

# 2015-2016 BULLETIN







## Michigan Engineers Make a Difference

The world is facing some big challenges: from energy, to health care, to transportation and security...and the list goes on. We need bold ideas and breakthrough solutions. Michigan Engineering graduates are prepared to be leaders. They are expert problem-solvers, and are ready to tackle the challenges of the 21st century.

**Educational Programs.** The University of Michigan is the only institution with top-rated engineering, law, business, performing arts and medical schools. Michigan Engineering offers an impressive range of educational programs and options, including:

- Top-ranked graduate and undergraduate programs in nearly every engineering field
- 13 departments/divisions and 60+ fields of study
- Flexible interdisciplinary degree programs for students who choose to customize their course of study
- Combined bachelor's/master's programs that enable students to earn both degrees in just five years
- Unique global study, travel and work opportunities

For more College of Engineering facts and figures, please visit [www.engin.umich.edu/college/about/facts](http://www.engin.umich.edu/college/about/facts)

Office of Student Affairs  
Chrysler Center  
143 Chrysler Center  
Ann Arbor, MI, 48109-2092  
[www.engin.umich.edu](http://www.engin.umich.edu)

## 2015-2016 College of Engineering Bulletin

The online Bulletin reflects the most up-to-date information available and is updated as changes are made to the curriculum. To view past versions of the College Bulletin in Adobe Acrobat format, please visit our archives. Note: Archived bulletins are only applicable to that academic year's course requirements. Please visit your advisor for more information, or if you have questions regarding this.

Students follow the rules of the College of Engineering Bulletin in effect for the academic term in which they begin their studies in the College of Engineering at the University of Michigan-Ann Arbor campus. Students who are readmitted into the College of Engineering at the University of Michigan-Ann Arbor campus follow the Bulletin in effect for the academic term in which they resume their studies.

The College of Engineering Bulletin reflects yearly curricular changes in the various degree programs. A student in a degree program that has degree requirement changes in a Bulletin produced during their academic career at the College of Engineering at the University of Michigan-Ann Arbor, may follow a subsequent Bulletin. This determination should be made in conjunction with the Program Advisor.

## **Representative Sample Schedules**

The information in this Bulletin for a number of the degree programs includes a schedule that that is an example of one leading to graduation in eight terms. This sample scheduled is for informational purposes only and should not be construed to mean that students are required to follow the schedule exactly.

A transfer students attending a community or liberal arts college and pursuing a pre-engineering degree program may not be able to follow a similar scheduled because of a lack of certain offerings. Departmental program advisors should always be consulted when planning course selections.

---

The University of Michigan  
College of Engineering  
2015-2016  
June 1, 2015

**The University of Michigan**

Mark S. Schlissel, President

Martha Pollack, *Provost and Executive Vice President for Academic Affairs*

Marschall Runge, *Executive Vice President for Medical Affairs*

Sally J. Churchill, *Vice President and Secretary of the University*

S. Jack Hu, *Interim Vice President for Research*

E. Royster Harper, *Vice President for Student Life*

Lisa Rudgers, *Vice President for Global Communications*

*And Strategic Initiatives*

Daniel Little, Chancellor, *University of Michigan - Dearborn*

Jerry A. May, *Vice President for Development*

Susan E. Borrego, Chancellor, *University of Michigan - Flint*

Timothy G. Lynch, *Vice President and General Counsel*

Kevin P. Hegarty, *Executive Vice President and Chief Financial Officer*

Cynthia H. Wilbanks, *Vice President for Government Relations*

**College of Engineering**

David C. Munson, Jr., *Robert J. Vlasic Dean of Engineering*  
*and Professor of Electrical Engineering and Computer Science*

Dawn Tilbury, *Associate Dean for Research*

Brian D. Noble, *Associate Dean for Undergraduate Education*

Alec Gallimore, *Associate Dean for Academic Affairs*

Thomas Zurbuchen, *Associate Dean for Entrepreneurial Programs*

Jennifer Linderman, *Associate Dean for Graduate Education*

**The Regents of the University of Michigan**

Michael J. Behm, Grand Blanc

Mark J. Bernstein, Ann Arbor

Laurence B. Deitch, Bloomfield Hills

Shauna Ryder Diggs, Grosse Pointe

Denise Ilitch, Bingham Farms

Andrew Fischer Newman, Ann Arbor

Andrew C. Richner, Grosse Pointe Park

Katherine E. White, Ann Arbor

Mark S. Schlissel (ex officio)

The information contained in this Bulletin is subject to change at any time. It is intended to serve only as a general source of information about the College of Engineering and is in no way intended to state contractual terms.

## Table of Contents

Introduction .....	1-2
Credits .....	3
Academic Calendar .....	5
Drop/Modify Dates .....	6
General Information .....	7-9
Undergraduate Admissions .....	10-14
Academic Rules .....	15-33
Undergraduate Education .....	34-57
Graduate Education .....	58-60
Aerospace Engineering .....	62-67
Biomedical Engineering .....	68-73
Chemical Engineering .....	74-78
Civil and Environmental Engineering .....	79-90
Climate and Space Sciences and Engineering (AOSS department name change, effective 9/1/15) .....	91-99
Computer Engineering, Computer Science and Electrical Engineering .....	100-111
Data Science .....	112-115
Engineering Physics .....	116-117
Industrial and Operations Engineering .....	118-124
Materials Science and Engineering .....	125-129
Mechanical Engineering .....	130-135
Naval Architecture and Marine Engineering .....	136-141
Nuclear Engineering and Radiological Sciences .....	142-148
Military Officer Education Program .....	149-153
Applied Physics .....	154-155
Concentrations in Environmental Sustainability (ConsEnSus) .....	156
Engineering Sustainable Systems .....	157
Integrative Systems and Design Division (IS+D) .....	158-164
Macromolecular Science and Engineering .....	165-167
Robotics Program .....	168-169
Office Directory .....	170-171
Index .....	172-175

# Academic Calendar

## University of Michigan—ANN ARBOR CAMPUS

### FALL TERM, 2015

Labor Day (Holiday)	Sept 7, Mon
Classes begin	Sept 8, Tues
Fall Study Break	Oct. 19 - 20, Mon - Tues
Thanksgiving recess, 5:00 p.m.	Nov 25, Wed
Classes end	Dec 14, Mon
Study Days	Dec 15, Tues; Dec 19 - 20, Sat - Sun
Examinations	Dec 16 - 18, Wed - Fri ; Dec 21 - 23, Mon - Wed
Fall Term ends	Dec 23, Wed
Commencement	Dec 20, Sun

### WINTER TERM, 2016

Classes begin	Jan 6, Wed
Martin Luther King, Jr. Day	Jan 18, Mon
University Symposia. No Regular Classes.	
Winter Vacation begins 12:00 noon	Feb 27, Sat
Classes resume	Mar 7, Mon
University Honors Convocation	Mar 20, Sun
Classes end	Apr 18, Mon
Study Days	Apr 19, Tues & Apr 22 - 24, Fri - Sun
Examinations	Apr 20 - 21, Wed - Thurs ; Apr 25 - Apr 28, Mon - Thurs
Winter Term ends	Apr 28, Thurs
Commencement Activities	Apr 28 - May 1, Thurs - Sun

### SPRING-SUMMER TERM, 2016

Classes begin	May 3, Tues
Memorial Day (Holiday)	May 30, Mon
Classes end (Spring Half)	June 20, Mon
Study Days	June 21 - 22, Tues - Wed
Examinations	June 23 - 24, Thurs - Fri
Spring Half Term ends	June 24, Fri
Summer Half Term classes begin	June 29, Wed
Independence Day (Holiday)	July 4, Mon
Classes end	Aug 16, Tues
Study Day	Aug 17, Wed
Examinations	Aug 18 - 19, Thurs - Fri
Full Term and Summer Half Term end	Aug 19, Fri

\*Students enrolling in Business Administration, Dentistry, Law, Pharmacy, Social Work, and Medicine should check with their respective schools for academic calendar information including registration dates. This calendar is subject to change. \*\*Jewish holy days begin and end at sundown on the first and last days listed. The University's policy concerning observance of religious holidays can be found at <http://www.umich.edu/~provost/dates/hdaymemo.html>  
Dearborn Campus – for registration and academic calendar information, visit: <http://www.umd.umich.edu/registration>

## **CoE Undergraduate Drop/Modify Deadlines 2015-2016**

**\*\*NOTE--Deadline ends when the office closes for business at 5:00 PM!**

### **Fall Term 2015 (2060)**

Fall **First 7 week** classes **begin** -- Tuesday, September 8

Fall **First 7 week** classes drop deadline **without** "W's" -- **Monday, September 21**

Fall **First 7 week** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, October 16**

Fall **First 7 week** classes **end** -- Friday, October 23

Fall **Full term** classes **begin** -- Tuesday, September 8

Fall **Full term** classes drop deadline **without** "W's" -- **Monday, September 28**

Fall **Full term** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, November 13**

Fall **Full term** classes **end** -- Monday, December 14

Fall **Second 7 week** classes **begin** -- Monday, October 26

Fall **Second 7 week** classes drop deadline **without** "W's" -- **Monday, November 9**

Fall **Second 7 week** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, December 4**

Fall **Second 7 week** classes **end** -- Monday, December 14

### **Winter Term 2016 (2070)**

Winter **First 7 week** classes **begin** -- Wednesday, January 6

Winter **First 7 week** classes drop deadline **without** "W's" -- **Tuesday, January 19**

Winter **First 7 week** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, February 12**

Winter **First 7 week** classes **end** -- Wednesday, February 24

Winter **Full term** classes **begin** -- Wednesday, January 6

Winter **Full term** classes drop deadline **without** "W's" -- **Tuesday, January 26**

Winter **Full term** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, March 11**

Winter **Full term** classes **end** -- Monday, April 18

Winter **Second 7 week** classes **begin** -- Monday, March 7

Winter **Second 7 week** classes drop deadline **without** "W's" -- **Monday, March 21**

Winter **Second 7 week** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, April 15**

Winter **Second 7 week** classes **end** -- Monday, April 18

### **Spring Term 2016 (2080)**

Spring **Half term** classes **begin** -- Tuesday, May 3

Spring **Half term** classes drop deadline **without** "W's" -- **Monday, May 16**

Spring **Half term** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, June 10**

Spring **Half term** classes **end** -- Monday, June 20

### **Spring/Summer Term 2016 (2090)**

Spring/Summer **Full term** classes **begin** -- Tuesday, May 3

Spring/Summer **Full term** classes drop deadline **without** "W's" -- **Monday, May 23**

Spring/Summer **Full term** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, July 8**

Spring/Summer **Full term** classes **end** -- Tuesday, August 16

### **Summer Term 2016 (2100)**

Summer **Half term** classes **begin** -- Wednesday, June 29

Summer **Half term** classes drop deadline **without** "W's" -- **Tuesday, July 12**

Summer **Half term** classes drop, pass/fail, and audit deadline **without** SSC Petition -- **Friday, August 5**

Summer **Half term** classes **end** -- Tuesday, August 16

*These deadlines are subject to change. 05/12/15 alb*



# General Information

## Michigan Engineering

Michigan Engineering is a place for a special kind of engineer. We welcome students from a diversity of backgrounds, who will flourish within an environment of wide-ranging possibilities. Our breadth of outstanding opportunities is unmatched.

Beyond excellent engineering research and teaching, a global footprint and significant resources, the University of Michigan College of Engineering provides the most well-rounded intellectual experience of any engineering institution. We aim to produce graduates who combine technical depth with lateral thinking and an ability to make an impact. And, we want our graduates to be globally competent engineers, through meaningful international experiences, broad exposure to diversity and development of communication and teamwork skills. We can create this unique environment because of a very special set of assets, including:

- twelve highly ranked engineering departments and divisions, and growing faculty headcount and student enrollment;
- extensive collaboration with our highly rated medical and business schools, and expanding interactions with our top-notch art and design, architecture and music programs;
- the country's first engineering/arts living-learning community;
- hundreds of student organizations and competitive teams, and the opportunity to learn under the tutelage of renowned professors of practice;
- major partnership with Shanghai Jiao Tong University, and other academic institutions on six continents;
- one of the nation's most successful centers of entrepreneurship.

Michigan Engineers are expected to become more than just great engineers. As well-balanced thinkers, they are challenged to lead teams, identify opportunities and solve complex problems requiring multidisciplinary

approaches. Faculty with unconventional ideas are welcome in this innovative, dynamic and diverse enterprise, where tradition and experience are respected, but talent and results are rewarded.

The College of Engineering is committed to not only making certain that students enjoy a high quality educational experience, but that personal interactions, classroom experiences and research activities are free from harassing and discriminatory behaviors. Our goal is a welcoming environment of respect and courtesy for all members of our campus community. Further, we are determined to investigate and address any allegations of misconduct that might occur. This can be accomplished through increased awareness of issues, access of information and prompt action. To insure that our students understand the consequences of strategies for the prevention of harassment and discrimination, we ask each member of the College of Engineering to commit to understanding, preventing, responding and reporting harassment and discrimination. We are certain that through awareness, knowledge and diligence, our College can become a safer community for all of us. For more information and to learn how to report an incident, please visit the Office of Student Affairs at 143 Chrysler Center.

## Michigan Engineering Mission

To be the place of choice for engineering education and research...A Michigan institution that challenges its students, faculty and staff to learn, to grow, to achieve and to serve the needs of society...A place where excellence, excitement, innovation and impact define the style and substance of its activities.

## Michigan Engineering Goals

1. To provide a continuously improving educational and research environment in which faculty, administrators, students and staff work together to educate our students to lead, to have impact and to make significant contributions to their professions, industry, government, academia and society.
2. To attract diverse, outstanding students and to motivate and educate them to reach their full potential as leaders in engineering professions.

## Degree Programs

The College of Engineering offers undergraduate and graduate programs through the doctoral level. The undergraduate program consists typically of a four-year schedule leading to a bachelor's degree. There are 14 courses of study that lead to the Bachelor of Science in Engineering degree (B.S.E.). By careful planning, an additional bachelor's degree (B.S. or A.B.) can be earned within the College of Engineering or in combination with another college within the University of Michigan in about one year beyond the time required for a single degree. Completion of both an engineering baccalaureate and a master's degree in approximately five years is also possible.

### Areas of undergraduate study at the College of Engineering include:

- Bachelor of Science in Engineering
  - Aerospace Engineering
  - Biomedical Engineering
  - Chemical Engineering
  - Civil Engineering
  - Climate and Meteorology (pending final approval June 2015)
  - Computer Engineering
  - Computer Science
  - Data Science
  - Electrical Engineering
  - Engineering Physics
  - Environmental Engineering
  - Industrial and Operations Engineering
  - Materials Science and Engineering
  - Mechanical Engineering
  - Naval Architecture and Marine Engineering
  - Nuclear Engineering and Radiological Sciences
  - Space Sciences and Engineering (pending final approval June 2015)

### Areas of graduate study include:

- Master of Science (M.S.)
- Master of Science in Engineering (M.S.E.)
- Master of Engineering (M.Eng)
- Doctor of Philosophy (Ph.D.)
- Doctor of Engineering (D.Eng)

## Departments:

- Aerospace Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil and Environmental Engineering
- Climate and Space Sciences Engineering (formerly known as Atmospheric, Oceanic and Space Sciences) (name change effective September 2015)
- Electrical Engineering and Computer Science
- Industrial and Operations Engineering
- Materials Science and Engineering
- Mechanical Engineering
- Naval Architecture and Marine Engineering
- Nuclear Engineering and Radiological Sciences

## Programs:

- Integrative Systems and Design:
  - Automotive Engineering
  - Design Science
  - Energy Systems Engineering
  - Global Automotive and Manufacturing Engineering
  - Manufacturing Engineering
  - Pharmaceutical Engineering (Please note: The Master of Engineering in Pharmaceutical Engineering degree is currently under review and revision by the College of Engineering. It is currently closed for the Fall 2015 and beyond.)
  - Systems Engineering + Design
- Applied Physics
- Concentrations in Environmental Sustainability (ConsEnSus)
- Engineering Sustainable Systems Dual Degree Program
- Macromolecular Science and Engineering
- Robotics

## Accreditation

The Computer Science program is accredited by the Computing Accreditation Commission of ABET, <http://www.abet.org>.

The Aerospace, Biomedical, Chemical, Civil, Computer Engineering, Electrical, Industrial and Operations, Materials Science and Engineering, Mechanical, Naval Architecture and Marine Engineering and Nuclear Engineering and Radiological Sciences programs are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

**Note:** Environmental Engineering is pending ABET approval, with expected accreditation in August 2015.

## The University of Michigan Nondiscrimination Policy Statement

The University of Michigan, as an equal opportunity/affirmative action employer, complies with all applicable federal and state laws regarding nondiscrimination and affirmative action. The University of Michigan is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight, or veteran status in employment, educational programs and activities, and admissions. Inquiries or complaints may be addressed to the Senior Director for Institutional Equity, and Title IX/Section 504/ADA Coordinator, Office for Institutional Equity, 2072 Administrative Services Building, Ann Arbor, Michigan 48109-1432, 734-763-0235, TTY 734-647-1388, [institutional.equity@umich.edu](mailto:institutional.equity@umich.edu). For other University of Michigan information call 734-764-1817.

## Important Residency Information for Tuition Assessment Purposes

The University of Michigan's tuition structure is two-tiered, reflecting resident and nonresident rates. To be eligible to pay resident classification rates, a student must demonstrate compliance with the University's Residency Classification Guidelines, which can be found at <http://ro.umich.edu/resreg.php>. The University's Guidelines differ from those of other schools and are independent of guidelines used by state authorities to determine residency for purposes such as tax liability, driving, voting, etc. Therefore, all students who believe they are eligible to pay resident rates must review "Circumstances Under Which You Must File A Residency Application" in the Guidelines to determine if they are required to file a separate Application for Residency Classification. An Application for Resident Classification can be downloaded from the web site.

## Who May Apply

### Undergraduate Admissions

To be admitted at the first year level, an applicant must be at least 16 years old and a graduate of an accredited secondary school. Graduates of unaccredited schools will be asked to take College Board Achievement Tests or the American College Test.

Home-schooled students and students attending unaccredited high schools should contact the Office of Undergraduate Admissions prior to September of their senior year to determine if additional credentials such as SAT II Subject Exams should be submitted.

For older students, the results of the General Education Development (GED) test may be presented in place of a high school diploma.

### First-Year Undergraduate

### Advanced Placement

Many students take Advanced Placement courses through the Advanced Placement Program in their high schools. Credit for these courses can be applied toward a degree, provided the student has performed satisfactorily on the Advanced Placement Program examination conducted nationally by the College Entrance Examination Board.

Any questions regarding the examination, scores or results should be directed to the Advanced Placement Program.

**Website:**

**<https://apstudent.collegeboard.org/home>** (U-M code is 1839)

See information of how credit will be awarded at this website: **<http://www.admissions.umich.edu/ap-guidelines>**

**By Mail:**

Advanced Placement Program  
PO Box 6671  
Princeton, NJ 08541-6671

**By Telephone:**

(609) 771-7300 or (888) CALL-4AP

**By Fax:**

(609) 530-0482

**By TTY:**

(609) 882-4118 (for the hearing impaired)

**By Email:**

[apexams@info.collegeboard.org](mailto:apexams@info.collegeboard.org)

All other questions about Advanced Placement should be referred to Engineering Advising Center, 230 Chrysler Center, College of Engineering, University of Michigan, Ann Arbor, MI 48109-2092. (Phone: 734-647-7106)

The following Web site lists the satisfactory scores required to receive credit in the College of Engineering:  
**<http://admissions.umich.edu/apply/freshmen-applicants/ap-ib-credit>**

### University Placement Examinations

There are a number of courses for which credit may be received by getting a satisfactory score on a Placement Examination offered by a department of the University. Language credit earned by U-M examination will be posted under the admitted term, even though the student may choose to take the exam during a later term.

Note: No credit is granted for math and chemistry placement exams given before or during orientation. The purpose of these exams is to determine your preparation for these entry level courses.

## Foreign Languages

Credit by test (e.g. Advanced Placement, A-Level and International Baccalaureate) can be used to satisfy Intellectual Breadth requirements except for the 3 credit humanities requirement. Foreign language credit by test at the 200-level or higher can count toward the LAC requirement but not the 3 credit humanities requirement. Foreign language credit by test at the 100-level can be used for General Electives only. In addition, language credit by test is limited to 8-credits.

CoE will grant credit for students passing a language placement test offered by the College of LSA provided the student has previously studied that language in a course in their secondary education. This will be verified using their high school or college transcripts.

"Study of a language in a course" means a student took coursework designed to teach them the fundamental vocabulary, grammar, pronunciation, and writing system of that language as a foreign language, as opposed to a class in literature, argumentative or essay writing, or creative writing in a language whose fundamentals they already knew.

The CoE values the study of language, so even when credit might not be granted students are encouraged to take any language placement test for which they may be qualified, so that they can be properly placed in a more advanced language course.

## Transfer Credit for Entering First-Year Students

Incoming freshmen who took a course(s) at a college or university while dually enrolled in high school may potentially receive transfer credit. The guidelines for transferring credit in these situations include that the course(s) must:

1. be taken on the physical campus of an accredited college/university
2. be taught by college/university instructors
3. be taken with other college/university students

Students seeking approval to transfer credit must request an official transcript from the institution. An official transcript should be mailed directly to the Office of Recruitment and Admissions - TC, 153 Chrysler Center, 2121 Bonisteel Boulevard, Ann Arbor, MI 48109-2092.

More info at our website: <http://www.engin.umich.edu/college/academics/undergrad/transfer/dual-enroll>

## Undergraduate Transfer

### Transfer Credit

An evaluation of the previous record from the transfer institution will be made at the time of application review to provide a preliminary assessment of the credit that will be transferred toward a bachelor's degree in the program specified by the applicant. This appraisal is subject to review by representatives of the departments involved and by the student's intended program advisor. The transfer credit may be revised if the academic progress of the student indicates that the student is unable to continue successfully because of an inadequate preparation.

Credits are granted only for transferable courses in which a grade of "C" or better is earned. A "C-" will be accepted only if earned on the University of Michigan-Ann Arbor Campus for courses other than math, science, engineering, or other prerequisites for admission. Classification level is determined by the number of hours transferred. Most transfer students enroll with approximately 60-65 credit hours.

***Students can request that credits be transferred from their previous institution to the U-M transcript at any time, but credits will be posted on the U-M transcript under the term admitted to the College of Engineering. This can have a retroactive tuition impact. Transferred credit will not be removed from the transcript for the purpose of lowering tuition. New students are responsible for reviewing their transcript when credits are posted and asking for removal of any transferred credits within their first term at the CoE University of Michigan.***

The U-M transcript of transfer students will not reflect grades earned while enrolled in an external institution. The transfer student's GPA is determined solely by the grades earned while enrolled in the College of Engineering. This does not apply to students transferring from other academic units located on the Ann Arbor campus of the University. If, at any time, a transfer student has questions regarding the transfer of credit, the Transfer Credit Evaluation Office should be consulted at [engincredit@umich.edu](mailto:engincredit@umich.edu).

## Cross-Campus Transfer Re-Registration Policy

Admitted cross-campus transfer students to the CoE are held accountable to the following policy:

1. Admitted cross-campus students must re-register under their Engineering program status. The re-registration of courses must be done no later than 3 weeks after the first day of classes of the admitted term:
  - Students who do not re-register their classes may have their enrollment discontinued from the College of Engineering.
  - Once a student is discontinued they will then have to reapply to the College of Engineering, which may involve being held accountable to new admissions standards.
  - A student who reapplies after being discontinued and is admitted must be reinstated to the original term of the College of Engineering admission. This will involve having all of the student's classes re-registered to that original term of admission and the student being billed for the differences in tuition and College of Engineering fees accordingly.
2. Students who want to be admitted to the College of Engineering who are near graduation and receive approval from an engineering department are held to the following:
  - The engineering department will determine under which past term the student should have been admitted. The student's classes

will then be re-registered back to that term for admission and the student will be billed for the differences in tuition and College of Engineering fees accordingly.

- A department will have the authority to go back as many past terms as they deem appropriate for the student's admission.

## Bachelor's Degree Holders Seeking a Second Bachelor's Degree

The College of Engineering welcomes students already in possession of a bachelor's degree, who are seeking a second bachelor's degree in engineering. Students who already possess a bachelor's degree in engineering or closely aligned field such as physics should consider a master's degree in an engineering discipline.

For students who have previously earned a bachelor's degree and elect to pursue admission for an additional bachelor's degree, the following rules and policies apply:

Students may not be admitted to pursue a CoE bachelor's degree that is substantially similar to a degree of the same or lower level (bachelor's or master's) as they already hold, or declare into such a similar degree program after admission. The Office of the Associate Dean for Undergraduate Education will have ultimate authority to decide if a candidate's prior degrees are too similar to a proposed degree to allow admission or declaration.

In order to be qualified for a second bachelor's degree, candidates should have taken Calculus 1 and 2, Physics 1, Chemistry, English Composition and/or introductory Technical Communications, and Introductory Programming at an institution of higher education and have an academic record that suggests high levels of accomplishment. These courses can have been completed as part of their original degree, but could also have been taken for other reasons. They should have been completed no more than ten (10) years before admission, and ideally less than seven (7) years prior to admission.

Coursework from the student's previous academic record, including credits used to satisfy requirements for a previous degree, will be eligible for entry on the UM academic record. Credits will not be transferred if they were used to satisfy more than one prior degree (no counting of credits between three (3) or more degrees).

To graduate, students must successfully complete all of the degree requirements in place at their term of admission, using the appropriate combination of transfer and UM credit. Program advisors can allow substantially equivalent substitutions from transferred courses. Students with a previous engineering degree must complete an additional fourteen (14) credits hours in pertinent technical subjects in addition to meeting all degree requirements.

A bachelor's degree holder admitted into the College of Engineering seeking a second bachelor's degree will be a senior when there are thirty-five (35) hours or fewer to complete.

## Undergraduate Readmission

A student who is not enrolled for twelve (12) months or more must request an Application for Readmission from the Office of Recruitment and Admissions, and should do so at least two months before the date of desired enrollment.

Students who are readmitted into the College of Engineering at the University of Michigan-Ann Arbor campus follow the Bulletin in effect for the academic term in which they resume their studies. A student whose enrollment has been withheld because of poor academic performance must first petition for Reinstatement to the Scholastic Standing Committee:

**[ossa.engin.umich.edu/scholastic-standing-committee/petitions/](http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/)**

Readmitted international students requesting F-1 or J-1 Visa status must also submit required documentation. For additional information on required documentation or to request an Application for Readmission, please contact the Office of Recruitment & Admissions, 153 Chrysler Center, 2121 Bonisteel Boulevard, Ann Ar-

bor, MI 48109-2092 (734) 647-7101 or at [enginrta@umich.edu](mailto:enginrta@umich.edu).

Students who have graduated from the College and wish to elect courses for an additional term must seek readmission through the Office of Recruitment and Admissions.

## Special Student Status

### Undergraduate Non-Candidate for Degree (NCFD)

The NCFD status is for those individuals who are approved to take courses in the College of Engineering in a non-degree capacity. Such students are designated as unclassified. Except in the case of international exchange students, NCFD admission is for one term and is granted only if space is available after all degree-seeking students have been accommodated.

### NCFD Status for Students from Other Colleges and Universities

A student from another college or university who seeks enrollment as a non-candidate for degree (NCFD) must meet the same academic standards of admission as a degree-seeking application for transfer admissions.

NCFD applicants should contact the Office of Recruitment and Admissions to request an application. A complete application will include:

- a completed application form
- official transcripts from previous colleges or universities
- written permission from instructors of classes in which you intend to enroll (applicant is responsible for obtaining this documentation).

Once an applicant has been evaluated and approved for admission, the applicant will be notified of their NCFD admission status.

Registration for courses can only be done on or after the first day of classes for the term of admission. If

more than one term is requested, the student cannot register for the subsequent term until his or her academic record has been reviewed and approved by an admissions counselor and the engineering departmental program advisor.

### **NCFD Status for Graduates of the College of Engineering**

A graduate with a conferred bachelor's degree from the College of Engineering who desires to take courses with NCFD status can request processing for enrollment by obtaining written approval from the program advisor for the department in which they intend to take course(s) and submitting an application for readmission to the Office of Recruitment and Admissions. The instructor(s) of the course(s) in which the student intends to enroll must also grant written permission. Approval to register is granted for one term only. The enrollment status is designated as unclassified. Course registration for individuals with special student status should not be done prior to the first day of classes. The engineering department from which the degree was conferred will also be notified of the NCFD status.

### **Unclassified Status**

When a student is no longer a candidate for a degree from the College of Engineering but is planning to transfer into another field of study, the student will be advised by the Engineering Advising Center to arrange for registration for an additional term in the College of Engineering on an "Unclassified" status.

### **International Exchange Students from CoE Partner Institutions**

Undergraduate students from CoE partner institutions may apply to study at the U-M for one or two terms. The CoE also accepts exchange student applications through the Global Engineering Education Exchange (GE3) program. Prospective exchange students must be nominated by their home institutions and all applications are coordinated by the International Programs in Engineering (IPE) office, 245 Chrysler Center, 2121 Bonisteel Boulevard, Ann Arbor, MI 48109-2092. Pro-

spective students should inquire with their home institution's International Exchange office.



# Academic Rules, Rights and Responsibilities

## General Standards of Conduct for Engineering Students

In establishing a standard of student conduct, the University of Michigan is committed to the basic principles of entrusting each student with a high degree of freedom to govern his or her life and conduct while enrolled at the University.

Being a successful member of the College of Engineering community involves intense, spirited and innovative collaboration with groups of people from diverse backgrounds. Therefore, the College of Engineering embraces a spirit of acceptance and understanding so that our community enjoys a high quality educational and work experience that contributes not only to our technical expertise and accomplishments, but to our ability to interact effectively as a team across disciplines, perspectives, cultures and around the globe. Our goal is a welcoming environment of respect and courtesy for all members of our campus community. This goal takes the active involvement of all of our community members to create an environment that values our diverse community and fosters intercultural skills.

The College of Engineering encourages its students to protect and use this freedom with wisdom and good judgment, and to accept and discharge the responsibility inherent to such freedom.

Students are expected to respect the rights and property of others and to comply with University regulations and public laws.

The College of Engineering welcomes the participation of students in decision-making relevant to their affairs and provides channels of communication, both at the college and department level, for that purpose. To benefit from such activity, each student should recog-

nize his or her responsibility to fellow students and to the faculty and staff, and should discharge all duties with the standards that make such student-college relationships effective and valuable.

The College of Engineering reserves the right to discipline, exclude from participation in relevant activities, or dismiss any student whose conduct or performance it considers in violation of its standards. Such a decision will be made only after review by the appropriate student and faculty committees. During this review, the student will have full opportunity to present his or her position. A student also has the right of appeal to the Executive Committee of the College.

