



College of ENGINEERING

Janie M. Fouke, DEAN

The College of Engineering attempts to develop the abilities of its students so that they may continually progress with the advancing field of engineering and take part in the solution of the technical as well as many of the economic and social problems which will arise during their lifetimes. Since engineering deals primarily with the adaptation of nature's forces, materials, and energies for the benefit of society, our engineering programs are planned to provide our engineering students with firm knowledge and understanding of the fundamental engineering sciences and of engineering methods for the application of this knowledge. They also require a strong base in mathematics as a universal language and tool of the engineer. Since the engineer will always work with others, we also urge our students to take advantage of the many opportunities to learn from the other academic areas on this campus.

UNDERGRADUATE PROGRAMS

There is an opportunity for students to choose alternative paths of study leading to the Bachelor of Science degree:

1. Programs with a major in the Engineering Professional Fields.
2. Programs with a major in Engineering Sciences.
3. The Engineering Arts Program.

Programs With a Major in the Engineering Professional Fields

The Bachelor of Science degree may be earned in programs designed to prepare students for work in biosystems engineering, chemical engineering, civil engineering, computer engineering, electrical engineering, engineering mechanics,

manufacturing engineering, materials science and engineering, and mechanical engineering.

Details of specific programs in these areas are given in sections that follow.

Programs With a Major in the Engineering Sciences

The Bachelor of Science degree may also be earned in Engineering Sciences with a major in computer science. Flexibility is provided in the selection of major and minor subject matter areas, and the program permits the individual student to select study areas not included in the programs of the professional engineering fields. Students are encouraged to combine the engineering science fields with supporting studies from other engineering areas or from business management, medicine, the social and behavioral sciences, or the physical sciences.

Detailed program requirements for majors in the engineering sciences are given in sections that follow.

The Engineering Arts Major

The Engineering Arts major is a cross-disciplinary major which enables students to develop an awareness of technology and apply it to a broad range of non-technical disciplines. Opportunities are available for interaction between technological awareness and business, communication arts and sciences, and agriculture (packaging). The purpose and course content of the Engineering Arts major is significantly different from the majors in either the engineering professional fields or the engineering sciences. Detailed requirements for the Engineering Arts major are given in a section that follows.

Engineering for International Service

Students who plan international engineering careers may wish to earn a Bachelor of Arts degree in an appropriate major in the College of Arts and Letters or the College of Social Science, in addition to the Bachelor of Science degree with a major in the College of Engineering. Interested students should consult the statement on *Requirements for a Second Bachelor's Degree* in the *Undergraduate Education* section of this catalog and contact their academic advisers for further information.

Biomedical Engineering Option

The biomedical engineering option is oriented toward biomechanics and biomaterials. The option is designed for students who plan to pursue graduate study in biomedical areas or to seek employment in selected medical areas.

The option, which is administered by the College of Engineering, is available as an elective to students who are enrolled in bachelor's degree programs in the College of Engineering or in other colleges.

With the approval of the department and college that administer the student's degree program, courses that are used to satisfy the requirements for the option may also be used to satisfy the requirements for the bachelor's degree.

Requirements for the Biomedical Engineering Option

The student must complete:

	CREDITS
1. The following course (4 credits):	
PSL 250 Introductory Physiology	4
2. One of the following courses (3 or 4 credits):	
BS 110 Organisms and Populations	4
BS 111 Cells and Molecules	3
3. At least 9 credits from the following courses:	
BME 424 Biomaterials and Biocompatibility	3
BME 441 Tissue Mechanics	3
BME 491 Special Topics (MTC)	3 to 12
MSM 490 Independent Study	1 to 6

Upon completion of the requirements for the biomedical engineering option, the student should contact the Assistant Dean for Undergraduate Studies in the College of Engineering and request certification for the completion of the option. After the certification is approved by the Dean of the College of Engineering, the Office of the Registrar will enter on the student's academic record the name of the option and the date that it was completed. This certification will appear on the student's transcript.

Cooperative Engineering Education

Cooperative Engineering Education is a program of alternating full-time employment in industry and full-time study on campus. A typical schedule alternates semesters of employment and study. Five years are required to complete requirements for the degree.

Employment provides practical on-the-job experience by exposing students to types of work done by engineers. Salaries vary and are set by agreement between the student and the employer. Locations of jobs are nationwide. Students must be willing to live away from home and away from the campus.

Because employment cannot be guaranteed for all applicants, enrollments in the Cooperative Engineering Education program may be limited. Students are selected to participate in the program on the basis of demonstrated academic ability and a firm commitment to pursuing careers in the technical sector.

The Cooperative Engineering Education program requires a minimum of three semesters of full-time employment in a position in industry that has been approved by the College of En-

gineering. The student is required to be enrolled in EGR 393 Engineering Cooperative Education during each term of employment. Upon completion of the Cooperative Engineering Education program, the student should contact the College of Engineering and request certification for the completion of the program. After the certification is approved by the Dean of the College, the Office of the Registrar will enter on the student's academic record the name of the program and the date that it was completed. This certification of completion will appear on the student's transcript.

Students who are interested in the Cooperative Engineering Education program should contact the Office of Cooperative Education, 1410 Engineering Building, during their first semester on campus.

Honors Study

The College of Engineering encourages honors students to develop distinctive undergraduate programs in either the engineering sciences or in the fields offered by the several professional departments. A member of the faculty is selected to serve as adviser to Honors College students in each major field, and it is his or her responsibility to help the student plan a rigorous and balanced program which will also reflect the student's special interests and competencies. Independent study experience is strongly encouraged when relevant to the student's total program.

Accreditation

The following degree programs have been accredited by the Accreditation Board for Engineering and Technology, Inc. (ABET): Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, Engineering Mechanics, Materials Science and Engineering, and Mechanical Engineering.

Registration as a Professional Engineer

In Michigan, the State Board of Registration for Professional Engineers provides an opportunity for students during the senior year to take the first half of a sixteen-hour, two-part examination as the first step toward registration, provided the degree is to be awarded within six months and the degree program is one that has been accredited by the ABET or determined as equivalent by the State Board. After a minimum of four years of experience, the applicant may take the second half of the examination.

On completion of registration, an engineer establishes professional standing on the basis of legal requirements and receives authority to practice the engineering profession before the public.

Freshmen

Students meeting the general University requirements shown in the *Undergraduate Education* section of this catalog are enrolled as Undergraduate University Division students but may declare a preengineering major preference in the College of Engineering. Such students are assigned faculty advisers from the College. In addition to the general University requirements for admission, students who elect a preengineering major preference should have completed three units of college preparatory mathematics (one and one-half units of algebra, one unit of plane geometry, and one-half unit of trigonometry). Additional work in mathematics and science is highly desirable and may make advanced placement in courses possible.

ENGINEERING Undergraduate Programs

Students entering with less than the minimum mathematics prerequisites may take some of the necessary courses after entering the University. However, such students will need additional time to complete the work for the degree.

Since the normal work of the freshman year and much of the sophomore year is the same for all programs in the College of Engineering, new students may defer the choice of a field of study in most cases until the end of the freshman year. However, special attention should be given to various *program requirements* as they appear below under the major fields. Thus the first year or so may be used in becoming acquainted with the opportunities offered by the various engineering areas best suited to a student's talents.

Admission as a Junior

Enrollments in the College of Engineering are limited. Minimal criteria for application to the College are:

1. Completion of at least 56 credits of the first two years of the Engineering program with a cumulative grade–point average of 2.00 or higher.
2. Completion of Mathematics 132, 133.
3. Completion of Chemistry 141 or 151.
4. Completion of Physics 183 or 183B.
5. Completion of Computer Science and Engineering 131 or 231.

Admission is based on the cumulative grade–point average of all courses taken and a grade–point average calculated on all courses in mathematics, the physical and biological sciences, and engineering. In addition, factors such as work experience, diversity, and residency may be considered.

For additional information about admissions criteria and procedures, students should contact the Office of the Assistant Dean for Student Affairs, College of Engineering.

Admission to a Second Bachelor's Degree Program

Students seeking admission to a second bachelor's degree program must meet the same requirements as for admission to the College as a junior.

Graduation Requirements for All Majors

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of the catalog; 120 credits, including general elective credits, are required for the Bachelor of Science degree in Computer Science and Engineering Arts, 124 credits are required for the Bachelor of Science degree in Manufacturing Engineering, and 128 credits, including general elective credits, are required for the Bachelor of Science degree with majors in the other Engineering Professional Fields.¹

Students who are enrolled in majors leading to the Bachelor of Science degree in the College of Engineering may complete an alternative track to Integrative Studies in Biological and Physical Sciences that consists of the following courses:

- a. One of the following courses: Biological Science 110, 111; Botany and Plant Pathology 105; Entomology 205; Microbiology 205, 301; Physiology 250; Zoology 141.
- b. Two of the following courses: Chemistry 141, Chemistry 151, Physics 183 or 183B, Physics 184.
- c. One of the following laboratory courses: Biological Science 110, 111L; Botany and Plant Pathology 106; Chemistry 161; Microbiology 206; Physics 191.

- d. Majors in the Bachelor of Science in Computer Science degree program must complete an additional laboratory course from item 1.c. above.

All other majors in the College of Engineering will fulfill this requirement of an additional laboratory course when they complete required courses in physical science within their majors.

Credits earned in the alternative track may also be counted toward College and major requirements for the Bachelor of Science degree.

2. The requirements of the College of Engineering for the Bachelor of Science degree that are listed below:
 - a. Mathematics 132, 133, 234, and 235. Computer Science majors may substitute Mathematics 314 for Mathematics 235.
 - b. Chemistry 141 or 151. Computer Science majors are not required to complete Chemistry 141 or 151.
 - c. Physics 183 or 183B and 184.
 - d. Computer Science and Engineering 131 or 231.

¹ A student electing advanced aerospace or military science studies may be required to earn part or all of the credits for that program in addition to the minimum credits required for graduation.

Students who are enrolled in bachelor's degree programs in the College of Engineering may elect a specialization in environmental studies. For additional information, refer to the *Specialization in Environmental Studies* statement in the *College of Natural Science* section of this catalog.

TEACHER CERTIFICATION OPTION

A computer science disciplinary minor in the College of Engineering is available for teacher certification.

Students who elect the computer science disciplinary minor must contact the Department of Computer Science and Engineering.

For additional information, refer to the statement on *TEACHER CERTIFICATION* in the *Department of Teacher Education* section of this catalog.

GRADUATE STUDY

The College of Engineering offers programs leading to the Master of Science and Doctor of Philosophy degrees in the following fields:

chemical engineering
civil engineering
computer science
electrical engineering
engineering mechanics
environmental engineering
materials science and engineering
mechanical engineering

Programs leading to the Master of Science and Doctor of Philosophy degrees in biosystems engineering are offered through the College of Agriculture and Natural Resources.

The College also offers programs leading to the Master of Science degree in the following fields:

civil engineering–urban studies
environmental engineering–urban studies

Programs leading to the Master of Science and Doctor of Philosophy degrees in agricultural engineering are offered through the College of Agriculture and Natural Resources.

All programs are designed to provide a fundamental approach to basic engineering principles with emphasis on scien-

tific methods, and to lead to careers in engineering research and development or teaching. Advanced work in the major field of specialization is combined with supporting courses in one or more other fields to develop individuals capable of creative work in engineering science and areas of application.

Master of Science

In addition to meeting the requirements of the University as described in the *Graduate Education* section of this catalog, students must meet the requirements specified below.

Admission

Regular Status. Admission to a master's degree program with regular status may be granted by the department, subject to the availability of resources and to the approval of the dean, upon consideration of the likelihood that the applicant will be able to pursue a master's program successfully without taking collateral courses. As evidence of eligibility for admission, the student may offer any of the following:

- a. The possession of a bachelor's degree in an accredited program in engineering with a grade-point average not lower than 3.00 for the final two years of the undergraduate program, or with standing in the upper quarter of the graduating class in the student's major.
- b. The possession of a bachelor's degree in engineering or a related field where the applicant has shown very high academic achievement, as certified by the department.
- c. Evidence of ability and resolution to complete a master's program, as attested by the department upon review of the applicant's academic record, test scores, experience, reference statements, professional qualifications, proposed studies, and other relevant information.

