3-6 hrs.  
A maximum of 6 hours may be applied toward the master’s degree. Prerequisite: consent of Dept. Chair.

**MFG 503  Supervision of Industrial Operations I**  
3 hrs.  
Principles in supervision of industrial operations: functional supervision for planning, organizing, and controlling industrial operations; relevant current philosophies of supervision.

**MFG 513  Advanced Manufacturing Processes**  
3 hrs.  
Materials, elements, machines, and devices in modern manufacturing processes and practices. Prerequisite: consent of department chair.

**MFG 514  Process Planning and Estimating**  
3 hrs.  
Analytical models and techniques in manufacturing, cost estimating, processing, materials selection, and related problems in manufacturing control. Prerequisites: MFG 313; CS 104.
Engineer, Graduate Program Director

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 525 is required for unconditional admission. All applicants must submit GRE general test scores by 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 course work if their transcripts do not show a satisfactory level of preparation in certain areas.

New students who are planning to take their course work 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.

Of the minimum requirement of 30 semester hours, three semester hours must be taken in advanced mathematics topics as appropriate to the student's program (plan of study). Courses in statistics, numerical methods, and engineering analysis are applicable to this requirement.

To achieve breadth, students concentrating in the area of mechanical systems will be required to take at least one of the following courses: ME 501, ME 515, ME 521. Similarly, students concentrating in energy systems/thermosciences will be required to take at least one course from the following: ME 502, ME 540, ME 544, CE 511. Other courses not in the area of concentration may be substituted with approval of the graduate program director.

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 during the last semester.

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 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; CE 304.

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 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 541 Advanced Design
3 hrs.
Practical design of complete project, requiring comprehensive engineering knowledge and resourcefulness. Prerequisite: ME 342.

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: ME 344; 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. Prerequisites: ME 301; CE 304.

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 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
1-4 hrs. each
Topics of special interest which may vary each time course is offered. Topic stated in current Academic Handbook. Graduate students may repeat the course up to a maximum of 8 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 631  Air Pollution and Engine Emissions
3 hrs.
Internal combustion engine as related to air pollution and smog formation; emission monitoring methods; formation, release, and atmospheric reaction of spark and compression ignition engine pollutants; effect of engine parameters on emission control methods; effect of emission control strategies on performance and economy. Prerequisites: ME 501, 503; 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 Academic Handbook. 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.