The Honor Code of the College of Engineering (below) bears witness to the deep trust that characterizes the student-faculty relationships in one of the most important aspects of student conduct.

## Honor Code

The engineering profession has a long-standing record of fostering high standards of integrity in the performance of professional services. Not until the 1930s, however, was the first Canon of Ethics for Engineers developed and adopted by national professional engineering societies. The Fundamental Canons, as they appear on the National Society of Professional Engineers website (<http://www.nspe.org/Ethics/CodeofEthics/index.html>) states "Engineers, in the fulfillment of their professional duties, shall:

### Fundamental Canons

1. Hold paramount the safety, health and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically and lawfully so as to enhance the honor, reputation and usefulness of the profession."

In 1915, the students of the College of Engineering proposed an Honor Code. This was approved by the faculty in 1916 and has been in effect since its inception. The Honor Code is a distinguishing feature of the College of Engineering.

## Applications of the Honor Code

The Honor Code holds that students are honorable, trustworthy people and encourages them to behave with integrity in all phases of university life. By conforming to the Code, students do their work in an environment conducive to establishing high standards of personal integrity, professional ethics, and mutual respect.

As a basic feature of the Code, students are placed upon their honor during all examinations, written quizzes, computer questions, homework, laboratory reports, and any other work turned in for credit, as required by the instructor. During examinations, the instructor is available for questions, but the examination is not proctored. As a reminder of the Honor Code, the student is asked to write and sign the following pledge on the examination paper:

"I have neither given nor received aid on this examination, nor have I concealed a violation of the Honor Code."

The Honor Code remains in force whether or not the student signs the Pledge, but an instructor is not obligated to grade an examination without a signature.

With regard to assignments made in class, each class/professor may have a different policy regarding what constitutes an Honor Code violation and this policy should be clearly outlined in the syllabus for the course. If a student is in doubt, the professor responsible for the course should be asked for clarification. In particular, be aware that some professors allow and/or encourage group work, while others may not even allow discussion of homework problems.

In general, the principles of the Honor Code also apply to homework when the instructor requires that the material be turned in for grading. While independent study

is recognized as a primary method of effective learning, some students may find that they benefit from studying together and discussing homework assignments and laboratory experiments. When any material is turned in for inspection and grading, the students should clearly understand whether, and to what degree, collaboration among students is permitted by the instructor. In some courses, full collaboration is allowed, while in other courses each student must work completely independently. The instructor may require the signing of the Pledge on homework assignments and expect the same high standards of integrity as during examinations.

It is always required that ideas and materials obtained from another student or from any other source be acknowledged in one's work. The latter is particularly important, because material is so freely available on the Internet. According to Merriam-Webster online dictionary, to plagiarize is "To steal and pass off (the ideas or words of another) as one's own." To avoid plagiarism, it is necessary to cite all sources of both ideas and direct quotations, including those found on the Internet. The Department of English website and the University Library handout provide thorough discussions of plagiarism: <http://www.lsa.umich.edu/english/undergraduate/advising/plagNote.asp>.

## The Honor Code Process

Either a student or the instructor may report a suspected Honor Code violation by contacting the Honor Code Representative to the Associate Dean for Undergraduate Education: Ms. Lindsay Coleman, Office of Student Affairs, 129 Chrysler Center 2029, 734-647-6955, [colemali@umich.edu](mailto:colemali@umich.edu). Suspected honor code violations must be reported no later than two months after the term in which the violation occurred.

The accusation is then investigated by the Engineering Honor Council, and if wrongdoing is found, a recommendation is sent to the Faculty Committee on Discipline (FCD). The FCD holds a hearing at which the student is asked to appear and testify on his/her own behalf. After the hearing (whether or not the student attends), the FCD reviews the recommendation made by the Honor Council, decides if an Honor Code viola-

tion has occurred, and determines an appropriate sanction, if so. The Honor Code Representative to the Associate Dean for Undergraduate Education then notifies the student of the FCD's decision.

Typical sanctions for a first violation may include a zero on the assignment, a reduction in grade for the course, and community service. For especially serious or repeated violations of the Honor Code, the sanctions may also include suspension or expulsion from the College of Engineering. The student may appeal the FCD's decision to the Executive Committee of the College of Engineering.

The Honor Council has prepared a booklet that explains the principles and operation of the Honor Code. The Honor Code booklet is available in the Office of Student Support and Accountability, 129 Chrysler Center and on the College of Engineering website: <http://ossa.engin.umich.edu/honor-council/>

## Statement of Student Rights and Responsibilities

### Introduction

The University of Michigan-Ann Arbor (the University) is dedicated to supporting and maintaining a scholarly community. As its central purpose, this community promotes intellectual inquiry through vigorous discourse. Values which undergird this purpose include civility, dignity, diversity, education, equality, freedom, honesty, and safety.

When students choose to accept admission to the University, they accept the rights and responsibilities of membership in the University's academic and social community. As members of the University community, students are expected to uphold its previously stated values by maintaining a high standard of conduct. Because the University establishes high standards for membership, its standards of conduct, while falling within the limits of the law, may exceed federal, state, or local requirements.

Within the University, entities (such as schools and colleges; campus, professional, and student organizations) have developed policies that outline standards of conduct governing their constituents and that sometimes provide procedures for sanctioning violations of those standards. This Statement of Student Rights and Responsibilities (the Statement) does not replace those standards; nor does it constrain the procedures or sanctions provided by those policies. This Statement describes possible behaviors which are inconsistent with the values of the University community; it outlines procedures to respond to such behaviors; and it suggests possible sanctions which are intended to educate and to safeguard members of the University community.

### Student Rights

Students at the University have the same rights and protections under the Constitutions of the United States and the State of Michigan as other citizens. These rights include freedom of expression, press, religion, and assembly. The University has a long tradition of student activism and values freedom of expression, which includes voicing unpopular views and dissent. As members of the University community, students have the right to express their own views, but must also take responsibility for according the same right to others.

Students have the right to be treated fairly and with dignity regardless of age, color, creed, disability, marital status, national origin or ancestry, race, religion, sex (including gender identity and gender expression), sexual orientation, or veteran status. The University has a long-standing tradition of commitment to pluralistic education. Accordingly, the University, through this Statement, will not discriminate on the basis of group status.

Students have the right to be protected from capricious decision making by the University and to have access to University policies which affect them. The University has an enduring commitment to provide students with a balanced and fair system of dispute resolution. Accordingly, this Statement will not deprive students of the appropriate due process protections to which they are entitled. This Statement is one of the Universi-

ty's administrative procedures and should not be equated with procedures used in civil or criminal court.

## Student Responsibilities

Along with rights come certain responsibilities. Students at the University are expected to act consistently with the values of the University community and to obey local, state, and federal laws.

For complete information on Students Rights and Responsibilities see the Office of Student Conflict Resolution, Division of Student Affairs at: <http://www.oscr.umich.edu/>.

## Registration, Grades and Policies

### Registration (Official Enrollment)

All students must register to be officially enrolled in classes. This process includes meeting with a departmental advisor (for students, advising is mandatory) so that appropriate classes are selected. This is followed by the actual registration process on Wolverine Access. To be considered as full-time students, undergraduate students must enroll for a minimum of 12 hours per semester.

Completion of both the advising and registration procedures are required before a student attends any classes or uses any University facilities. The tuition and registration fees for fulltime enrollment as an undergraduate student in the College of Engineering may be found on the Registrar's website . As of the first day of class, a late registration fee of \$50 will be assessed. Exceptions to the Late Registration Fee are late admissions, non-degree students, Ph.D. students registering to defend their dissertations, or students who have an official waiver based on a University action. The Late Registration Fee is increased by \$25 at the beginning of each subsequent month.

Unless a student is registered, there is no obligation on the part of faculty members to permit attendance in their classes.

A student who completes the registration procedure (including early registration) and fails to attend classes must officially withdraw at the Registrar's Office of the College of Engineering, for undergraduate students, 145A Chrysler Center. The student is responsible for the usual registration and disenrollment fees as stated in the current Schedule of Classes.

Students should be aware that receiving test or transfer credit can have an impact on tuition, because tuition increases once a student has Junior or Senior standing (55 credit hours or more). Credit will not be removed from the transcript for the purpose of lowering tuition. Students are responsible for reviewing their transcript when credits are posted and asking for removal of any credits within their first term at the University of Michigan. Note also that credit is always posted for the term in which it was earned, not the term in which it was posted; the posting of credit can therefore have a retro-active impact on tuition owed. Current students should carefully consider this issue before asking for credit to be posted on their transcript.

### Class Standing

The number of credit hours accumulated toward graduation at the close of a given term is used to determine a student's class standing for statistical purposes. Questions concerning class-level designations for undergraduate students should be referred to the CoE Registrar's Office, 145A Chrysler Center:

Class	Hours
Lower Division	Freshman 0 to 24
	Sophomore 25 to 54
Upper Division	Junior 55 to 84
	Senior 85 or more

## Indebtedness to the University

Students shall pay all accounts due the University in accordance with regulations set forth for such payments by the Executive Vice President and Chief Financial Officer. When a student's account shows indebtedness, no transcript of academic record or diploma will be issued, nor will future registration be permitted.

## Half Term Courses During Fall or Winter Terms (2 credits)

Begin and End dates:

- All departments will have the same begin and end dates for classes.
- For Fall and Winter Terms the first half-term course will begin on the regular first day of classes.
- For Fall, the second half term will start at the beginning of the 8th week whenever possible.
- For Winter, the start of the second half term will be the Monday immediately following Spring Break.
- Beginning days will be adjusted so that no class will begin on a Friday.

*Drop/Modify Schedule:* Drop/Modify periods without a "W" will end by the end of the 2nd week for both half terms. Students must petition the Scholastic Standing Committee to drop or modify a class after the fifth week of a half term.

*Fee Adjustments:* There is a two-week deadline (coinciding with Drop/Modify deadlines) for fee adjustments. Documentation is needed for fee adjustments after the deadline. Fee adjustments are finalized through the University of Michigan Registrar's Office.

**Important Note:** Students should register for second half-term classes during the normal full-term registration period.

## Add/Drop/Modify & Course Withdrawals

### Add/Drop/Modify Policy (Change of Elections)

During the first three weeks of classes (first two weeks in a Spring or Summer half term), students may drop without a "W" or add courses using Wolverine Access.

#### Third week through ninth week:

From the third week through the ninth week of classes (second week through fifth week in a Spring or Summer half term), students must obtain Add/Drop forms from their program advisor (for undeclared students, these forms must be signed by an advisor in the Engineering Advising Center) to add or drop courses. These forms must be signed by the program advisor and instructor, and must be submitted to the College Registrar's Office, for undergraduate students, 145A Chrysler Center. A "W" will appear for courses dropped during this time period. To modify a course to pass/fail only an advisor's signature is necessary on the form.

#### Ninth week through last day of classes:

After the ninth week (fifth week for a Spring or Summer half term), course additions, section changes, credit modifications and cross-list changes are processed using an Add/Drop form obtained from the program advisor (for undeclared students, these forms must be signed by an advisor in the Engineering Advising Center). Forms must be signed by the program advisor and instructor. Students should submit them to the College Registrar's Office, for undergraduate students, 145A Chrysler Center. Certain of these changes will be approved only in exceptional circumstances.

For pass/fail or visit modifications after the ninth week (fifth week for a Spring or Summer half term), students will need to petition the Scholastic Standing Committee (SSC) 129 Chrysler Center. Documentation will need to be submitted with the Exceptions to College Rules Petitions requesting pass/fail and visit modifications. Petitions are available online at: <http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/>.

International students need to meet with the International Center (Central Campus: 515 E. Jefferson St.) to determine if a withdrawal will impact their visa status. Student athletes must contact their advisor in the Academic Success Program regarding all changes to their election for written approval. This is in addition to the signatures required by the College of Engineering (advisor & instructor signatures).

## Course Withdrawals

1. The incomplete (I) should be the default mechanism for addressing a disruption that arises late in the term.
2. Only the most serious circumstances warrant dropping a course after the ninth week of the term. In order for the SSC to grant a drop at this time, some non-academic, extraordinary event (like severe health issues, prolonged family illness or a severe personal disruption) would have occurred after the ninth-week (fifth week of a half-term) drop deadline and would make completion of a course or courses very difficult if not impossible; the SSC assumes that the student's academic performance up to the point of the disruptive event has been satisfactory.
3. Approved drops will be posted to the official record with a "W."

Petitions are available online at <http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/> and will need to be submitted to the Scholastic Standing Committee in 129 Chrysler Center.

### After the last day of classes, or after the term has ended:

Individual course additions, section changes, credit modifications and cross-list changes are processed using an Add/Drop form obtained from the program advisor (for undeclared students, these forms must be signed by an advisor in the Engineering Advising Center). Forms must be signed by the program advisor and instructor. Students should submit them to the College Registrar's Office, for undergraduate students, 145A Chrysler Center.

Pass/fail or visit modifications after the last day of clas-

ses or the term has ended, students will need to petition the Scholastic Standing Committee (SSC). Documentation will need to be submitted with the Exceptions to College Rules petition. Petitions are available at 129 Chrysler Center or on the web at <http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/>.

Late withdrawal of courses after the term has ended:

- Will be rare and discouraged.
- Only the most serious circumstances warrant dropping a course after the end of a term. In order for the SSC to grant a withdrawal at this time, some non-academic, extraordinary event (like serious illness or a severe personal disruption) must have occurred after the ninth-week (fifth week of half-term) drop deadline and that would make completion of a course or courses very difficult if not impossible; the SSC assumes that the student's academic performance up to the point of the disruptive event has been satisfactory.
- Adverse circumstances that occur during most of a term generally have foreseeable consequences on performance that should be addressed by students' seeking advice and help, by advisors and faculty reaching out to students, and when necessary through the rules for dropping courses during the term. In addition, the incomplete (I) should be the default mechanism for dealing with a disruption that arises late in the term.
- Additional documentation will need to be provided regarding the reason the petition for a late withdrawal was not submitted during the term in which the student took the courses.
- A clear rationale should be provided for not giving a "W" in all courses, addressing why the extenuating circumstances did not impact all work.
- A 12-month deadline will apply to petition for retroactive withdrawal from courses from a past term.
- If a petition to late withdraw after the end of term is granted, the instructing faculty member whose grade has been changed to "W" will be notified.

The grade for any course dropped without completing the proper procedures will be recorded as "ED" (unofficial drop) and computed as "E" in grade-

point averages.

Junior and senior students enrolled in a Military Officer Education Program must also have approval of the Chair in charge of the unit before they can drop a Military Officer Education Program course or be relieved of the obligation assumed when enrolling in the program.

## Pass/Fail Information

### Pass/Fail Option (Elective)

Elective courses used to satisfy the Intellectual Breadth requirement or courses to be used as General Electives can be taken pass/fail. A maximum of fourteen (14) credit hours can be used toward CoE degree(s) requirements. Pass/fail course elections are limited to two courses per full term (Fall or Winter) or one course in a half term (Spring or Summer). Course elections exceeding the full/half term limits will be reverted to the grade earned. Course/credit limits will be calculated in academic term order of election. Any course that is offered only on a pass/fail basis will not be counted in the above totals.

1. The decision to elect a course on a pass/fail basis or on a graded basis must be made within the first nine weeks of the term (or first five weeks of a Spring or Summer half term). No changes in election as a graded course or as a pass/fail course can be made after the ninth week of a term, (or first five weeks of a half term).
2. Instructors are not notified of pass/fail elections; they will report grades as usual, "A+" through "E." The University of Michigan Registrar's Office will then translate grades as follows:
  1. A grade of "C-" through "A+" in a course elected on a pass/fail basis is considered satisfactory and will be recorded as "P" (pass—for credit toward the degree and no effect on the grade point average).
  2. A grade of "D+" or lower in a course elected on a pass/fail basis is considered unsatisfactory and will be recorded as "F" (fail—no credit and no effect on grade point average).
3. To be eligible for the Dean's Honor List, a minimum

of 12 credit hours (6 for a half term) must be elected for letter grades, with a grade point average of 3.5 or better.

4. To be eligible for Recognition on the Diploma, a minimum of 45 hours of credit with grades must be completed with a grade point average of 3.2 or better.
5. If a student completes a course for pass/fail and subsequently changes the degree program of study to one in which the course comes into conflict with the stated constraints for pass/fail elections in the new program, the course will be accepted in the new program as follows:
  1. A record of "P" (pass) is regarded as a satisfactory completion of the program requirement.
  2. A record of "F" (fail) is regarded as unsatisfactory completion and the course must be repeated for grades.

### Courses Offered on a Pass/Fail Basis Only (Mandatory)

A department or instructor may offer an undergraduate pass/fail course on the following basis:

1. The instructor will report the grade as pass/fail for each student enrolled.
2. The grade will be treated the same as when the student chooses to elect a course on a pass/fail basis if the following conditions are satisfied:
  1. The course is not required for any program or department.
  2. It is the type of course which might be considered appropriate to a pass/fail grading system. Examples of such courses may include: design, survey-type, individual directed research, laboratory, or undergraduate seminars.
3. The pass/fail nature of the course is announced by the instructor at the beginning of the term, with the exception of individual instruction courses. See the University Registrar's Office schedule of classes website (<http://www.umich.edu/~regoff/schedule>).

## Academic Definitions

### Visit

With permission of the advisor and course instructor, a student may enroll in a course as a visitor. In such a case, the course will be entered on the permanent record with a "VI" instead of a letter grade. The same fee will be charged whether the student enrolls for credit or as a visitor. A course elected as "VI" does not count toward a student's full time status.

A change in elections from credit to visit must be made during the first nine weeks of a term. Note that advisors typically will not approve changes in Visit elections after the third week (second week in Spring and Summer half terms). In such cases, withdrawing or changing to an election of Pass/Fail is generally more appropriate. After the ninth week, students must petition for an exception to College Rules to change Visit status. Required courses may not be elected as a visit.

### Term

A term (semester) extends over approximately four months, including examinations. The University's year-round calendar, by months, is approximately as follows:

Term	Months
Fall	Sept., Oct., Nov., Dec.
Winter	Jan., Feb., Mar., Apr.
Spring/Summer	May, June, July, Aug.

The Spring-Summer term may be scheduled as two half terms, approximately as follows:

Term	Months
Spring	May, June
Summer	July, Aug.

## Course Offerings

The appropriate Bulletin and the Schedule of Classes (<http://www.umich.edu/~regoff/schedule/>) prepared for each term will serve the student as a guide in planning each term's schedule. The College of Engineering reserves the right to withdraw the offering of any elective course not chosen by at least eight students.

### Credit Hour

A credit hour (semester hour) generally represents one hour of recitation or lecture per week for a term, or two for a half term; preparation for each credit hour normally requires a minimum of three hours of study per week. Generally, one period of laboratory work is considered to be equal to one hour of credit.

### Work Load

The number of credit hours a student is able to carry in any one term depends upon a number of factors—including abilities, health, and the amount of time devoted to extracurricular activities or to outside work. Twelve credit hours are considered a minimum full-time academic schedule for a full term (six for half term). Reduced program fees apply to 11 credit hours or less for undergraduate students.

Unless approved by the program advisor (for undeclared students, the Director of the Engineering Advising Center), the student may not elect courses (or change elections) for which the total number of hours for a term is less than 12 or more than 18, and for a half term, less than six or more than nine. A student should have a 3.0 average or more for the previous term to be permitted to carry a term load of more than 18 hours. Attention is called to the section on "Time Requirements" for a statement on estimating the time needed for a bachelor's degree.

### Attendance and Absences

Regular and punctual attendance in classes is one of a number of expressions of interest and maturity. The reasons for good attendance should be obvious, and



students may expect unexcused absences to be reflected in their final grade.

All students should account for their absences to their instructors. A student who has been absent from studies for more than one week because of illness or other emergency should consult the program advisor to determine the advisability of reducing course loads.

## Examinations

Examinations may be given at any time, with or without notice, on any part of the work. An examination at the end of the term is an essential part of the work of the course. The instructor is required to observe the official final examination schedule established by the University.

Any student absent from an examination should report to the instructor as soon thereafter as possible. If a student presents a valid excuse for being absent, a make-up examination may be arranged by the instructor for another time.

## Transfer Credit Information

### Transfer Credit for Enrolled Students (Transfer Credit Approval Form)

Currently enrolled students can receive transfer credit from classes taken at other institutions by following the instructions on the website for the Transfer Credit Approval Form. The Transfer Credit Approval Form can be accessed online at <http://tcaf.engin.umich.edu/>. The form itself must only be completed if a course needs to be evaluated for transfer credit. An evaluation typically takes two to four weeks and results in the notification of course transferability and the credit hours that will be earned upon completion of the course(s) with a grade of "C" or better. Online courses will be evaluated for transfer credit in the same manner and should also be submitted for approval via the Transfer Credit Approval Form. The College of Engineering allows a maximum of 12 credits for online transfer coursework. Transfer evaluations are generally conducted by the Department that owns the equivalent

course. Note that some Departments do not accept online courses.

For CoE undergraduate enrolled students, please send your official transcript to:

College of Engineering, Office of Recruitment  
and Admissions  
153 Chrysler Center  
2121 Bonisteel Boulevard  
Ann Arbor, MI 48109-2092

This information along with important rules to keep in mind can be found on the website shown above. Questions can be emailed to Credit Evaluation at [engincredit@umich.edu](mailto:engincredit@umich.edu) or answered in-person at Suite 145 Chrysler Center.

### Transfer Credit for International Programs

Currently enrolled students must consult with the International Programs in Engineering (IPE) office regarding course approvals, transfer credit and registration for all study abroad programs. Any student participating in an international experience must have a record in M-Compass.

Transcripts for IPE-Sponsored Programs should be sent to:

International Programs in Engineering  
245 Chrysler Center  
2121 Bonisteel Boulevard  
Ann Arbor, MI 48109-2092

### Declaring (or Changing) Major

Students may declare a major as early as their second term in the College, and are urged to declare a specific engineering major by the start of their 3rd term of enrollment. Undeclared students cannot register for a 4th term in the College unless they have met with an advisor and developed a plan to select and declare a major within a reasonable time. This plan can be developed in coordination with the EAC advisors and departmental program advisors.

Students who meet all of the criteria below can declare any undergraduate engineering major. Students not meeting these criteria must meet with a departmental program advisor to establish any specific steps they must take in order to declare that major.

Students can declare or change into any undergraduate engineering major if they:

1. Have completed at least one full term of courses on the U-M Ann Arbor campus.
2. Have an overall U-M GPA of 2.0 or better in courses taken at the U-M Ann Arbor campus and are in good standing.
3. Have completed or earned credit by exam or transfer for one or more courses in each of these categories:
  - Calculus (e.g. Math 115, 116, 156)
  - Calculus-based physics lectures (e.g. Physics 140, 160) or chemistry lectures (e.g. Chemistry 130)
  - Required engineering courses (Engr 100, 101, 151)

**A student must have a grade of C or better in every math course, science lecture and engineering course taken at U-M Ann Arbor to declare, unless waived by the program advisor, including 1-3 above. For repeated courses the most recent grade counts.**

## Transfers and Withdrawals, Readmission

### Transferring Out

A student who wishes to pursue studies in another unit of the University must apply for admission to that unit and be accepted in order to continue enrollment in the University. In most cases, a student must be in good scholastic standing to be eligible for admission to other colleges/schools.

### Term Withdrawals

The rules and procedures for term withdrawals vary based on when the withdrawal takes place, as outlined below:

- **Before the first day of classes:** Students must withdraw through the University of Michigan Office of the Registrar. This may be done in-person at B430 LL Pierpont Commons or Rm 1207 LSA Bldg., 500 S. State Street; via e-mail ([ro.registration.questions@umich.edu](mailto:ro.registration.questions@umich.edu)); by fax (734-763-9053 or 734-763-7961); or by mail (University of Michigan Office of the Registrar, Room 1207 LSA Building, Ann Arbor, MI 48109-1382). The term in question is fully removed from the academic record.
- A student who withdraws after registration shall pay a disenrollment fee according to the rules in effect at the time of withdrawal as found on the Office of the Registrar's website.
- **First day of classes to third-week deadline:** Student must report to the College Registrar's Office, for undergraduate students, (145A Chrysler Center); The term is fully removed from the academic record. No documentation is needed.
- **Third-week deadline to ninth-week deadline:** Student must report to the College Registrar's Office, for undergraduate students (145A Chrysler Center); a "W" will appear for each course. No documentation is needed.
- **Ninth-week deadline to last day of classes:** Student must report to the Scholastic Standing Committee

Office (129 Chrysler Center); a "W" will appear for each course. No documentation is needed. The student is not eligible to enroll in next full term. "Not to Register" is denoted on the record.

- After last day of classes (retroactive): Student must petition the Scholastic Standing Committee (129 Chrysler Center).
  - Late drop of courses after the last day of classes:
    - Will be rare and discouraged.
    - Only the most serious circumstances warrant dropping a course after the end of a term. In order for the SSC to grant a withdrawal at this time, some non-academic, extraordinary event (like serious illness or a severe personal disruption) must have occurred after the ninth-week (four and a half week of a half-term) drop deadline and that would make completion of a course or courses very difficult if not impossible; the SSC assumes that the student's academic performance up to the point of the disruptive event has been satisfactory.
    - Adverse circumstances occurring during most of a term generally have foreseeable consequences on performance that should be addressed by students' seeking advice and help, by advisors and faculty reaching out to students, and when necessary through the rules for dropping courses during the term. In addition, the incomplete "I" should be the default mechanism for dealing with a disruption that arises late in the term.
    - Additional documentation will need to be provided regarding the reason the petition for a late withdrawal was not submitted during the term in which the student took the courses.
    - If the student wishes to withdraw from only some of the courses in the term, a clear rationale should be provided for not giving a "W" in all

courses, addressing why the extenuating circumstances did not impact all work. Such partial withdrawals are approved very rarely.

- A 12 months deadline will apply to petition for retroactive withdrawal from courses from a past term.
- If a petition to late withdraw after the end of term is granted, the instructing faculty member whose grade has been changed to "W" will be notified.

Petitions are available on the web at **<http://www.engin.umich.edu/students/scholasticstanding/petitions.html>**.

Students withdrawing after the ninth-week deadline are not eligible to enroll in the next full term. A "Not to Register" designation will be placed on their academic record. If they are already registered they will be disenrolled. When they are eligible to return a "Permission to Register" designation will be placed on their academic record. Students with extenuating circumstances may petition the Scholastic Standing Committee (129 Chrysler Center) to waive this rule as an Exception to College Rules. Such petitions must be carefully documented, and exceptions are rarely granted.

**All students withdrawing from the College of Engineering will be asked to complete an exit survey.** Tuition and fee adjustments are in accordance with the Office of the Registrar.

International students need to meet with the International Center (Central Campus: 515 E. Jefferson St.) to determine if a withdrawal will impact their visa status. Student athletes must contact their advisor in the Academic Success Program regarding the term withdrawal.

## Unofficial Transcript

Each student's transcript is the cumulative record of courses elected and grades earned while enrolled at the University of Michigan.

Unless withheld for infringement of rules, an individual may obtain an official copy of his or her transcript from

the University Office of the Registrar at no charge. An unofficial copy of the transcript may be obtained through Wolverine Access.

## Grades

The grades are valued per hour of credit as follows:

Letter Grades	Honor Points
A+	4
A (excellent)	4
A-	3.7
B+	3.3
B (good)	3
B-	2.7
C+	2.3
C (satisfactory)	2
C-	1.7
D+	1.3
D	1
D-	0.7
E (not passed)	0
ED (unofficial drop)	0

These items do not affect grade point averages:

- **Pass/Fail**
  - P (passed) credit, no honor points
  - F (failed) no credit, no honor points
- **Credit/No Credit**
  - CR (credit) credit, no honor points
  - NC (no credit) no credit, no honor points
- **Satisfactory/Unsatisfactory**
  - S (satisfactory) credit, no honor points
  - U (unsatisfactory) no credit, no honor points
- **Withdrawal/Drop**
  - W (official withdrawal) no credit, no honor points
  - ED (dropped unofficially) no credit, no honor points  
(A notation of ED for a graded election has the same effect on the grade point average as does an E.)

### • Incomplete/Work in Progress

- I\*(incomplete) no credit, no honor points
- Y\*(work in progress for no credit, no honor points, project approved to extend for two successive terms)  
("Y" can only be used with courses specially approved by College of Engineering Curriculum Committee as "two-term" sequence courses.)

### • Official Audit (VI)

- VI (Visitor) no credit, no honor points

### • Miscellaneous Notation (NR)

- NR\*\*(no report) no credit, no honor points

\*A notation of "I," if not replaced by a passing grade, lapses to "E" the last day of classes for the next full term and, for graded elections, is computed into the term and cumulative grade point average.

\*\*A notation of "NR" becomes an "ED" and has the same effect on the grade point average as does an "E." In the remainder of this section of the Bulletin, the term "a grade" applies to any of the grades "A+" through "E."

## C- and D Grades

Credit is generally allowed for a course in which a grade of "C-" or "D" is earned while enrolled in the College of Engineering, but there are restrictions:

- The "D" level of performance ("D+" or lower) is not considered satisfactory for a course that is a prerequisite for a later-elected course; in this case, the course must be repeated before electing the next course unless waived by the program advisor.
- A grade of "D+" and lower is not acceptable in any program for Engineering 100, Engineering 101.
- A grade of "C-" is not a satisfactory level of performance in some programs for any required course.
- "C-" grades in math, science or introductory engineering courses may negatively impact a student's eligibility to declare a degree program. Please consult the rules for declaring a major.
- It is the student's responsibility to review course performance with their advisor as soon as the grade is

known in order to make any changes that may be necessary in future course elections.

Transfer credit will be granted for courses taken outside the University of Michigan, Ann Arbor campus, provided a grade of "C" or better is earned. Transfer credit will be granted for courses, other than math, science, engineering, or other prerequisites for admission into the College of Engineering, taken in any academic unit at the University of Michigan, Ann Arbor campus, provided a grade of "C-" or better is earned.

Students should be aware that some programs limit the number of "C-" grades or require that courses completed with a "C-" or lower grade be repeated. Some programs may have a higher minimum grade requirement for some courses.

## E Grades

Neither credit nor Michigan Honor Points are granted for a course in which a student earns the grade of "E." A course required by the student's program must be repeated as soon as possible.

## Incompletes

When a student is prevented by illness, or by any other cause beyond the student's control, from taking an examination or from completing any part of a course, or if credit in a course is temporarily withheld for good reason, the mark "I" may be reported to indicate the course has not been completed. This mark should be used only when there is a good probability that the student can complete the course. The instructor and student should mutually understand the reasons for the "I" mark and agree on methods and timeline for completing the work.

No qualifying grade will be recorded on the student's academic record. The "I" mark will not be used in computing either the term or cumulative grade point averages. Scholastic standing at the end of any term is determined on the basis of work graded as "A+" through "E," or "ED."