Provisional Status. Admission to a master's degree program with provisional status may be granted by the department, subject to the approval of the dean:

- a. To an applicant qualified for regular admission except that collateral courses are deemed necessary, or
- b. To an applicant whose record is incomplete.

If collateral courses are required, the minimum acceptable grades and the semesters by which those courses must be completed will be specified on the admission form. The provisional status will be changed to regular status when the conditions specified on the admission form have been met, as certified by the department and approved by the dean.

Program Filing

The student's program of study must be approved before the student completes 6 credits of graduate work in order for the student to continue to enroll in the master's degree program.

For any independent study or selected topics course that is included in the student's approved program of study, the subject material and the instructor must be specified.

Modification of Program

With reference to the student's approved program of study, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass-No Grade, or Credit-No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF-Deferred marker.

3. Adding or deleting a course which the student dropped after the middle of the semester and for which "W" or "N" or "0.0" was designated.
4. Adding or deleting a course during the final semester of enrollment in the master's degree program.

Requirements for the Master of Science Degree

The student must:

1. Complete a minimum of 30 credits in 400-, 800-, and 900-level courses under either Plan A (with thesis) or Plan B (without thesis). Courses below the 400 level may not be counted toward the requirements for the degree.
 - a. *Requirements for Plan A:* The student must:
 - (1) Complete a minimum of 20 credits in courses at the 800-900 level.
 - (2) Complete at least 4, but not more than 8, credits in Master's Thesis Research (course number 899 in the department of the student's major).
 - (3) Provide to the major professor and to the department a hard-bound copy of the thesis made from the original unbound manuscript submitted to the Office of The Graduate School. Arrangements for delivery of the copies shall be made when the original manuscript is submitted to the Office of The Graduate School.
 - b. *Requirements for Plan B:* The student must:
 - (1) Complete a minimum of 18 credits in courses at the 800-900 level.
2. Pass the final certifying examination administered by the student's department. It is the student's responsibility to obtain detailed information about this examination from the department.

Academic Standards

1. **Grades.** The student must earn a grade of 2.0 or higher in each course in the approved program of study. The student must repeat any course for which the grade earned was below 2.0.
2. **Cumulative Grade-Point Average.** The student must maintain a cumulative grade-point average of at least 3.00 in the courses in the approved program of study.
3. **Probational Status.** A student is placed on probational status if the student's cumulative grade-point average for the courses in the approved program of study is below 3.00. A student in probational status is not allowed to carry more than 7 credits per semester or to enroll in any course the primary focus of which is independent study.
4. **Retention In and Dismissal From the Program.**
 - a. **Cumulative Grade-Point Average.** Should a student's cumulative grade-point average fall below 3.00 after having completed 16 or more credits in courses in the approved program of study, the student may be enrolled in probational status in the master's degree program for one additional semester. If at the end of the additional semester the student's cumulative grade-point average is 3.00 or higher, the student may continue to enroll in the master's degree program. If at the end of the additional semester the student's cumulative grade-point average is still below 3.00, the student will be dismissed from the program.
 - b. **Academic Progress and Professional Potential.** Each student's academic progress and professional potential are evaluated by March 15 of each year. A student who in the judgment of the faculty is making satisfactory academic progress and has professional

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potential may continue to enroll in the master's degree program. A student who in the judgment of the faculty is not making satisfactory academic progress or lacks professional potential will be dismissed from the program.

Transfer Credits

As a member of the Michigan Coalition for Engineering Education (MCEE), MSU will accept up to one less than half of the course credits required for the Master of Science degree program in the College of Engineering in transfer from other MCEE member institutions provided that (1) the student earned a grade of at least 3.0, or the equivalent, in the related courses; (2) the credits were not earned in research or thesis courses; and (3) the total number of credits accepted in transfer from MCEE member institutions and from other institutions does not exceed one less than half of the credits required.

Doctor of Philosophy

In addition to meeting the requirements of the University as described in the Graduate Education section of this catalog, students must meet the requirements specified below.

Admission

Regular Status. Admission to a doctoral degree program with regular status may be granted by the department, subject to the availability of resources and to the approval of the dean, upon consideration of the likelihood that the applicant will be able to pursue a doctoral program successfully without taking collateral courses. As evidence of eligibility for admission, the student may offer any of the following:

- a. The possession of a master's degree in engineering or a related field.
- b. The completion of the equivalent of a master's degree program in the major field.
- c. Evidence of ability and resolution to complete a doctoral program, as attested by the department upon review of the applicant's academic record, test scores, experience, reference statements, professional qualifications, proposed studies, and other relevant information.

Admission to the doctoral program without a master's degree, or the equivalent thereof, will require special consideration by the department and the dean.

Provisional Status. Admission to a doctoral degree program with provisional status may be granted by the department, subject to the approval of the dean:

- a. To an applicant qualified for regular admission except that collateral courses are deemed necessary, or
- b. To an applicant whose record is incomplete.

If collateral courses are required, the minimum acceptable grades and the semesters by which those courses must be completed will be specified on the admission form. The provisional status will be changed to regular status when the conditions specified on the admission form have been met, as determined by the department and approved by the dean.

Guidance Committee

The student's guidance committee is appointed by the department chairperson in consultation with the student and the appropriate faculty members, and with the approval of the dean. At least two members of the guidance committee shall be from the major department and at least one member shall be from a department outside of the college. The chairperson of the

guidance committee will be appointed by the department chairperson after consultation with the student and the person recommended to chair the committee.

Guidance Committee Report

The student's program of study shall be submitted for approval to the department and to the Dean by no later than the end of the student's second semester of enrollment in the doctoral program. For any independent study or selected topics course that is included in the student's program of study, the subject material and the instructor must be specified.

The student's program of study must be approved in order for the student to continue to enroll in the doctoral degree program beyond the second semester.

Modification of Program

With reference to the student's approved guidance committee report, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass–No Grade, or Credit–No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF–Deferred marker.
3. Adding or deleting a course which the student dropped after the middle of the semester and for which “W” or “N” or “0.0” was designated.
4. Adding or deleting a course during the final semester of enrollment in the doctoral degree program.

Requirements for the Doctor of Philosophy Degree

The student must:

1. Pass the qualifying examination administered by the student's department. It is the student's responsibility to obtain detailed information about this examination from the department.
2. Pass the doctoral comprehensive examination at least six months prior to the final oral examination in defense of the dissertation. The examination may be retaken no more than twice. It is the student's responsibility to obtain detailed information about this examination from the department.
3. Provide to the major professor and to the department a hard-bound copy of the dissertation made from the original unbound manuscript submitted to the Office of the Graduate School. Arrangements for delivery of the copies shall be made when the original manuscript is submitted to the Office of The Graduate School.

Academic Standards

1. **Grades.** The student must earn a grade of 2.0 or higher in each course in the approved guidance committee report, including collateral courses and courses accepted in transfer. The student must repeat any course for which the grade earned was below 2.0.
2. **Cumulative Grade-Point Average.** The student must maintain a cumulative grade-point average of at least 3.00 in courses in the approved guidance committee report, with the exception of collateral courses and courses accepted in transfer.
3. **Deferred Grades.** A student may accumulate no more than 3 deferred grades (identified by the DF–Deferred marker) in courses other than those courses the primary focus of which is independent study.

4. *Probational Status.* A student is placed on probational status if either or both of the following conditions apply:
 - a. The student's cumulative grade–point average for the courses in the approved guidance committee report is below 3.00.
 - b. The student has accumulated more than three deferred grades (identified by the DF–Deferred marker) in courses other than those courses the primary focus of which is independent study.

A student in probational status is not allowed to carry more than 7 credits per semester or to enroll in any course the primary focus of which is independent study.

5. *Retention In and Dismissal From the Program.*
 - a. *Cumulative Grade–point Average.* Should a student's cumulative grade–point average fall below 3.00 after having completed half of the courses in the approved guidance committee report, the student may be enrolled in probational status in the doctoral degree program for one additional semester. If at the end of the additional semester the student's cumulative grade–point average is 3.00 or higher, the student may continue to enroll in the doctoral degree program. If at the end of the additional semester the student's cumulative grade–point average is still below 3.00, the student will be dismissed from the program.
 - b. *Deferred Grades.* Should a student accumulate more than 3 deferred grades (identified by the DF–Deferred marker) in courses other than those courses the primary focus of which is independent study, the student may be enrolled on probational status in the doctoral degree program for one additional semester. If at the end of the additional semester the student has no more than 3 deferred grades, the student may continue to enroll in the doctoral degree program. If at the end of the additional semester the student still has more than 3 deferred grades, the student will be dismissed from the program.
 - c. *Academic Progress and Professional Potential.* Each student's academic progress and professional potential are evaluated by March 15 of each year. A student who in the judgment of the faculty is making satisfactory academic progress and has professional potential may continue to enroll in the doctoral degree program. A student who in the judgment of the faculty is not making satisfactory academic progress or lacks professional potential will be dismissed from the program.

GRADUATE SPECIALIZATION IN ENVIRONMENTAL TOXICOLOGY

The College of Engineering, the College of Agriculture and Natural Resources, and the College of Natural Science administer the graduate specialization in environmental toxicology. The College of Agriculture and Natural Resources is the primary administrative unit. For additional information, refer to the *Graduate Specialization in Environmental Toxicology* statement in the *College of Agriculture and Natural Resources* section of this catalog.

DEPARTMENT of AGRICULTURAL ENGINEERING

Ajit Srivastava, Chairperson

The Department of Agricultural Engineering is administered jointly by the College of Engineering and the College of Agriculture and Natural Resources.

UNDERGRADUATE PROGRAM

The department offers a Bachelor of Science degree program with a major in biosystems engineering through the College of Engineering. That program is described below.

The department also offers a Bachelor of Science degree program with a major in building construction management through the College of Agriculture and Natural Resources. For information about that program, refer to the statement on the *Department of Agricultural Engineering* in the *College of Agriculture and Natural Resources* section of this catalog.

Students who are enrolled in the Bachelor of Science degree program with a major in biosystems engineering may elect a specialization in agricultural and natural resources biotechnology. For additional information, refer to the *Specialization in Agricultural and Natural Resources Biotechnology* statement in the *College of Agriculture and Natural Resources* section of this catalog.

BIOSYSTEMS ENGINEERING

Bachelor of Science

The biosystems engineering program is for students who are interested in designing and managing complex biosystems. The program emphasizes the search for sustainable solutions to problems related to the production and processing of food, efficient use of natural resources, and protection of the environment. The biosystems engineering program integrates the basic sciences of biology, chemistry, mathematics, and physics with engineering and systems sciences and engineering design.

Biosystems engineers are employed in companies that design and manufacture equipment to make food and biologically-based products; in government agencies that protect the environment and food supply; and in consulting firms in the areas of waste management, water quality control, and bioprocess engineering.

Requirements for the Bachelor of Science Degree in Biosystems Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Biosystems Engineering.

The University's Tier II writing requirement for the Biosystems Engineering major is met by completing Biosystems Engineering 487. That course is referenced in item 3. a below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.
2. The requirements of the College of Engineering for the Bachelor of Science degree.

The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.

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Department of Agricultural Engineering

3. The following requirements for the major:		CREDITS
a.	All of the following courses:	39
	BE 230 Principles of Biosystems Engineering	3
	BE 232 Food Production and Processing System	1
	BE 331 Machinery Principles in Biosystems Engineering	3
	BE 333 Biosystems Engineering Laboratory	1
	BE 350 Heat and Mass Transfer in Biosystems	3
	BE 351 Environmental Thermodynamics	3
	BE 486 Biosystems Design Fundamentals	3
	BE 487 Biosystems Design Project (W)	3
	CE 321 Introduction to Fluid Mechanics	4
	CEM 143 Survey of Organic Chemistry	4
	CEM 161 Chemistry Laboratory I	1
	EC 210 Economic Principles Using Calculus	3
	ECE 345 Electronic Instrumentation and Systems	3
	MSM 206 Introduction to Solid Mechanics	4
b.	Three of the following courses:	9
	BE 430 Power and Control Hydraulics	3
	BE 431 Resource Optimization	3
	BE 438 Design and Machinery Structures	3
	BE 453 Engineering Principles of the Plant Environment	3
	BE 456 Electric Power and Control	3
	BE 457 Postharvest Engineering	3
	BE 477 Food Engineering	3
	BE 481 Agricultural and Small Watershed Hydrology	3
c.	Engineering Electives ²	6
	The student must complete a minimum of 6 credits of approved courses.	
d.	Cognate. ²	15
	The student must complete a minimum of 15 credits in an approved cognate that includes courses in the College of Agriculture and Natural Resources, in the College of Engineering, or in the biological science areas of the College of Natural Science.	

¹ Chemistry 251 may be used as a substitute for Chemistry 143.
² The courses that are used to satisfy the Engineering Electives requirement and the Cognate requirement must be chosen to form a career objective. Those courses must be approved by the student's academic adviser.

GRADUATE STUDY

The department offers Master of Science and Doctor of Philosophy programs in biosystems engineering through the College of Agriculture and Natural Resources. For information about those programs, refer to the statement on the *Department of Agricultural Engineering* in the *College of Agriculture and Natural Resources* section of this catalog.

**DEPARTMENT of
CHEMICAL ENGINEERING**

Bruce E. Dale, Chairperson

UNDERGRADUATE PROGRAM

Chemical engineers convert raw materials to finished products via pathways involving both chemical and physical changes. The principles of mass, energy, and momentum conservation, chemical reactions, thermodynamics, and economics are utilized in designing and operating large-scale manufacturing processes. These principles are in turn based on the sciences of chemistry, physics, mathematics, and biology which form the underlying foundation of the discipline.

The work of the chemical engineer may be in the production of chemicals, plastics, petroleum products, pharmaceuticals, textiles, foods, energy, specialty materials of construction, and other products. Within these areas, chemical engineers work in research and development and in design, construction, and operation of equipment, processes, and manufacturing plants.

Principles developed in the chemical engineering curriculum also prepare the student for a wide variety of alternate career choices including medicine, law, business, and education.

In the past several years, there has been increasing interest in the application of chemical engineering principles to biological processes and to the production of high-strength materials. In response to this, the Department offers special course sequences that address these topics from a chemical engineering viewpoint.

**Requirements for the Bachelor of Science Degree
in Chemical Engineering**

- The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Chemical Engineering. The University's Tier II writing requirement for the Chemical Engineering major is met by completing Chemical Engineering 316 and 433. Those courses are referenced in item 3. b. below.
- Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.
- The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.

3. The following requirements for the major:		CREDITS
a.	All of the following courses:	63
	CEM 151 General and Descriptive Chemistry	4
	CEM 152 Principles of Chemistry	3
	CEM 161 Chemistry Laboratory I	1
	CEM 162 Chemistry Laboratory II	1
	CEM 351 Organic Chemistry I	3
	CEM 352 Organic Chemistry II	3
	CEM 355 Organic Laboratory I	2
	CEM 361 Analytical-Physical Chemistry I	3
	CEM 362 Analytical-Physical Chemistry II	3
	CHE 201 Material and Energy Balances	3
	CHE 301 Chemical Engineering as a Profession	1
	CHE 311 Fluid Flow and Heat Transfer	4
	CHE 312 Mass Transfer and Separations	4
	CHE 316 Unit Operations Laboratory	3
	CHE 321 Thermodynamics for Chemical Engineering	4
	CHE 422 Transport Phenomena	3
	CHE 431 Chemical Reaction Engineering	3
	CHE 432 Process Dynamics and Control	3
	CHE 433 Process Design and Optimization I	4
	CHE 434 Process Design and Optimization II	2
	CHE 473 Chemical Engineering Principles in Polymers and Material Systems	3
	ECE 345 Electronic Instrumentation and Systems	3
	STT 351 Probability and Statistics for Engineering	3
b.	One of the following courses:	3
	CHE 472 Composite Materials Processing	3
	CHE 481 Biochemical Engineering	3
c.	One of the following courses:	3 or 4
	BS 111 Cells and Molecules	3
	MIC 205 Allied Health Microbiology	3
	MIC 301 Introductory Microbiology	3
	PSL 250 Introductory Physiology	4
d.	At least 3 credits in an Engineering Science course.	3
e.	Electives.	

NOTE: Elective courses must be taken at the 200 level or higher, unless prerequisites for higher level courses are required for the major in which they are offered.

Options in Chemical Engineering

In response to increasing interest in the application of chemical engineering principles to related fields, the Department of Chemical Engineering offers options in biochemical engineering, food science, and environmental engineering to students wishing an area of specialization in the degree. Options are available to, but not required of, any student enrolled in the Bachelor of Science degree program in chemical engineering.

NOTE: Completing the Bachelor of Science degree in chemical engineering with an option may require more than 128 credits.

Biochemical Engineering Option

To earn a Bachelor of Science degree in Chemical Engineering with a biochemical engineering option, students must complete requirement 3. a. above and the following:

<i>All of the following courses:</i>		13
BCH 401	Basic Biochemistry	4
BS 111	Cells and Molecules	3
CHE 481	Biochemical Engineering	3
MIC 301	Introductory Microbiology	3
<i>One of the following courses:</i>		3
CHE 491	Selected Topics in Chemical Engineering	3
CHE 882	Advanced Biochemical Engineering	3

Environmental Option

To earn a Bachelor of Science degree in Chemical Engineering with an environmental option, the student must complete requirement 3. a. above and the following:

<i>All of the following courses:</i>		15
CE 280	Introduction to Environmental Engineering	3
CE 483	Water and Wastewater Treatment	3
CE 485	Solid and Hazardous Waste Management	3
CHE 481	Biochemical Engineering	3
MIC 205	Allied Health Microbiology	3
<i>One of the following courses:</i>		3
CE 481	Environmental Engineering Chemistry	3
CE 487	Microbiology for Environmental Health Engineering	3

Food Science Option

To earn a Bachelor of Science degree in Chemical Engineering with a food science option, students must complete requirements 3. a. and 3. b. above and all of the following:

<i>All of the following courses:</i>		15
BE 477	Food Engineering	3
FSC 401	Food Chemistry	3
FSC 421	Food Laws and Regulations	3
FSC 440	Food Microbiology	3
MIC 205	Allied Health Microbiology	3

Upon completion of the required courses for one of these options, the student should contact the Department of Chemical Engineering and request certification for the completion of the option. After the certification is approved by the chairperson of the department and the Dean of the College of Engineering, the Office of the Registrar will enter on the student's academic record the name of the option and the date that it was completed. This certification will appear on the student's transcript.

GRADUATE STUDY

The Department of Chemical Engineering offers Master of Science and Doctor of Philosophy degree programs in chemical engineering. The department also offers a Doctor of Philosophy degree program in chemical engineering—environmental toxicology.

Students who are enrolled in the Doctor of Philosophy degree program with a major in chemical engineering may elect a specialization in biotechnology. For additional information, refer to the statement on the specialization in the *College of Natural Science* section of this catalog.

CHEMICAL ENGINEERING

Emphasis in the graduate programs in chemical engineering is placed upon a fundamental approach to chemical engineering principles and the applications of chemistry and advanced mathematics. Selected topics in chemical engineering are developed from a fundamental viewpoint, with opportunity for study and research in such areas as process analysis, chemical engineering thermodynamics, chemical reaction engineering, composite materials, polymers, heat transfer, mass transfer, distillation, absorption, extraction, transport phenomena, diffusion, and biochemical engineering.

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant for admission to the master's degree program in chemical engineering must hold a bachelor's degree in chemical engineering or a related field and must have a grade-point average that would indicate success in graduate study.

International applicants must submit their scores on the Graduate Record Examination General Test.

Students who are admitted to the program with a bachelor's degree in a field related to chemical engineering will be required to complete the following collateral courses, in addition to the courses that are required for the master's degree:

	CREDITS
CHE 432 Process Systems Control	3
CHE 433 Process Design and Optimization I	3
CHE 804 Thermodynamics and Kinetics in Chemical Engineering	3
CHE 805 Transport and Separation Processes	3

Equivalent undergraduate-level chemical engineering courses may be substituted for Chemical Engineering 804 and 805.

Requirements for the Master of Science Degree in Chemical Engineering

The students must complete a total of 30 credits for the degree under Plan A (with thesis) or a total of 36 credits for the degree under Plan B (without thesis), and meet the requirements specified below:

Requirements for Both Plan A and Plan B:

	CREDITS
1. <i>Core Courses.</i> All of the following courses:	15
CHE 801 Advanced Chemical Engineering Calculations	3
CHE 821 Advanced Chemical Engineering Thermodynamics	3
CHE 822 Transport Phenomena	3
CHE 831 Advanced Chemical Reaction Engineering	3
CHE 892 Seminar	3
2. <i>Supporting Courses.</i> Six credits in courses outside the Department of Chemical Engineering approved by the student's academic adviser. This requirement is waived for those students who are admitted to the master's degree program with a bachelor's degree in a discipline related to chemical engineering.	6

Additional Requirements for Plan B

Six to 9 credits in a coordinated technical minor.

Doctor of Philosophy

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant for admission to the Ph.D. degree program in chemical engineering must hold a bachelor's or master's degree in chemical engineering or a related field and must have a grade-point average that would indicate success in graduate study.

International applicants must submit their scores on the Graduate Record Examination General Test.

Requirements for the Doctor of Philosophy Degree in Chemical Engineering

The guidance committee report must be proposed by the student and approved by the student's major professor, the stu-

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dent's guidance committee, the chairperson of the Department of Chemical Engineering, and the Dean of the College of Engineering.

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified by their guidance committees.

**CHEMICAL ENGINEERING—
 ENVIRONMENTAL TOXICOLOGY**

Doctor of Philosophy

For information about the Doctor of Philosophy degree program in chemical engineering—environmental toxicology, refer to the statement on *Multidepartmental Doctoral Programs in Environmental Toxicology* in the *Graduate Education* section of this catalog.

**DEPARTMENT of
 CIVIL and ENVIRONMENTAL
 ENGINEERING**

Ronald S. Harichandran, Chairperson

UNDERGRADUATE PROGRAM

The civil engineering major is designed to provide graduates with a broad understanding of the physical factors involved in the planning, design, and operation of public and private facilities.

The bachelor's degree program in civil engineering is oriented to the application of engineering principles to several areas of specialization, including transportation, structures, geotechnical engineering, environmental engineering, water resources, and pavements and materials. An Environmental Engineering Option is available as an elective to students in the program.

**Requirements for the Bachelor of Science Degree
 in Civil Engineering**

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Civil Engineering.

The University's Tier II writing requirement for the Civil Engineering major is met by completing Civil Engineering 312 and 321. Those courses are referenced in item 3. a. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

2. The requirements of the College of Engineering for the Bachelor of Science degree.

The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.