The required work may be completed and the grade

submitted by the instructor whether or not the student is enrolled in the subsequent term. The student should plan to complete the work as soon as possible. To secure credit, the required work must be completed by the end of the first full term (not including Spring or Summer terms) in which the student is enrolled after the term in which the "I" mark was recorded. It is the student's responsibility to remind the instructor to submit a grade report through the grading system in Wolverine Access when the work is completed. If the final grade is not reported by the last day of classes, the University Registrar will automatically change the "I" to an "ILE." Incomplete extensions must be arranged with the instructor. Forms are available at the College Registrar's Office, 145A Chrysler Center.

Any grade changes made to the student record as a result of Incompletes either being completed or lapsed will result in reevaluation of a student's academic record by the Scholastic Standing Committee and may result in changes to their academic standing.

## Other Irregularities

Irregularities associated with a failure to submit changes in academic status are identified on the student's transcript by an appropriate designation such as "ED" (unofficial drop) or "NR" (no report). "NR" (no reports) are automatically converted to "ED" when entered into the grading system in Wolverine Access. An unofficial drop will be considered the same as an "E" in computing the term and cumulative averages and will affect the scholastic standing.

## Repeating Courses

For "C-," "D" and "E" grades, see above. Except as provided for grades "C-" through "D-," a student may not repeat a course he or she has already passed. In exceptional cases, this rule may be waived by the student's program advisor (for undeclared students, the Director of the Engineering Advising Center) after consultation with the department of instruction involved. If the rule is waived, the course and grade will appear on the transcript, but no additional credit or Michigan Honor Points (MHPs) will be granted.

A student repeating a course in which a "C-" through "D-" was previously earned will receive MHPs but no additional credit. All attempts at a course are used in computing the overall grade point average.

## Grade Point Averages

The term grade point average (GPA) and the cumulative GPA are computed for each student at the end of each term and become part of the academic record.

The grade point average is computed by dividing the grade points (Michigan Honor Points or MHP) by the graded hours attempted (Michigan Semester Hours or MSH).

Grades associated with transfer credit are neither recorded nor used in computing the cumulative average. The only exception to this rule is for courses elected on the Ann Arbor campus (effective November 1986).

## Honor Point Deficit Calculator

**(Michigan Semester Hours \* 2) - Michigan Honor Points = Honor Point Deficit**

Use cumulative totals to calculate cumulative deficit; use term totals to calculate term deficit. The result reflects the number of "B" credits needed to raise cumulative or semester GPA above 2.0.

The GPA is figured by dividing Michigan Honor Points (MHP) by Michigan Semester Hours (MSH):  $25.6 \text{ MHP} / 16.00 \text{ MSH} = 1.600 \text{ GPA}$ .

The term honor point deficit is calculated by multiplying MSH by 2 and subtracting MHP:  $(16.00 \text{ MSH} \times 2) - 25.60 \text{ MHP} = 6.4 \text{ honor point deficit}$ .

Thus, this student needs 6.4 credits of "B" grades to raise his/her term GPA above 2.00.

## Academic Honors and Awards

### The Dean's List (College of Engineering)

Students pursuing an undergraduate degree who elect courses and complete a minimum of 12 credit hours with grades (6 for a half Spring or Summer term) and earn a 3.50 GPA term average or better, attain the distinction of the Dean's List for the term.

### University Honors (University of Michigan)

Students who earn a minimum of 14 credits in courses which include 12 credits elected on a graded basis ("A" through "E"), and who earn a 3.5 grade point average are eligible for University Honors. This Honor will be awarded each full term of classes (Fall & Winter terms). This distinction is posted on a student's transcript by the University of Michigan Registrar's Office. Students who receive this honor for two consecutive terms will be invited to attend the annual Honors Convocation.

### James B. Angell Scholars (University of Michigan)

James B. Angell Scholars are students who earn all "A+," "A," or "A-" grades for two or more consecutive terms based on a minimum of 14 credits earned in courses which include 12 credits earned on a graded ("A"- "E" basis elected each term); all other grades must be "P," "S," or "CR". Terms of fewer than 14 credits completed with grades of "A+," "A," "A-," "P," "S," or "CR" enable a student to maintain standing as an Angell Scholar. Any other grades earned during a full or half-term make a student ineligible for this honor. Angell Scholar Honors are posted on a student's transcript by the University Office of the Registrar, and recipients of this honor are invited to attend the annual Honors Convocation. Angell Scholars are selected and honored annually.

### William J. Branstrom Freshman Prize (University of Michigan)

Students in the top five percent of the freshman class are eligible for this honor, administered by the University Registrar's Office, if they have earned at least 14 graded credits at Michigan. A book with an inscribed nameplate is presented to each student. Recipients of this award are invited to attend the annual Honors Convocation.

### **Marian Sarah Parker Scholars (College of Engineering)**

The Marian Sarah Parker Scholars Program is a joint program of the College of Engineering and the U-M Women in Science and Engineering (WISE) Program. The Marian Sarah Parker Scholars Program invites high-achieving women, by Fall Term of their junior year, to participate in a two-year exploration of graduate school. Participation as a Marian Sarah Parker Scholar leads to a greater understanding of the graduate school process by means of seminars, panel discussions, and an academic research project.

### **Special Awards (College of Engineering)**

The College gives special recognition to students with high scholastic achievement, with records of service to the College and its student organizations, or with evidence of extraordinary potential for leadership. Information on qualification requirements can be obtained in the Office of Student Affairs, 143 Chrysler Center.

### **Society Recognition (College of Engineering)**

Distinguished scholarship and service to the College are also recognized by election to a number of honor societies that are listed under "Student Activities and Co-Curricular Opportunities."

### **Recognition on Diploma (College of Engineering)**

A student graduating with at least 45 hours of credit completed, with grades, while enrolled in this College will be recommended for a degree(s) with recognition on the diploma if the student qualifies according to the following:

#### **Grade Point Average Distinction**

3.20-3.49..... cum laude

3.50-3.74..... magna cum laude

3.75-4.00..... summa cum laude

## **Grievances Procedures**

### **Grade Grievances Procedure**

If there is justification to question the accuracy of an assigned grade, the student should first pursue the matter with the instructor. The responsibility for the assign-

ment of grades is primarily that of the instructor and should be settled between the student and instructor whenever possible. Further pursuit of a grade grievance should be addressed with the instructor's Department Chair. The final appeal at the College level is by petition to the Associate Dean for Undergraduate Education or the Associate Dean for Graduate Education.

### **Student Grievances**

The College of Engineering has a grievance procedure to address student complaints.

Undergraduate and Graduate students should follow these steps until a resolution is achieved:

1. Attempt to resolve the grievance directly with the individual involved (faculty member, staff member, or fellow student).
2. If the matter is unresolved, and the grievance is with a faculty member or teaching assistant, discuss the grievance with the appropriate Department Chair.
3. If the issue is still unresolved, undergraduate students should see the Associate Dean for Undergraduate Education and graduate students should see the Associate Dean for Graduate Education who are both located in the Robert H. Lurie Engineering Center.
4. All students have the right to appeal to the Dean of the College if they feel their grievances have not been resolved satisfactorily by another dean.

## **Scholastic Standing Committee**

129 Chrysler Center

Phone: (734) 647-6955

Fax: (734) 763-5345

[sscresponse@umich.edu](mailto:sscresponse@umich.edu)

The Scholastic Standing Committee (SSC) is comprised of faculty representatives and academic services staff members. Faculty members are appointed for a three-year term. The SSC studies problems related to, and defines criteria for, scholastic performance. In ad-

dition the SSC reviews all petitions within the College, including the Petition for Reinstatement, the Petition for Late Drop, the Petition for Exception to College Rules, and the Petition for Retroactive Term Withdrawal.

## Standards Governing Scholastic Standing for Unsatisfactory Performance

All students will be in one of the following classifications:

- **Good Standing:** 2.00 GPA or better for both the term and the cumulative average.
- **Probation:** a deficiency of up to 10 MHP for the term or cumulative average.
- **Enrollment Withheld:** a deficiency of 10 MHP\* or above for the term or cumulative average; or the third or greater incidence of probation.
- **Reinstated on Probation:** Enrollment Withheld, but reinstated by the Scholastic Standing Committee.
- **Enrollment Withheld Waived:** Enrollment Withheld status remains but the petition process is waived because previous reinstatement conditions were met.
- **Mandatory Leave:** SSC decision requiring a leave from the College of Engineering based upon unsatisfactory academic performance. Students will have to petition for reinstatement to return after their required leave has been fulfilled.
- **Dismissal:** SSC decision based upon failure to meet the conditions of reinstatement. Student is no longer eligible to enroll in the College of Engineering or petition the Scholastic Standing Committee for reinstatement.

Scholastic standing action will be determined as follows:

### Probation

When a student has a deficiency between 0 and 10 MHPs for either the term or cumulative GPA, the student is placed on probation. The notation "Probation" will be entered on the unofficial transcript.

A student on probation may continue enrollment, but is required to meet with a program advisor (undeclared students are required to meet with an advisor in the Engineering Advising Center) regarding course selection for the following term. Failure to do so will result in an academic hold on his or her account, preventing enrollment in future terms. Probation is a serious warning that there is a need to improve scholastic performance or further enrollment may be jeopardized.

### Enrollment Withheld

A student will have the notation "Enrollment Withheld" placed on his/her transcript and will not be allowed to enroll in classes if: a) on Probation for the third or greater time; or, b) a deficiency of 10 MHP or more in either the term or the cumulative GPA.

When a student is on Enrollment Withheld, the student must submit a petition to the Scholastic Standing Committee (SSC, <http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/>) requesting reinstatement. The student must meet with his/her program advisor to discuss the petition (undeclared students must meet with their advisor in the Engineering Advising Center). The petition must document the reasons for the unsatisfactory performance, and it needs to offer sufficient and convincing evidence that another opportunity is warranted. If illness has been a factor, students must include supporting information, including a statement (with dates) from their physician. Documentation supporting other contributing factors must also be included.

Reinstatement petitions must be submitted to the Scholastic Standing Committee via the online petition system. Failure to petition the SSC in time and follow the correct procedure will result in a forfeiture of the right to petition for reinstatement for that term and disenrollment from the College.



Students who were enrolled in the previous term must submit their reinstatement petitions in accordance with the following deadlines:

Fall Term 2015	July 1, 2015
Winter Term 2016	January 6, 2016
Spring Term 2016	May 8, 2016
Summer Term 2016	July 13, 2016
Fall Term 2016	July 1, 2016

Students returning after time away from the College must submit their reinstatement petitions in accordance with the following deadlines:

Fall Term 2015	July 1, 2015
Winter Term 2016	November 1, 2015
Spring Term 2016	March 1, 2016
Summer Term 2016	May 1, 2016
Fall Term 2016	July 1, 2016

Reinstatement petitions will not be accepted after the deadline.

It is the policy of the College and the SSC not to reinstate students with 128 credit hours solely for the purpose of improving their grade point average or removing an honor point deficiency to meet the 2.0 cumulative grade point average requirement for the baccalaureate (B.S.E.) degree requirements.

Students seeking reinstatement may be required to meet the SSC, where two committee members hear the student's case. The Committee will either approve the student's reinstatement, or require a permanent or temporary dismissal. When a student is reinstated, he or she is required to sign a contract that states the conditions he or she must meet in order to continue in future terms.

Reinstated students are not permitted to register for future terms unless they can demonstrate they have met their conditions of reinstatement. Students must wait until grades are posted or complete a progress report, before early registration, available at <http://ossa.engin.umich.edu/scholastic-standing-committee/progress-reports/>. The Progress Report must be submitted to the SSC, 129 Chrysler Center, once completed.

Questions, appointments and petition forms are handled by the SSC, 129 Chrysler Center, (734) 647-6955. All petitions are available online at <http://ossa.engin.umich.edu/scholastic-standing-committee/petitions/>. It is recommended that you submit petitions and documentation via the online petition tool.

Students who are not reinstated will be placed on suspension and disenrolled.

## Mandatory Leaves

Two (2) Enrollment Withheld (EW) notations require a student to take a leave from the College of Engineering for one (1) full term (Fall or Winter).<sup>\*</sup> A student may also be required to take a mandatory leave with less than two EW notations if they have a very large deficit and/or have issues that need immediate attention.

If a student with two EW's intends to return to the College after the required leave, he/she is required to petition the Scholastic Standing Committee for reinstatement. The deadlines for submitting reinstatement petitions are:

Fall Term 2015	July 1, 2015
Winter Term 2016	November 1, 2015
Spring Term 2016	March 1, 2016
Summer Term 2016	May 1, 2016

<sup>\*</sup>Students receiving their second EW at the end of the Winter term will not be eligible to enroll in the Spring, Summer, Spring-Summer or Fall terms at the University of Michigan.

## Dismissal

Permanent dismissal from the College of Engineering is a Scholastic Standing Committee decision based upon a student's failure to meet the conditions of reinstatement. Students are no longer eligible to enroll in or attend the College of Engineering. Students also lose the privilege of petitioning the Scholastic Standing Committee for reinstatement.

# Degree Requirements

## Requirements for a Bachelor's Degree

To obtain a bachelor's degree in the College of Engineering, Ann Arbor campus, 128 credit hours must be earned and a student shall meet the following requirements, subject to approval of the program advisor:

1. The student must achieve a satisfactory level in those subjects specified by the program of his or her choice. A grade of "D" in a required course may not be considered satisfactory unless approved by the program advisor. In some programs, a grade of "C-" is likewise not considered satisfactory. A student may receive credit toward a degree in one or more of the following ways:

- By passing a course for credit on the Ann Arbor campus ("C-" or "D" grades may not be acceptable as a proper level of attainment for a required course, as noted above.)
- By Advanced Placement Program examination for college-level work completed in high school (See "Advanced Placement," under "Admission.")
- By an examination regularly offered by a department of the University, or by a recognized testing service.
- By transfer of equivalent credit from another recognized college (See "Adjustment of Advanced Credit")
- By demonstrating competence in a higher-level course or series covering similar material (e.g., honors-level).
- By demonstrating equivalent and parallel knowledge that enables the student to enroll at an advanced level. In this case, the student will not be allowed credit hours on the transcript, but may be excused from enrolling in courses in which the program advisor judges the student proficient. To qualify, the student must petition the program advisor and, as a condition, may be required to demonstrate his or her proficiency by an appropriate examination.

2. The student must accumulate a final grade point average of 2.00 or more for all credit hours not taken

under the pass/fail option while enrolled in the College of Engineering. In addition, a student must earn a cumulative grade point average of 2.00 or higher in all courses taken within the student's academic department. Consult your department for additional information.

3. The student must complete at least 50 credit hours of course work offered by the University of Michigan-Ann Arbor campus. This course work must generate credits towards program (CTP) on the student's transcript. A few courses, for example, ENGR 196, ENGR 301 and ENGR 400, do not generate CTP.
4. The student must complete a minimum of 30 credit hours of advanced level (300 or higher) technical courses, as required by the degree program, offered by the College of Engineering, Ann Arbor campus. This course work must generate credits towards program (CTP) on the student's transcript. A few courses, for example, ENGR 301 and ENGR 400, do not generate CTP.
5. The College of Engineering does not allow a single class to meet the program requirements of both a CoE degree program and two or more other degree programs, regardless of school or college in which the latter degrees are offered.
6. The student must file formal application for the diploma. (See "Diploma and Commencement" below.)

## Time Requirement

The time required to complete a degree program depends on the background, abilities, and interests of the individual student. Note: A full-time schedule averaging 16 hours of required subjects will allow a student to complete the degree requirements (128 credit hours) in eight terms as noted in the sample schedules appearing with the program descriptions.

A student who is admitted with advanced preparation, with demonstrated levels of attainment, or with ability to achieve at high levels may accelerate his or her progress. A student who is partially self-supporting while at the campus may find it desirable to plan a schedule longer than eight terms.

A student who plans to continue studies beyond the

bachelor's degree may (after attaining senior standing) elect a limited number of graduate-level courses concurrently with the courses required for the bachelor's degree. A course required for the bachelor's degree generally cannot be used for graduate credit also, except as allowed by the Sequential Undergraduate/Graduate Studies Program. For details, refer to the regulations published by the University of Michigan Horace H. Rackham School of Graduate Studies.

## Requirements for an Additional Bachelor's Degree

Additional bachelor's degrees can be conferred in the College of Engineering, Ann Arbor campus.

1. To obtain additional bachelor's degrees in the College of Engineering, a student must complete the requirements of each of the degree programs. Furthermore, for each additional degree, the student must complete at least a minimum of 14 additional credit hours in pertinent technical subjects. Approval by involved departments is required.
2. Students are encouraged to carefully consider whether a relevant graduate degree would be more appropriate than a second undergraduate degree. Students are strongly discouraged from declaring three (or more) undergraduate majors, and may not use the same course to meet the program requirements of both an Engineering degree program and two or more other degree programs, regardless of school or college in which the latter degrees are offered.
3. To obtain an additional bachelor's degree with a school or college on the University of Michigan-Ann Arbor campus, refer to the program requirements under Combined Programs for details.

## Substitution

Substitution of a course for one which is a requirement for graduation must be approved by the program advisor of the student's degree program.

## Diploma and Commencement

For the College of Engineering to recommend the granting of a degree, a student who satisfies all other requirements must apply for graduation through Wolverine Access. A student completing the requirements for a College of Engineering degree and a second degree in one of the other schools/colleges on the University of Michigan-Ann Arbor campus must apply for graduation for each of the degrees for the same graduation date.

A student should apply for graduation at the beginning of the term in which the student is reasonably certain of completing the work for the degree.

When a student does not meet the requirements as planned, the student must re-apply at the appropriate time. Degrees are awarded at the end of the fall, winter, and spring-summer terms.

All students who are entitled to receive diplomas are welcome at the Commencement exercises appropriate to the date of graduation.

# Undergraduate Education

## Mission Statement

### Objectives

A University of Michigan undergraduate engineering graduate will be prepared to generate value for society through a lifetime of technical and professional creativity. Our graduates will display reasoning skills and proficiency in problem definition, problem solving and quantitative expertise, a respect for measurement and data and the wisdom of experience. Our graduates will use these skills to achieve the following objectives within a few years of graduation:

- Contribute to technical engineering practice
- Pursue graduate education in engineering or science, either following a path towards a professional masters degree and practice, or a doctoral degree
- Pursue careers in law, medicine, education or other fields, bringing engineering problem solving skills — honed through practice in problem definition and quantitative problem solving — to bear in those disciplines

Michigan Engineers will excel in all of these areas of endeavor. They will also be prepared to become successful leaders, managers, entrepreneurs and humanitarians.

Our graduates must understand that solutions, especially for society's most critical needs, are not just technical in scope but depend on many disciplines working together and that as engineers their core contribution will include bringing data-driven, quantitative problem solving skills to the table. We also understand that our students have many varied aspirations and that our primary duty is to provide them with a foundational education that they can carry forward into any of the career paths they may follow over the decades of their careers.

To prepare our students for the careers of the 21st century, whether they continue in engineering or pursue other paths after graduation, our undergraduate pro-

grams support our students in developing:

- An understanding of the fundamental knowledge in a discipline
- An ability to recognize and define a problem, and the vision to see a solution
- An ability to identify, understand, and solve ill-defined problems even in the face of uncertainty and imperfect information
- Strong quantitative and qualitative problem solving skills
- A mindset and skills that support continued learning both during and long after their CoE career
- Personal attributes of success including:
  - high personal expectations
  - persistence
  - the ability to work in teams
  - the ability to plan a project and carry it out
  - the ability to gather resources and overcome barriers to success
  - the ability to manage risk
  - the ability to communicate professionally
- An understanding of the human, social, and environmental dimensions of engineering practice
- A drive and capability to make a difference by bringing their solutions into production

Many of the College's undergraduate degree programs are accredited by the Accreditation Board for Engineering Education and Technology (ABET). Each such program has statements of educational objectives and outcomes that are based on the College's mission and on the needs of its constituents. Those constituents include our alumni, students, employers of our students and the graduate schools at which many of our students later study.

### Outcomes

Graduates of the College's undergraduate programs will be able to:

1. Apply their knowledge of mathematics, science and engineering within their chosen field. (a)
2. Recognize and define engineering problems and develop practical solutions using the techniques and

- skills of modern engineering practice. (e,k)
3. Design products and processes applicable to their chosen field. (c)
  4. Design, conduct and interpret the results of engineering experiments. (b)
  5. Work effectively in diverse teams and provide leadership to teams and organizations. (d)
  6. Communicate effectively using oral, graphic and written forms. (g)
  7. Understand the impact of engineering decisions in global, social, economic and environmental context. (h)
  8. Understand professional and ethical responsibility and apply ethical reasoning to the work. (f).
  9. Engage in life-long learning and recognize the importance of doing so. (i)
  10. A broad education necessary to contribute effectively beyond their professional careers.
  11. Understand and make a contribution to society. (j)
- (letters) are references to ABET Engineering Accreditation Commission outcomes a through k.

## Curricular Information in the Bulletin

In this edition of the College of Engineering Bulletin, our traditional "Sample Schedule for Required Programs" has been updated to reflect the current undergraduate engineering curriculum and curricular plans in each department and program. It is important to note that the curriculum revision process is an ongoing one; therefore, the program requirements and specific course requirements, especially upper-division courses, listed here should be viewed as works-in-progress. Always confirm your course plan with your academic advisor. Upon entering the College, undeclared students will be assigned an advisor in the Engineering Advising Center. After declaring a degree program, a student's advising home moves to that program's Advising Office. Each department's Program Advising Office and Web site information has been provided for your assistance in determining specific program changes.

## Core Requirements

### Planning the Student's Program

Students vary in their goals and objectives, in their level of achievement and in their high school or pre-engineering preparation. Considerable variety and flexibility are provided to plan each student's schedule so that the individual may reach graduation as efficiently as possible. The objective is to place each new student in courses commensurate with his or her academic profile, previous experience and potential for academic success.

Most courses have prerequisites. The completion of courses on schedule and with satisfactory grades is essential to the student's progress.

The appropriate schedule for each student in each term will depend on a number of factors such as: past scholastic record; placement test results; extracurricular activities; election of co-op, international or Military Office Education Programs; health; and need for partial self-support. A schedule of 12 to 18 hours is considered full-time.

All College of Engineering B.S.E. programs require successful completion of a program of 128 credit hours. An average of 16 credit-hours per term allows a student to complete these programs in 8 terms, generally requiring 4 years of study.

### First- and Second-Year Programs

At the time of each student's first advising session, all of the high school and advance placement records may not yet be in the student's file. It is the entering student's responsibility to make certain that all pertinent information is brought to the attention of an Engineering Advising Center (EAC) Advisor. Any changes in test scores or transfer credits will affect final course selection and need to be discussed with an advisor. With complete information available, the advisor and the student will be able to make carefully considered adjustments in course elections for the first-term course schedule.

## First-Year

Assuming the necessary academic preparation and no advanced placement credit, each student will be expected to complete some combination of the following courses:

1. Mathematics 115 and 116 or one of the honors Math sequences.
2. Chemistry 130 and 125/126, or, for some, 130, 210, and 211.
3. Engineering 100
4. Engineering 101 or Engineering 151 (ENGR 151 is an approved alternative to ENGR 101 for all CoE programs)
5. Physics 140 and 141

Additional course information will be available during the advising session.

## Second Year

All students will continue with the mathematics, physics and intellectual breadth courses common to all programs. A second-term student who has selected a degree program should be meeting with that program advisor for third-term elections.

Students who have not selected a degree program should consult the Engineering Advising Center for their course selections.

## LSA Honors-Level Courses

Some math and science courses in LSA are considered honors level equivalents of the core math and science requirements. A student whose record indicates qualifications to perform at an advanced level should discuss this option with an advisor in the Engineering Advising Center.

## Minimum Common Requirements

Each of the degree programs offered by the College includes credit hours that are common to all programs, subject to appropriate adjustment for equivalent alter-

natives. See individual sample schedules for required programs in each program section of this Bulletin. Some programs may have a higher minimum grade requirement for some courses.

## Engineering 100: Introduction to Engineering

Engineering 100 introduces students to the professional skills required of engineers and provides them with an overview of engineering at the beginning of their program. An important component of the course is the real-world engineering project. Important engineering skills developed in Engineering 100 include:

- Preparation of written technical reports and oral presentations to communicate ideas to a broad audience
- Technical problem solving and the creative engineering design process
- Teamwork and team management
- Professional responsibility
- The influence of engineers on society
- Sustainable engineering
- Decision-making skills

Numerous sections are offered both Fall and Winter semesters, featuring a variety of design projects. Students are strongly encouraged to select a section that aligns with their interests. Details on each of the sections can be found at the Engineering 100 website:

**<http://eng100.engin.umich.edu>**

**Important Note:** You must receive a grade of C- or better in Engineering 100 to fulfill the requirement, however earning a grade lower than C may negatively impact a student's eligibility to declare a program and may require repeating the course. Note: A grade of "C" is required for EECS Programs. Transfer students must complete English composition or a course equivalent to ENGR 100 as a prerequisite for transfer admission. Be sure to consult with the Office of Recruitment and Admissions if you have questions.

## Advanced Placement English Credit

Advanced Placement (AP) English Literature credit is assessed as English departmental credit and can be used towards the Liberal Arts Courses (LACs) of the Intellectual Breadth Requirement. You will not receive credit for Sweetland Writing Center courses.

## Engineering 101: Introduction to Computers and Programming

The objective of Engineering 101 is to introduce students in engineering to the algorithmic method that drives the information age. Algorithms are an organized means to construct the solution of a problem, structured as a well-defined set of steps that can be carried out by a mechanism such as a computer.

Engineering 101 focuses on the development of algorithms to solve problems of relevance in engineering practice and on the implementation of these algorithms using high-level computer languages. It is centered on quantitative and numerical problems that are suited to computational solutions. These often arise as part of larger, more complex problems in engineering practice.

Engineering 101 also ties itself to the introductory physics and math courses, and provides concrete examples of some of the concepts being covered in those classes. Sample problem types might include:

- Finding area and volume
- Simulating statistical processes
- Data analysis
- Physical simulation
- Simulating complex systems with simple rules
- Minimization and optimization
- Computer graphics
- Logic Puzzles

In addition to the problem-solving component, students who take Engineering 101 will learn aspects of the C++ programming languages and be exposed to the MATLAB programming language. C++ and MATLAB are used today in many fields of engineering. MATLAB is also popular and has powerful capa-

bilities for handling computation involving matrices and for visualizing data using 2-D and 3-D graphics. It is important to note that MATLAB will be useful in future math and engineering courses.

Students entering Engineering 101 are not expected to know how to program; this skill will be taught as part of the class. Visit the Engineering 101 website for detailed information on specific sections of the class.

## Engineering 151: Accelerated Introduction to Computers and Programming

Engineering 151 provides an accelerated alternative to Engineering 101 for students either with previous programming experience or with strong motivation and natural intuition for algorithms. It introduces students to the algorithm development, procedural programming concepts and languages covered in Engineering 101 but at a faster pace. It also introduces object-oriented programming, engineering analysis methods and additional topics such as parallel computing or embedded systems. Visit the Engineering 151 website for more detailed information.

**Important notes** (1) You must receive a grade of "C-" or better in Engineering 101 or Engineering 151 to fulfill the requirement, however earning a grade lower than C may negatively impact a student's eligibility to declare a program and may require repeating the course.

## Mathematics

The mathematics courses of 115 (4 credits), 116 (4 credits), 215 (4 credits), and 216 (4 credits) provide an integrated 16-credit-hour sequence in college mathematics that includes analytic geometry, calculus, elementary linear algebra and elementary differential equations.

All students with strong preparation and interest in mathematics are encouraged to consider one of the honors-level math sequences. Qualified and interested students should consult their engineering advisor about these options. It is not necessary to be in an honors pro-

gram to enroll in these courses.

Earning a grade lower than C may negatively impact a students' eligibility to declare a program and may require repeating the course. Experience indicates that students earning a grade of C- or below in a math class may have an insufficient foundation for further study in the quantitative field of engineering.

## Chemistry

Chem 130 (3 credits) with laboratory Chem 125/126 (2 credits) is required by most degree programs. Students will normally elect these courses during the freshman year. The following degree programs require additional chemistry: Biomedical Engineering, Chemical Engineering and Materials Science and Engineering. Students expecting to enter one of these degree programs would normally elect Chem 130 (3 credits), and Chem 210 (4 credits) with laboratory, Chem 211 (1) during the freshman year depending on UM placement exam results.

**Important Notes:** (1) If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution you will have met the Chemistry Core Requirement for CoE. (2) Students who place into Chem 210/211 will not be given credit for Chem 130. (3) Earning a grade lower than C may negatively impact a students' eligibility to declare a program and may require repeating the course.

## Physics

The usual first year schedule includes Physics 140 (4 credits) with laboratory, Physics 141 (1 credit). This course requires completion of Calculus I. A second course, Physics 240 (4 credits) with laboratory, 241 (1 credit), is required by all programs and is normally scheduled in the third term.

**Important Notes:** (1) If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit for Physics 140/141 and 240/241 from another institution you will have met the Physics Core Requirement for CoE. (2) All students with strong preparation

and interest in physics are encouraged to consider the honors-level physics sequence. (3) Earning a grade lower than C may negatively impact a students' eligibility to declare a program and may require repeating the course.

## Transfer credits for Core Math and Science

Students who through use of transfer credit or credit-by-test have fewer than 31 credits total in: math covering the introductory sequence (equivalent to Math 115 – 214/216); introductory physics (Phys 140, 141, 240, 241); and introductory chemistry (Chem 130, 125/126); but have learned the required content as assessed by the math, physics or chemistry department must nevertheless make up the difference in credit hours. This can be done using any number of elective courses in math or science, or, at the discretion of the program advisor, using engineering courses with a mathematical or science focus (e.g. engineering statistics, solid state or nuclear physics, etc.), to make up the total of 31 credits.

Note: ABET Criterion 5 requires all students to have a minimum of 32 credits of college level math and basic sciences, some with an experimental experience. They must also have 48 credits of engineering topics (engineering science and design). All of our programs provide at least one additional credit of math or science within departmental curricula, and in applying this policy for missing math and science credits “basic science” and “engineering science” will be appropriately distinguished.

## Intellectual Breadth

Note: For students matriculated into the College of Engineering before September 2011, the Humanities and Social Science Requirements apply. You can also refer to the previous edition of the Bulletin as appropriate to your year of matriculation.

For students matriculated for Fall term 2011 and after the following requirements apply:

It is important that our students learn about modes of



thought and areas of human accomplishment beyond the purely technical. This breadth can be designed by students to provide context to their engineering work by learning about human modes of thought, the structure and history of the human societies that they serve as engineers, how humans behave and interact, and how humans express their aspirations in the arts, literature and music. This breadth will help students to understand the impact of engineering solutions in a global, economic, environmental and societal context. This breadth makes our students more flexible, creative and better able to work with diverse groups.

We cannot precisely define all of these possibilities for every student so we strive to create a broad intellectual opportunity for students to pursue their interests both beyond and within engineering. Students are encouraged to use these credits in a coherent way to build a foundation of understanding in both the liberal arts and other disciplines that might contribute to their development of creativity or professional foundation.