3. The following requirements for the major:

a.	All of the following courses:	CREDITS	33
	CE 280 Introduction to Environmental Engineering	3	
	CE 305 Structural Analysis	3	
	CE 312 Soil Mechanics	3	
	CE 321 Introduction to Fluid Mechanics	4	
	CE 337 Civil Engineering Materials I ¹	4	
	CE 341 Transportation Engineering ¹	3	
	CEM 161 Chemistry Laboratory I	1	
	MSM 205 Statics	3	
	MSM 211 Mechanics of Deformable Solids	3	

	MSM 306 Dynamics	3	
	STT 351 Probability and Statistics for Engineers	3	
b.	One of the following courses:	3	3
	BE 351 Environmental Thermodynamics ^{2,3}	3	
	ECE 345 Electronic Instrumentation and Systems ³	3	
	ME 201 Thermodynamics ^{2,3}	3	
c.	One of the following course:	3 or 4	3 or 4
	BE 351 Environmental Thermodynamics ^{2,3}	3	
	CE 271 Engineering Surveying	4	
	CE 400 Structural Mechanics	3	
	ECE 345 Electronic Instrumentation and Systems ³	3	
	ME 201 Thermodynamics ^{2,3}	3	
	MSM 250 Materials Science and Engineering	3	
d.	A minimum of 16 design credits from the following courses:	16	
	CE 405 Design of Steel Structures	3	
	CE 406 Design of Concrete Structures	3	
	CE 418 Geotechnical Engineering	4	
	CE 421 Engineering Hydrology ²	3	
	CE 422 Applied Hydraulics ²	3	
	CE 431 Pavement Design and Analysis I	4	
	CE 442 Airport Planning and Design	3	
	CE 443 Advanced Airport Systems Design	3	
	CE 448 Transportation Planning	3	
	CE 449 Highway Design	4	
	CE 483 Water and Wastewater Treatment ²	3	
	CE 485 Solid and Hazardous Waste Management ²	3	
	CE 490 Independent Study	1 to 3	
	CE 491 Civil Engineering Design Project	3	

¹ For students who complete the Environmental Engineering Option, this requirement is waived.

² This course may be used to satisfy both the requirements for the Bachelor of Science degree with a major in Civil Engineering and the requirements for the Environmental Engineering Option.

³ This course may be used to satisfy either the requirement referenced in item 3.b. or the requirement referenced in item 3. c., but not both of those requirements.

Environmental Engineering Option¹

The environmental engineering option is available to students who are enrolled in the Bachelor of Science degree program in civil engineering. Students who elect this option must complete the following courses:

		CREDITS	
1.	All of the following courses:	12	
	CE 483 Water and Wastewater Treatment ²	3	
	CE 485 Solid and Hazardous Waste Management ²	3	
	CEM 361 Analytical-Physical Chemistry I	3	
	CHE 201 Material and Energy Balances	3	
2.	One of the following courses:	3 or 4	
	BE 351 Environmental Thermodynamics ²	3	
	CHE 321 Thermodynamics for Chemical Engineering	4	
	ME 201 Thermodynamics ²	3	
3.	One of the following courses:	3	
	CE 421 Engineering Hydrology ²	3	
	CE 422 Applied Hydraulics ²	3	
4.	One of the following courses:	3	
	CEM 142 General and Inorganic Chemistry	3	
	CEM 152 Principles of Chemistry	3	
5.	One of the following courses:	3	
	CEM 251 Organic Chemistry I	3	
	CEM 351 Organic Chemistry I	3	
6.	One of the following groups of courses:	3 or 4	
a.	CE 480 Water and Wastewater Analysis Laboratory	1	
	CE 481 Environmental Engineering Chemistry	3	
b.	CE 487 Microbiology for Environmental Health Engineering	3	

¹ For students who satisfy the requirements for the Environmental Engineering option, 3 of the credits that are required for the option may also be used to satisfy the 3 credits in engineering science that are required for the Bachelor of Science degree with a major in Civil Engineering.

² This course may be used to satisfy both the requirements for the Environmental Engineering Option and the requirements for the Bachelor of Science degree with a major in Civil Engineering.

Upon completion of the required courses, the student should contact the Department of Civil and Environmental Engineering and request certification for the completion of the Environmental Engineering Option. After the certification is approved by the chairperson of the department and the Dean of the College of Engineering, the Office of the Registrar will enter on the student's academic record the name of the option and the date that it was completed. This certification will appear on the student's transcript.

GRADUATE STUDY

The Department of Civil and Environmental Engineering offers the graduate degree programs that are listed below:

Master of Science

- Civil Engineering
- Civil Engineering—Urban Studies
- Environmental Engineering
- Environmental Engineering—Urban Studies

Doctor of Philosophy

- Civil Engineering
- Civil Engineering—Environmental Toxicology
- Environmental Engineering
- Environmental Engineering—Environmental Toxicology

Descriptions of the degree programs, organized by fields of study in alphabetical order, are presented below.

Students who are enrolled in Master of Science degree programs in the Department of Civil and Environmental Engineering may elect a specialization in environmental toxicology. For additional information, refer to the *Graduate Specialization in Environmental Toxicology* statement in the *College of Agriculture and Natural Resources* section of this catalog.

CIVIL ENGINEERING

Students in the master's and doctoral degree programs in civil engineering may pursue advanced study in the areas of structures, fluid mechanics and hydraulics, geotechnical engineering, pavements, and transportation.

Master of Science

The student plans a program of study with the help of his or her academic adviser and subject to the approval of the adviser.

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant for admission to the master's degree program in civil engineering should have a bachelor's degree in civil engineering or a related field and should have a grade-point average that would indicate success in graduate study. Examples of fields that are related to civil engineering are other engineering professional fields, physics, computer science, urban planning, and chemistry.

Depending on their undergraduate programs and their specialties within civil engineering, students who are admitted to the master's degree program with bachelor's degrees in fields related to civil engineering may be required to complete collateral courses.

All applicants are encouraged to submit their scores from the Graduate Record Examination General Test.

Requirements for the Master of Science Degree in Civil Engineering

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis).

A student under Plan A must complete at least 4, but not more than 8, credits of Civil Engineering 899. Should the student complete more than 8 credits of Civil Engineering 899, no

more than 8 credits may be counted toward the requirements for the degree.

A student under Plan B may choose to complete a research project or a design project as part of the 30 credits required for the degree. A student who elects either of these options must complete at least 1, but not more than 3, credits of Civil Engineering 892 or at least 3, but not more than 5, credits of Civil Engineering 893.

Doctor of Philosophy

Admission

All applicants are encouraged to submit their scores from the Graduate Record Examination General Test.

Requirements for the Doctor of Philosophy Degree in Civil Engineering

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified by their guidance committees.

CIVIL ENGINEERING— ENVIRONMENTAL TOXICOLOGY

Doctor of Philosophy

For information about the Doctor of Philosophy degree program in civil engineering—environmental toxicology, refer to the statement on *Multidepartmental Doctoral Programs in Environmental Toxicology* in the *Graduate Education* section of this catalog.

CIVIL ENGINEERING—URBAN STUDIES

The Department of Civil and Environmental Engineering offers an interdepartmental Master of Science degree program in civil engineering—urban studies.

Admission

To be admitted to the major in civil engineering—urban studies, students must meet the requirements for admission to the Master of Science degree program with a major in civil engineering. They must also meet the requirements for admission as specified in the statement on *Interdepartmental Graduate Programs in Urban Studies* in the *Graduate Education* section of this catalog.

Requirements for the Master of Science Degree in Civil Engineering—Urban Studies

Students who are admitted to the major in civil engineering—urban studies must meet the requirements for the major in civil engineering leading to the Master of Science degree. They must also meet the requirements for the urban studies component of the program as specified in the statement on *Interdepartmental Graduate Programs in Urban Studies*.

ENVIRONMENTAL ENGINEERING

Students in the master's and doctoral degree programs in environmental engineering may pursue advanced study in the areas of biological and chemical treatment of hazardous substances in soils, leachates, industrial wastes, and groundwa-

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ter; the fate and movement of chemical contaminants in surface water, groundwater, and soils; and environmental chemistry.

Master of Science

The student plans a program of study with the help of his or her academic adviser and subject to the approval of the adviser.

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

Applicants for admission are expected to have a level of competency equivalent to that achieved by earning an undergraduate degree in environmental engineering, or in civil engineering with an environmental engineering specialization. The undergraduate program should have included courses in mathematics through differential equations, chemistry, physics (mechanics), fluid mechanics, computer programming, and the design of water and wastewater treatment processes.

Depending on their undergraduate programs and their specialties within environmental engineering, students who are admitted to the master's degree program with bachelor's degrees in fields related to environmental engineering may be required to complete collateral courses.

All applicants are encouraged to provide their scores from the Graduate Record Examination General Test.

Requirements for the Master of Science Degree in Environmental Engineering

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis).

A student under Plan A must complete at least 4, but not more than 8, credits of Environmental Engineering 899. Should the student complete more than 8 credits of Environmental Engineering 899, no more than 8 credits may be counted toward the requirements for the degree.

A student under Plan B may choose to complete a research project or a design project as part of the 30 credits required for the degree. A student who elects either of these options must complete at least 1, but not more than 3, credits of Environmental Engineering 892 or at least 3, but not more than 5, credits of Environmental Engineering 893.

Doctor of Philosophy

Admission

All applicants are encouraged to submit their scores from the Graduate Record Examination General Test.

Requirements for the Doctor of Philosophy Degree in Environmental Engineering

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified by their guidance committees.

ENVIRONMENTAL ENGINEERING— ENVIRONMENTAL TOXICOLOGY

Doctor of Philosophy

For information about the Doctor of Philosophy degree program in environmental engineering—environmental toxicology, refer to the statement on *Multidepartmental Doctoral Programs in Environmental Toxicology* in the *Graduate Education* section of this catalog.

ENVIRONMENTAL ENGINEERING— URBAN STUDIES

The Department of Civil and Environmental Engineering offers an interdepartmental Master of Science degree program in environmental engineering—urban studies. Both Plan A (with thesis) and Plan B (without thesis) are available. A minimum of 36 credits is required for the degree under Plan B.

Admission

To be admitted to the major in environmental engineering—urban studies, students must meet the requirements for admission to the Master of Science degree program with a major in environmental engineering. They must also meet the requirements for admission as specified in the statement on *Interdepartmental Graduate Programs in Urban Studies* in the *Graduate Education* section of this catalog.

Requirements for the Master of Science Degree in Environmental Engineering—Urban Studies

Students who are admitted to the major in environmental engineering—urban studies must meet the requirements for the major in environmental engineering leading to the Master of Science degree. They must also meet the requirements for the urban studies component of the program as specified in the statement on *Interdepartmental Graduate Programs in Urban Studies*.

DEPARTMENT of COMPUTER SCIENCE and ENGINEERING

George C. Stockman, Acting Chairperson

UNDERGRADUATE PROGRAM

Computer science studies the broad areas of communication, processing and display of information via computers. Computer science graduates are employed in essentially all areas of industry, government and education. They serve as systems analysts, involved with problems in business, social and/or scientific research and development; designers and planners of process and production control software systems; computer component and systems designers; programmers and teachers.

The early work in the major centers around the digital computer, its organization and basic operation. By the end of the junior year several programming languages will have been

studied and used extensively. These include high-level languages from various paradigms, as well as machine and assembly language. The final year is devoted primarily to studies of the design of language processors, database systems, software design or intelligent systems and to various aspects of digital architecture and digital communications systems. The total program is designed to provide the necessary foundation for either continued study at the graduate level or for productive work in business and industry, government, or research. Complementing these major areas, the cognate provides an excellent opportunity for development of an individually selected area of interest.

Students majoring in computer science with interests in other areas have the opportunity to consult and work with interested faculty from a wide range of academic disciplines.