The College of Engineering requires all students to complete 16 credits of intellectual breadth courses, and between 9 and 16 credits of general electives (depending on engineering major). Each student selects 16 credits of intellectual breadth courses - subject to these rules:

- **Humanities:** At least 3 credits of Humanities classes marked HU in the LSA course guide; credit by test cannot be used to meet this requirement.
- **Professional & Creative Development Courses (PCDC):** no more than 4 credits of PCDC (defined below).
- **Liberal Arts Courses (LACs):** The remainder of the 16 credits are drawn from any of the LACs (defined below).
- At least 3 credits in the Humanities or LACs must be at the 300 level or higher.

The currently approved numbers of general elective hours for each degree program are:

Degree Program	Credits of General Electives
Aerospace Engineering	9
Biomedical Engineering	11
Chemical Engineering	12
Civil and Environmental Engineering	12
Climate and Meteorology (pending final stage of approval)	11
Computer Engineering	13-16
Computer Science	15
Data Science	15
Earth System Science and Engineering	11
Electrical Engineering	11
Engineering Physics	12
Environmental Engineering	12
Industrial and Operations Engineering	9-12
Materials Science Engineering	12
Mechanical Engineering	9
Naval Architecture and Marine Engineering	9
Nuclear Engineering and Radiological Sciences	10
Space Science and Engineering (pending final stage of approval)	10

## Definition of Liberal Arts Courses

Liberal Arts Courses (LACs) are intended to give students the broader education in qualitative critical thinking and human society that can give context to their engineering practice and to their contributions as citizens. For the sake of the College of Engineering's intellectual breadth requirements, Liberal Arts Courses (LACs) are meant to exclude mathematics and science courses, as well as some courses that are considered preparatory to the CoE experience. Student's elections of LACs are expected to be in this spirit. The precise operational definition of a LAC is:

- Any course offered by any UM-Ann Arbor unit marked as HU or SS in the LSA course guide is considered a LAC.
- For a course not marked as HU or SS but offered under one of the LSA subjects listed below, it is considered a LAC if it is not marked BS, NS, QR/1 or QR/2 in the LSA course guide.
- In addition, if a course is not marked HU or SS in the LSA course guide, but is marked EXPERIENTIAL or INDEPENDENT, then explicit permission of a CoE program advisor is needed to use it for a LAC course.
- Study Abroad Courses (STDABRD) might be counted as LACs, but only by explicit permission of a CoE program advisor. This is not meant to discourage study abroad, but reflects the broad nature of the STDABRD designation, which otherwise defies classification. As described below, transfer credit from US and foreign institutions may also be accepted as LACs credit.

Note: Chemical Engineering, Civil & Environmental Engineering, Mechanical Engineering and Materials Science & Engineering each requires one course in economics. This economics requirement can overlap with the LAC requirement.

Arabic, Armenian, Persian, Turkish & Islamic Studies (AAPTIS)	Ancient Civilizations & Biblical Studies (ACABS)	American Culture (AMCULT)
Anthropological Archaeology (ANTHRARC)	Cultural Anthropology (ANTHRCUL)	Armenian Studies (ARMENIAN)
Asian Studies (ASIAN)	Asian Languages (ASIANLAN)	Bosnian, Croatian, & Serbian (BCS)
Afroamerican & African Studies (CAAS)	Japanese Studies (CJS)	Classical Archaeology (CLARCH)
Classical Civilization (CLCIV)	Classical Linguistics (CLLING)	Complex Systems (CMPLXSYS)
Communication Studies (COMM)	Comparative Literature (COMPLIT)	Comprehensive Studies Program (CSP)
Czech (CZECH)	Dutch (DUTCH)	Economics (ECON)
English (ENGLISH)	Environment (ENVIRON)	French (FRENCH)
Geography (GEOG)	German (GERMAN)	Greek (GREEK)
Great Books (GTBOOKS)	History of Art (HISTART)	History (HISTORY)
Hebrew & Jewish Cultural Studies (HJCS)	College Honors (HONORS)	International and Comparative Studies (CICS)
Judiac Studies (JUDIAC)	Latin American & Caribbean Studies (LACS)	Latin (LATIN)
Lloyd Hall Scholars (LHSP)	Linguistics (LING)	Medieval & Early Modern Studies (MEMS)
Middle Eastern & North African Studies (MENAS)	Modern Greek (MODGREEK)	Museum Studies (MUSEUMS)
Organizational Studies (ORGSTUDY)	Philosophy (PHIL)	Polish (POLISH)
Political Science (POLSCI)	Portuguese (PORTUG)	Psychology (PSYCH)
Russian, East European & Eurasian Studies (REEES)	Religion (RELIGION)	Romance Languages & Literatures (ROMLANG)
Romance Linguistics (ROMLING)	Russian (RUSSIAN)	Screen Arts & Culture (SAC)
South Asian Studies (SAS)	Scandinavian (SCAND)	Slavic Linguistics, Literary Theory, Film & Surveys (SLAVIC)
Sociology (SOC)	Spanish (SPANISH)	Southeast Asian Studies (SEAS)
Ukrainian (UKRAINE)	Women's Studies (WOMENSTD)	Yiddish (YIDDISH)

## Professional or Creative Development Courses (PCDC)

Professional and creative development courses offer a student the opportunity to build on non-engineering and non-technical courses to develop their creativity and professional capabilities as engineers. PCDC courses include any course from the following subjects in the indicated units, provided they are not marked BS or NS in the LSA course guide:

- Taubman College of Architecture and Urban Planning: Architecture (ARCH), Urban Design (UD), Urban Planning (UP).
- School of Art & Design (ARTDES, UARTS)
- Ross School of Business: Accounting (ACC), Business Administration (BA), Business Economics and Public Policy (BE), Entrepreneurial Studies (ES), Law History & Communication (LHC), Marketing (MKT), Management and Organization (MO), Strategy (STRATEGY)
- School of Music, Theatre & Dance: Music Composition (COMP), Musicology (MUSICOL), Music Theory (THEORY), Theater & Drama (THTREMUS)
- School of Natural Resources and Environment (NRE)
- Ford School of Public Policy (PUBPOL)
- School of Public Health: Health Behavior & Health Education (HBEHED), Health Management & Policy (HMP).

## Transfer Credit and Credit by Test

College course credit transferred as any course meeting these requirements will be accepted as an HU, LAC or PCDC. Courses transferred as departmental credit can be accepted at the discretion of a CoE program advisor. Courses evaluated for transfer credit may also be marked HU or SS, in which case they are considered humanities or liberal arts courses, as described above. In addition, courses transferred as English Composition (ENGCMPTC) also count as an LAC. Credit by test (e.g. Advanced Placement, A-Level and International Baccalaureate) can be used to satisfy any of these requirements except for the 3 credit humanities require-

ment. Foreign language credit by test at the 200-level or higher can count toward the LAC requirement but not the 3-credit humanities requirement. Foreign language credit by test at the 100-level can be used for General Electives only. In addition, language credit by test is limited to 8 credits.

## Credit for Foreign Language

The CoE will grant credit for students passing a language placement test offered by the College of LSA provided the student has previously studied that language in a course in their secondary education. This will be verified using their high school or college transcripts. AP language credit will also be granted.

"Study of a language in a course" means a student took coursework designed to teach them the fundamental vocabulary, grammar, pronunciation, and writing system of that language as a foreign language, as opposed to a class in literature, argumentative or essay writing or creative writing in a language whose fundamentals they already knew.

The CoE values the study of language, so even when credit might not be granted, students are encouraged to take any language placement test for which they may be qualified, so that they can be properly placed in a more advanced language course.

## General Electives

General electives are intended to allow students to explore any dimension of intellectual endeavor that they elect, in both technical (including engineering) and non-technical fields. This requirement can be met by any course offered by the UM Ann Arbor, subject to the following restrictions, or by transfer credit subject to the same restrictions in spirit.

Restrictions: Courses that require tutoring of other students enrolled in courses are limited to a maximum of 3 credits, with the exception of Physics 333 & Physics 334 which are both allowed for a maximum of 6 credits.

All undergraduate degree programs in the College of Engineering will accept credits earned in 200-, 300- and 400-level courses in military, naval or air science.

Tutorial courses are not acceptable for credit of grade points but will be included on the student's official record.

## Degree Options

### Undergraduate Engineering Degrees

The College of Engineering offers 15 undergraduate programs of study, all of which lead to a Bachelor of Science in Engineering (B.S.E.) degree. Twelve of these programs have specialized accreditation by ABET.

The available undergraduate degree programs and the major department responsible for each are:

**EAC:** These programs are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

**CAC:** This program is accredited by the Computing Accreditation Commission of ABET, <http://www.abet.org>.

Degree Program	Major Department	ABET Accreditation
B.S.E. in Aerospace Engineering	Aerospace Engineering (AERO)	EAC
B.S.E. in Biomedical Engineering	Biomedical Engineering (BME)	EAC
B.S.E. in Chemical Engineering	Chemical Engineering (ChE)	EAC
B.S.E. in Civil Engineering	Civil and Environmental Engineering (CEE)	EAC
B.S.E. in Climate and Meteorology (pending final stage of approval in June 2015)	Climate and Space Sciences and Engineering	No
B.S.E. in Computer Engineering	Electrical Engineering & Computer Science (EECS)	EAC
B.S.E. in Computer Science	Electrical Engineering & Computer Science (EECS)	CAC
B.S.E. in Data Science	Electrical Engineering & Computer Science (EECS)	No
B.S.E. in Electrical Engineering	Electrical Engineering & Computer Science (EECS)	EAC
B.S.E. in Engineering Physics	Nuclear Engineering and Radiological Sciences (NERS)	No
B.S.E. in Environmental Engineering	Civil and Environmental Engineering (CEE)	Pending EAC final approval in August 2015
B.S.E. in Industrial and Operations Engineering	Industrial and Operations Engineering (IOE)	EAC
B.S.E. in Materials Science and Engineering	Materials Science and Engineering (MSE)	EAC
B.S.E. in Mechanical Engineering	Mechanical Engineering (ME)	EAC
B.S.E. in Naval Architecture and Marine Engineering	Naval Architecture and Marine Engineering (NAME)	EAC
B.S.E. in Nuclear Engineering and Radiological Sciences	Nuclear Engineering and Radiological Sciences (NERS)	EAC
B.S.E. in Space Science and Engineering (pending final stage of approval in June 2015)	Climate and Space Sciences and Engineering	No

Each of the undergraduate degree programs has core requirements that are common to all Programs. These common requirements include 16 credits of math (calculus, differential equations and linear algebra), 15 credits of science (physics and chemistry), 16 credits of Intellectual Breadth and 8 credits of first year engineering courses. In addition, each program has between 9 and 15 credits of general electives. The remaining credit hours are specific to the B.S.E. degree program that the student elects to pursue.

Many of the courses required for one program may be used to meet the requirements of another. This opportunity to obtain additional undergraduate engineering degrees must be discussed with the pertinent program advisor. See "Requirements for an Additional Bachelor's Degree."

## Declaring One of the Degree Programs

To give students the opportunity to explore the numerous engineering degrees offered by the College, first year undergraduate engineering students not transferring from another institution of higher education enter the College without declaring a specific engineering major. None of the majors require any 100-level courses to be taken by a student other than those in the common engineering, math and science core. Students are urged to declare a specific engineering major by the start of their 3rd term of enrollment. Undeclared students cannot register for a 4th term in the College unless they have met with their advisor and developed a plan to select and declare a major within a reasonable time. This plan can be developed in coordination among the EAC advisors and departmental program advisors.

Criteria to declare a degree program are described in the Rules section of the bulletin: <http://engin.umich.edu/college/academics/bulletin/rules/registration>

## Dual Baccalaureate Degree Opportunities

Students with interest in more than one program offered by the College may work for an additional bachelor's degree concurrently if they plan their course elections carefully. Students will find that it is possible to satisfy the subject requirements of both programs in a minimum amount of time by conferring early with the respective program advisors. Approval by involved departments is required. See the Rules section of the Bulletin: <http://engin.umich.edu/college/academics/bulletin/rules/graduation>. The College generally recommends that students consider pursuing some of the many co- and extra-curricular activities offered as an alternative to a second CoE degree.

Opportunities to obtain an additional bachelor's degree in the College of Literature, Science, and the Arts, the School of Business Administration, the School of Music and other academic units are also available under Multiple Dependent Degree Program options and are described below. These programs may take 11 to 12 terms to complete because of the differences in degree requirements between the degrees offered in different colleges.

## Combined Degree Programs

### Simultaneous Bachelor's Degrees from the College of Engineering and the College of Literature, Science, and the Arts

Students enrolled for a bachelor's degree in the College of Engineering or the College of Literature, Science, and the Arts (LS&A) may obtain the degrees in both colleges simultaneously by enrolling in the Combined Degree Program that has been established by the two colleges, and by fulfilling the requirements as outlined below. This program has been developed to make it convenient for students to obtain a broader education than would normally be possible by enrolling in only one college.

It is particularly advantageous for students who wish to develop some depth of understanding in both the technically oriented studies offered in the College of Engineering and the physical, natural, or social sciences and humanities available in LS&A. Such a combination can provide a truly liberal education for the 21st century and should be excellent preparation for meeting the challenges of modern society, which involve, to an ever-increasing extent, both technical and sociological issues.

## Program Requirements

Candidates for a Bachelor of Science in Engineering (B.S.E.) in the College of Engineering combined with a Bachelor of Arts (B.A.) in LS&A must:

- satisfy the requirements of one of the degree programs in the College of Engineering;
- take a minimum of 90 credit hours of work in LS&A, satisfy the distribution requirements of LS&A, and fulfill the concentration requirements for one of the LS&A programs; and
- have a cumulative grade point average of 2.00 or higher.

Candidates for a Bachelor of Science in Engineering (B.S.E.) in the College of Engineering, combined with a Bachelor of General Studies (B.G.S.) in LS&A must:

- satisfy the requirements of one of the degree programs in the College of Engineering;
- take a minimum of 90 credit hours of work in LS&A of which 40 credit hours must be for courses numbered 300 or higher and are passed with a grade of "C" or higher, with no more than 15 of these 40 credit hours to consist of courses in any one department; and
- have a cumulative grade point average of 2.00 or higher.

Students transferring to the University of Michigan with advanced standing and entering a Combined Degree Program must complete a minimum of 60 credit hours of work in LS&A in residence.

All students should consult the program advisors in

their field of specialization in every college each term to develop an optimum set of courses for the particular combination of fields of specialization of interest to them.

In general, advisors working with students in this Combined Degree Program will, whenever possible, attempt to minimize the total number of courses required by recommending those that will contribute toward fulfilling requirements in both colleges. Thus, many of the courses needed to fulfill the requirements in mathematics, chemistry and physics in the College of Engineering will contribute toward fulfilling natural science distribution requirements and prerequisites for concentration in fields such as astronomy, chemistry, geology-mineralogy, mathematics and physics in LS&A.

Likewise, requirements in humanities and liberal arts courses for the College of Engineering can be selected from courses taken to fulfill distribution requirements in LS&A. In this way, it is usually possible for students carrying average loads of 16 credit hours per term to complete the requirements of this Combined Degree Program in 10 or 11 terms.

In order to ensure that the courses selected apply effectively and efficiently to both degrees, students must assume responsibility for maintaining contact between their two advisors. They should become thoroughly familiar with the general regulations and procedures of both colleges and with the academic requirements and course offerings in both fields of specialization as set forth in the Bulletin of each college. If unusual difficulties or special problems arise, students should consult the Combined Degree Program advisors who will work with the students and their faculty advisors in attempting to find a solution.

## Regulations

The following regulations for enrollment will apply:

1. Students initially enrolled in either the College of Engineering or LS&A may enter this Combined Degree Program.
2. To be qualified for admission, students normally should have completed 30 credit hours of the

appropriate course work. LS&A students must have an overall grade point average equal to, or higher than, the current minimum grade point average for cross-campus transfer for the particular engineering degree sought. Engineering students must have an overall grade point average of at least 2.7.

3. Students considering this program must obtain the signature of the College of Engineering Registrar to apply for admission and to establish advising procedures as soon as their interests are firmly established, preferably by the end of the first year. Upon applying for admission, students must choose a field of specialization in each college. Application for admission must then be approved by the Associate Dean's Office of each college and by the academic advisor in each of these fields of specialization.
4. After being admitted to this program, students will continue to register in the college in which they first enrolled, and that college will be responsible for maintenance of their primary academic records.
5. Students participating in this program should consult with the program advisor for their field of specialization in each college prior to registration each term, to obtain approval of course elections. To be permitted to continue in this Combined Degree Program, students must satisfy the requirements of both colleges with regard to good scholastic standing.
6. Students in good scholastic standing who wish to withdraw from this Combined Degree Program may continue to enroll for a single degree in their original college. If they wish to transfer, they may do so provided their record is acceptable to the other college. For instructions regarding transfers, students should consult the appropriate officials of the college in which they are registered. Students not in good scholastic standing will normally remain in the college in which they initially enrolled and be subject to the rules of that college.
7. Upon satisfying the program requirements of both colleges, students will receive both degrees on the same date. At the beginning of the term in which they expect to graduate, they must apply for graduation through Student Business in Wolverine Access in each college.

## **Simultaneous Bachelor's Degrees from the College of Engineering and the Ross School of Business**

Students originally enrolled in an undergraduate degree program in the College of Engineering who are admitted to the Ross School of Business may obtain degrees in both simultaneously by enrolling in the Multiple Dependent Degree Program (MDDP) that has been established between the two. This program is designed to allow students to develop a course of study that offers broader academic opportunities than would normally be possible by enrolling in only one college. These combined degrees are open to students initially enrolled in Engineering who are accepted into the Ross School of Business BBA program.

In order to ensure that the courses selected apply efficiently to both degrees, students must maintain coordination between their College of Engineering and Business School advisors. The students must consult the program advisors in their degree disciplines for specific requirements for the appropriate degrees.

Degree requirements must be met for both colleges simultaneously to be eligible to receive the appropriate undergraduate degrees. Upon satisfying the program requirements of both colleges, students will receive both degrees on the same date. At the beginning of the term in which they expect to graduate, students must apply for graduation through Student Business in Wolverine Access in each college/school and must ask their program advisor in each unit to submit an appropriate notification of their eligibility for graduation to the appropriate office in the College or School.

Students who are admitted to the BBA program and wish to pursue the MDDP must make this clear to both colleges. Unless this is done, admission to the BBA program can result in the student being disenrolled from the College of Engineering. Like most other dual degree programs, this program will generally require 11 to 12 terms to complete both degrees.

## Combined Degree in Music and Engineering

This program is designed to allow students to develop a course of study that offers broader academic opportunities than those offered by the College of Engineering or the School of Music, Theatre and Dance individually.

The program is intended for students who seek the technical studies associated with the College of Engineering in combination with the professional training in applied or academic studies associated with the School of Music, Theatre and Dance. These dual degrees are open to students enrolled in the College of Engineering or the School of Music, Theatre and Dance. They lead to concurrent bachelor's degrees from both units, and are intended for students who were admitted as first-year students to both units.

Each student should consult faculty advisors in both engineering and music to develop the best plan of study. Primary responsibility for planning the academic program and continued contact with academic advisors in the two fields rests with the student, who is also responsible for becoming familiar with the academic policies and procedures of both units and the academic requirements in both fields as described in the Bulletins of both the College of Engineering and of the School of Music, Theatre and Dance. The student is responsible for maintaining contact with the appropriate engineering department (or, if undeclared, the Engineering Advising Center) in order to receive proper advising for course selection, etc.

Candidates for the combined Bachelor of Science in Engineering (B.S.E.) in the College of Engineering and appropriate degree (B. Mus., B.M.A., or B.F.A.) in the School of Music, Theatre and Dance must:

- complete one of the degree programs in the College of Engineering;
- complete one of the degree programs in the School of Music, Theater and Dance (usually 90 credits); and
- maintain a minimum cumulative grade point average of 2.00 and good scholastic standing in both the College of Engineering and the School of Music, Theatre and Dance.

It is usually possible for students electing 16-17 credits per term to meet all requirements in 11 or 12 terms.

Students interested in this program will be admitted as first-year students into both the College of Engineering and the School of Music, Theatre and Dance.

Students who are dually enrolled and decide not to pursue a degree from the School of Music, Theatre and Dance do not have to reapply for admission to the College of Engineering.

## Combined Degree in Art & Design and Engineering

Students enrolled in an undergraduate degree in the College of Engineering (CoE) or School of Art & Design (A&D) may obtain degrees from both simultaneously by enrolling in the Multiple Dependent Degree Program (MDDP) that has been established between the two. This program is designed to allow students to develop a course of study that offers broader academic opportunities than would normally be possible by enrolling in only one unit or the other.

Students are required to meet regularly with advisors in both A&D and CoE to review specific course requirements and to develop a plan of study. It is the student's responsibility to develop a strategy for completing the degree requirements for both undergraduate degrees, as well as learn the academic policies for both units as described in the A&D Undergraduate Student Handbook and the CoE Bulletin. In order to remain in good academic standing in both A&D and CoE, MDDP students must maintain a minimum cumulative grade point average of 2.0, and must follow additional academic policies of both academic units.

Degree requirements must be met for both programs simultaneously to be eligible to receive the appropriate undergraduate degrees. Candidates must complete a Bachelor of Science in Engineering (B.S.E.) in the College of Engineering, and a Bachelor of Fine Art (B.F.A.) in the School of Art & Design. Upon completion of the requirements of both academic units, MDDP students are granted concurrent degrees. If a requirement for either degree is lacking, neither degree will be conferred. The student must submit a separate Diplo-



ma Application through Wolverine Access to each unit along with any additional required documents.

## Combined Bachelor's/Master's Programs

In many fields, the Master's degree provides substantial benefits for engineering graduates seeking employment. The College of Engineering therefore offers two different options for those students who wish to obtain a combined Bachelor's and Master's degree. Both of these options are academically demanding and require recommendation from the student's undergraduate program advisor. The combined programs in the College of Engineering include the Sequential Undergraduate/Graduate Studies Program (SUGS) and the Engineering Global Leadership Honors Program (EGL).

## Sequential Undergraduate/Graduate Study(SUGS)

The five-year Sequential Undergraduate/Graduate Study (SUGS) Program permits students who enter the program in the first term of their senior year to receive the B.S.E. and M.S.E. degrees (or the B.S.E. and M.Eng. degrees) upon completion of a minimum of 149 credit hours (depending on program). The baccalaureate may be awarded upon completion of the undergraduate requirements or concurrently with the Master's degree. Students apply to the SUGS program at the end of their junior year or early in the first semester of their senior year. Consult with the appropriate graduate departmental coordinator for specific deadlines. Recommendation from the appropriate Undergraduate Program Advisor is required, and the standard department graduate admission process is used. SUGS admissions requirements will vary and each program will have a minimum GPA for admission; interested students should contact the department in which they would like to pursue graduate study. For a list of SUGS programs by department, please refer to the degree program listings under the B.S.E. home department.

## Engineering Global Leadership Honors Program (EGL)

Employers tell us that the inability of many professionals to communicate across cultures and across the engineering and business boundary is one of the greatest barriers to global competitiveness. The EGL Honors Program prepares students to bridge these gaps. The required business coursework offers a focus in operations management, along with the basics of marketing, accounting and finance. Completion of the International Minor for Engineers exposes students to the language, history and customs of another part of the world. The success of EGL graduates confirms that this preparation is in high demand.

The EGL program is a specialization offered through the CoE Honors Program. Students admitted to the CoE Honors Program who choose a global business/operations focus are eligible to apply to EGL.

## Honors Program

The College of Engineering Honors Program identifies highly talented students who demonstrate extraordinary academic ability, intellectual curiosity and clear potential to make a difference as a leader in their field. Honors Program students pursue challenging coursework and enrich their academics through significant engagement beyond the classroom. The program is intended to inspire and enable highly motivated students to reach beyond the traditional curriculum in both breadth and depth.

Students must choose a capstone experience area, such as research, entrepreneurship, design, global business/operations or public service, and are required to develop academic breadth and leadership experience:

### Core Academic Requirements

- Maintain a cumulative GPA of 3.6
- Complete 9 credits of advanced electives in an identified focus area, selected in consultation with the capstone supervisor.

These credits cannot be required by the minor or specifically required by the major. They can include technical elective credit.

- Complete an honors capstone experience (e.g. a project, research experience, thesis, etc.)

This capstone can draw on the major design experience, but must extend beyond that experience to demonstrate the student's individual scholarly or professional work. Each student will identify a capstone supervisor to oversee this experience. See below for more details.

## Academic Breadth and Leadership Requirements

- Participate in an honors seminar each year. The honors seminar will center on leadership development, community building and discussion related to the student's focus area. Portions of the seminar will be required for all honors students, while other topics offered will be specific to a student's focus area. Existing seminars and colloquia will also be leveraged.
- Develop academic breadth through the completion of a UM minor.

## Additional Rules

- Courses counting toward the Honors Program cannot be elected as pass/fail.
- Students must apply for the program at least a year and a half before they plan to graduate, so that they can participate in leadership seminars and community building experiences.
- The honors program faculty advisor may approve specialized curriculum plans in both the core and breadth components of the Honors Program.

## Admission criteria and process

In order to be admitted, students must,

- Have completed two full-time terms at UM (or, for

transfer students, one term).

- Have declared a major within the College of Engineering.
- Maintain a 3.6 minimum GPA.
- Submit an Honors Program application, including essays, an academic plan, two recommendation forms, and a resume.
- Be interviewed and recommended for admission by an admission committee (comprising the honors program faculty advisor, a representative of the Faculty Advisory Board, a staff advisor and a student representative).

## Honors capstone process and completion

Each student will identify a capstone supervisor (typically a CoE faculty member) to oversee the honors capstone experience. Honors capstone proposals must be approved by the student's capstone supervisor, and the honors program faculty advisor; these parties will ensure that sufficient rigor is present in the proposed project. Students should meet regularly with their capstone supervisor to assess progress and establish goals throughout the duration of the project. The project will be considered complete once it has been publicly presented and the capstone supervisor and honors program faculty advisor have certified its completion. The Faculty Advisory Board will work with the honors program faculty advisor to establish criteria for ensuring the quality of capstone projects. Students must display their capstone project at a public forum, typically CoE Design Expo, and the project must be published online in the Honors Capstone Library.

## Program completion

Students who complete the program will graduate "with honors" and will receive a notation on their transcript and diploma.

## Engineering Global Leadership Honors Program

The Engineering Global Leadership (EGL) Honors Program is a specialization of the Honors Program. Em-

players tell us that the inability of many professionals to communicate across cultures and across the engineering and business boundary is one of the greatest barriers to global competitiveness. The EGL Honors Program prepares students to bridge these gaps. The business coursework offers a focus in operations management, along with the basics of marketing, accounting and finance. Completion of the International Minor for Engineers exposes students to the language, history and customs of another part of the world. The success of EGL graduates confirms that this preparation is in high demand. Students admitted to the CoE Honors Program who choose a global business/operations focus are eligible to apply to EGL.

The EGL Honors Program requires the completion of the following:

- All requirements of the College of Engineering Honors Program
- The International Minor for Engineers (simultaneously fulfills CoE Honors required minor)
- 9 credits of coursework in the Ross School of Business, as required by the Tauber Institute for Global Operations (simultaneously fulfills CoE Honors required focus area)
- The Tauber Institute for Global Operations Team Project (simultaneously fulfills CoE Honors Capstone Experience)
- A UM College of Engineering Master's degree
- 6 credits of elective coursework in the Ross School of Business (typically completed during the Master's program)

### **College of Engineering Honors Program**

Email: [coehonors@umich.edu](mailto:coehonors@umich.edu)

Website: [honors.engin.umich.edu](http://honors.engin.umich.edu)

## **Cooperative Education**

The Cooperative (co-op) Education Program assists students in pursuing an optional program of work while studying in the College of Engineering. Students can find co-op positions independently or by using ECRC resources such as ENGenius.Jobs, a web-based recruiting system. A co-op search is just as any other job

search—students apply to organizations and then may be invited to interview. Students must work a minimum of thirty hours per week for a minimum of six weeks while on a co-op work assignment.

Full-time students are eligible to participate in the Cooperative Education Program. A student can be enrolled in the Cooperative Education Program for a single semester or multiple semesters. Co-op students participating in the program for multiple semesters may tailor their work assignments for consecutive terms, for example May to December, January to August or alternate work and school semesters.

### **Finding a Position through the ECRC**

The ECRC displays co-op positions on its web-based recruiting system, ENGenius.Jobs. Employers provide the ECRC with a job description and requirements for the co-op position. Students should submit their resumés via instructions on ENGenius.Jobs. The employer will review the resumes and select students to interview on campus, at the employer location, or by telephone.

Final selection of a student for co-op work assignment is a mutual agreement entered into by the employer and the student, and the student becomes an employee of that company. Note that the ECRC does not guarantee a co-op position for every applicant; however, every effort is made to assist students finding appropriate positions.

### **Work Assignment**

While working a co-op assignment, students are subject to the rules and regulations of the employer. Work assignments must be at least 30 hours per week for a minimum of six weeks. The employer will evaluate the student's performance at the end of the co-op work term and forward the evaluation to the Engineering Career Resource Center. Co-op students are also required to complete and return an evaluation report of their learning experience to the ECRC.

### **Getting Started**

Students interested in the co-op programs should contact or visit the ECRC to pick up a co-op packet and discuss the rules and regulations of the Cooperative

Education Program with the co-op coordinator. Co-op students are registered in ENGR 400 while on a co-op work assignment; registration is by permission only and must be completed through the ECRC.

### **Engineering Career Resource Center**

230 Chrysler Center

Ann Arbor, Michigan 48109-2192

Phone: (734) 647-7160

[career.engin.umich.edu](http://career.engin.umich.edu)

## **Education Abroad**

The International Programs in Engineering (IPE) office provides support for a variety of education abroad opportunities for CoE students. International experiences for CoE students can take many forms from traditional study abroad for academic credit to work/internship abroad, research, volunteer and co-curricular international projects in conjunction with CoE student organizations.

### **College of Engineering Study Abroad**

IPE sponsors full-year, semester and summer study abroad programs for academic credit. CoE students may choose from programs taught in English or foreign languages, depending on their skill levels and prior experience. IPE staff members advise students about program options and provide assistance with applications and course approvals. Undergraduate students in good academic standing are eligible to participate in College of Engineering study abroad programs. Graduate students may apply for select programs with the approval of IPE and their respective CoE Academic Advisor. Additional requirements may apply; please see the IPE website, <http://www.ipe.engin.umich.edu> for program specific admission guidelines.

Most forms of student financial aid can be applied to College of Engineering study abroad programs. IPE offers walk-in advising Monday-Friday from 1:00pm to 4:30pm, no appointment needed.