Requirements for the Bachelor of Science Degree in Computer Science

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 120 credits, including general elective credits, are required for the Bachelor of Science degree in Computer Science.
 The University's Tier II writing requirement for the Computer Science major is met by completing Computer Science and Engineering 498, referenced in item 3. a. below.
 Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement.
2. The requirements of the College of Engineering for the Bachelor of Science degree.
 The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

CREDITS

a.	Bioscience - Courses may not be used to satisfy both (1) and (2) below	5 to 10
	(1) <i>One of the following courses:</i>	
	BOT 105 Plant Biology	3
	BS 110 Organisms and Populations	4
	BS 111 Cells and Molecules	3
	ENT 205 Pests, Society and Environment	3
	MIC 205 Allied Health Microbiology	3
	PSL 250 Introductory Physiology	4
	ZOL 141 Introductory Human Genetics	3
	(2) <i>Two of the following courses:</i>	
	BOT 106 Plant Biology Laboratory	1
	BS 110 Organisms and Populations	4
	BS 111L Cell and Molecular Biology Laboratory	2
	CEM 161 Chemistry Laboratory I	1
	CEM 162 Chemistry Laboratory II	1
	MIC 206 Allied Health Microbiology Laboratory	1
	PHY 191 Physics Laboratory for Scientists, I	1
	PHY 192 Physics Laboratory for Scientists, II	1
b.	All of the following courses:	38
	CSE 232 Introduction to Programming II	4
	CSE 260 Discrete Structures in Computer Science	4
	CSE 320 Computer Organization and Assembly Language Programming	4
	CSE 331 Algorithms and Data Structures	4
	CSE 410 Operating Systems	4
	CSE 420 Computer Architecture	4
	CSE 460 Computability and Formal Language Theory	3
	CSE 470 Software Engineering	4
	CSE 498 Collaborative Design (W)	4
	STT 351 Probability and Statistics for Engineering	3
c.	At least two of the following courses:	6 to 8
	CSE 422 Computer Networks	4
	CSE 440 Artificial Intelligence and Symbolic Programming	4
	CSE 450 Translation of Programming Languages	4
	CSE 452 Organization of Programming Languages	4
	CSE 471 Media Processing and Multimedia Computing	4
	CSE 472 Computer Graphics	4
	CSE 480 Database Systems	4
	MTH 416 Introduction to Algebraic Coding	3
	MTH 451 Numerical Analysis I	3
	MTH 481 Discrete Mathematics I	3
d.	Required Cognate:	12
	A minimum of four courses totaling 12 or more credits outside the College of Engineering.	
	Option A: At least 6 of the 12 credits must be in courses at the 300-400 level.	
	Option B: A four course sequence in a foreign language.	
	Option C: The Eli Broad College of Business	
	<i>Both of the following courses:</i>	
	ACC 230 Survey of Accounting Concepts	3

EC	210 Economics Principles Using Calculus	3
	<i>Two of the following courses:</i>	
	FI 320 Introduction to Finance	3
	GBL 323 Introduction to Business Law	3
	MSC 327 Introduction to Marketing	3

Both the cognate and the related courses must be approved by the academic adviser of the Department of Computer Science and Engineering. The cognate should enhance the student's ability to apply analytic procedures in a specific subject area. Cognates in the following areas are available to students in Computer Science: business, communication arts, foreign language, mathematics, the natural sciences, philosophy, psychology, the social sciences, and telecommunication. Students may complete cognates in other areas with the approval of the Department of Computer Science and Engineering academic adviser.

TEACHER CERTIFICATION OPTION

A computer science disciplinary minor is available for teacher certification.

Students who elect the computer science disciplinary minor must contact the Department of Computer Science and Engineering.

For additional information, refer to the statement on *TEACHER CERTIFICATION* in the *Department of Teacher Education* section of this catalog.

GRADUATE STUDY

The Department of Computer Science and Engineering offers programs leading to the Master of Science and Doctor of Philosophy degrees. Advanced study is available in the areas of computer architecture, design automation, distributed systems, computer networks, artificial intelligence, knowledge-based systems, database systems, parallel systems and algorithms, pattern recognition, image processing, computer vision, software engineering, and theory of computing. Interdisciplinary work with other departments is encouraged.

The Department operates a number of different laboratories with a variety of modern computing equipment. The Artificial Intelligence and Knowledge Based Systems Laboratory is supported by Sun and Macintosh workstations. The Pattern Recognition and Image Processing Laboratory provides multiple systems for digitizing and processing both intensity and range images and provides a workstation environment for users. The Advanced Computing Systems Laboratory supports a 640 node nCUBE parallel processor, a 96-node BBN Butterfly GP-1000 parallel processor, and access to an array of other parallel machines at the Advanced Computer Research Facility of Argonne National Laboratory.

The instructional laboratories include a digital system simulation laboratory for the design and modeling of digital circuits, as well as several open laboratories equipped with networked workstations and terminals. All computer science graduate students have a permanent email address. Via computer networks, students can keep in contact with colleagues, research groups, data bases, and agencies throughout the world. Other college and university resources include the Case Center for Computer-Aided Design and Manufacturing, the Electronics Research and Development Laboratory for VLSI design, an IBM 3090/180E vector processor, and a quad processor Convex C-240 system.

Students who are enrolled in master's or doctoral degree programs in the Department of Computer Science and Engineering may elect an interdepartmental specialization in cognitive science. For additional information, refer to the statement on *Interdepartmental Graduate Specializations in Cognitive Science* in the *College of Social Science* section of this catalog. For additional information, contact the Department of Computer Science and Engineering.

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

Applicants for admission should possess a bachelor's degree in computer science or a related field such as mathematics, physics, or electrical engineering. All applicants must submit their scores from the Graduate Record Examination (GRE) General Test. They must also submit their scores from the GRE Subject Test in Computer Science or a closely related field.

Requirements for the Master of Science Degree in Computer Science

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis) and meet the requirements specified below:

Requirements for Both Plan A and Plan B:

The student must complete:

1. At least one semester of a graduate seminar.
2. A minimum of 20 credits in 800–900 level courses, excluding Computer Science and Engineering 890.

Additional Requirements for Plan A:

The student must complete:

1. At least *one* course from *each* of the following groups of courses:
 - a. Computer Science and Engineering 802, 803, 841. Computer Science and Engineering 845 and 846 combined may be substituted for one of those courses.
 - b. Computer Science and Engineering 807, 808, 814, 880.
 - c. Computer Science and Engineering 812, 820, 822, 838.
 - d. Computer Science and Engineering 830, 835, 860, 862.
2. At least 6, but not more than 8, credits of CSE 899 Master's Thesis Research.

Additional Requirements for Plan B:

The student must complete *one* of the following two options:

Option 1:

A minimum of 30 credits in courses approved by the student's academic adviser.

Option 2:

- a. At least *one* course from *each* of the following groups of courses:
 - (1) Computer Science and Engineering 802, 803, 841. Computer Science and Engineering 845 and 846 combined may be substituted for one of those courses.
 - (2) Computer Science and Engineering 807, 808, 814, 880.
 - (3) Computer Science and Engineering 812, 820, 822, 838.
 - (4) Computer Science and Engineering 830, 835, 860, 862.
- b. A supervised project while enrolled in 4 credits of Computer Science and Engineering 898.

Doctor of Philosophy

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

Applicants should be in the top 25 percent of their master's degree classes and should have a grade–point average of at least 3.50 on a scale of 4.0. For persons who are enrolled in MSU's master's degree program in computer science, their progress in the Ph.D. Qualifying Examination will also be considered.

Applicants must submit their scores on the Graduate Record Examination General Test and Subject Test in Computer Science. A score of 85 percent or higher on the Computer Science Subject Test is required for admission.

Applicants who have a Bachelor of Science degree and who demonstrate exceptional potential for graduate study may be accepted for admission to the doctoral program.

Requirements for the Doctor of Philosophy Degree in Computer Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified by their guidance committees. All courses that are used to satisfy the requirements for the degree must have been completed under the numerical grading system.

DEPARTMENT of ELECTRICAL and COMPUTER ENGINEERING

Jes Asmussen, Chairperson

UNDERGRADUATE PROGRAMS

COMPUTER ENGINEERING

Computer engineering is concerned with the organization and design of computers and computer systems. The study of computer hardware and software, and their integration and application, is emphasized. The undergraduate program in computer engineering integrates studies in mathematics, basic sciences, engineering sciences, and engineering design. The program is structured to establish analytical and design skills in areas such as computer architecture, digital logic design, computer communication networks, digital computer control, integrated circuit engineering, software engineering, operating systems, data structures and algorithms, computer–aided engineering, and electronic design automation. Complementing these fundamentals, the program also provides opportunities for specialization in individually selected areas of interest.

Requirements for the Bachelor of Science Degree in Computer Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Computer Engineering.

The University's Tier II writing requirement for the Computer Engineering major is met by completing Electrical and Computer Engineering 381 and 482. Those courses are referenced in item 3. b. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

2. The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

	CREDITS
a. One of the following courses:	1
CEM 161 Chemistry Laboratory I.	1
PHY 191 Physics Laboratory for Scientists, I.	1
b. All of the following courses:	50
CSE 231 Introduction to Programming I.	4
CSE 232 Introduction to Programming II.	4
CSE 260 Discrete Structures in Computer Science	4
CSE 410 Operating Systems	4
CSE 420 Computer Architecture	4
ECE 200 Electric Circuits.	4
ECE 230 Digital Logic Fundamentals.	3
ECE 302 Electronic Circuits.	3
ECE 303 Electronics Laboratory	1
ECE 313 Control Systems.	3
ECE 331 Microprocessors and Digital Systems.	4
ECE 360 Signals and Linear Systems.	4
ECE 381 Professionalism, Communication and Ethics (W)	1
ECE 482 Capstone: Computer Systems Design (W).	4
STT 351 Probability and Statistics for Engineering.	3
c. One of the following courses:	3
ME 201 Thermodynamics.	3
MSM 205 Statics.	3
d. One of the following three groups of courses:	8
(1) ECE 410 VLSI Design.	4
ECE 411 Electronic Design Automation	4
(2) CSE 450 Translation of Programming Languages	4
CSE 470 Software Engineering	4
(3) CSE 422 Computer Networks	4
ECE 457 Communication Systems.	3
ECE 458 Communication Systems Laboratory.	1
e. Technical electives selected from an approved list in consultation with the student's academic adviser	7 to 9

ELECTRICAL ENGINEERING

The program provides both required and elective studies in communications, computers, control systems, electromagnetics, electronics, materials processing, power, signals, solid state, and biomedical engineering. It places emphasis on the fundamentals of science and mathematics and their application to the solution of contemporary problems that are within the purview of professional electrical engineers. The program is designed to establish a sound scientific basis for continuous growth in professional competence.

Requirements for the Bachelor of Science Degree in Electrical Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Electrical Engineering. The University's Tier II writing requirement for the Electrical Engineering major is met by completing Electrical and Computer Engineering 381 and one of the following courses: Electrical Engineering 481, 482, 483, 484, or 485. Those courses are referenced in items 3. b. and 3. e. below. Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.
2. The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

	CREDITS
a. One of the following courses:	1
CEM 161 Chemistry Laboratory I.	1
PHY 191 Physics Laboratory for Scientists, I.	1
b. All of the following courses:	26
CSE 231 Introduction to Programming I.	4
ECE 200 Electric Circuits.	4
ECE 230 Digital Logic Fundamentals.	3

ECE 302 Electronic Circuits.	3	
ECE 303 Electronics Laboratory	1	
ECE 305 Electromagnetic Fields and Waves I	3	
ECE 360 Signals and Linear Systems	4	
ECE 381 Professionalism, Communication and Ethics (W)	1	
STT 351 Probability and Statistics for Engineering.	3	
c. One of the following courses:		3
ME 201 Thermodynamics.	3	
MSM 205 Statics.	3	
d. Four of the following courses:		13 or 14
ECE 306 Electromagnetic Fields and Waves II.	4	
ECE 320 Energy Conversion and Power Electronics	3	
ECE 331 Microprocessors and Digital Systems.	4	
ECE 413 Control Systems.	3	
ECE 474 Principles of Electronic Devices	3	
e. At least 9 credits in at least three of the following courses, including at least one course that has a laboratory:		9 to 12
ECE 410 VLSI Design.	4	
ECE 411 Electronic Design Automation	4	
ECE 418 Algorithms of Circuit Design	3	
ECE 421 Power System Analysis	4	
ECE 435 Electromagnetic Waves	4	
ECE 457 Communication Systems.	3	
ECE 458 Communication Systems Laboratory	1	
ECE 466 Digital Signal Processing and Filter Design	3	
ECE 476 Electro-Optics	3	
f. One of the following courses:		4
ECE 481 Capstone: Automotive Sensing and Control	4	
ECE 482 Capstone: Computer Systems Design (W)	4	
ECE 483 Capstone: Integrated Circuit Design and Fabrication (W).	4	
ECE 484 Capstone: Applications of Analog Integrated Circuits (W)	4	
ECE 485 Capstone: Digital Control and Robotics (W)	4	
g. At least 9 credits from a list of approved technical electives available from the Department of Electrical and Computer Engineering.		9

GRADUATE STUDY

The Department of Electrical and Computer Engineering offers programs leading to the Master of Science and Doctor of Philosophy degrees. Programs for advanced study are available in the areas of signal processing, communication sciences, digital circuits and computers, electromagnetics (radiation, scattering, interactions), plasmas, electronic materials and devices, electronic circuits and instrumentation, VLSI design, systems and control, power, robotics, and neural networks.

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

Applicants for admission should possess a Bachelor of Science degree in electrical engineering or a related field such as physics, mathematics, or computer science, and should have a grade-point average that would indicate success in graduate study.

Students who are admitted without a Bachelor of Science degree in electrical engineering may be required to complete collateral courses.

International applicants are required to submit Graduate Record Examination General Test scores.

Requirements for the Master of Science Degree in Electrical Engineering

The student must complete a total of 30 credits under either Plan A (with thesis) or Plan B (without thesis) and meet the requirements specified below:

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Requirements for Both Plan A and Plan B:

1. *Core Courses.* At least *one* course from at least *three* of the following six areas:
 - a. Communication and Signal Processing: Electrical and Computer Engineering 847, 863, 864.
 - b. Digital Circuits and Computers: Electrical and Computer Engineering 809, 813, 820.
 - c. Electromagnetics: Electrical and Computer Engineering 835, 836, 841, 850.
 - d. Electronic Devices and Circuits: Electrical and Computer Engineering 831, 874, 875.
 - e. Systems and Control: Electrical and Computer Engineering 826, 827, 829.
 - f. Power Systems: Electrical and Computer Engineering 823, 824, 825.
2. *Supporting Courses:* At least 6 credits in approved courses in areas such as mathematics, statistics, or physics.

Doctor of Philosophy

Admission

International applicants are required to submit Graduate Record Examination General Test scores.

Requirements for the Doctor of Philosophy Degree in Electrical Engineering

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified by their guidance committees. All courses that are used to satisfy the requirements for the degree must have been completed under the numerical grading system.

DEPARTMENT of MATERIALS SCIENCE and MECHANICS

Nicholas J. Altiero, Chairperson

UNDERGRADUATE PROGRAMS

ENGINEERING ARTS

It is the intent of the Engineering Arts major to provide educational opportunities for the undergraduate student who wishes to develop an awareness of technology and apply it to one of a broad range of nontechnical areas. The program is designed to develop an individual who is: (1) knowledgeable of the impact of technology on society; (2) capable of recognizing how analytical tools are used in the solution of problems; (3) aware of the theoretical constraints under which new developments must work; (4) able to aid in the application of these techniques to a wide range of problems; and (5) competent in a specific area of application.

This program is designed to develop a uniquely qualified individual capable of functioning in a variety of employment

contexts which are directly dependent on the application area. A few of the cross-disciplinary areas include: technical sales, technical journalism, communications, telecommunications, packaging, industrial management, production management, public administration, urban applications, environmental issues, political analysis, law, and virtually any area in which it is desirable to combine technical awareness with nontechnical fields.

Requirements for the Bachelor of Science Degree in Engineering Arts

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 120 credits, including general elective credits, are required for the Bachelor of Science degree in Engineering Arts.

The University's Tier II writing requirement for the Engineering Arts major is met by completing Electrical and Computer Engineering 345 and Materials Science and Mechanics 400. Those courses are referenced in item 3. a. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.
2. The requirements of the College of Engineering for the Bachelor of Science degree.

The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

	CREDITS
a. All of the following courses:	29
CE 280 Introduction to Environmental Engineering	3
CEM 161 Chemistry Laboratory I	1
ECE 345 Electronic Instrumentation and Systems	3
ME 201 Thermodynamics	3
MSM 160 Engineering Communications	3
MSM 205 Statics	3
MSM 211 Mechanics of Deformable Solids	3
MSM 250 Materials Science and Engineering	3
MSM 300 Technology, Society and Public Policy	2
MSM 400 System Methodology	2
STT 351 Probability and Statistics for Engineers	3
b. Cognate:	22 to 33
Cognates in Business-Supply Chain Management, Packaging, Product Design, and Telecommunication are available to majors in Engineering Arts. Students should consult with their adviser prior to their selection of a cognate. Students must select <i>one</i> of the following cognates.	
Business-Supply Chain Management	22
ACC 230 Survey of Accounting Concepts	3
EC 210 Economics Principles Using Calculus	3
FI 320 Introduction to Finance	3
GBL 323 Introduction to Business Law	3
MGT 325 Management Skills and Processes	3
MSC 303 Introduction to Supply Chain Management	3
MSC 305 Supply Chain Management	4
Packaging	30
<i>All of the following courses:</i>	
CEM 143 Survey of Organic Chemistry	4
EC 210 Economics Principles Using Calculus	3
PKG 101 Principles of Packaging	3
PKG 221 Packaging with Glass and Metal	3
PKG 370 Packaging and the Environment	3
PKG 432 Packaging Processes	4
PKG 475 Packaging Economics	3
PKG 480 Packaging Laws and Regulations	3
<i>One of the following courses:</i>	
PKG 322 Packaging with Paper and Paperboard	4
PKG 323 Packaging with Plastics	4
Product Design	33
STA 110 Drawing I	3
MSM 260 Computer Aided Design Tools	3
MSM 360 Introduction to Product Design	3
MSM 361 Computer Aided Product Design	3
MSM 401 Intermediate Mechanics of Deformable Solids	3
MSM 402 Computational Mechanics	3
MSM 445 Biomechanical Design	3
MSM 481 Manufacturing Processes (W)	3
MSM 499 Senior Research and Design Project (W)	6
Technical elective	3
Telecommunication	31
ACC 230 Survey of Accounting Concepts	3
EC 201 Introduction to Microeconomics	3
TC 100 The Information Society	3
TC 200 History and Economics of Telecommunication	4
TC 201 Introduction to Telecommunication Technology	4
TC 310 Basic Telecommunication Policy	4
TC 361 Telecommunication System and Service Policies	3
TC 463 Digital Telecommunication Networks	3
TC 465 Telecommunication Network Management (W)	4

INTEGRATED BACHELOR'S and MASTER'S DEGREE PROGRAM IN MANUFACTURING ENGINEERING and MANAGEMENT

The integrated program in manufacturing engineering and management consists of the Bachelor of Science degree program with a major in manufacturing engineering that is available through the College of Engineering and the Master of Science degree program with a major in manufacturing management that is available through The Eli Broad College of Business and The Eli Broad Graduate School of Management. A total of 158 credits is required for the two degree programs combined.

The integrated program in manufacturing engineering and management is designed to provide educational opportunities for the student who wishes to integrate a basic understanding of manufacturing engineering with solid principles of managing the manufacturing enterprise. The general objective of the program is to prepare manufacturing professionals who will view the engineering and management of manufacturing as a seamless enterprise which creates consumer goods to satisfy consumer demands while being attentive to the well-being of the enterprise and the environment. The specific goal of the program is to prepare a technology manager who is:

1. Technically capable of solving manufacturing problems.
2. Aware of the theoretical constraints under which new developments must be implemented.
3. Able to demonstrate the integration of theory and practice in the workplace.
4. Knowledgeable and able to demonstrate effective oral and written communication skills.
5. Well versed in matters of sound economic and managerial policy.
6. International in scope.

The Bachelor of Science and Master of Science degrees will be awarded simultaneously to students who complete the requirements for the integrated program. To receive a Bachelor of Science degree with a major in manufacturing engineering, the student must also complete the requirements for the Master of Science degree with a major in manufacturing management. Furthermore, to receive a Master of Science degree with a major in manufacturing management, the student must also complete the requirements for the Bachelor of Science degree with a major in manufacturing engineering.

Any undergraduate student who voluntarily withdraws from the Bachelor of Science degree program with a major in manufacturing engineering, or who is dismissed from the program for failing to meet the required academic standards, may transfer to the undergraduate major in engineering arts or in materials science and engineering if he or she is otherwise in good standing in the College of Engineering and the University. If the student has completed courses according to the program plan for students enrolled in the Bachelor of Science degree program in manufacturing engineering, normally an additional semester of course work will be needed to complete the requirements for the Bachelor of Science degree with a major in materials science and engineering.

The Bachelor of Science degree program in manufacturing engineering emphasizes the merging of the engineering design of a product with the process design for its manufacture, often referred to as concurrent (or simultaneous) engineering. The Master of Science degree program in manufacturing management builds on the bachelor's degree program.

In addition to meeting the requirements of the University for bachelor's and master's degrees, and of the College of Engineering for the Bachelor of Science degree, the student must meet the requirements specified below.

Admission

During the junior year, students who are enrolled in the Bachelor of Science degree program in manufacturing engineering are required to apply for admission to the Master of Science degree program in manufacturing management in the Broad College. To be considered for admission to the master's degree program, an applicant must take the Graduate Record Examination (GRE) General Test or GMAT and have the scores submitted to the Department of Materials Science and Mechanics.

The process of applying for admission to the master's degree program must be completed by the end of the junior year.

Admission decisions for the Master of Science degree program with a major in manufacturing management are made by the program directors appointed by the Colleges of Engineering and Business. Admission decisions are based on a review of the applicant's academic record, test scores, and any other information provided by the student. Minimal requirements for admission to the Master of Science degree program with a major in manufacturing management are as follows:

1. A cumulative grade-point average of at least 3.00 in the bachelor's degree program.
2. Strong scores on the GRE General Test or GMAT.

Admission to the master's degree program is competitive, and meeting the minimal requirements referenced above does not guarantee admission to the program.

Those students who are admitted to the Master of Science degree program with a major in manufacturing management are enrolled in that program after they have completed at least 124 credits. Following enrollment in the Master of Science degree program, the student pays graduate fees and is eligible for the privileges extended to graduate students. However, the Bachelor of Science degree is not granted until the student completes the requirements for both the Bachelor of Science degree with a major in manufacturing engineering and the Master of Science degree with a major in manufacturing management.

Requirements for the Bachelor of Science Degree in Manufacturing Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 124 credits, including general elective credits, are required for the Bachelor of Science degree in Manufacturing Engineering.

The University's Tier II writing requirement for the Manufacturing Engineering major is met by completing Materials Science and Mechanics 481 and 482. Those courses are referenced in item 3. a. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Science that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

2. The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

		CREDITS
a.	All of the following courses (52 credits):	
	CEM 161 Chemistry Laboratory I	1
	EC 210 Economics Principles Using Calculus ¹	3
	ECE 345 Electronic Instrumentation and Systems	3
	ECE 413 Control Systems	3
	ECE 415 Computer Aided Manufacturing	3
	EGR 393 Engineering Cooperative Education	3
	EGR 888 Capstone Project in Manufacturing	3
	ME 201 Thermodynamics	3
	ME 371 Mechanical Design I	3
	MSM 160 Engineering Communication	3
	MSM 205 Statics	3
	MSM 211 Mechanics of Deformable Solids	3
	MSM 250 Materials Science and Engineering	3
	MSM 306 Dynamics	3
	MSM 355 Mechanical Behavior of Materials	3
	MSM 481 Manufacturing Systems I	3

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MSM 482	Manufacturing Systems II	3
STT 351	Probability and Statistics for Engineers	3
b.	Engineering or Business Electives	9

Elective credits chosen from an approved list in consultation with the student's academic adviser.

¹ Economics 201 and 202 may be substituted for Economics 210.

Requirements for the Master of Science Degree in Manufacturing Management

Refer to the Department of Marketing and Supply Chain Management statement in *The Eli Broad College of Business and The Eli Broad Graduate School of Management* section of this catalog.