### **International Programs in Engineering**

245 Chrysler Center

Ann Arbor, MI, 48109-2092

Phone: (734) 647-7192

Email: [ipe-office@umich.edu](mailto:ipe-office@umich.edu)

### **Campus-Wide Study Abroad Programs**

CoE students may also participate in study abroad programs sponsored by other UM Schools and Colleges. The LS&A Center for Global & Intercultural Study (CGIS) offers a broad range of study abroad programs that are open to CoE students. Students considering a CGIS study abroad program must consult the International Programs in Engineering office to determine applicability of credit to engineering degree requirements. For CoE students, grades for STDABRD credit programs will generally not be calculated into the cumulative GPA, but for STDABRD courses taught by UM faculty, students may petition for an exception to this rule. Campus-wide study abroad programs can be found in M-Compass, <https://mcompass.umich.edu>.

### **Non-UM Study Abroad Programs**

Students studying abroad on a program that is not sponsored by a UM office may earn transfer credit if the program sponsor is a fully accredited institution of higher learning, an official transcript is furnished by that institution, and the course is evaluated for transfer credit. Students considering non-UM study abroad must register their plans in the CoE travel registry prior to departure and consult with the IPE Office about course approvals and transfer credit. CoE Registry, <http://www.ipe.engin.umich.edu/registry>

### **Work/Internship Abroad**

IPE in partnership with the Engineering Career Resource Center (ECRC) assist students pursuing a work or internship position abroad. Overseas work experience can enhance your future job prospects, provide exposure to foreign business environments and help you understand global trends in the engineering profession. Whether it's an internship with a multinational corporation or a research position in a foreign laboratory, overseas employment presents unique opportunities for professional development.

Students should meet with a Career Counselor from ECRC or an International Programs Advisor from IPE to discuss work abroad and internship search strategies. The ECRC can also critique resumes and provide resources to help adapt application documents for a non-U.S. audience. More information can be found online at <http://workabroad.engin.umich.edu>.

## International Travel with CoE Student Organizations

IPE in partnership with the CoE Office of Student Affairs provides support and assistance for student organizations that travel internationally. Beyond traditional study and work abroad opportunities, the College encourages student organizations to consider developing international experiences for their members. International travel can be a great way to maximize an organization's impact and to build leadership skills for their members. Check M-Compass, <https://mcompass.umich.edu>, to see where CoE student organizations are currently engaged globally. There are many resources available to student organizations who want to travel internationally, please visit [http://studentorgs.engin.umich.edu/students\\_leadership\\_international-experiences-travel](http://studentorgs.engin.umich.edu/students_leadership_international-experiences-travel) for more details.

## Undergraduate Research Opportunity Program (UROP)

The UROP program enables students to work one-on-one or as part of a small group of students on research projects conducted by faculty, graduate students, post-doctoral fellows, and research scientists all across campus. Students will choose research projects by looking through a catalog of over 900 research projects and will then interview for the positions with the faculty researcher. Students spend an average of nine to ten hours per week working on their research projects. Students can participate in the program for academic credit through ENGR 280 if working with an engineering researches or UC280 if working outside of the COE. Students receive one credit per three hours of work per week. Most students register for three credits, which is a nine-hour commitment per week. Students with work-study awards in their financial aid package can also participate for work-study support. All students participating in the program are also required to attend a bi-weekly research peer seminar, meeting monthly with a peer advisor, read research-related articles (e.g., research ethics, research in specific disciplines, research methods) and complete short journal assignments.

For more information and to access the online application, please visit the UROP website at <http://www.lsa.umich.edu/urop>.

## CoE Minors and Supplemental Studies

### Climate and Space Sciences and Engineering Minor

The primary goal of the Climate and Space Sciences and Engineering (Climate & Space) Minor is to provide exposure to research opportunities in atmospheric, climate and space science and engineering for those students who wish to work in the geoscience or space industry but are not majoring in Climate and Space Sciences and Engineering. The secondary goal is to increase awareness of the Climate and Space Sciences and Engineering and the educational and research opportunities within Climate & Space within the College of Engineering as a whole. This program is for undergraduate students in the College of Engineering.

Students must have:

- Registered no later than the last day to add courses for the semester in which they complete the last courses for the minor,
- Submitted his or her program of study for the minor to the Climate & Space undergraduate advisor.
- Attained a minimum GPA of 2.0 in the designated courses
- Completed the Climate & Space Minor as part of a degree program

### Requirements

A. Prerequisite coursework:

Math (8 Credits)

MATH 115 ,and

MATH 116;

Physics: (10 Credits)

PHYSICS 140, 141, and

PHYSICS 240, 241;

**B. Required Coursework (9 credits)**

One course from SPACE 101 (Introduction to Rocket Science – 3 credits),

CLIMATE 102 (Extreme Weather – 3 credits), SPACE 103 (Introduction to Space Weather – 3 credits) or CLIMATE 105 (Our Changing Climate – 3 credits)

CLIMATE 320/SPACE 320 (Earth and Space System Evolution, 3 credits)

CLIMATE 321/SPACE 321 (Earth and Space System Dynamics, 3 credits)

**C. Core Focus Courses (minimum 6 credits)**

At least two courses from one of the following tracks:

- Meteorology
- Climate Science and Impacts Engineering
- Space Sciences
- Space Engineering

For additional information go to:

<http://aoss.engin.umich.edu>

Effective 9/1/15, <http://clasp.engin.umich.edu>

**International Minor for Engineers**

The global business environment demands engineers who are able to combine technical expertise with international understanding. Today's graduates work in multinational teams, create products for a global marketplace and solve problems that cross national borders and cultures. The International Minor for Engineers addresses a core set of skills and experiences that will prepare CoE graduates for the challenges of the global engineering profession.

- Foreign Language Requirement (6-10 credits)

Students are required to have foreign language proficiency (cannot be English or dead/extinct language) equivalent to fourth-semester College-level.

- International Courses (9-15 credits)

These requirements include at least two-courses on non-U.S. cultures or societies plus a comparative perspectives course. At least one of these courses

must be listed at the 300-level or above; a minimum of 3 credit hours of international courses at the 300-level or above is required..

- ENGR 260: Engineering Across Cultures (1 credit)

This course explores the role of local culture in identifying and solving engineering problems. Lectures, guest speakers and group discussions focus on intercultural knowledge and case studies of engineering projects in a global context. The final course project is a culture-specific needs assessment of a technical project outside the United States.

- Required International Experience

Students may satisfy this requirement through study, work, research or organized volunteer work abroad, spanning a minimum of six contiguous weeks within the same country outside the U.S. All international experiences must be approved by the International Programs Faculty Advisor. International students may not satisfy this requirement through programs in their home countries.

In total, the minor requires 16-20 credits to complete.

This assumes that students meet a two-semester (or equivalent) foreign language pre-requisite before declaring the minor. More information can be found at <http://intlminor.engin.umich.edu>.

**Minor in Electrical Engineering (EE)**

A Minor in Electrical Engineering (EE), offered through the EECS Department, is open to undergraduate students. LSA requirements are described in the LSA Bulletin and interested students should consult with both LSA and CoE Electrical Engineering Advisors. CoE students may declare the EE minor provided they have met the following eligibility requirements:

1. Students must have an average of 2.0 or higher at time of declaring the EE minor
2. Students must have completed all Math and Physics prerequisites with a grade of C or better
3. Students pursuing a major in Electrical Engineering (EE), Computer Engineering (CE) and Computer Science (CS -- including LSA/CS) are not eligible for the EE minor

The EE minor is completed in 15 credit hours; at least one elective must be at the 400-level. All courses for

the EE minor must be completed with a grade of C or better.

- EECS 215
- One of the following program core courses: 216, 230, 270, 320
- Two electives from among the following courses: 216, 230, 270, 320, 311, 312, 330, 334, 351, 370, 373, 411, 413, 414, 420, 421, 423, 425, 427, 429, 430, 434, 438, 452, 455, 460, 461, 470, 530

## Suggested Program Options

1. Systems: Communications, Control, Signal Processing
2. Electromagnetics and Optics
3. Circuits and Solid State

## Sample Paths:

Paths Option	Required Core	Path Preparation Core	Elective Options (select two, no duplicates)
Systems	215	216	351, 452, 455, 460, 461
Electromagnetics and Optics	215	230	330, 334, 411, 430, 434, 438, 530
Circuits and Solid State	215	216	320, 411, 413, 414, 420, 421, 423, 425, 427, 429

## Minor in Environmental Engineering

Administered through the Department of Civil and Environmental Engineering, the minor in Environmental Engineering provides students with a basic background in the tools environmental engineers use to assess environmental impacts, model contaminant fate, and perform sustainable engineering decision-making. CoE students may declare the minor provided they meet the following eligibility requirements:

- Students must have a grade point average of 2.0 or higher at the time of declaration
- Students must have completed the prerequisite coursework for the "core" minor courses with a C or better
- Students pursuing a major in Civil or Environmental Engineering are not eligible for the minor

A minimum of 16 credit hours, three core courses and two electives, is required to complete the Environmental Engineering minor. All courses for the minor must be completed with a grade of C or better as follows:

Required core courses (10-11 credits):

- CEE 265
- CEE 325 or equivalent from: MECHENG 320, CHE 342, NERS 344, NAVARCH 320, AEROSP 225, BIOMEDE 331, MATSCIE 335
- CEE 365

Two electives (6 credits) from the following courses:

- CEE 482, 460, 465, 481, 482, 563

For additional information, please visit the Civil and Environmental Department website at <http://cee.umich.edu/minor-environmental-engineering>.

## Minor in Naval Engineering

The primary goal of the Naval Engineering Minor is to provide a coherent path to employment in the marine industry and an exposure to research opportunities in the Marine industry for those students who wish to work in the marine industry but are not majoring in naval architecture and marine engineering. The secondary goal is to increase awareness of the marine industry and its needs within the College of Engineering as a whole.

The marine industry includes naval architecture firms, the shipping and offshore industries, and the United States Navy and Coast Guard as major entities. In addition to naval architects and marine engineers, this industry requires engineers from a wide range of disciplines, including mechanical, electrical, and civil engineers, computer and material scientists, and industrial operations researchers. The scale and harshness of the marine environment poses particular challenges not found in other realms of engineering practice, and grad-

uates with knowledge of these marine –related disciplines will be better prepared to meet these challenges.

This program is well-suited for undergraduate students in the College of Engineering and undergraduate Military Officer Education Students, including the Army, Air Force, and Navy/Marine programs who may be enrolled in other UM Colleges. More information on the Naval Engineering Minor website.

## Multidisciplinary Design Minor

The Multidisciplinary Design Minor offers multi-term, on-campus, immersive design team experiences for credit. This minor is not built on a list of required courses, rather it is earned with set of four experiences that can be tailored to a student's interests. Note: This minor is also open to students from outside the College of Engineering.

The MD minor is comprised of 15 total credits across four experiences:

Introductory "Design, Build, Test" Experience  
Connections Course  
Multi-Term Design Project Work  
ENGR 456: Leadership/Mentorship Course

### Introductory "Design, Build, Test" Experience (at least 2 credits)

Must include a team-based, complete Design/Build/Test process. For engineering students this is most often fulfilled through ENGR 100. For non-engineering students, other design-based courses or an introductory/extra semester on the design project team may also be allowed to fulfill this requirement.

### Connections Course (at least 3 credits)

A connections course is required to support the Multi-Term Design Project: providing additional breadth or depth in specific skills relevant to the project, but outside of the student's major coursework. This requirement can be met with any course outside of a student's required classes for their major. This course is taken prior to or during the final semester of project work.

## Multi-Term Design Project Work (at least 7 upper-level design credits over at least 2 semesters)

The Multidisciplinary Design Program offers various team-based, multidisciplinary engineering design project options, including:

1. MDP-organized\* externally-sponsored: industry/government/non-profit
2. MDP-organized\* faculty-based research teams: also called Vertically Integrated Projects/"VIP"
3. Significant work on student organization project teams (Solar Car, Steel Bridge, BlueLab, etc) with permission from the team's faculty advisor and MDP
4. Students may also propose their own, unique multi-term design project. To propose a project, please contact the MDP Office.

The Multi-term Design Project can be curricularized utilizing the ENGR x55 course sequence, departmental design courses and/or independent study courses. The project must span a minimum of two consecutive semesters of in-depth work: the credits cannot all be earned in the same semester.

\*Recruitment for MDP-organized projects occurs annually in October

### ENGR 456: Leadership/Mentorship Course (2 credits)

Students study models of leadership and mentorship while participating in reflective and integrative learning exercises based on previous design team experience. Simultaneously, students take on mentorship/leadership roles within a design team to offer technical, professional, and interpersonal guidance. Students must have significant previous multidisciplinary design project experience to enroll.

Completing the minimum credit hours for the above list adds up to 14 credit hours; therefore the student needs at least one extra credit hour in any one of the first three components to meet the minimum of 15 required credits. The following rules apply to the Multidisciplinary Design Minor:

1. Transfer credit may not be used to fulfill



requirements of this minor.

2. Only the 2-credit mentorship and leadership requirement (ENGR 456) can be taken Pass/Fail.
3. The Academic Advisor of the Multidisciplinary Design Minor Program is responsible for approving any variance in course requirements for the minor.

For more information, please visit <http://mdp.engin.umich.edu>.

## Program in Sustainable Engineering (PISE)

Administered through the Department of Civil and Environmental Engineering, the Program in Sustainable Engineering (PISE) provides students an opportunity to develop their understanding of the challenges associated with sustainable design of technology systems, exploring economic, environmental and social challenges of sustainable development across disciplines. Upon completing the program, students should be able to:

- Quantify the environmental and economic impacts of design decisions
- Understand the difference between life cycle design and environmentally sustainable design
- List key sustainability considerations in the design of an engineering system
- Identify trade-offs among social, economic and environmental drivers in engineering decision making
- Identify more sustainable choices among engineering options

The program consists of the following requirements:

- 3-credit foundation course Sustainable Engineering Principles (CEE 265) of Sustainable Engineering and Design (ME 499)
- 3-credits of coursework from a selection of courses identified within the College of Engineering that feature significant content in sustainable engineering.
- 3-credits of coursework from a selection of courses identified outside the College of Engineering that feature significant content in sustainability, specifi-

cally considering non-engineering issues at the intersection of technology and society.

If planned well in advance of the senior year, the program should not add to the 128 credits required for a B.S.E. For complete information, visit the Program in Sustainable Engineering website at <http://pise.engin.umich.edu>.

## Other Approved Academic Minors

Engineering students have considerable flexibility in electing courses from other colleges through their Intellectual Breadth courses and general electives. In the interest of helping students make coherent choices in selecting these courses, we allow and encourage our students to pursue minors offered in LSA, Art & Design, Ross School of Business and the School of Social Work.

Minors also serve as recognition, via a transcript notation, of the completion of these more in-depth course sequences. Electing to earn an academic minor is optional and there is no limit on the number of academic minors a student may elect.

In practice, a student will meet with an advisor in the minor discipline and together map out the minor courses. The certification that the appropriate courses have been completed will be communicated from the offering department to a student's undergraduate program advisor in CoE as well as the College of Engineering Student Records Office. The student will be responsible for making sure this paperwork arrives at the appropriate offices.

## Minors Approved by the College of Engineering

The list below shows the minors approved for students in the College of Engineering..

### Minors Offered Through LSA (list subject to change):

- Afroamerican and African Studies
- American Culture
- Anthropology
- Applied Statistics
- Arab and Muslim American Studies
- Asian Languages and Cultures
- Asian Studies
- Asian/Pacific Islander American Studies
- Astronomy and Astrophysics
- Biochemistry
- Biological Anthropology
- Biology
- Biophysics
- Bosnian/Croatian/Serbian Literature and Culture
- Central Eurasian Studies
- Chemical Measurement Science
- Chemical Physics
- Chemistry
- Classical Archaeology
- Classical Civilization
- Complex Systems
- Computer Science
- Creative Writing
- Crime and Justice
- Czech Language, Literature, and Culture
- Digital Studies
- Drama: Text to Performance
- Early Christian Studies
- Earth Sciences
- East European Studies
- Ecology and Evolutionary Biology
- Economics
- Entrepreneurship
- Environment
- Environmental Geology
- Epistemology and Philosophy of Science
- French and Francophone Studies
- Gender and Health
- Gender, Race, and Ethnicity
- General Philosophy
- Geology
- German Studies
- Global History
- Global Media Studies
- Greek (Ancient) Language and Literature
- Greek (Modern) Language and Literature
- History
- History of Art
- History of Law and Policy
- History of Medicine and Health
- History of Philosophy
- Interdisciplinary Astronomy
- International Studies
- Islamic Studies
- Italian
- Judaic Studies
- Latin American and Caribbean Studies
- Latin Language and Literature
- Latina/o Studies
- Law, Justice and Social Change
- Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ) and Sexuality Studies
- Linguistics
- Mathematics
- Medical Anthropology
- Medieval and Early Modern Studies
- Mind and Meaning
- Modern Greek Studies
- Modern Middle Eastern and North African Studies
- Moral and Political Philosophy
- Museum Studies
- Music
- Native American Studies
- Near Eastern Languages and Cultures
- Oceanography
- Paleontology
- Peace and Social Justice
- Physics
- Plant Biology
- Polish Language, Literature, and Culture
- Political Science
- Polymer Chemistry
- Portuguese

- Religion
- Russian Language, Literature, and Culture
- Russian Studies
- Scandinavian Studies
- Science, Technology, and Society
- Spanish Language, Literature, and Culture
- Statistics
- Sustainability
- Translation Studies
- Ukrainian Language, Literature and Culture
- Urban Studies
- Writing

### **Policies and Procedures for Declaring and Completing LSA Academic Minors**

The following describes the policies and procedures to be followed for declaring and completing LSA minors:

1. Each B.S.E. student who wishes to complete an approved academic minor must develop a plan for the minor in consultation with the designated LSA advisor, who must also approve it. The faculty and staff advisors in the LSA units will advise Engineering students on course selection and complete the minor declaration form and confirm completion of the minor. No prior approval is required from an Engineering advisor.
2. Students may not elect two academic minors offered by the same department or program.
3. The minor declaration form must be received by the College of Engineering Student Records Office. Upon receipt of the declaration form, the staff member will enter the minor in the M-Pathways database. The form will be available through all Engineering academic departments, the Engineering Advising Center and all relevant LSA departments.
4. Student Transcripts:
  - The unofficial transcript for an Engineering student who has declared a minor will show the minor in the program action history section.
  - The Official Transcript issued by the Registrar's Office will show the minor at the beginning of the transcript when the student has completed the degree.
5. Minors cannot be completed and added to the transcript after a student has graduated.

More information on LSA minors can be found in the LSA Bulletin.

### **Minor in Art & Design**

Undergraduate engineering students can complete an academic Minor in Art & Design in consultation with an advisor in the School of Art & Design. Appointments may be scheduled by visiting or calling the Smucker-Wagstaff Academic Programs Center, Art & Architecture Building, room 2038, or (734) 764-0397. The requirements for the Minor are maintained by the School.

Students must secure written approval from their home school/college to pursue an A&D minor and must develop a plan for the minor in consultation with an A&D advisor.

### **Minors in Other Schools/Colleges**

- Minor in Business (Ross School of Business) <https://www2.bus.umich.edu/MyiMpact/academics/businessminor>
- Minor in Community Action and Social Change (School of Social Work) <http://ssw.umich.edu/offices/casc-undergraduate-minor>

# Graduate Education

## Mission Statement

- Provide support, improve communication, and start new initiatives for graduate students, departments, and interdisciplinary programs.
- Provide a positive graduate student experience and increase the retention of graduate students through various programs and activities.
- Utilize a variety of recruitment programs to attract a high-quality and diverse graduate student body.

## Admissions

<http://www.engin.umich.edu/college/admissions/graduate>

## Application Information

Depending on which degree you seek, choose one of the following applications:

### **M.S., M.S.E., Ph.D. (Horace H. Rackham School of Graduate Studies)**

Rackham administers the admission process for more than 14 engineering departments and programs that offer graduate and graduate/professional degrees. Departments recommend admission to Rackham. Rackham monitors requirements and procedures and certifies the admission recommendation as appropriate. Rackham highly encourages applications via the web; however if there are extenuating circumstances, it is possible to submit a paper application. Please be advised that paper applications take considerably longer to process and may delay official admission decisions. Web Application <http://www.rackham.umich.edu/prospective-students/admissions/applying/submit-your-application/start/apply-annarbor> (For Ann Arbor campus only)

Applicants are then required to send supplemental materials to either the Rackham Graduate School and/or their College of Engineering department of interest. If you are confused about where to send your application

materials, please contact the appropriate official departmental admission contact.

### **M.Eng., D.Eng. (College of Engineering)**

The following form is for students interested in the Master of Engineering degree with majors in the following fields of study: Applied Climate, Automotive Engineering, Construction Engineering & Management, Energy Systems Engineering, Global Automotive and Manufacturing Engineering, Manufacturing, Space Engineering, Structural Engineering, Systems Engineering + Design, and the Doctor of Engineering in Manufacturing degree. To request materials, please visit:

- Inquiry Form, <https://www.applyweb.com/public/inquiry?s=umenginq>
- Web Application, <https://www.applyweb.com/umengin/>

## Application Status

Some departments or programs review applications on a rolling basis as applications are received; others review applications on a scheduled basis. Before contacting the department or program please allow at least six weeks for processing.

## Admissions Criteria

Contact individual departments or programs for specific admissions criteria: <http://adge.engin.umich.edu/graduate-education/gradprogcontacts>. Admission is usually determined by an evaluation of the following:

- Transcript of your academic record.
- Recommendations from two or three faculty members who have supervised your course work or research.
- While the GRE general test is required of all applicants, including the University of Michigan graduates who apply to CoE Ph.D. programs, our focus is on the student's academic and research potential. Since GRE scores have been shown to have little or no correlation with student excellence in research at the University of Michigan, we will no longer

require a minimum score for the combined Verbal and Quantitative tests or for the Analytical Writing test.

- Statement of Purpose for your graduate study objectives.
- Personal statement that explains any extenuating circumstances (optional).
- Test of English as a Foreign Language (TOEFL), or the Michigan English Language Assessment Battery (MELAB), for applicants who studied at an institution where the language of instruction is not English or for whom English is not their native language.
- Although departments may adjust their GPA requirements to reflect their own applicant needs, the average GPA of the Fall 2013 entering class of Ph.D. students is 3.7. The average GPA for master's students is 3.6.

## Degree Options

<http://grad.engin.umich.edu/home>

### Dual Master's

Graduate students in the College of Engineering can pursue dual master's degrees within the College or across units of the University of Michigan campus.

## Engineering Degrees

Master of Engineering (M.Eng.)

Doctor of Engineering in Manufacturing (D.Eng.)

Information on these programs can be requested on the following website: <https://www.applyweb.com/public/inquiry?s=umenginq>

## Rackham Graduate School

<http://www.rackham.umich.edu/prospective-students>

## Master of Science/Master of Science in Engineering

The Master of Science and Master of Science in Engineering degrees represent mastery of a particular disci-

pline in the College of Engineering. They require 30 credits of course work, taken predominantly from the area of study. Some programs involve theses or internships. Others require only coursework.

## Doctor of Philosophy (Ph.D.)

The doctoral degree is conferred in recognition of marked ability and scholarship in a chosen field of knowledge. There is no general course or credit requirement for the doctorate. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in related subject areas outside the department, called cognate subjects. In most areas, a student must pass a comprehensive examination in a major field of specialization and be recommended for candidacy for the doctorate. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the results of the investigation in the form of a dissertation. A special doctoral committee is appointed for each applicant to supervise the work of the student both as to election of courses and in preparation of the dissertation.

A student can apply directly for admission to the doctoral program after graduating with a B.S. degree from a relevant field. The student becomes a pre-candidate for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in the field of specialization. Candidacy is achieved when the student demonstrates competence in his/her broad field of knowledge through completion of a prescribed set of courses and passing a comprehensive exam.

Requirements regarding foreign language and non-technical courses are left to individual departments or programs, and to the Rackham Graduate School. A prospective doctoral student should consult the program advisor for specific details.

## Funding and Fellowships for Graduate Students

<http://grad.engin.umich.edu/funding>

### Funding for Ph.D. Students

The College of Engineering at the University of Michigan operates under a fully-funded model for all Ph.D. students. Students receive a guarantee of full funding at the point of admission and throughout the duration of their four- or five-year program. This funding commitment is guaranteed provided the student meets all necessary milestones and fulfills program requirements as stipulated by their individual faculty advisor and/or department/graduate program. This comprehensive package includes tuition, fees, University health insurance and a monthly stipend. The funding package can come from a variety of sources including University of Michigan, College of Engineering or Rackham Graduate School fellowships, Graduate Student Research Assistant (GSRA) appointments or Graduate Student Instructor (GSI) positions. Some students also receive funding from documented external fellowships or any combination of the aforementioned. The typical guarantee of funding for a Ph.D. student admitted directly from a bachelor's degree program is five years while those admitted directly from a master's degree program is four years. Exact funding amounts will vary between engineering departments.

### Funding for Master's Students

The College of Engineering offers some partial fellowships for new master's students. A number of fellowships are awarded to U.S. citizens and permanent residents. The award amount (\$10,000 for Michigan residents, \$20,000 for out-of-state residents) is disbursed during the fall and winter semester of the first year. Admitted master's students are automatically considered for the awards based on the information in their official admission applications. Funding for the majority of new master's students is limited, in that there is no guaranteed funding package. Departments may have some special fellowships or awards designated for master's students. In some cases, individual departments may have Graduate Student Instructor (GSI) po-

sitions or Graduate Student Research Assistant (GSRA) appointments available that master's students can apply for. Master's students who have interest in a Ph.D. program can re-apply at the appropriate application deadline to receive consideration for admission and full funding to a Ph.D. program.

For additional funding resources and opportunities for new and continuing Master's and Ph.D. students visit: <http://grad.engin.umich.edu/funding>. Using the Funding Sources and Fellowships website, graduate students will find resources from across the Michigan campus, tips on applying to fellowships, as well as a number of external funding opportunities.

# Aerospace Engineering

## Overview

Aerospace technology has grown out of the problems of design, construction and operation of vehicles that move above the Earth's surface, vehicles ranging from airplanes and helicopters to rockets and spacecraft. Design of such vehicles has always been challenging, not only because of the high premium placed on light-weight vehicles performing efficiently and with high reliability, but also because they must sometimes operate in hostile environments. These same requirements exist not only for future spacecraft and high-performance transport aircraft, but also for the next generation of ground transportation, such as high-speed trains, over-water transportation and automated motor vehicles. In addition to working on vehicle-oriented design problems, aerospace engineering graduates are often involved in systems management in the broadest sense. Because of the anticipated life mission of the aerospace student, the undergraduate curriculum at the University of Michigan is designed to convey a clear understanding of the fundamental aspects of the fields most pertinent to aerospace engineering. Real-life problems in aerospace and related areas are emphasized in the applications of theory. In their senior year, students select a design course in which they are given an appreciation of the interrelation of the various areas of study in the design of a whole system.

## Department Administration

### Department Chair

Dan Inman, Clarence "Kelly" Johnson Professor of Aerospace Engineering, 3064 FXB.

### Contacts

Aerospace Engineering Department  
3000 Francois-Xavier Bagnoud Building (FXB)  
1320 Beal Ave  
Ann Arbor, MI 48109-2140  
Phone: (734) 764-3310  
Website: <http://aerospace.engin.umich.edu/>

## Mission

To provide internationally recognized leadership in aerospace engineering education, through a continuously improving educational program that graduates students with strong engineering science fundamentals while incorporating applied engineering aspects.

## Goals

- Educate students who are widely known for
- exceptional strength in technical fundamentals across all aerospace disciplines, who are cognizant of modern aerospace technologies and who are sought after by top graduate schools and by aerospace and related industries worldwide.
- Support vibrant and highly recognized research programs that serve the educational goals of the undergraduate and graduate degree programs, that make major contributions to the knowledge base in aerospace sciences and technology and that are turned to by industry and government for solutions.
- Create an environment of intellectual challenge and excitement that at the same time is collegial and conducive to higher learning.
- Take full advantage of knowledge, technology, facilities and resources at the University of Michigan.

## Objectives

The Undergraduate Program Educational Objectives are that, within 3-5 years after graduation:

- Alumni of the program will use their breadth and depth of knowledge and skills in the fundamental disciplines of aerospace engineering to pursue successful professional careers
- Alumni will feel that they received outstanding preparation for the next step in their careers, whether it be graduate school or work in industry, government or academia
- Alumni of the program will be emerging leaders in engineering, science, academia, business and public service
- Alumni of the program will be productive citizens

with high professional and ethical standards.

The above program educational objectives are accomplished by a rigorous curriculum that emphasizes fundamentals in basic sciences, mathematics and the humanities and integrates classroom and laboratory experiences in the fundamental disciplines of Aerospace Engineering. More specifically our curricular goals are to:

- Educate students in the following fundamental disciplines of Aerospace Engineering, aerodynamics, materials, structures, propulsion, flight mechanics, orbital mechanics, software and stability and control
- Educate students in the methodology and tools of design and the synthesis of fundamental aerospace disciplines necessary to carry out the design of an aerospace vehicle or system
- Educate students in the basics of instrumentation and measurement, laboratory techniques and how to design and conduct experiments
- Develop students' ability to function on multi-disciplinary teams and provide them with teamwork experiences throughout their curriculum
- Develop students ability to communicate effectively
- Expose students to environmental, ethical and contemporary issues in Aerospace Engineering
- Expose students to other disciplines of engineering beyond the aerospace field.

## Outcomes

Program Student Outcomes are that UM Aerospace Engineering graduates demonstrate:

- An ability to apply knowledge of mathematics, science and engineering;
- An ability to design and conduct experiments as well as to analyze and interpret data;
- An ability to design a system, component or process to meet desired needs;
- An ability to function on multi-disciplinary teams;
- An ability to identify, formulate and solve engineering problems;
- An understanding of professional and ethical re-

sponsibility;

- An ability to communicate effectively;
- The broad education necessary to understand the impact of engineering solutions in a global and societal context;
- A recognition of the need for, and an ability to engage in life-long learning;
- A knowledge of contemporary issues;
- An ability to use the techniques, skills and modern engineering tools necessary for engineering practice;
- A knowledge of aerodynamics, aerospace materials, structures, propulsion, flight mechanics, orbital mechanics and stability and control;
- Competence in the integration of aerospace science and engineering topics and their application in aerospace vehicle design.