Academic Standards

Students who are enrolled in the Master of Science degree program with a major in manufacturing management must maintain:

1. A minimum grade–point average of 3.00 each semester.
2. A minimum cumulative grade–point average of 3.00.

A student who does not maintain a 3.00 grade–point average will be placed on final probation. Such a student will be given the next semester of enrollment to achieve a 3.00 grade–point average; otherwise, the student will be dismissed from the program.

MATERIALS SCIENCE and ENGINEERING

Materials science and engineering is the study of the structure and composition of materials ranging from atomic and molecular to microscopic scales. The field is concerned with development of new materials, improvement of traditional materials, and synthesis and processing of materials through an understanding of structure and composition of materials. Evaluation of material performance is another very important aspect of the field. Investigation of structure requires such techniques as optical microscopy and image analysis, x–ray diffraction, and transmission and scanning electron microscopy. Processing of materials includes traditional techniques as well as the more modern microwave, plasma, and high–energy laser processing. Performance evaluation requires mechanical testing of various kinds and mechanics of materials. Technology related to the processing and fabrication of engineered materials such as composites, super alloys for jet engines, high–temperature superconductors, and materials for microelectronics is of great national importance. Thus, materials science and engineering will continue to enjoy challenging opportunities.

Requirements for the Bachelor of Science Degree in Materials Science and Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Materials Science and Engineering.

The University's Tier II writing requirement for the Materials Science and Engineering major is met by completing Materials Science and Engineering 499. That course is referenced in item 3. a. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

2. The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
3. The following requirements for the major:

a.	All of the following courses:	CREDITS
		58

CEM 152	Principles of Chemistry	3
CEM 161	Chemistry Laboratory I	1
ECE 345	Electronic Instrumentation and Systems	3
MSM 205	Statics	3
MSM 211	Mechanics of Deformable Solids	3
MSM 250	Materials Science and Engineering	3
MSM 351	Thermochemistry of Materials	3
MSM 352	Diffusion in Solids	3
MSM 355	Mechanical Behavior of Materials	3
MSM 365	Physical Metallurgy I	3
MSM 375	Materials Science Laboratory I	1
MSM 376	Materials Science Laboratory II	1
MSM 380	Polymeric Materials	3
MSM 444	Introduction to Composite Materials	3
MSM 454	Ceramic and Refractory Materials	3
MSM 455	Theory of Solids	3
MSM 465	Design and Application of Engineering Materials	3
MSM 466	Failure Analysis	3
MSM 481	Manufacturing Systems I	3
MSM 499	Senior Research and Design Project (W)	6
PHY 192	Physics Laboratory for Scientists, II	1
b.	One of the following courses:	3
CEM 251	Organic Chemistry I	3
CEM 351	Organic Chemistry I	3
PHY 215	Thermodynamics and Modern Physics	3
c.	Option: The student must complete one of the following four options:	12
	Biomaterials Engineering	
(1)	All of the following courses (9 credits):	
BME 424	Biomaterials and Biocompatibility	3
MSM 451	X-Ray Crystallography	3
STT 351	Probability and Statistics for Engineers	3
(2)	At least 3 credits from the following courses:	
BME 441	Tissue Mechanics	3
BME 445	Biomechanical Design	3
BME 491	Special Topics (MTC)	3
MSM 442	Biodynamics	3
MSM 491	Selected Topics	1 to 3
	Mechanics of Solids	
(1)	All of the following courses (9 credits):	
MSM 401	Intermediate Mechanics of Deformable Solids	3
MSM 405	Experimental Mechanics	3
MTH 314	Linear Algebra I	3
(2)	At least one of the following courses (3 credits):	
MSM 306	Dynamics	3
MSM 402	Computational Mathematics	3
	Physical Metallurgy	
(1)	Both of the following courses (6 credits):	
MSM 451	X-Ray Crystallography	3
STT 351	Probability and Statistics for Engineers	3
(2)	One of the following courses (3 credits):	
MSM 366	Physical Metallurgy II ¹	3
MSM 476	Physical Processing of Materials ¹	3
(3)	At least one of the following courses:	
MSM 356	Deformation Mechanisms	3
MSM 366	Physical Metallurgy II ¹	3
MSM 476	Physical Processing of Materials ¹	3
MSM 480	Chemical Processing of Materials	3
MSM 483	Environmental Effects on Materials	3
	Processing and Manufacturing	
(1)	Both of the following courses (6 credits):	
MSM 451	X-Ray Crystallography	3
STT 351	Probability and Statistics for Engineers	3
(2)	At least one of the following courses (3 credits):	
CHE 472	Composite Materials Processing	3
MSM 356	Deformation Mechanisms	3
MSM 476	Physical Processing of Materials	3
MSM 480	Chemical Processing of Materials	3
MSM 482	Manufacturing Systems II	3
MSM 483	Environmental Effects on Materials	3
(3)	At least one of the following courses (3 credits):	
ACC 230	Survey of Accounting Concepts	3
EC 210	Economics Principles Using Calculus	3
GBL 395	Law, Public Policy, and Business	3
STT 471	Statistics for Quality and Productivity	3

¹ Re the **Physical Metallurgy** option: Materials Science and Mechanics 366 and 476 may be used to satisfy *either* the requirement referenced in item (2) *or* the requirement referenced in item (3), but not both of those requirements.

ENGINEERING MECHANICS

Mechanics is an engineering science dealing with the behavior of matter under the action of external environments such as forces, pressures, and thermal effects. Its role in engineering lies in the application of physics, mathematics, and experimental techniques to some complex problems of modern technology. Mechanics applications are found in all areas of

engineering and in many interdisciplinary fields, such as biomechanics, geomechanics, and environmental science.

Many of the techniques of applied mathematics were developed simultaneously with the science of mechanics, and to this day the application of the principles of mechanics requires a strong capability in applied mathematics. Concurrently, modern experimental measurement and data acquisition, and reduction techniques, are also important. This curriculum recognizes these needs, and requires a balanced program in the classical and modern principles of mechanics, mathematics, and experimental methods. The program is designed to develop in the student the ability to model the behavior of matter mathematically, to predict its responses to forces, and to understand it physically through the use of experimental methods.

This program provides flexibility to enable undergraduates to build a strong background in mechanics and to develop a minor in one of the allied areas of the traditional professional fields.

Requirements for the Bachelor of Science Degree in Engineering Mechanics

- The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Engineering Mechanics.

The University's Tier II writing requirement for the Engineering Mechanics major is met by completing Materials Science and Mechanics 499. That course is referenced in item 3. a. below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

- The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.
- The following requirements for the major:

	CREDITS	
a. All of the following courses:	38	
CEM 152 Principles of Chemistry	3	
CEM 161 Chemistry Laboratory I	1	
ECE 345 Electronic Instrumentation and Systems	3	
MSM 160 Engineering Graphic Communications	3	
MSM 205 Statics	3	
MSM 211 Mechanics of Deformable Solids	3	
MSM 250 Materials Science and Engineering	3	
MSM 306 Dynamics	3	
MSM 401 Intermediate Mechanics of Deformable Solids	3	
MSM 402 Computational Mechanics	3	
MSM 499 Senior Research and Design Project (W)	6	
MTH 314 Linear Algebra I	3	
PHY 192 Physics Laboratory for Scientists, II	1	
b. One of the following courses:	4	
CE 321 Introduction to Fluid Mechanics	4	
CHE 311 Fluid Flow and Heat Transfer	4	
ME 332 Fluid Mechanics	4	
c. One of the following courses:	3	
ME 201 Thermodynamics	3	
MSM 351 Thermochemistry of Materials	3	
d. One of the following courses:	3	
MSM 403 Intermediate Dynamics ¹	3	
MSM 405 Experimental Mechanics ^{1,2}	3	
MSM 442 Biodynamics ¹	3	
e. <i>Option:</i> The student must complete <i>one</i> of the following five options:	22 to 37	
(1) Biomechanics (22 or 23 credits):		
(a) All of the following courses (16 credits):		
BME 424 Biomaterials and Biocompatibility	3	
BME 441 Tissue Mechanics	3	
BME 445 Biomechanical Design	3	
MSM 442 Biodynamics	3	
PSL 250 Introductory Physiology	4	
(b) One of the following courses (3 or 4 credits):		
ANT 316 General Human Anatomy	3	
BS 110 Organisms and Populations	4	
BS 111 Cells and Molecules	3	
(c) One of the following courses (3 credits):		
MTH 424 Applied Advanced Calculus	3	
STT 351 Probability and Statistics for Engineering	3	
(2) Computational Mechanics (25 or 26 credits):		

(a) All of the following courses (10 credits):		
ME 461 Mechanical Vibrations	4	
MSM 444 Introduction to Composite Materials	3	
MSM 466 Failure Analysis	3	
(b) Three of the following courses (9 or 10 credits):		
ME 410 Heat Transfer ³	3	
ME 432 Intermediate Fluid Mechanics ³	3	
ME 440 Aerospace Engineering Fundamentals ³	3	
ME 451 Control Systems ³	4	
MSM 355 Mechanical Behavior of Materials	3	
MSM 356 Deformation Mechanisms	3	
MSM 405 Experimental Mechanics ²	3	
PHY 480 Computational Physics	3	
(c) Two of the following courses (6 credits):		
MTH 424 Applied Advanced Calculus	3	
MTH 443 Boundary Value Problems for Engineers	3	
MTH 451 Numerical Analysis I	3	
STT 351 Probability and Statistics for Engineering	3	
(3) Experimental Mechanics (32 to 37 credits):		
(a) All of the following courses (11 credits):		
MSM 355 Mechanical Behavior of Materials	3	
MSM 376 Materials Science Laboratory II	1	
MSM 466 Failure Analysis	3	
PHY 191 Physics Laboratory for Scientists, I	1	
STT 351 Probability and Statistics for Engineering	3	
(b) One of the following courses (3 credits):		
MSM 403 Intermediate Dynamics ¹	3	
MSM 405 Experimental Mechanics ¹	3	
MSM 442 Biodynamics ¹	3	
(c) Fourteen credits from the following courses:		
BME 441 Tissue Mechanics	3	
BME 445 Biomechanical Design	3	
MSM 375 Materials Science Laboratory I	1	
MSM 444 Introduction to Composite Materials	3	
MSM 475 Deformation Processing of Materials	3	
PHY 440 Electronics	4	
STT 471 Statistics for Quality and Productivity ³	3	
(d) One of the following <i>groups</i> of courses (4 or 9 credits):		
Group 1		
ME 410 Heat Transfer	3	
ME 412 Heat Transfer Laboratory	1	
Group 2		
ME 432 Intermediate Fluid Mechanics	3	
ME 433 Intermediate Fluid Mechanics Laboratory	1	
Group 3		
PHY 215B Thermodynamics and Modern Physics, CBI	3	
PHY 431 Optics I	3	
Phy 432 Optics II	3	
(4) Mechanics of Manufacturing (24 credits):		
(a) All of the following courses (15 credits):		
EC 201 Introduction to Microeconomics	3	
MSM 355 Mechanical Behavior of Materials	3	
MSM 466 Failure Analysis	3	
MSM 481 Manufacturing Processes	3	
STT 351 Probability and Statistics for Engineering	3	
(b) One of the following courses (3 credits):		
ACC 230 Survey of Accounting Concepts	3	
EC 202 Introduction to Macroeconomics	3	
GBL 395 Law, Public Policy, and Business	3	
(c) Two of the following courses (6 credits):		
BME 445 Biomechanical Design	3	
BME 491 Special Topics (MTC)	3	
CHE 472 Composite Materials Processing	3	
MSM 356 Deformation Mechanisms	3	
MSM 444 Introduction to Composite Materials	3	
MSM 482 Product Development	3	
STT 471 Statistics for Quality and Productivity ³	3	
(5) Mechanics of Materials (23 credits):		
(a) All of the following courses (17 credits):		
MSM 355 Mechanical Behavior of Materials	3	
MSM 356 Deformation Mechanisms	3	
MSM 365 Physical Metallurgy I	3	
MSM 375 Materials Science Laboratory I	1	
MSM 376 Materials Science Laboratory II	1	
MSM 380 Polymeric Materials	3	
MSM 454 Ceramic and Refractory Materials	3	
(b) Two of the following courses (6 credits):		
BME 445 Biomechanical Design	3	
MSM 366 Physical Metallurgy II	3	
MSM 444 Introduction to Composite Materials	3	
MSM 455 Theory of Solids	3	
MSM 465 Design and Application of Engineering Materials	3	
MSM 466 Failure Analysis	3	

¹ Materials Science and Mechanics 403, 405, and 442 may be used to satisfy *either* the requirement referenced in item 3. d. or the requirements for the **Experimental Mechanics** option, but not both of those requirements.

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² Materials Science and Mechanics 405 may be used to satisfy *either* the requirement referenced in item 3. d. or the requirements for the Computational Mechanics option, but not both of those requirements.

³ Only *one* of the following courses may be used to satisfy the requirements for the Computational Mechanics option: Mechanical Engineering 410 or 432 or 440 or 451.

GRADUATE STUDY

The Department of Materials Science and Mechanics offers programs leading to the Master of Science and Doctor of Philosophy degrees. From a wide range of course offerings and research activities, an individual program can be designed to fit the background, capabilities, and aims of the student. Studies in the department may be supplemented with courses offered by other departments in the College of Engineering and in other colleges. For all fields, special emphasis is placed on the mastery of basic principles and methods. Courses and research opportunities are available in the following areas:

MATERIALS SCIENCE AND ENGINEERING: biomaterials, ceramic materials, composite materials, electron microscopy, high-temperature superconductors, impact damage, intermetallic alloys, laser processing of metals, mechanical and physical metallurgy, phase transformation, polymer materials, processing of ceramics, polymers and their composites, shape memory alloys, surface modification of metals and polymers, structural thin film, and superplasticity of metals.

ENGINEERING MECHANICS: applied mathematics, biomechanics, buckling, computational mechanics, continuum mechanics, dynamics, experimental mechanics, fracture mechanics, linear and nonlinear elasticity, mechanics of fatigue, mechanics of composite materials, micromechanics, optical methods of measurement, plasticity, stochastic methods in mechanics, thermoelasticity, vibration, and wave propagation.

ENGINEERING MECHANICS

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

The department welcomes applications from students who possess a bachelor's degree in a related engineering or science discipline.

Students who are admitted to the master's program with a degree in a discipline other than engineering mechanics and who have not completed Materials Science and Mechanics 205, 211, 306, and 401 or equivalent courses may be admitted with provisional status. Such students will be required to demonstrate proficiency in the material in the courses referenced above, either by completing each of those courses with a grade of at least 3.0 or by passing an examination on the material in those courses sanctioned by the Department Graduate Studies Committee. Of the courses referenced above, only Materials Science and Mechanics 401 may be counted toward the requirements for the master's degree.

Requirements for the Master of Science Degree in Engineering Mechanics

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis) and must meet the requirements specified below:

Requirements for Both Plan A and Plan B:

1. The following core courses in engineering mechanics: Materials Science and Mechanics 801 or 805, 810, and 813.
2. At least *one* of the following core courses in materials science and engineering: Materials Science and Mechanics 851, 855, 862, or 865.
3. At least one credit of Materials Science and Mechanics 885.
4. At least one course in mathematics or statistics at the 400-level or above approved by the student's academic adviser.

Doctor of Philosophy

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant for admission must identify at least one prospective faculty adviser that he or she would like to direct his or her program of study. Admission to the Ph.D program is contingent on a faculty adviser accepting the student as an advisee.

Requirements for the Doctor of Philosophy Degree in Engineering Mechanics

The student must complete:

1. At least *one* of the following core courses in materials science and engineering: Materials Science and Mechanics 851, 855, 862, or 865.
2. At least one course in mathematics or statistics at the 400-level or above.

These requirements are waived for those students who completed equivalent courses prior to enrolling in the doctoral program.

MATERIALS SCIENCE AND ENGINEERING

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

The department welcomes applications from students who possess a bachelor's degree in a related engineering or science discipline.

Students who are admitted to the master's program with a degree in a discipline other than materials science and engineering and who have not completed Materials Science and Mechanics 351, 355, 365, and 451 or equivalent courses may be admitted with provisional status. Such students will be required to demonstrate proficiency in the material in the courses referenced above, either by completing each of those courses with a grade of at least 3.0 or by passing an examination on the material in those courses sanctioned by the Department Graduate Studies Committee. Of the courses referenced above, only Materials Science and Mechanics 451 may be counted toward the requirements for the master's degree.

Requirements for the Master of Science Degree in Materials Science and Engineering

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis) and meet the requirements specified below:

Requirements for Both Plan A and Plan B:

The student must complete:

1. The following core courses in materials science and engineering: Materials Science and Mechanics 851, 855, and 862 or 865.
2. At least *one* of the following core courses in engineering mechanics: Materials Science and Mechanics 801, 805, 810, or 813.
3. At least one credit of Materials Science and Mechanics 885.
4. At least one course in mathematics or statistics at the 400-level or above approved by the student's academic adviser.

Doctor of Philosophy

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant for admission must identify at least one prospective faculty adviser that he or she would like to direct his or her program of study. Admission to the Ph.D. program is contingent on a faculty adviser accepting the student as an advisee.

Requirements for the Doctor of Philosophy Degree in Materials Science and Engineering

The student must complete:

1. At least *one* of the following core courses in engineering mechanics: Materials Science and Mechanics 801, 805, 810, or 813.
2. At least one course in mathematics or statistics at the 400-level or above.

These requirements are waived for those students who completed equivalent courses prior to enrolling in the doctoral program.

These principles are delineated in the subjects of solid and fluid mechanics, thermodynamics, heat transfer, design, systems analysis and simulation, and material science. Practicing mechanical engineers work in a broad area of application which includes such industries as automotive, chemical, foundry, power plants, food processing, aerospace and aircraft, computer, machine tool, and many others.

The undergraduate engineering program is directed to emphasize fundamental principles, to develop analytical and experimental capabilities of students to model and solve engineering problems, to use appropriate mathematical language, and to introduce students to design, experimental methods, computers, and systems.

For students who desire an international experience as part of their education, the department sponsors the Mechanical Engineering in Aachen Program. During the spring semester a small group of juniors, escorted by a faculty member, travels to Aachen, Germany, to pursue their normal studies overseas at the Technical University of Aachen. Students have outstanding opportunities to participate in German research, explore industrial activities, and experience German culture and life-style.

Students admitted to the mechanical engineering major who have strong academic records in their first two years are invited to participate in the Mechanical Engineering Honors Program. The purpose of the program is to provide an enriched, research-oriented experience. No additional credits are required for the degree.

Requirements for the Bachelor of Science Degree in Mechanical Engineering

1. The University requirements for bachelor's degrees as described in the *Undergraduate Education* section of this catalog; 128 credits, including general elective credits, are required for the Bachelor of Science degree in Mechanical Engineering.

The University's Tier II writing requirement for the Mechanical Engineering major is met by completing Mechanical Engineering 332, 412, 451, 461, and 481. Those courses are referenced in item 3. b. (1) below.

Students who are enrolled in the College of Engineering may complete the alternative track to Integrative Studies in Biological and Physical Sciences that is described in item 1. under the heading *Graduation Requirements for All Majors* in the College statement. Certain courses referenced in requirement 3. below may be used to satisfy the alternative track.

2. The requirements of the College of Engineering for the Bachelor of Science degree. The credits earned in certain courses referenced in requirement 3. below may be counted toward College requirements as appropriate.

3. The following requirements for the major: CREDITS

a.	All of the following courses outside the Department of		
	Mechanical Engineering		22
	CEM 161	Chemistry Laboratory I	1
	ECE 345	Electronic Instrumentation and Systems	3
	MSM 160	Engineering Graphics Communications	3
	MSM 205	Statics	3
	MSM 211	Mechanics of Deformable Solids	3
	MSM 250	Materials Science and Engineering	3
	MSM 306	Dynamics	3
	STT 351	Probability and Statistics for Engineering	3
b.	The following courses in the Department of		
	Mechanical Engineering		44
	<i>All of the following courses (32 credits):</i>		
	ME 201	Thermodynamics	3
	ME 332	Fluid Mechanics	4
	ME 371	Mechanical Design I	3
	ME 391	Mechanical Engineering Analysis	3
	ME 410	Heat Transfer	3
	ME 412	Heat Transfer Laboratory	2
	ME 451	Control Systems	4
	ME 461	Mechanical Vibrations	4
	ME 471	Mechanical Design II	3
	ME 481	Mechanical Engineering Design Projects	3

Senior Electives (a minimum of 12 credits with at least 3 credits from b. below):

a.	ME 442	Introduction to Combustion	3
	ME 432	Intermediate Fluid Mechanics	3
	ME 433	Intermediate Fluid Mechanics Laboratory	1
	ME 444	Automotive Engines	3
	ME 490	Independent Study in Mechanical Engineering	1 to 3
	ME 491	Selected Topics in Mechanical Engineering	1 to 4
b.	<i>Design-intensive courses</i> (a minimum of 3 credits):		

DEPARTMENT of MECHANICAL ENGINEERING

Ronald Rosenberg, Chairperson

UNDERGRADUATE PROGRAM

Mechanical engineers apply the fundamental principles of mechanics, thermosciences, and design to the needs of people.

ENGINEERING
Department of Mechanical Engineering

ME	414	Vehicle Thermal System Design	3
ME	416	Computer Assisted Design of Thermal Systems	3
ME	442	Turbomachinery	3
ME	445	Automotive Powertrain Design	3
ME	475	Computer Aided Design of Automotive Structures	3

GRADUATE STUDY

The Department of Mechanical Engineering offers study leading to the Master of Science and Doctor of Philosophy degrees. Areas for advanced study include fluid mechanics, combustion, heat transfer, internal combustion engines, system dynamics, control theory, computer-aided design, bioengineering, machine design, mechanisms, thermodynamics, vibrations, nonlinear dynamics, wave motion in continuous media, and numerical simulation.

Master of Science

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

An applicant should possess a bachelor's degree in mechanical engineering or a related field.

The applicant must submit scores from the Graduate Record Examination General Test.

A student who is admitted to the program without a bachelor's degree in mechanical engineering must complete at least one course in *each* of the *five* areas referenced in item 1. under the heading *Requirements for Both Plan A and Plan B* below. With the approval of the student's academic adviser, a 400-level Mechanical Engineering course, or an 800-level Mechanical Engineering course that is not included in item 1., may be used to satisfy the requirement in *one* of the 5 areas.

Requirements for the Master of Science Degree in Mechanical Engineering

The student must complete a total of 30 credits for the degree under either Plan A (with thesis) or Plan B (without thesis) and meet the requirements specified below:

Requirements for Both Plan A and Plan B:

1. The student must complete at least *one* course in *each* of *four* of the following 5 areas:
 - a. Design: Mechanical Engineering 871, 873, 875.
 - b. Fluid Mechanics: Mechanical Engineering 830, 832, 834, 836.
 - c. Heat Transfer: Mechanical Engineering 802, 812, 814, 816, 822.
 - d. Systems and Control: Mechanical Engineering 852, 855, 857.
 - e. Vibrations: Mechanical Engineering 860, 863.

Additional Requirements for Plan A:

The student must:

1. Complete at least 20 credits in courses at the 800-900 level including at least 6, but not more than 8, credits in Mechanical Engineering 899.
2. Submit a brief thesis proposal for approval by the student's academic adviser early in the student's program of study.

Additional Requirements for Plan B:

The student must complete at least 22 credits in courses at the 800-900 level.

Doctor of Philosophy

In addition to meeting the requirements of the University and of the College of Engineering, students must meet the requirements specified below.

Admission

The applicant must submit scores from the Graduate Record Examination General Test.

Requirements for the Doctor of Philosophy Degree in Mechanical Engineering

In addition to meeting the requirements of the University and the College of Engineering, students must meet the requirements specified by their guidance committees.