## Undergraduate

### Degree Program

The degree program gives the student a broad education in engineering by requiring basic courses in aerodynamics and propulsion (collectively referred to as "gas dynamics"), structural mechanics and flight dynamics and control systems. These courses cover fundamentals and their application to the analysis, design and construction of aircraft, spacecraft and other vehicular systems and subsystems. Courses in gas dynamics treat fluid and gas flow around bodies and through turbojet engines and rocket nozzles. In courses on structural mechanics, lightweight structures are studied from their strength, elastic, stiffness, stability and dynamic behavior. Flight dynamics and control systems courses deal with the dynamical behavior of vehicles and systems as a whole, their stability and controllability both by human pilots and as autonomous systems. Integration of all these subjects takes place in the capstone aircraft design course or space system design course that is chosen by students. The aerospace engineering program offers considerable flexibility through technical and general electives, in which students have an opportunity to study in greater depth any of the areas mentioned above. In addition, other technical elective areas are available to aerospace engineering students,



including aerophysical sciences, environmental studies, computers, person-machine systems and transportation. Elective courses in each technical elective area include courses taught both inside and outside the aerospace engineering department.

## Sample Schedule

### B.S.E. in Aerospace Engineering

The Aerospace Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://aerospace.engin.umich.edu/AcademicPrograms/undergrad/sampleplan.html>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
ENGR 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
ENGR 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	-	-	-	-	4	4
<b>Related Technical Core Subjects (12 hours)</b>									
MECHENG 240, Intro to Dynamics and Vibrations	4	-	-	-	4	-	-	-	-
MATSCIE 220, Intro to Materials	4	-	-	-	-	-	-	4	-
EECS 314, Circuit Analysis and Electronics	4	-	-	-	-	4	-	-	-
<b>Aerospace Science Subjects (29 hours)</b>									
AEROSP 201, Introduction to Aerospace Engineering	3	-	-	3	-	-	-	-	-
AEROSP 215, Introduction to Solid Mechanics and Aerospace Structures	4	-	-	-	4	-	-	-	-
AEROSP 225, Introduction to Gas Dynamics	4	-	-	-	4	-	-	-	-
AEROSP 315, Aircraft and Spacecraft Structures	4	-	-	-	-	4	-	-	-
AEROSP 325, Aerodynamics	4	-	-	-	-	-	4	-	-
AEROSP 335, Aircraft and Spacecraft Propulsion	4	-	-	-	-	4	-	-	-
AEROSP 347, Space Flight Mechanics	3	-	-	-	-	3	-	-	-
AEROSP 348, Aircraft Dynamics and Control	3	-	-	-	-	-	3	-	-
<b>Aerospace Engineering Subjects (16 hours)</b>									
AEROSP 205, Intro Aerospace Engineering Systems	3	-	-	3	-	-	-	-	-
AEROSP 285, Aero Engineering Seminar	1	-	-	1	-	-	-	-	-
AEROSP 305, Aerospace Engineering Lab I	4	-	-	-	-	-	4	-	-
AEROSP 405, Aerospace Engineering Lab II	4	-	-	-	-	-	-	4	-
AEROSP 481, Aircraft Design or AEROSP 483, Space System Design	4	-	-	-	-	-	-	-	4
<b>Electives (16 Hours)</b>									
Technical Electives <sup>3</sup>	7	-	-	-	-	-	-	4	3
<b>General Electives</b>	9	-	-	-	-	-	5	-	4
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>15</b>	<b>16</b>	<b>16</b>	<b>15</b>

Candidates for the Bachelor of Science in Engineering in Aerospace Engineering - B.S.E. in Aerospace E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

- <sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.
- <sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.
- <sup>3</sup> Technical electives must total at least 7 hours of approved upper division courses (that is, 300 level or above). At least 3 hours must be approved mathematics or science courses, a maximum of 3 hours is allowed for directed study and a maximum of 2 hours is allowed for seminar courses. Recommended courses that satisfy the mathematics or science technical electives are described in a document that can be obtained from the Department or on the Department website.

## Focus of Study

The Aerospace Engineering department offers a variety of areas of focus for students to consider. Specific information about the requirements can be found on the department advising website.

- Propulsion, Aerodynamics and Combustion
  - Air-Breathing Propulsion and Combustion Science
  - Space Propulsion
  - Aerodynamics and Turbulence
  - Computational Fluid Dynamics of Transonic and Hypersonic Vehicles
- Structural Mechanics
  - Advanced Materials for Airframe Applications
  - Adaptive Materials and Constitutive
  - Modeling for Aerospace Structures
  - Aeroelasticity, Structural Dynamics, Optimal Design of Structures
- Flight Dynamics and Control
  - Dynamics and Control of Aircraft
  - Dynamics and Control of Spacecraft
  - Astrodynamics
- Aerospace Vehicles

## Sequential Undergraduate/Graduate Study (SUGS)

The five-year Sequential Undergraduate/Graduate Study (SUGS) Program permits students who enter the program in the first term of their senior year to receive the B.S.E. and M.S.E. degrees (or the B.S.E. and M.Eng. degrees) upon completion of a minimum of 149 credit hours. Students should speak with the department advising office to learn more about the SUGS application process and procedures. SUGS admissions requirements will vary. <http://www.engin.umich.edu/college/academics/bulletin/ug-ed/combined>

- B.S.E. in Aerospace Engineering/M.S.E. in Aerospace Engineering
- B.S.E. in Aerospace Engineering/M.Eng. in Space Engineering

## Graduate

### Graduate Degrees

- Master of Science in Engineering (M.S.E.) in Aerospace Engineering
- Master of Engineering (M.Eng.) in Space Engineering
- Doctor of Philosophy (Ph.D.) in Aerospace Engineering

### M.S.E. in Aerospace Engineering

This degree is designed for students who desire a curriculum that is focused on the scientific aspects of Aerospace Engineering. A total of 30 credit hours is required (typically 10 classes). Of these, 15 credit hours must be 500-level classes in Aerospace Engineering with a B grade or better (excluding AEROSP 590 and AEROSP 585), and 6 credits must be from approved courses in mathematics. The remaining credits can be fulfilled with any Rackham-approved AEROSP courses, where up to six credit hours of directed study (AEROSP 590) and three credit hours of aerospace engineering seminar series (AEROSP 585) may be elected. Students are encouraged to take advantage of directed study and become involved in research as part of their M.S.E. experience. The M.S.E. program does not include an option for a thesis per se; however, through AEROSP 590, students can perform research work in close supervision of a faculty member and investigate a problem of common interest.

Admission requirements include a strong performance in an undergraduate program in engineering or science and submission of acceptable Graduate Record Exam (GRE) scores.

Students are strongly encouraged to consult with faculty in their intended areas of specialization to discuss the composition of their program.

### M.Eng. in Space Engineering

The M.Eng. in Space Engineering provides a compre-

hensive set of courses and training in space-related science and engineering, and the systems approach to design and manage complex space systems. The M.Eng. in Space Engineering requires 30 credits of course work, of which 18 must be at the 500-level or higher and 24 must be graded (not P/F).

Course elections must include:

- Depth in a main area (9 credits). For example, a student could select dynamics and control, structures or propulsion.
- Breadth by crossing engineering/science boundaries (9 credits)
- Systems engineering (6 credits)
- Team design experience (6 credits)

### **Doctor of Philosophy (Ph.D.) in Aerospace Engineering**

Study towards the Ph.D. degree requires a strong background in an area of specialization and an ability to carry out independent research. Students must complete, in order:

#### **Precandidacy Status**

A student must apply for and be admitted to precandidacy status before taking the Preliminary Exam.

To be admitted as a precandidate, the student's GPA must be above 6.5 out of 9.0 (equivalent to 3.5/4.0) in relevant courses and the student must have been working with a Ph.D. advisor who will endorse the student's application for precandidacy. Admission is determined by the Graduate Committee.

Students admitted directly to the doctoral program may also earn a Master degree by fulfilling the Master degree requirements concurrently with the Doctoral degree. The embedded Aero M.S.E. degree is awarded at the end of the Ph.D. studies.

#### **Preliminary Exam**

The Ph.D. degree requires a sound background in aerospace engineering combined with strong knowledge of applied mathematics and computational sciences. The Ph.D. dissertation requires that the student demonstrate

ability to pursue and solve an original research problem, which implies the ability to carry out independent research.

A student who intends to work toward the Ph.D. degree must complete the following steps:

1. **Pre-candidacy Status:** A student must apply to the Graduate Committee of the Department of Aerospace Engineering for admission to pre-candidacy status in Aerospace Engineering. If already in the Ph.D. program, a student must have a GPA of 6.5/9.0 or above in coursework relevant to the doctoral degree and the endorsement of an Aerospace Engineering faculty member as his/her Ph.D. adviser. The GPA is based on at least five graduate courses taken at UM excluding Directed Study (AE 590) and Aerospace Engineering Seminar (AE 585).
2. **Research Involvement:** Each student in the doctoral degree program must initiate a research activity with a faculty member as an adviser in their first year of graduate study at UM. This can be achieved through several approaches: (1) directed study (AE 590); (2) appointment as a graduate research assistant; or (3) through alternative arrangements with the faculty adviser.
3. **Preliminary Examination Requirement:** Before advancing to Ph.D. candidacy, a pre-candidate must demonstrate a high level of competency by successfully completing an oral preliminary examination in Aerospace Engineering.

#### **Candidacy**

Candidacy status is achieved upon successful completion of the Preliminary Exam. Students must also meet other academic credit requirements as described in the Rackham Graduate School Academic Policies.

#### **The Dissertation**

The student must perform original research, present a written dissertation and defend the dissertation at a final oral presentation. The research is done under the supervision of a faculty adviser in the Aerospace Engineering department and a dissertation committee. Students are expected to begin research in their first year of graduate study.

**Ph.D. Degree**

The Ph.D. degree is awarded upon successful completion of a Ph.D. dissertation, a Ph.D. defense, and other academic credit requirements. See the Rackham Graduate School Academic Policies for details. Students should have taken a minimum of 16 graduate courses beyond the bachelor's degree. There is no foreign language requirement, and there are no specific course requirements.

# Biomedical Engineering

## Overview

Students who enjoy math, physics and chemistry, but who also have a keen interest in biology and medicine, should consider a career in Biomedical Engineering (BiomedE). Synthetic heart valves, the fMRI scanner and automatic bio-sensors for rapid gene sequencing are each examples of BiomedE. BiomedE is the newest engineering discipline, integrating the basic principles of biology with the tools of engineering.

With the rapid advances in biomedical research, and the severe economic pressures to reduce the cost of health care, BiomedE plays an important role in the medical environment of the 21st century. Over the last decade, BiomedE has evolved into a separate discipline bringing the quantitative concepts of design and optimization to problems in biomedicine.

The opportunities for biomedical engineers are wide ranging. The medical-device and pharmaceutical industries are increasingly investing in biomedical engineers. As gene therapies become more sophisticated, biomedical engineers will have a key role in bringing these ideas into real clinical practice. Finally, as technology plays an ever-increasing role in medicine, there will be a larger need for physicians with a solid engineering background. From biotechnology to tissue engineering, from medical imaging to microelectronic prosthesis, from biopolymers to rehabilitation engineering, biomedical engineers are in demand.

## Department Administration

### Department Chair

Lonnie Shea, William and Valerie Hall Department  
Chair of Biomedical Engineering  
Professor of Chemical Engineering and Biomedical  
Engineering  
1107 Carl A. Gerstacker Building

## Contacts

Biomedical Engineering Department  
1107 Carl A. Gerstacker Building  
2200 Bonisteel, Blvd.  
Ann Arbor, MI 48109-2099  
E-mail: [biomede@umich.edu](mailto:biomede@umich.edu)  
Phone: (734) 764-9588  
Fax: (734) 936-1905  
Website: <http://www.bme.umich.edu>

## Mission

The mission of the Department of Biomedical Engineering is to provide leadership in education, training and cutting-edge research by translating science and engineering to solve important challenges in medicine and life sciences to the benefit of humanity.

## Goals

To provide students with the education needed for a rewarding career.

## Objectives

The Accreditation Board for Engineering and Technology (ABET) defines the Program Educational Objectives as accomplishments that are expected of our graduates within a few years after graduation. In recognition of the fact that BiomedE graduates may pursue a broad range of careers, the BiomedE Program Objectives are phrased to reflect the preparation provided by the program for these career options. The Program Educational Objectives for the Department of BiomedE are that our students are:

1. Prepared for professional practice in entry-level BiomedE positions or to pursue graduate study in engineering, medicine and other professional degree programs through rigorous instruction in the engineering sciences and biology, including laboratory and design experience;
2. Prepared for a variety of careers resulting from the opportunity to deepen their technical understanding in a particular subject via a program of related tech-

nical electives and from the development of teamwork, communication and other non-technical skills.

## Outcomes

- An ability to apply knowledge of mathematics, science and engineering to biomedical engineering problems. (ABET 3a)
- An ability to design and conduct experiments, as well as to analyze and interpret data. (ABET 3b)
- An ability to design a system; component, or process to meet desired needs. (ABET 3c)
- An ability to function on multi-disciplinary teams. (ABET 3d)
- An ability to identify, formulate and solve engineering problems. (ABET 3e)
- An understanding of professional and ethical responsibility. (ABET 3f)
- An ability to communicate effectively orally and in writing. (ABET 3g)
- The broad education necessary to understand the impact of engineering solutions in a global and societal context. (ABET 3h)
- A recognition of the need for, and an ability to engage in life-long learning. (ABET 3i)
- A knowledge of contemporary issues. (ABET 3j)
- An ability to use the techniques, skills and modern engineering and computing tools necessary for engineering practice. (ABET 3k)
- A knowledge of biology and physiology. (Program)
- The capability to apply advanced mathematics (including differential equations and statistics), science and engineering to solve the problems at the interface of engineering and biology. (Program)
- An ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems. (Program)

## Undergraduate

### Degree Program

BiomedE offers a four year undergraduate degree along with a recommended one year masters degree in a Sequential Undergraduate/Graduate Studies (SUGS) program. Qualified undergraduates may pursue a combined undergraduate/graduate program in one of three concentrations: biochemical, bioelectronics, or biomechanics, leading to a Bachelor of Science in Engineering degree (B.S.E. in Biomedical Engineering). Six graduate concentrations: bioelectronics, biomaterials, biomechanics, biotechnology, biomedical imaging, and medical product development, leading to a Master of Science in Engineering degree (M.S. in Biomedical Engineering).

# Sample Schedule

## B.S.E. in Biomedical Engineering

The Biomedical Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website: <http://www.bme.umich.edu/programs/undergrad/current.php>.

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8	9	10
<b>Subjects Required by all Programs (53 hours)</b>											
Mathematics 115, 116, 215, 216	16	4	4	4	4	-	-	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-	-	-
Chemistry 130 <sup>1</sup>	3	3	-	-	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-	-	-
Intellectual Breadth	16	-	4	4	4	4	-	-	-	-	-
<b>Advanced Science and Math (12 hours)</b>											
Biology 172 or 174, Introduction to Biology (If using AP Bio credit (195), then Bio 173 (2) is required.)	4	-	-	-	4	-	-	-	-	-	-
Chemistry 210/211, Structure and Reactivity I and Lab	5	-	-	5	-	-	-	-	-	-	-
MCDB 310, Introduction to Biological Chemistry or BIOCHEM 415, Introduction to Biological Chemistry or Chemistry 351, Fundamentals of Biochemistry	3	-	-	-	-	-	3	-	-	-	-
<b>Required Program Subjects (36 hours)</b>											
BIOMEDE 211, Circuits & Systems for Biomedical Engineers	4	-	-	-	-	4	-	-	-	-	-
BIOMEDE 221, Biophysical Chemistry & Thermodynamics	4	-	-	-	-	4	-	-	-	-	-
BIOMEDE 231, Introduction to Biomechanics	4	-	-	-	4	-	-	-	-	-	-
BIOMEDE 241, Biomedical Undergraduate Lab	4	-	-	-	-	4	-	-	-	-	-
BIOMEDE 350, Introduction to Biomedical Design	3	-	-	-	-	-	3	-	-	-	-
BIOMEDE 418, Quantitative Cell Biology	3	-	-	-	-	-	3	-	-	-	-
BIOMEDE 419, Quantitative Physiology	4	-	-	-	-	-	-	4	-	-	-
BIOMEDE 450, Biomedical Design or	4	-	-	-	-	-	-	-	4	-	-
BIOMEDE 451, Biomedical Design, Part I and	2	-	-	-	-	-	-	2	-	-	-
BIOMEDE 452, Biomedical Design, Part II	3	-	-	-	-	-	-	-	3	-	-
BIOMEDE 458, Biomedical Instrumentation & Design	4	-	-	-	-	-	-	4	-	-	-
MATSCIE 250, Principles of Engineering Materials	4	-	-	4	-	-	-	-	-	-	-
<b>Concentration Requirements and Electives<sup>3</sup> (14 hours)</b>											
General Electives (11 hours)	11	-	-	-	-	-	4	4	3	-	-
<b>Total</b>	<b>128</b>	<b>16</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>17</b>	<b>16-18</b>	<b>12-13</b>	<b>-</b>	<b>-</b>
<b>M.S. Biomedical Engineering</b>											
<b>Required Program Subjects M.S. (14-15 hours)</b>											
Advanced Math	3	-	-	-	-	-	-	-	-	3	-
Advanced Statistics	3	-	-	-	-	-	-	-	-	-	3
BIOMEDE 500, Seminar	1	-	-	-	-	-	-	-	-	-	1
BIOMEDE 550, Ethics & Enterprise	1	-	-	-	-	-	-	-	-	1	-
BIOMEDE 590, Directed Research (2-3) or BIOMEDE 599, Graduate Design, Part I (3) and BIOMEDE 599, Graduate Design, Part II (4)	2-7	-	-	-	-	-	-	-	-	1-3	1-4
Life Science	3	-	-	-	-	-	-	-	-	3	-
M.S. Concentration Requirements <sup>3</sup> (8 hours)	8	-	-	-	-	-	-	-	-	4	4
<b>M.S. Total Hours</b>	<b>21-26</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>12-14</b>	<b>9-12</b>

Candidates for the Bachelor of Science in Engineering in Biomedical Engineering - B.S.E. in Biomed E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> Concentration requirements and electives: A list of approved courses is available on the department website and in 1111 Gerstacker.



## Concentrations

The undergraduate program is divided into three concentrations: the biochemical, bioelectrical and biomechanical. Organization of the undergraduate curriculum into concentrations allows students to gain deeper preparation in a chosen subarea of BiomedE. The concentrations are structured similarly, and each concentration consists of a set of required concentration courses as well as a list of concentration electives from which students must fulfill their credit requirements.

### Biochemical concentration

Advances in cellular and molecular biology have changed and expanded the ways that therapeutic devices and drugs are designed. Modern biotechnology depends on scientists and engineers who study the fundamental properties of cell, molecular and tissue biology and apply this to engineer chemicals and materials to interact with living systems. Goals include production of improved biomaterials for medical implants and prosthetics, tissues engineered for specific functionality and new therapeutic drugs. The biochemical curriculum emphasizes critical areas of chemistry, molecular biology, and cell biology, but also exposes students to a broad range of engineering approaches necessary for this interdisciplinary field. Graduates of this concentration are well prepared for jobs in the pharmaceutical or medical device industries, to attend professional schools or study for a Ph.D. in BiomedE.

### Bioelectrical concentration

The bioelectrical area has a long history as a part of BiomedE programs. This concentration allows students to study electrical and systems engineering in an integrated fashion. A goal of this concentration is to produce students who can see the interdependence of different engineering disciplines in the development of modern medical devices and analysis systems. Individuals completing this program will be able to work as engineers in the rapidly expanding medical diagnostic, therapeutic and systems industry. Students are prepared to pursue Ph.D. programs in Electrical Engineering, Systems Science or other BiomedE fields, and this concentration also provides the foundation for advanced degrees in medicine or basic medical science.

### Biomechanical concentration

Biomechanics permeates a wide range of fields that affect our everyday lives. Examples include designing work tasks to reduce physical stresses, designing surgical devices to withstand loads and developing advanced prostheses and surgical procedures to ensure proper physiological function. Biomechanics is a hybrid discipline requiring a thorough understanding of classic engineering mechanics, physiology and cell biology, as well as the interfaces between these fields. The goal of the biomechanical concentration is to provide students with a rigorous background in the mechanics and dynamics of solids and fluids, as well as physiology, cell biology and molecular biology. Graduates are prepared for a wide range of professions including the medical device industry, automotive safety and biotechnology industries concerned with mechanically functional tissue. Students graduating from this concentration also have excellent preparation to attend medical school or pursue a Ph.D. in BiomedE or related fields.

## Sequential Undergraduate/Graduate Study (SUGS)

The five-year Sequential Undergraduate/Graduate Study (SUGS) program permits students who enter the program in the first term of their senior year to receive the B.S.E. and M.S.E. degrees (or the B.S.E. and M.S. degrees) upon completion of a minimum of 149 credit hours. Students should speak with the department advising staff to learn more about the SUGS application process and procedures. SUGS admissions requirements will vary. <http://www.engin.umich.edu/college/academics/bulletin/rules/graduation>

Available programs include:

- B.S.E. in Biomedical Engineering/M.S.E. in Biomedical Engineering
- B.S. in Cell and Molecular Biology/M.S. in Biomedical Engineering
- B.S.E. in Chemical Engineering/M.S.E. in Biomedical Engineering
- B.S.E. in Electrical Engineering and Computer Science/M.S.E. in Biomedical Engineering

- B.S.E. in Industrial and Operations Engineering/  
M.S.E. in Biomedical Engineering
- B.S.E. in Material Science Engineering/M.S.E. in  
Biomedical Engineering
- B.S.E. in Mechanical Engineering/M.S.E. in Bio-  
medical Engineering

## Graduate

### Graduate Degrees

- Master of Science (M.S.) in Biomedical Engineer-  
ing
- Doctor of Philosophy (Ph.D.) in Biomedical Engi-  
neering

### M.S. in Biomedical Engineering

The Department of Biomedical Engineering's graduate program at the University of Michigan is in the Rackham School of Graduate Studies granting the M.S. and Ph.D. degrees in Biomedical Engineering.

The department is interdisciplinary. A student may plan a widely diversified educational program to advance the student's personal goals. Research opportunities are as diversified as the range of activities conducted by the University units supporting the department.

#### Entrance Requirements for the Department of Biomedical Engineering

Those students with a Bachelor of Science in Engineering or Physics degree should present a minimum background of:

- One course in biochemistry
- One course in either basic biology or introductory physiology, including a laboratory experience
- One course in a generally related area of the biological sciences such as anatomy, experimental psychology, microbiology, physiology, pharmacology, etc.

Those students with a Bachelor of Science or Bachelor

of Arts degree with majors such as experimental psychology, physiology, zoology, microbiology or biochemistry, must present the above background required of engineers, plus the following:

- Two terms of college physics
- Mathematics through differential equations
- One course in basic electronic circuits
- Two courses of either mechanics, fluid mechanics or thermodynamics

The admissions committee frequently admits students who have not completed all of the listed prerequisites during their undergraduate studies. These students must satisfactorily complete these courses as graduate students. Please note, however, that course credits from these prerequisites may not be applied toward the graduate degree. Under special circumstances students may petition to waive the non-mathematics and non-physics prerequisites. Completing these courses will be in addition to the requirements stipulated for the Master of Science or Doctor of Philosophy degree in Biomedical Engineering.

### Degree Requirements

In order to obtain the master's degree in Biomedical Engineering, students must satisfactorily complete (B or better) a minimum of 30 credit hours of graduate study beyond the bachelor's degree. Within this requirement, a group of core courses or their equivalents in the biological sciences, and several graduate level engineering and physical science courses must be completed. Directed research work is required to familiarize the student with the unique problems associated with biological systems research. The core course requirements or their equivalent total 12-23 credit hours for each sub-group of the curriculum. There are six (6) curriculum options available:

- Bioelectrical
- Biomaterials
- Biomechanics
- Biotechnology
- Biomedical Imaging
- Medical Product Development

Please see department web site for further details. A grade of "B" or better must be attained in each course used toward the master's degree.

## **Ph.D. in Biomedical Engineering**

The Ph.D. degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by the committee. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the result of the investigation in the form of a dissertation.

A student becomes an applicant for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in a field of specialization. Candidacy is achieved when the student demonstrates competence in her/his broad field of knowledge through completion of a prescribed set of courses and passing a comprehensive examination.

All Ph.D. students must satisfactorily complete (B or better) a minimum of nine (9) credit hours of letter graded course work (any electives with Rackham credit and approved by the student's research advisor) beyond those which are required for a master's degree. A special doctoral committee is appointed for each applicant to supervise the work of the student both as to election of courses and in preparation of the dissertation.

Requirements regarding foreign language and non-technical courses are left to individual departments or programs, and to the Graduate School. A prospective doctoral student should consult the program advisor regarding specific details.

# Chemical Engineering

## Overview

The degree program in chemical engineering was established in 1898 at the University of Michigan, one of four schools to introduce the profession in the United States. The University of Michigan student chapter of the American Institute of Chemical Engineers was established in 1922. Chemical engineering, among all branches of engineering, is the one most strongly and broadly based upon chemical and life sciences. It has been defined by the directors of the American Institute of Chemical Engineers as "the profession in which a knowledge of mathematics, chemistry and other natural sciences gained by study, experience and practice is applied with judgment to develop economic ways of using materials and energy for the benefit of mankind." Thanks to a broad and fundamental education, the chemical engineer can contribute to society in many functions, including research, development, process design, product engineering, plant operation, environmental protection, marketing, sales, teaching, law, medicine, public health, or government work.

The work of the chemical engineer encompasses many industries, from the manufacture of chemicals and consumer products and the refining of petroleum, to biotechnology, food manufacturing and the production of pharmaceuticals. Because of this breadth, there are many fields in which chemical engineers may specialize. More information on careers for chemical engineers is available at the AIChE career page, <http://www.aiche.org/community/students/career-resources-k-12-students-parents>. The program allows 12 credits of general electives, 3 credits of engineering electives and 16 credits of Intellectual Breadth electives. A student may use this elective freedom to develop individual abilities and interests, or to prepare to continue their studies in engineering, medicine, law, business, education, public health or public policy, among many options. The electives also provide the opportunity for combined degree programs or for preparation in fields within or related to chemical engineering such as polymers, pharmaceuticals, environmental engineering, energy and fuels, and biotechnology. Stu-

dents can choose to focus their elective courses by selecting a concentration within their Chemical Engineering degree. Current optional concentration areas include: BioPharmaceutical Engineering, Electrical Engineering-Electronic Devices, Energy Systems Engineering, Environmental Engineering, Life Sciences, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering and Petroleum and Gas Exploration.

## Department Administration

### Department Chair

Mark Burns  
3074 HH Dow Building

### Contacts

Chemical Engineering Department  
3074 H. H. Dow  
2300 Hayward St.  
Ann Arbor, MI 48109-2136  
E-mail: [cheme@umich.edu](mailto:cheme@umich.edu)  
Phone: (734) 764-2383  
Fax: (734) 763-0459  
Website: <http://che.engin.umich.edu/>

## Mission Statement

### Mission

To provide a solid and current technical foundation that prepares students for a career in chemical engineering or related fields.

### Goals

To educate and support diverse students and prepare them to be leaders in chemical engineering or related fields.

### Objectives

Within a few years of graduation, UMChE graduates will have attained leadership roles among peers in

---

chemical engineering, or another field, such as medicine, law, business and education, through:

- effectiveness as creative problem solvers and innovators
- ability to think critically to solve relevant problems
- effectiveness as communicators to gain and convey information
- competence and comfort in multifunctional and multicultural environments
- exhibiting and demanding high ethical standards

## Outcomes

The outcomes we desire are that graduates of the University of Michigan Chemical Engineering Program demonstrate:

- An ability to apply knowledge of mathematics, science and engineering to chemical engineering problems;
- An ability to design and conduct experiments, as well as to analyze and interpret data;
- An ability to design a system, component or process to meet desired needs;
- An ability to function on multi-disciplinary teams;
- An ability to identify, formulate and solve engineering problems;
- An understanding of professional and ethical responsibility;
- An ability to communicate effectively orally and in writing;
- The broad education necessary to understand the impact of engineering solutions in a global and societal context;
- A recognition of the need for and an ability to engage in life-long learning;
- A knowledge of contemporary issues;
- An ability to use the techniques, skills and modern engineering and computing tools necessary for engineering practice.

## Sample Schedule

### B.S.E. in Chemical Engineering

The Chemical Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://www.engin.umich.edu/che/undergraduate>.

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (53 Hours)</b>									
Mathematics 115+, 116+, 215+, 216+	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering +	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers +	4	-	4	-	-	-	-	-	-
Chemistry 130 <sup>1</sup>	3	3	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth (to include a micro or macro economics)	16	4	-	-	-	4	-	4	4
<b>Advanced Chemistry (11 Hours)</b>									
Chemistry 210/211, Structure and Reactivity I and Lab +	5	-	5	-	-	-	-	-	-
Chemistry 215/216, Structure and Reactivity II and Lab +	5	-	-	5	-	-	-	-	-
Chemistry 261 Introduction to Quantum Chemistry <sup>35</sup>	1	-	-	-	-	1	-	-	-
<b>Related Technical Subjects (11 Hours)</b>									
Biology/Life Science Elective <sup>3</sup>	4	-	-	-	-	-	4	-	-
Materials Elective (MSE 250 or MSE 220) +	4	-	-	-	-	-	-	4	-
Engineering Electives <sup>4</sup>	3	-	-	-	-	-	-	-	3
<b>Program Subjects (41 Hours)</b>									
ChE 230 Material and Energy Balances +	4	-	-	4	-	-	-	-	-
ChE 330 Chemical and Engineering Thermodynamics +	4	-	-	-	4	-	-	-	-
ChE 341 Fluid Mechanics +	4	-	-	-	4	-	-	-	-
ChE 342 Mass and Heat Transfer +	4	-	-	-	-	4	-	-	-
ChE 343 Separation Processes +	4	-	-	-	-	4	-	-	-
ChE 344 Reaction Engineering and Design +	4	-	-	-	-	-	4	-	-
ChE 360 Chemical Engineering Laboratory I +	4	-	-	-	-	-	4	-	-
ChE 460 Chemical Engineering Laboratory II +	4	-	-	-	-	-	-	-	4
ChE 466 Process Dynamics and Control	3	-	-	-	-	-	-	3	-
ChE 485 Chemical Engineering Process Economics +	1	-	-	-	-	-	1	-	-
ChE 487 Chemical Process Simulation and Design <sup>6</sup>	5	-	-	-	-	-	-	-	5
<b>General Electives (12 Hours)</b>									
<b>Total</b>	<b>128</b>	<b>15</b>	<b>18</b>	<b>21</b>	<b>12</b>	<b>16</b>	<b>16</b>	<b>14</b>	<b>16</b>

Candidates for the Bachelor of Science in Engineering in Chemical Engineering - B.S.E. in Chem E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

- <sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.
  - <sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.
  - <sup>3</sup> See department list for courses that satisfy the Biology/Life Science elective requirement.
  - <sup>4</sup> Engineering courses are to be at the 200 or higher level and cannot include seminar courses. Engineering research hours at the 400 level or higher may be used to satisfy this requirement. Up to 8 hours of ChE 490 or ChE 695 research may be taken for a grade. Beyond that, ChE 490 or 695 hours must be taken pass/fail.
  - <sup>5</sup> Either Physics 390 or Materials Science 242 can be taken to fulfill the Chemistry 261 requirement.
  - <sup>6</sup> ChE 488 and 489, the Chemical Product Design two-semester sequence, is available as a substitute for ChE 487 for a limited number of students.
- (+) Students must earn a "C-" or better in prerequisite courses indicated by the (+).

## Concentrations

Chemical Engineering students have the option of focusing their technical and some free electives in a specific area, fulfilling a concentration within their chemical engineering degree. Concentration areas include:

- BioPharmaceutical Engineering
- Electrical Engineering - Electronic Devices
- Energy Systems Engineering
- Environmental Engineering
- Life Sciences
- Materials Science and Engineering
- Mechanical Engineering
- Nuclear Engineering
- Petroleum and Gas Exploration

All optional concentrations consist of 12 credits and must include at least one 300 or higher level course. Only elective courses can be used as part of a concentration. Students may not earn a concentration in a field in which they are also enrolled for a dual degree. More information on concentration requirements is available at <http://www.engin.umich.edu/che/undergraduate/program/options>.

## Sequential Undergraduate/Graduate Study (SUGS)

The following programs are available for chemical engineering students interested in pursuing joint B.S.E. and M.S.E. or M.Eng. degrees. For more information on each of these programs, including program requirements and graduate program contact information, please visit <http://www.engin.umich.edu/che/undergraduate/program/options/sgus>.

### **B.S.E. in Chemical Engineering / M.S.E. in Biomedical Engineering**

This SUGS program is open to all undergraduate students from Chemical Engineering who have achieved senior standing (85 credit hours or more) and have an overall cumulative GPA of 3.2 or higher.

### **B.S.E. in Chemical Engineering / M.S.E. in Chemical Engineering**

A University of Michigan undergraduate with a GPA of 3.5 or greater may apply, after completing the first term of the junior year, for admission to the departmental SUGS combined degree program leading to both the baccalaureate and master's degrees. Up to 9 hours of prior approved elective coursework may be applied toward both degrees (typically leading to a total of 128 for the B.S.E. plus 30 for the M.S.E.) for 149 total credit hours. The 9 double counted elective credits must be acceptable for Rackham credit. The 21 chemical engineering graduate credits may include up to 6 hours of CHE 698 (directed study or practical training under faculty supervision) or CHE 695 (research).

### **B.S.E. in Chemical Engineering / M.Eng. in Energy Systems Engineering**

The program aims to prepare students to design and implement energy systems for innovative applications. An overall GPA of 3.5 or above at time of admission is required.

### **B.S.E. in Chemical Engineering / M.S.E. in Environmental and Water Resources Engineering**

The program is open to all Chemical Engineering undergraduate students who have completed 75 or more credit hours with a cumulative GPA of at least 3.5.

### **B.S.E. in Chemical Engineering / M.S.E. in Industrial and Operations Engineering**

Non-IOE engineering students pursue the IOE master's degree for a number of reasons. Some students use it as the first step toward the IOE Ph.D. degree. Other students pursue the degree to enhance their qualifications for professional engineering careers. Applicants must have a minimum GPA of 3.5.

### **B.S.E. in Chemical Engineering / M.S.E. in Macromolecular Science and Engineering**

The Master's in Macromolecular Science and Engineering degree is a 30-credit program. There are several specializations or options from which to choose. A 3.2 GPA is required to apply for this program.

**B.S.E. in Chemical Engineering / M.Eng. in Manufacturing**

The Master of Engineering in Manufacturing (M.Eng. in Mfg.) degree is a professional practice-oriented degree designed to further the education of engineers who already have experienced working in industry and plan to return to an industrial environment after completing their studies. The degree requirements can be completed in one calendar year (12 months). This degree combines course work from various engineering disciplines (80%) and business (20%). Applicants to this program must have completed 80 or more credits of course work with a GPA of 3.6 or better.

**B.S.E. in Chemical Engineering / M.S.E. in Materials Science and Engineering**

Students who enter a Chemical Engineering program out of an interest in chemistry could opt to pursue a master's in Materials Science and Engineering. This master's degree enhances their understanding of the relationship between chemical structure, processing and material properties, which in turn prepares them to pursue careers in research, design or manufacturing of materials. A GPA of 3.5 is required to apply.

**B.S.E. in Chemical Engineering / M.Eng. in Pharmaceutical Engineering**

The Master of Engineering (M.Eng.) degree is intended to focus more on professional practice in the pharmaceutical field than the traditional Master of Science in Engineering (M.S.E.) degree. A GPA of 3.5 is required to apply.

## Graduate

### Graduate Degrees

- Master of Science in Engineering (M.S.E.) in Chemical Engineering
- Doctor of Philosophy (Ph.D.) in Chemical Engineering

**M.S.E. in Chemical Engineering**

The minimum requirement for the M.S.E. degree for a student entering with a baccalaureate degree in chemical engineering is 30 graduate credit hours with an av-

erage grade of "B." A thesis is not required. The course work must include at least 21 hours in chemical engineering (courses with a CHE prefix), of which up to 6 credit hours of research are accepted (e.g., CHE 695); and at least two courses outside the chemical engineering program. The required courses are Fluid Flow (CHE 527), Statistical and Irreversible Thermodynamics (CHE 538), Chemical Reactor Engineering (CHE 528), Transport Processes (CHE 542), Chemical Engineering Research Survey (CHE 595) and Math for Chemical Engineers (CHE 505). Each student is encouraged to develop a program to fit his or her professional objective and should consult with the graduate advisor concerning a plan of study.

**Ph.D. in Chemical Engineering**

The doctoral degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by the committee. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the result of the investigation in the form of a dissertation.

A student becomes an applicant for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in a field of specialization. Candidacy is achieved when the student demonstrates competence in her/his broad field of knowledge through completion of a prescribed set of courses and passing a comprehensive examination.

The course requirements are the same as the M.S.E. degree, plus six (6) additional graduate level credits. Students must pass a comprehensive examination in chemical engineering and be recommended for candidacy for the doctorate. A special doctoral committee is appointed for each applicant to supervise the work of the student both as to election of courses and in preparation of the dissertation.

Information on the general procedure leading to the doctorate is available at the Graduate School website, <http://www.rackham.umich.edu>.



# Civil Engineering and Environmental Engineering

## Overview

Civil and environmental engineers design, plan and construct infrastructure systems including buildings, bridges, highways, airports, tunnels, pipelines, channels, waste-water systems, waste site, remediation systems, power generating plants, manufacturing facilities, dams and harbors. These infrastructure systems are key to sustaining human development and activities, and civil and environmental engineers must consider technical as well as economic, environmental, aesthetic and social aspects.

To recognize the distinct qualifications of engineers entering the fields of Civil and Environmental Engineering, the department offers undergraduate programs leading to a Bachelor of Science in Engineering in Civil Engineering and a Bachelor of Science in Engineering in Environmental Engineering. The Civil Engineering major offers several focus areas of specialization including: Construction Engineering, Environmental Engineering, Geotechnical Engineering, Hydraulic and Hydrological Engineering, Civil Engineering Materials, and Structural Engineering. The Environmental Engineering major allows curricular focus in the areas of Water Quality and Health, Atmospheric and Earth Systems, Environmental Fluid Dynamics, and Energy and Sustainable Infrastructure, and Environmental Policy and Entrepreneurship. For more information on these fields and majors, please visit [www.engin.umich.edu/college/academics/bulletin/depts/cee](http://www.engin.umich.edu/college/academics/bulletin/depts/cee).

A minor in Environmental Engineering is also offered through the department. Eligibility information and requirements of the minor are described at <http://cee.engin.umich.edu/minor-environmental-engineering>

Students who do well in their undergraduate program are encouraged to consider graduate work and may take

some of their electives in preparation for graduate study. The Sequential Undergraduate/Graduate Studies programs available in this department are described <http://cee.engin.umich.edu/sequentialapplicants>.

Information and assistance regarding fellowships and assistantships for graduate studies may be obtained in the Student Services Office of the Department of Civil and Environmental Engineering.

## Department Administration

### Department Chair

Kim Hayes  
2340 G G Brown Laboratory

### Contacts

Civil and Environmental Engineering Department  
2340 G. G. Brown Building  
2350 Hayward St.  
Ann Arbor, MI 48109-2125  
Phone: (734) 764-8495  
Fax: (734) 764-4292  
Website: <http://cee.engin.umich.edu>

## Civil Engineering

### Mission

As a leading educational and research institution, we are driving the development of innovative technologies that:

- Enhance the performance and sustainability of civil and environmental infrastructure
- Have a favorable impact on the natural environment
- Manage complex issues at the intersection of built and natural systems.

We are committed to solving major societal problems by providing forward-looking education, enhancing multidisciplinary research and performing broad-based service.

## Goals

To accomplish our mission, we must:

- Provide an enriching educational environment, together with extracurricular and service opportunities, that prepare our students to:
  - Excel as leaders in the understanding, design, construction, operation and maintenance of civil and environmental infrastructural systems,
  - Be ethical stewards of the built and natural environments, and
  - Adapt to an ever-changing profession through lifelong learning.
- Recruit, educate and support students, researchers, staff and faculty from diverse backgrounds, and provide them with the foundation to become global leaders;
- Enhance the department's positive impact nationally and internationally and make transformative contributions within the State of Michigan;
- Champion the translation of research findings into professional practice;
- Provide a technical foundation for shaping policy that addresses the complex issues facing civil and environmental infrastructure systems and the natural environment;
- Foster a leading-edge collaborative environment that is well-positioned to address high-impact research issues and provide solutions to critical societal challenges; and
- Foster and support the spirit of entrepreneurship among our students, faculty, and staff.

## Objectives

The following set of objectives describes what our graduates are expected to achieve within several years of graduation.

- The graduates of the Civil Engineering Program at Michigan will have the necessary intellectual tools and technical skills to take on careers of leadership in the development of new technologies, construction of modern infrastructure and to contribute to-

society through participation in policy making and governance. Graduates will have a solid foundation in civil engineering and will achieve success in graduate education and a broad range of career opportunities.

- Our graduates will become team leaders and will successfully address open-ended problems applying critical thinking.
- The U-M Civil Engineering graduates will become effective communicators of technical and professional information in written, oral, visual and graphical form.
- Professional careers of U-M graduates will be distinguished with a high degree of awareness of moral, ethical, legal and professional obligations to protect human health, human welfare and the environment.

## Outcomes

The outcomes we desire are that graduates of the University of Michigan Civil Engineering Program demonstrate:

- An ability to apply knowledge of mathematics, science and engineering within civil engineering;
- An ability to design and conduct experiments, and to critically analyze and interpret data;
- An ability to design a system, component or process to meet desired needs;
- An ability to function in multi-disciplinary teams;
- An ability to identify, formulate and solve engineering problems;
- An understanding of professional and ethical responsibility;
- An ability for effective oral, graphic and written communication;
- An understanding of the impact of engineering solutions in a global and societal context;
- A recognition of the need for, and an ability to engage in, life-long learning;
- A knowledge of contemporary issues that affect civil engineering;
- An ability to use the techniques, skills and modern engineering tools necessary for engineering practice;
- A proficiency in a minimum of four major civil

engineering areas;

- An understanding of professional practice issues and the importance of licensure.

## Environmental Engineering

### Mission

To provide an outstanding education in environmental engineering that prepares students for leadership positions in the improvement of human and ecological health at the intersection of built and natural systems.

### Goals

To provide an enriching educational environment that prepares students with the environmental science and engineering design principles to develop sustainable solutions to environmental problems and the professional skills to become leaders in the discipline.

### Objectives

The following objectives describe what our graduates are expected to achieve within several years of graduation.

- Demonstrate the critical thinking, technical and communication skills that will allow their advancement into leadership positions in engineering practice or other professional careers that involve the application of analytic engineering thinking;
- Pursue lifelong learning through continued education including engineering graduate study, or other professional education;
- Exhibit a high degree of awareness of ethical and professional obligations through involvement in professional societies, community activities or educational outreach.

### Outcomes

The outcomes we desire are that graduates of the program demonstrate:

- An ability to apply knowledge of mathematics, science and engineering;
- An ability to design and conduct experiments, and to critically analyze and interpret data;
- An ability to design a system, component or process to meet desired needs;
- An ability to function on multidisciplinary teams;
- An ability to identify, formulate and solve engineering problems;
- An understanding of professional and ethical responsibility;
- An ability to communicate effectively;
- The broad education necessary to understand the impact of engineering solutions in a global/societal context;
- A recognition of the need for and an ability to engage in life-long learning;
- A knowledge of contemporary issues;
- An ability to use the techniques, skills and modern engineering tools necessary for engineering practice;
- An ability to formulate material and energy balances, analyze the fate and transport of substances, and design environmental engineering systems that involve considerations of risk, uncertainty, sustainability and life-cycle impacts;
- An understanding of professional practice issues related to environmental engineering.

## Civil Engineering

Civil engineers design, plan, and improve the built environment and infrastructure systems, including buildings, power generation facilities, water supply networks, pollution control works, flood protection structures, dams, and canals, as well as vital network systems for commerce such as roadways, airports, railroads, and ports. Civil engineering encompasses several subdisciplines, including hydraulics and hydrology, structural, geotechnical, construction, environmental, civil engineering materials, and transportation engineering.

Coursework in the major builds especially on a strong foundation in math and physics, and exposes students to these subdisciplines. An emphasis in the sustainable

engineering of civil infrastructure is also provided by the curriculum.

## **Civil Engineering Focus**

### **Areas**

The following are areas of focus within Civil Engineering at Michigan:

#### **Construction Engineering and Management**

Planning, estimating, scheduling and managing the construction of engineered facilities using modern construction methods, materials and equipment. Business and legal principles of construction contracting. Planning, analysis, design, and optimization of field construction operations. Simulation and visualization of construction processes and products. Computer applications and information technology in design, construction, operations and maintenance of constructed facilities.

#### **Environmental Engineering**

The principles, design and methods for implementation of sustainable environmental and earth systems; water resource development, management, conservation and systems design; engineering of water quality and pollution control processes and systems; treatment, distribution and collection networks and infrastructures for optimal municipal and industrial water use, recovery and recycle; environmental design for efficient energy and resource utilization and minimization of water and air pollution and solid wastes generation; modeling of the fate and transport of contaminants in environmental media and systems and quantitative assessment of associated human and ecological risks.

#### **Geotechnical Engineering**

The evaluation of soil properties and environmental conditions in foundations of earth-supported structures; mass stability in excavations and subsurface construction; use of soil characteristics and properties and soil classification in design and construction of highways, railways, airports and other surface facilities; behavior of soils subjected to dynamic loading.

#### **Hydraulic and Hydrological Engineering**

The application of the fundamental principles of hydraulics and hydrology to the optimum development of surface water and ground-water resources; the study of flood prediction and flood control, flow and contaminant transport in surface and ground waters, transients in pipelines and channels, coastal engineering and design of structures to interface with the water environment.

#### **Civil Engineering Materials**

The analysis, engineering, and testing of civil engineering materials pertaining to infrastructure renewal and high-performance structures, including the study of infrastructure rehabilitation (including bridge and pavement technology), advanced emerging materials (including cement-based composites, polymers and ceramics), micromechanics of composite materials, durability of materials and innovative materials and structures.

#### **Structural Engineering**

The theory, analysis, design and construction of structures such as bridges, buildings, towers, and housing, involving the use of steel, reinforced concrete, prestressed concrete, fiber reinforced concrete, advanced FRP composites and wood; studies of inelastic behavior of materials and structures; studies of dynamic forces and their effects on structures.

## **Environmental Engineering**

Environmental engineers design systems to provide safe water, air, and land for human habitation, and to address the impact of human activities on the environment. For example, environmental engineers may be involved in the design of technologies to remove emerging contaminants from drinking water, monitor and mitigate greenhouse gas compounds, recover resources and energy from waste streams, design sustainable alternative energy sources, cleanup hazardous waste sites, or restore streams and lakes damaged by human activities.

In this major, a strong foundation in math, chemistry, physics, biology, and earth science is important, and

the engineering tools to apply them are provided in the curriculum. The social and policy issues associated with environmental problems are also explored.

## Sample Schedules

### B.S.E. in Civil Engineering

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET,

<http://www.abet.org>. Additional information can be found on the department advising website,

<http://cee.engin.umich.edu/academics/undergrad-studies/advising>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth (includes Economics 101 or 102)	16	4	4	-	4	-	-	-	4
<b>Mathematical Methods (7 hours) +</b>									
CEE 270, Statistical Methods	3	-	-	-	-	3	-	-	-
CEE 303, Computational Methods	4	-	-	-	-	-	4	-	-
<b>Required Program Subjects (26 hours)<sup>3</sup> +</b>									
CEE 200, Intro to Civil and Environmental Engineering	1	-	-	-	1	-	-	-	-
CEE 211, Statics and Dynamics	4	-	-	4	-	-	-	-	-
CEE 212, Solid and Structural Mechanics	3	-	-	-	3	-	-	-	-
CEE 230, Thermodynamics and the Environment or CEE 370, Sensors and Circuits	3	-	-	3 or 3	-	-	-	-	-
CEE 265, Sustainable Engineering Principles	3	-	-	3 or 3	-	-	-	-	-
CEE 325, Fluid Mechanics	4	-	-	-	-	4	-	-	-
CEE 345, Geotechnical Engineering	4	-	-	-	-	4	-	-	-
CEE 402, Professional Issues & Design	4	-	-	-	-	-	-	-	4
<b>Science Elective (3 hours) +</b>									
Biology 171, 172, or 174									
Earth & Environmental Sciences 119, 201, 222, 284, or 320	3	-	-	-	-	-	-	3	-
CEE 482/582, Environmental Microbiology									
<b>Program Electives (16 hours)<sup>4</sup> +</b>									
CEE 312, Structural Engineering									
CEE 351, Civil Engineering Materials									
CEE 365, Environmental Engineering Principles	16	-	-	-	-	4	8	4	-
CEE 421, Hydrology and Hydraulics									
CEE 431, Construction Contracting									
<b>Technical Electives (9 hours)<sup>5</sup> +</b>									
Construction: CEE 534, CEE 536, CEE 537									
Structural: CEE 413*, CEE 415*, CEE 412									
Materials: CEE 547*, CEE 574*									
Geotechnical: CEE 540, CEE 545, CEE 546, CEE 549									
Hydraulics/Hydrology: CEE 526*, CEE 428, CEE 521, CEE 522	9	-	-	-	-	-	-	6	3
Environmental: CEE 465*, CEE 480, CEE 481/581, CEE 482/582									
Transportation: CEE 470									
<b>General Electives (12 hours)</b>	12	-	-	-	-	-	4	4	4
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>15</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>15</b>

Candidates for the Bachelor of Science in Engineering in Civil Engineering - B.S.E. in C.E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

Fall Winter

(+) Civil Engineering students must earn a C- or better in all courses whose categories are marked with a plus.

\* Mandatory Course in that focus area.

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> CEE will accept equivalent courses offered by other departments in the College of Engineering. Please see program advisor.

<sup>4</sup> At least four of the five program electives are required.

<sup>5</sup> At least two of the three technical electives must be in the same focus area.

## B.S.E. in Environmental Engineering

The Environmental Engineering program is pending final accreditation approval in August 2015 by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://cee.engin.umich.edu/academics/undergrad-studies/advising>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 130 and 125/126 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth (includes Economics 101 or 102)	16	4	4	-	-	-	4	4	-
<b>Mathematical Methods (7 hours) +</b>									
CEE 270, Statistical Methods	3	-	-	-	-	3	-	-	-
CEE 303, Computational Methods	4	-	-	-	-	-	4	-	-
<b>Technical Core Subjects (32 hours)<sup>3</sup> +</b>									
Chemistry 210, Organic Chemistry	4	-	-	-	4	-	-	-	-
CEE 200, Intro to Civil & Environmental Engineering	1	-	-	-	1	-	-	-	-
CEE 211, Statics and Dynamics	4	-	-	4	-	-	-	-	-
CEE 230, Thermodynamics and the Environment	3	-	-	3	-	-	-	-	-
CEE 265, Sustainable Engineering Principles	3	-	-	-	3	-	-	-	-
CEE 325, Fluid Mechanics	4	-	-	-	4	-	-	-	-
CEE 365, Environmental Engineering Principles	4	-	-	-	-	4	-	-	-
CEE 366, Environmental Engineering Laboratory	2	-	-	-	-	-	2	-	-
CEE 421, Hydrology and Floodplain Hydraulics	4	-	-	-	-	-	-	4	-
CEE 465, Environmental Process Engineering	3	-	-	-	-	-	3	-	-
<b>Environmental Sciences (9 hours) +</b>									
Earth Science Elective: AOSS 320, 410, or 475; EARTH 305, 315, 321, 323, 427, 442, or 477	3	-	-	-	-	3	-	-	-
CEE 481/581, Aquatic Chemistry	3	-	-	-	-	-	3	-	-
CEE 482/582, Environmental Microbiology	3	-	-	-	-	-	-	3	-
<b>Environmental Engineering Design (4 hours) +</b>									
CEE 402, Professional Issues and Design	4	-	-	-	-	-	-	-	4
<b>Technical Electives (9 hours)<sup>4</sup> +</b>									
<i>Water Quality and Health:</i> CEE 428*, CEE 480*, CHE 342, EHS 500	9	-	-	-	-	-	-	3	6
<i>Atmospheric and Earth Systems:</i> CEE 549, CEE 563, AOSS 463, AOSS 467, EARTH 513									
<i>Environmental Fluid Dynamics:</i> CEE 428*, CEE 521, CEE 522, CEE 526*									
<i>Energy and Sustainable Infrastructure:</i> CEE 567, UP 423, EARTH 344									
<i>Environmental Policy and Entrepreneurship:</i> ENGR 520, NRE 475, AOSS 480									
<b>General Electives (12 hours)</b>	12	-	-	-	-	4	-	2	6
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>14</b>	<b>16</b>	<b>16</b>	<b>16</b>

Candidates for the Bachelor of Science in Engineering in Environmental Engineering - B.S.E. in Env.E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

Fall Winter

(+) Environmental Engineering students must earn a C- or better in all courses whose categories are marked with a plus.

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for CoE.

<sup>3</sup> CEE will accept equivalent courses offered by other departments in the College of Engineering. Please see program advisor.

<sup>4</sup> At least two of the three technical electives must be CEE courses, including one design course: CEE 428, 480, or 526 (Denoted with \*).

## Program in Sustainable Engineering

Sustainable engineering is achieved by finding economically viable technology solutions that reduce important environmental and societal concerns. Sustainable Engineering includes finding market and policy pathways to implement technologies that allow people and the planet to prosper and thrive.

The Program in Sustainable Engineering is an academic program that allows undergraduate engineering students to take 9 credit hours of courses focused on sustainability to earn the following notation on their transcript: "Program in Sustainable Engineering". In-person advising available in 2334 G.G. Brown (Matt Blank, CEE Department). Course requirements and additional information can be found on the PISE website, <http://pise.engin.umich.edu>.

## Sequential Undergraduate/Graduate Study (SUGS)

SUGS is a program of the Rackham Graduate School which enables students to pursue a five-year combined B.S.E./M.S.E. Civil and Environmental Engineering undergraduate students who have a cumulative GPA of at least 3.5 may apply. Students earning dual bachelor's degrees are not eligible for SUGS. Please contact the department or see the website for more information visit <http://cee.engin.umich.edu/sequentialapplicants>.

The following degree combinations are available through SUGS:

- B.S.E in Civil Engineering / M.S.E. in Civil Engineering
- B.S.E. in Civil Engineering / M.S.E. in Construction Engineering and Management
- B.S.E. in Civil Engineering / M.Eng. in Construction Engineering and Management
- B.S.E. in Civil Engineering / M.S.E. in Environmental Engineering
- B.S.E. in Environmental Engineering / M.S.E. in Environmental Engineering

## Graduate

### Civil and Environmental Engineering Graduate Programs

Graduate programs of advanced study, research and design are available in the five major areas listed below. The strength of the curriculum is enhanced by a variety of complementary programs of study and research available throughout the University of Michigan.

#### Construction Engineering and Management

- Construction Organization
- Construction Project
- Construction Operations

#### Environmental and Water Resources Engineering

Graduate degrees offered in either Civil or Environmental Engineering.

- Ecohydrology and Hydraulic Engineering
- Environmental Microbiology and Biotechnology
- Environmental Chemistry and Soil Physics
- Energy and Clean Tech

#### Geotechnical Engineering

- Site Characterization
- Foundation Design
- Stability of Earth Masses
- Soil Improvement
- Soil and Foundation Dynamics
- Geotechnical Earthquake Engineering
- Engineering Geology
- Rock Mechanics
- Soil Behavior
- Numerical and Analytical Modeling



## Structural and Materials Engineering

- Earthquake Resistant Design
- Behavior of Buildings and Bridges under Extreme Loading
- Design and Validation of Smart Structure Technologies
- Evaluation and Improvement of New and Existing Highway Bridges
- Design and Development of High Performance Mechanistic Evaluation of Properties of Concrete Pavement

## Infrastructure Systems

- Dynamical Modeling of Complex Infrastructure Systems
- Cyber-Physical Infrastructure Systems
- Resilience Through Adaptation
- Ultra-low Power Sensing and State Estimation for Civil Infrastructure Systems
- Advanced Functional Materials for Intelligent Infrastructure Systems
- Integrated Structure and Materials Design for Infrastructure Resiliency and Sustainability
- Intelligent Water Grids
- Energy Harvesting

## Graduate Degrees

- Master of Science in Engineering (M.S.E.) in Civil Engineering
- Master of Science in Engineering (M.S.E.) in Construction Engineering and Management
- Dual M.S.E. in Construction Engineering and Management/Master of Architecture
- Dual M.S.E. in Construction Engineering and Management/Master of Business Administration
- Master of Engineering (M.Eng.) in Construction Engineering and Management
- Master of Engineering (M.Eng.) in Structural Engineering
- Dual M.Eng. in Construction Engineering and Management/Master of Architecture
- Dual M.Eng. in Construction Engineering and Management/Master of Business Administration

- Master of Science in Engineering (M.S.E.) in Environmental Engineering
- Dual M.S.E. in Environmental Engineering/M.S. in Natural Resources and Environment
- Doctor of Philosophy (Ph.D.) in Civil Engineering
- Doctor of Philosophy (Ph.D.) in Environmental Engineering

## Master of Science Programs / Master of Engineering Programs

The Department of Civil and Environmental Engineering (CEE) offers three Master of Science in Engineering (M.S.E.) degree programs and two Master of Engineering (M.Eng.) degree programs, as well as multiple options for dual degrees in collaboration with other programs at the university. The M.S.E. and M.Eng. programs require 30 credit hours of graduate work (typically 10 courses) and do not require a thesis or other major research project. At least two courses, of which one is mathematically oriented, must be taken in departments other than CEE.

The Graduate Record Examination (GRE) is required for application to the M.S.E. program. Letters of recommendation are also required. Degree programs differ in the undergraduate degrees they require for regular admission.

Students who do not meet undergraduate degree requirements for regular admission may be granted conditional admission. Students may be required to take courses without graduate credit to remedy the deficiencies in their undergraduate programs.

## M.S.E. in Civil Engineering

This program requires at least 15 hours of CEE courses. A student should expect to take at least eight hours in the area of specialization but will not be permitted to apply more than 21 hours in one area of specialization toward the M.S.E. degree. Study programs are available in the following areas of specialization:

- Construction Engineering and Management
- Geotechnical Engineering
- Hydraulic and Hydrologic Engineering

- Infrastructure Systems
- Materials and Highway Engineering
- Structural Engineering

Regular admission is open to students holding an undergraduate degree in Civil Engineering or an equivalent.

### **M.S.E. in Construction Engineering and Management**

This program requires at least 18 hours of graduate courses in the Construction Engineering and Management Program. Regular admission is open to students holding a degree in any engineering discipline.

### **Dual M.S.E. in Construction Engineering and Management / Master of Architecture**

Dual M.S.E degree programs combine a 30-hour M.S.E. (CE&M) program with another 30-hour Master's program resulting in a 51-hour program, 9 hours of which satisfy requirements for both programs. Usually these 9 hours are core courses from the other Master's program, used as electives in the Construction Engineering and Management program. An applicant who has recently received or is working toward a Master's degree in another area of engineering at Michigan can complete the M.S.E. (CE&M) with an additional 21 hours of coursework.

### **Dual M.S.E. in Construction Engineering and Management / Master of Business Administration**

The dual degree program requires the 12 hours of core courses and 9 hours of graduate construction electives in the M.S.E. (CE&M) program and the 30 hours of core courses and 15 hours of electives in the MBA program. Students also take a 3-hour independent study course (CEE 630) to integrate general Construction Engineering and Management skills. Students also take Construction Contracting (CEE 431) if they have not taken it or its equivalent previously. The dual degree program combines the two-year, 60-hour MBA program with the one-year, 30-hour M.S.E. (CE&M) pro-

gram, resulting in a two-year (including Spring and/or Summer terms) 66- or 69-hour program. The dual degree program can be completed in two years if the first year is devoted to core MBA courses.

### **M.Eng. in Construction Engineering and Management**

This program requires at least 18 hours of graduate courses in the Construction Engineering and Management Program. Regular admission is open to students holding a degree in any engineering discipline. Applicants with bachelor's degrees in architecture or other non-engineering programs may be granted admission if they have taken a year of calculus and a year of physics.

### **Dual M.Eng in Construction Engineering and Management / Master of Architecture**

The dual degree program combines the two-year 60-hour M.Arch. program with the one-year, 30-hour M.Eng. (CE&M) program, resulting in a two and one-half year, 75-hour program.

### **Dual M.Eng in Construction Engineering and Management / Master of Business Administration**

The dual degree program requires the 12 hours of core courses and 9 hours of graduate construction electives in the MEng (CE&M) program and the 30 hours of core courses and 15 hours of electives in the MBA program. Students also take a 3-hour independent study course (CEE 630) to integrate general Construction Engineering and Management skills. Students also take Construction Contracting (CEE 431) if they have not taken it or its equivalent previously. The dual degree program combines the two-year, 60-hour MBA program with the one-year, 30-hour M.Eng. (CE&M) program, resulting in a two-year (including Spring and/or Summer terms) 66- or 69-hour program. The dual degree program can be completed in two years if the first year is devoted to core MBA courses.

## **M.Eng. in Structural Engineering**

A minimum of 30 credit hours is required to complete the M.Eng. in Structural Engineering degree. Students will elect a broad array of structural engineering courses. Features of the program include the requirement to have a minor area of professional emphasis either within or outside the CEE Department, and the requirement for a structural engineering project based on professional practice in structural engineering.

## **M.S.E. in Environmental Engineering**

This program requires at least 18 hours of graduate courses in the Environmental and Water Resources Engineering Program. Specific course requirements are given in the departmental Guidelines for this M.S.E. degree. Students holding an engineering or science degree will be considered for regular admission.

## **Dual M.S.E. in Environmental Engineering / M.S. in Natural Resources and Environment: "Engineering Sustainable Systems: Specialization in Sustainable Water Resources or Energy Systems"**

This dual degree program combines a Master of Science in Engineering (M.S.E.) in Civil Engineering or in Environmental Engineering, and a Master of Science (M.S.) degree in Natural Resources and Environment. More detailed information is available in the program guidelines.

## **Environmental Sustainability Concentration**

The Department of Civil and Environmental Engineering participates actively in the College of Engineering Concentrations in Environmental Sustainability (ConsEnSus) Program for M.S., M.S.E. and Ph.D. students. The general description of the ConsEnSus program can be found [here](#). Students interested in further details on implementation of this program in the Department of Civil and Environmental Engineering should contact one of the Department ConsEnSus Advisors.

## **Ph.D. Programs**

The Department of Civil and Environmental Engineering (CEE) offers the Doctor of Philosophy (Ph.D.) with two designations: Civil Engineering and Environmental Engineering. Ph.D. programs usually include 50 to 60 hours of graduate coursework beyond the bachelor's degree level. Foreign languages are not required. The focus of doctoral studies is the student's dissertation research, which must make a significant contribution to professional knowledge in the field. Major steps toward the Ph.D. degree include:

- qualifying examination (usually taken after completion of one or two terms of coursework beyond the master's degree)
- appointment of dissertation committee
- completion of coursework and English proficiency requirement
- preliminary examination
- advancement to candidacy
- completion of dissertation
- final oral examination

Admission to the Ph.D. program is granted only to students who show promise and provide sufficient evidence that they can meet scholastic requirements of study, including independent research, at an advanced level. The qualifying examination is only open to students with a GPA of better than B+.

## **Ph.D. in Civil Engineering**

Areas of specialization include:

- Construction Engineering and Management
- Geotechnical Engineering
- Hydraulic and Hydrologic Engineering
- Infrastructure Systems
- Materials and Highway Engineering
- Structural Engineering

**Ph.D. in Environmental Engineering**

Areas of specialization include:

- Environmental Chemistry and Microbiology
- Hazardous Substance Treatment and Control
- Hydraulics and Fluid Mechanics
- Management Policy and Economics
- Surface and Groundwater Hydrology
- Watershed Hydrology and Ecohydrology
- Water Quality Engineering
- Geostatistical Modeling and Optimization
- Atmospheric Modeling

# Climate and Space Sciences and Engineering

## Overview

Climate & Space interests bridge both engineering and science and prepare students to answer a growing demand for expertise in atmospheric, climate and space science. Climate & Space programs focus on the description of atmospheric characteristics and phenomena on the Earth and other planets and the interrelationships between the Earth and the Sun. Because of the integrated nature of the program, Climate & Space students have an extensive background in atmospheric and space science, weather and climate, and the engineering of complex and highly reliable space systems and instrumentation.

Climate & Space students are prepared for positions in space engineering, climate, meteorology, and space science research and teaching, environmental assessment, resource management, risk management, or in one of the growing number of fields interested in climate change. Climate & Space has actively participated in the Nation's space program since its inception. For more than 60 years, Climate and Space Sciences and Engineering faculty members have been at the forefront of many engineering and theoretical breakthroughs. In 1946, a probe was deployed on a V-2 rocket to measure electrons in the upper atmosphere. In 1956, Climate & Space researchers were studying atmospheric pollution by aeroallergens, penetration of particulates into buildings, dynamic wind loading of structures, and industrial air pollution. Climate & Space was involved with NASA's Pioneer Venus and Dynamic Explorer Program from its inception in the early 1970s to its completion in the 1990s. Today, Climate & Space researchers are involved in many space missions exploring Mercury, Earth, Mars, Jupiter, and Saturn as well as new initiatives in climate change.

Climate & Space offers high quality academic programs that combine extensive hands-on experience at all levels with a strong emphasis on the theoretical and applied aspects of a student's area of concentration.

Atmospheric scientists are focused on the weather and climate of the Earth, with topics ranging from fundamental research of basic processes to preparing for adaptation to climate change. The focus of planetary/space scientists includes the effects of space weather on Earth, planetary atmospheres and environments, and the construction of satellite-platform instruments for observation of the Earth-atmosphere-ocean system.

## Department Administration

### Department Chair

James A. Slavin, Ph.D.

1517 Space Research Laboratory

### Contacts

Climate and Space Sciences and Engineering

*(Note: Department name change is effective 9/1/15)*

Space Research Building

2455 Hayward St.

Ann Arbor, MI 48109-2143

E-mail: [clasp-um@umich.edu](mailto:clasp-um@umich.edu)

Phone: (734) 764-3282

Fax: (734) 763-0437

Website: <http://aoss.engin.umich.edu>

Effective 9/1/15, <http://clasp.engin.umich.edu>

## Undergraduate

### Undergraduate Degree Programs

The department of Climate and Space Sciences and Engineering offers two degree programs in Climate and Meteorology (CM) and Space Science and Engineering (SSE). CM students begin to understand the interactions among all of the Earth system components while gaining in-depth knowledge in one of two concentrations: Meteorology or Climate Science and Impact Engineering. SSE students begin to understand the space environments of the Sun and planets (especially Earth) as they develop a deep understanding of the fundamental physical processes of energy transfer throughout the solar system.

The B.S.E. degrees in Climate & Space prepares graduates for employment in the National Weather Service, private weather forecasting companies, air- and water-quality management firms, NASA and the growing number of fields interested in climate change. As importantly, Climate & Space students who complete either of the two degree programs will be exceptionally well prepared for graduate studies in atmospheric science, environmental sciences, space science or space engineering.

Graduates of the Space Sciences and Engineering degree program are prepared to pursue graduate degrees in the space sciences or join the space industry, which is facing a severe workforce shortage. They can also join government agencies and federal laboratories that deal with space related disciplines.

In addition to the College of Engineering core courses, all Climate & Space undergraduate students take five Climate & Space core courses that introduce the various aspects of atmospheric, oceanic and space sciences, emphasizing the common elements of, and the interactions between, the various disciplines and the scientific basis of the phenomena that are observed. Additional courses are specific to the degree and concentration. Students have a number of technical and general electives they may also take to complete 128 credit hours. The electives must be at the 300 level or above. Completion of a concentration will be noted on the student's transcript. For the most current information, visit **<http://clasp.engin.umich.edu>**.

## Sample Schedule

### B.S.E. in Climate and Meteorology

Not an ABET accredited program. Additional information can be found on the department advising website:

Current: <http://aoss.engin.umich.edu/pages/undergraduate>

Effective 9/1/15: <http://clasp.engin.umich.edu/pages/undergraduate>

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	4	-	-	-	-
<b>Required Core Subjects (38 hours)</b>									
CLIMATE 320, Earth and Space System Evolution	3	-	-	3	-	-	-	-	-
CLIMATE 321, Earth and Space System Dynamics	3	-	-	-	3	-	-	-	-
CLIMATE 323, Earth System Analysis	4	-	-	-	4	-	-	-	-
CLIMATE 350, Atmospheric Thermodynamics	3	-	-	-	-	-	3	-	-
CLIMATE 380, Introduction to Radiative Transfer	3	-	-	-	-	3	-	-	-
CLIMATE 401, Geophysical Fluid Dynamics	3	-	-	-	-	3	-	-	-
CLIMATE 410, Earth System Modeling	4	-	-	-	-	-	-	4	-
CLIMATE 414, Weather Systems	3	-	-	-	-	-	3	-	-
CLIMATE 462, Instrumentation for Atoms & Space Sciences	4	-	-	-	-	-	4	-	-
CLIMATE 405, Data Analysis and Visualization <sup>3</sup>	4	-	-	-	-	-	4	-	-
CLIMATE 455, Capstone Design <sup>4</sup>	4	-	-	-	-	-	-	-	4
<b>Concentrations: (select one)</b>									
<b>Meteorology (35 hours total)</b>									
CLIMATE 411, Cloud and Precipitation Process	3	-	-	-	-	-	-	-	3
CLIMATE 405, Remote Sensing <sup>5</sup>	3	-	-	-	-	-	-	-	3
CLIMATE 422, Boundary Layer Meteorology	4	-	-	-	-	4	-	-	-
CLIMATE 440, Meteorological Analysis Laboratory	4	-	-	-	-	-	-	4	-
<b>Technical Electives</b>	12	-	-	-	-	4	-	4	4
<b>General Electives</b>	9	-	-	-	-	3	3	3	-
<b>Total</b>	128	17	17	16	15	17	17	15	14
<b>Climate Sciences and Impacts Engineering (35 hours total)<sup>6</sup></b>									
CLIMATE 473, Climate Physics	3	-	-	-	-	-	-	-	3
Statistics/GIS Elective	3	-	-	-	-	3	-	-	-
Climate/Climate Change Elective <sup>6</sup>	3	-	-	-	-	-	-	-	3
Energy/Sustainability Elective <sup>6</sup>	3	-	-	-	-	-	-	3	-
Interactions Elective <sup>6</sup>	4	-	-	-	-	-	-	-	4
<b>Technical Electives</b>	10	-	-	-	-	3	-	4	3
<b>General Electives</b>	9	-	-	-	-	3	3	3	-
<b>Total</b>	128	17	17	16	15	15	17	14	17

Candidates for the Bachelor of Science in Engineering in Climate and Meteorology must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> New Course

<sup>4</sup> New Course. Students may take year-long (2 hours each term) CLIMATE 499 Directed Study as a Senior Thesis option.

<sup>5</sup> New Course. Student may elect to take NRE 541 Remote Sensing (4 hours).

<sup>6</sup> See department undergraduate program office for list of approved courses.

---

## Concentrations

### Climate Science and Impact Engineering Concentration

The aim of the Climate Science and Impact Engineering concentration is to provide a flexible program for those interested in pursuing further graduate education or careers in industry. The Climate Science and Impact Engineering concentration prepares you for graduate studies, climate modeling, and a position in "value added" industries that provide water resource, agricultural, seasonal recreation, and transportation industries with near-term climate analyses and predictions. Positions in government agencies serving to make policy or federal laboratories conducting climate research also are open to you. The program also provides students who are interested in both climate science and in a second area of expertise, such as the traditional engineering disciplines, policy, or law course options. There is a need for scientists and engineers who can carry out evaluation and engineering activities that require expertise both in climate science and in the engineering disciplines. These include issues related to air quality, energy engineering, sustainability, and water resources.

### Meteorology Concentration

Graduates with a concentration in Meteorology are prepared for careers in weather forecasting, corporations that are increasingly the source of weather analyses and predictions modeling, and for graduate studies in meteorology and the technologies that enable weather and climate prediction.

Students electing this concentration are encouraged to complete an internship in a weather forecasting office.



## Sample Schedule

### B.S.E. in Space Sciences and Engineering

Not an ABET accredited program. Additional information can be found on the department advising website:

Current: <http://aoss.engin.umich.edu/pages/undergraduate>

Effective 9/1/15: <http://clasp.engin.umich.edu/pages/undergraduate>

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	4	-	-	-	-
<b>Required Core Subjects (53 hours)</b>									
SPACE 320, Earth and Space System Evolution	3	-	-	3	-	-	-	-	-
SPACE 321, Earth and Space System Dynamics	3	-	-	-	3	-	-	-	-
SPACE 323, Earth System Analysis	4	-	-	-	4	-	-	-	-
PHYSICS 340, Waves, Heat and Light	3	-	-	-	-	3	-	-	-
PHYSICS 341, Waves, Heat and Light Lab	1	-	-	-	-	1	-	-	-
SPACE 370, Solar-Terrestrial Relations	4	-	-	-	-	4	-	-	-
SPACE 380, Introduction to Radiative Transfer	3	-	-	-	-	3	-	-	-
PHYSICS 405, Intermediate Electricity and Magnetism	3	-	-	-	-	-	3	-	-
PHYSICS 390, Modern Physics	3	-	-	-	-	-	3	-	-
SPACE 462, Instrumentation for Atoms & Space Sciences	4	-	-	-	-	-	4	-	-
NERS 471, Introduction to Plasmas	3	-	-	-	-	-	-	3	-
SPACE 405, Space Environment	3	-	-	-	-	-	-	3	-
SPACE 405, Data Analysis and Visualization <sup>3</sup>	4	-	-	-	-	-	-	-	4
SPACE 477, Space Weather Modeling	4	-	-	-	-	-	-	-	4
SPACE 495/595/598 <sup>4</sup>	4	-	-	-	-	-	-	-	4
SPACE 499 <sup>5</sup>	4	-	-	-	-	-	-	2	2
<b>Technical Electives (10 hours)</b>	<b>10</b>	-	-	-	-	-	3	4	3
<b>General Electives (10 Hours)</b>	<b>10</b>	-	-	-	-	3	4	3	-
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>15</b>	<b>14</b>	<b>17</b>	<b>15</b>	<b>17</b>

Candidates for the Bachelor of Science in Engineering in Space Sciences and Engineering must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

- <sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.
- <sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.
- <sup>3</sup> New Course.
- <sup>4</sup> Students should take one of these courses (each offered every other year).
- <sup>5</sup> New Course. Student may take either year-long (2 hours each term) SPACE 499, Directed Study as a Senior Thesis option, or SPACE 455 Senior Capstone Design.

## Climate and Space Sciences and Engineering Minor

The primary goal of the Climate and Space Sciences and Engineering (Climate & Space) Minor is to provide exposure to research opportunities in atmospheric, climate and space science and engineering for those students who wish to work in the geoscience or space industry but are not majoring in Climate and Space Sciences and Engineering. The secondary goal is to increase awareness of the Climate and Space Sciences and Engineering and the educational and research opportunities within Climate & Space within the College of Engineering as a whole. This program is for undergraduate students in the College of Engineering.

Students must have:

- Registered no later than the last day to add courses for the semester in which they complete the last courses for the minor,
- Submitted his or her program of study for the minor to the Climate & Space undergraduate advisor.
- Attained a minimum GPA of 2.0 in the designated courses
- Completed the Climate & Space Minor as part of a degree program

### Requirements

#### A. Prerequisite coursework:

Math (8 Credits)

MATH 115 ,and

MATH 116;

Physics: (10 Credits)

PHYSICS 140, 141, and

PHYSICS 240, 241;

#### B. Required Coursework (9 credits)

One course from SPACE 101 (Introduction to Rocket Science – 3 credits),

CLIMATE 102 (Extreme Weather – 3

credits), SPACE 103 (Introduction to

Space Weather – 3 credits) or CLI

MATE 105 (Our Changing Climate – 3 credits)

CLIMATE 320/SPACE 320 (Earth and Space

System Evolution, 3 credits)

CLIMATE 321/SPACE 321 (Earth and Space System Dynamics, 3 credits)

#### C. Core Focus Courses (minimum 6 credits)

At least two courses from one of the following tracks:

- Meteorology
- Climate Science and Impacts Engineering
- Space Sciences
- Space Engineering

For additional information go to:

<http://aoss.engin.umich.edu>

Effective 9/1/15, <http://clasp.engin.umich.edu>

## Sequential Undergraduate/Graduate Study (SUGS)

In our increasingly technical world, master's degrees are becoming the minimum accepted level of education in the industry. Climate & Space SUGS programs are designed to provide a comprehensive knowledge of atmospheric/space sciences or space engineering and to increase your depth of knowledge beyond the baccalaureate degree level. The SUGS program offers breadth, depth and hands-on experience in both areas of concentration. Students interested in completing their undergraduate and master's level education in five years may select either the SUGS in Atmospheric Science or in Space Engineering.

Each degree (B.S.E. and M.S. or M.Eng.) is awarded upon completion of the requirements. Students will typically enter the SUGS program by provisional enrollment in the junior year. Once SUGS students are within six credit hours of completing the required undergraduate degree, they must officially enroll in the Climate & Space M.S. program for a minimum of two full terms, normally the last two semesters, and pay full graduate tuition for these two terms. Students are allowed to "double count" a certain number of credit hours for the two degrees.

## SUGS in Applied Climate

The Climate & Space M.Eng. in Applied Climate, effectively a subset of the broad discipline of environmental engineering, is a professional degree designed for students whose interests lie in applying a basic understanding of climate science to engineered solutions requiring: adaptation to intensities and frequencies of extremes of weather associated with regional climate change, and mitigation of regional and global climate change through actions such as altered emission of short- and long-lived radiatively active gases and aerosols.

## SUGS in Atmospheric/Space Science

The program is designed to provide a comprehensive knowledge of atmospheric or space science and the various components of each system. Students enjoy extensive computational facilities as well as laboratories for measurement of the chemical and physical properties of the atmosphere and space weather. Climate & Space atmospheric scientists and students are solving problems related to short- and long-term forecasting, air quality, atmospheric turbulence and convection, biogeochemical cycling, and precipitation processes, among a growing list of areas. Space Science faculty and students are studying planetary, solar and cosmic weather used in determining the systemic relationships between a planet and its atmosphere.

## SUGS in Space Engineering

For students interested in studying the scientific, engineering and management aspects of space engineering, this program, developed with Aerospace Engineering and Electrical Engineering and Computer Science, allows them to structure the program to a specific area of interest. The program is designed to provide a comprehensive knowledge of space science and engineering and their interrelationship; to teach the systems approach to conceiving, designing, manufacturing, managing and operating complex space systems; and to provide practical experience in space system design, project development and management. Eight program concentrations are currently available: Space Science;

Propulsion; Plasma Electrodynamics and Sensors; Instrumentation and Sensor Payloads; Launch Vehicles; Telemetry and Spacecraft Communication; Astrodynamics; and Computer Control and Data Handling.

The most up-to-date information on the Climate & Space SUGS programs, including example concentration course schedules is available at: <http://clasp.engin.umich.edu/SGUS>. Or, for more information, contact one of the SUGS Advisors at: [http://clasp.engin.umich.edu/sgus\\_advisors](http://clasp.engin.umich.edu/sgus_advisors) or Sandra Pytlinksi at [clasp.um@umich.edu](mailto:clasp.um@umich.edu).

## Graduate

### Graduate Degrees

- Master of Engineering (M.Eng.) in Applied Climate
- Master of Engineering (M.Eng.) in Space Engineering
- Master of Science (M.S.) in Atmospheric, Oceanic and Space Sciences
- Doctor of Philosophy (Ph.D.) in Atmospheric, Oceanic and Space Sciences
- Doctor of Philosophy (Ph.D.) Joint Program in Space and Planetary Physics

### M.S. in Atmospheric, Oceanic and Space Sciences

Applicants to the master's program may have a bachelor's degree in any field of study, but they are expected to have completed minimum requirements in mathematics, physics and chemistry. Normally this would include five semesters of mathematics; eight credit hours of physics including two laboratories; and five credit hours of chemistry. Thirty semester hours are required for the master's degree, fifteen of which must be from the Department's offerings. A minimum of four additional hours must be in mathematics and/or natural science. A student will select a research topic if required in conjunction with an appropriate faculty member, who will guide the student in the preparation of both the research and the thesis or research essay. Satisfactory completion of the thesis or research essay will normally count for six credit hours of the total thirty hours required for the Master of Science degree.

## **Ph.D. in Atmospheric, Oceanic, and Space Sciences, Ph.D. Joint Program in Space and Planetary Physics**

Applicants for a doctorate are expected to have the ability and scholarship of a high order in one of the following areas: atmospheric science, space and planetary physics, or geoscience and remote sensing. Doctoral students are expected to carry a course load of nine to twelve semester hours (three to four courses) each semester until the dissertation work is begun. There are no foreign language requirements. During the first year, students must select courses from among the core courses for their particular program. After the second year, students must pass a qualifying examination before they can be advanced to candidacy. After reaching candidate status, students will concentrate on a dissertation topic under the guidance of an advisor.

### **Ph.D. in Atmospheric, Oceanic and Space Sciences**

This program gives students the basic courses to allow them to specialize later in a broad range of sub-disciplines. Students are expected to learn the basic morphology of the atmosphere and the space environment, as well as the necessary physics, chemistry, and mathematics.

Offered as an option, is a concentration in Geoscience and Remote Sensing, which explores the science and engineering behind remote measurements from space of the structure, composition and dynamics of Earth and planetary atmospheres and their underlying surface.

### **Ph.D. Joint Program in Space and Planetary Physics**

This graduate program is a joint program with the Physics Department, and requires taking additional classes in Physics. Its emphasis is on the physics of the heliosphere, planetary magnetospheres, ionospheres and upper atmospheres (including those of the Earth). Unlike the standard A.O.S.S. Ph.D. program, the Space and Planetary Physics Joint Program includes a heavy emphasis on the underlying fundamental physical prin-

ciples. Enrollment in the program must be by approval of either the A.O.S.S. or Physics graduate advisor. The most up-to-date information on the A.O.S.S. graduate programs is available online at <http://aoss.engin.umich.edu/grad/>.

### **M.Eng. in Applied Climate**

The A.O.S.S. M.Eng. Program in Applied Climate combines theoretical and applied aspects of weather and climate with a significant design or monitoring project. This design ensures that students graduate with skills necessary for success as practicing engineers. The Program offers an interdisciplinary education at the nexus of Earth system science and engineering, with opportunities for breadth through courses in such areas as public policy, public health, or business. Students are allowed to structure their coursework to meet the needs of their individual areas of interest. Specific concentrations are suggested to assist students and their advisors with course planning.

Students will learn:

- Current tenets of climate science and practices useful for their continuing education in this evolving science;
- An engineering approach to managing the complexity of the Earth's climate-related environment, its systems components, and a number of closely coupled internal sub-systems including those involving human society;
- A set of tools and skills useful in practical engineering problem solving in team environments; and
- Technologies of climate adaptation and associated mitigation strategies that minimize risks to commercial and government operations, and to their physical assets.

### **Areas of Study**

Course concentrations will be defined through discussions between students and their program advisors to match the student's career aspirations.

- Climatological and meteorological observing systems
- Emission inventory modeling principles, methods and

- practices
- Data analysis, Geographical Information Systems (GIS) and processing tools
- Climate and Weather modeling
- The intersection of climate and water resources
- Integrated Assessment

- Launch Vehicles Program
- Telemetry and Spacecraft Communications Program
- Astrodynamics Program
- Computer Control and Data Handling Program

## **M.Eng. in Space Engineering**

The A.O.S.S. M.Eng. program in Space Engineering combines strong emphasis on both theoretical and applied aspects with extensive hands-on experience at all levels. The program is designed to develop students into a new type of interdisciplinary engineer prepared for future managerial and systems engineering roles in space related industries and government agencies.

If you are interested in studying the scientific, engineering and management aspects of space engineering, this program, developed with the Aerospace Engineering and Electrical Engineering and Computer Science Departments, allows you to structure the program to your specific area of interest.

### **Program Objectives**

- To provide a comprehensive knowledge of space science and engineering and their interrelationship.
- To increase depth beyond the baccalaureate level in a space-related discipline.
- To teach the systems approach to conceiving, designing, manufacturing, managing, and operating complex space systems.
- To provide practical experience in space system design, project development and management.

### **Program Concentrations**

While your specific concentration curriculum will be decided through discussions with your program advisors, suggested programs have been developed in the following areas:

- Space Science Program
- Propulsion Program
- Plasma Electrodynamics and Sensors Program
- Instrumentation and Sensor Payloads Program

# Computer Engineering, Electrical Engineering and Computer Science

## Overview

The expanding roles of electrical engineers, computer engineers, and computer scientists in today's society reflect the variety and scope of these exciting professions. In recognition of the distinct qualifications required of engineers and scientists entering these fields, the Electrical Engineering and Computer Science Department offers undergraduate programs in the following four areas: an electrical engineering program leading to a Bachelor of Science in Engineering in Electrical Engineering - B.S.E. in E.E.; a computer engineering program leading to a Bachelor of Science in Engineering in Computer Engineering - B.S.E. in C.E.; a computer science program leading to a Bachelor of Science in Engineering in Computer Science - B.S.E. in C.S. offered through the College of Engineering; or a Bachelor of Arts or Bachelor of Science degree offered through the College of LS&A. (Please consult the LS&A Bulletin for information about completing a computer science degree through LS&A.)

Throughout each program, students work with modern laboratory equipment and computer systems, and they are exposed to the most recent analytical techniques and technological developments in their field. Students have many opportunities to associate with outstanding faculty, most of whom are actively engaged in research and/or professional consulting. Such interaction serves to acquaint students with the opportunities and rewards available to practicing electrical or computer engineers and scientists. Our students are encouraged to seek an advanced degree if further specialization and a higher degree of competence in a particular area is desired.

## Department Administration

### Department Chair, CSE Division

Marios Papaefthymiou, Ph.D.

3713 Bob & Betty Beyster Building

### Department Chair, ECE Division

Khalil Najafi, Arthur F Thurnau Professor and Schlumberger Professor

2402 Electrical Engineering & Computer Science Building

## Contacts

**Departmental Website:** <http://www.eecs.umich.edu/>

### Electrical Engineering & Computer Science Department

#### Computer Science & Engineering Division

2808 Beyster Building

2260 Hayward St.

Ann Arbor, MI 48109-2121

Phone: (734) 763-6563

#### Electrical & Computer Engineering Division

3310 EECS Building

1301 Beal Avenue

Ann Arbor, MI 48109-2122

Phone: (734) 764-2390

# Computer Engineering

## Mission

To provide a solid technical foundation that prepares students for a career that can adapt to rapidly changing technology in computer engineering.

## Goals

To educate students with a broad and in-depth knowledge of computing systems, and to develop leaders in this field.

## Objectives

- Graduates should be able to apply the technical skills necessary to design and implement low level computer systems and applications.
- Graduates should have the theoretical and practical skills needed for advanced graduate education.
- Graduates should be able to work effectively on teams, to communicate in written and oral form, to practice life-long learning, and to develop the professional responsibility needed for successful technical leadership positions.

## Outcomes

The outcome we desire is that our graduates demonstrate:

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design, implement, test, and evaluate a computer system, component, or algorithm to meet desired needs.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.

- The broad education necessary to understand the impact of computer engineering solutions in a global and societal context.
- A recognition of the need for an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- A knowledge of probability and statistics, including applications appropriate to computer engineering.
- A knowledge of mathematics through differential and integral calculus, basic sciences, and engineering sciences necessary to analyze and design complex systems containing hardware and software components, as appropriate to program objectives.
- A knowledge of discrete mathematics.

# Computer Science

## Mission

To provide each student with a solid foundation in the scientific, engineering, and societal aspects of computing that prepares the student for a career that can advance the creation and application of computing technologies for the benefit of society.

## Goals

To educate students with core knowledge of the software, hardware, and theory of computing; to give each student in-depth knowledge in one or more computing areas; and to develop leaders in this field.

## Objectives

- To provide the necessary foundation in the principles and methods of computer science while preparing students for a broad range of responsible technical positions in industry and/or advanced graduate education.
- To provide the technical skills necessary to design and implement computer systems and applications, to conduct open-ended problem solving, and apply critical thinking.

- To provide an opportunity to work effectively on teams, to communicate in written and oral form, and to develop an appreciation of ethics and social awareness needed to prepare graduates for successful careers and leadership positions.

## Outcomes

The outcome we desire is that our graduates demonstrate:

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design, implement, test, and evaluate a computer system, component, or algorithm to meet desired needs.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve computer science problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of computer science solutions in a global and societal context.
- A recognition of the need for an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern tools necessary for computer science practice.
- A knowledge of probability and statistics, including applications appropriate to computer science.
- A knowledge of mathematics, basic sciences, and engineering sciences necessary to analyze and design complex computing systems, as appropriate to program objectives.

## Electrical Engineering

### Mission

To provide an outstanding education for engineers in electrical engineering and to develop future leaders.

## Goals

To provide students with the education for a rewarding and successful career.

## Objectives

- Graduates should be prepared for entry-level engineering jobs, or for graduate school, based on their rigorous education in the fundamentals of electrical engineering, including laboratory and design work.
- Graduates should be able to pursue a variety of careers, based on a curriculum that allows for tradeoffs between a deep education in one area and a broad education in several areas.
- Graduates should be able to work effectively on teams, to communicate in written and oral form, to practice life-long learning, and to develop the professional responsibility needed for successful technical leadership positions.

## Outcomes

The outcome that we desire is that our graduates demonstrate:

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of electrical engineering solutions in a global and societal context.
- A recognition of the need for an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern



- engineering tools necessary for engineering practice.
- Knowledge of probability and statistics, including applications appropriate to electrical engineering.
  - Knowledge of mathematics through differential and integral calculus, basic sciences, and engineering sciences necessary to analyze and design complex devices and systems, containing hardware and software components, as appropriate to program objectives.
  - A knowledge of advanced mathematics, typically including differential equations, linear algebra, and complex variables.

## Undergraduate

### Degree Program

#### Computer Engineering

The program in Computer Engineering provides each student with a broad and well-integrated background in the concepts and methodologies that are needed for the analysis, design, and utilization of information processing systems. Although such systems are often popularly called "computers," they involve a far wider range of disciplines than merely computation, and the Computer Engineering Program is correspondingly broad. A set of required technical courses (along with the college-wide requirements) gives the essential material in circuits, digital logic, discrete mathematics, computer programming, data structures, signals and systems, and other topics. Following completion of this work, the student can select courses in a wide range of subject areas. These include operating systems, programming languages and compilers, computer architecture, microprocessor-based systems, computer aided design and VLSI, digital signal processing, and computer networking, among others. A broad selection from several areas is recommended for most undergraduate students. Specialization in particular areas is more typical of graduate programs of study.

#### Computer Science

Computer scientists are experts on the subject of com-

putation: both the theory of the fundamental capabilities and limitations of computation, and how computation can be practically realized and applied. A computer scientist understands how to design and analyze algorithms that apply computation effectively, how to store and retrieve information efficiently, how computers work to deliver computation, and how to develop software systems that solve complex problems. Specialists within computer science might have expertise in developing software applications, in designing computer hardware, in analyzing and developing algorithms, or in other emerging specializations..

The computer science (CS) program at the University of Michigan is available to students in both the Colleges of Engineering and of Literature, Science, and the Arts. The program requires students to have a solid foundation in computer software, hardware, and theory, but also gives a student ample opportunity to take advanced electives in areas of computer science such as databases, architecture, networks, artificial intelligence, and graphics, or in emerging interdisciplinary areas such as electronic commerce, web information systems, and computer game design.

#### Electrical Engineering

The Electrical Engineering program provides students with a fundamental background in the basic theoretical concepts and technological principles of modern electrical engineering. A flexible curriculum allows students to emphasize a wide variety of subject areas within the field, including: analog and digital circuits, communication systems, control systems, electromagnetics, integrated circuit (microprocessor) design, signal processing, microelectromechanical devices, solid state electronics, and optics and photonics.

As seen from the list of subject areas, a degree in electrical engineering can lead to a wide range of work opportunities. Automotive applications include engine control processors, sensors to trigger airbags or activate antilock brake systems, development of sophisticated audio systems, and the systems that power electric vehicles. Electrical engineers work in the wireless communications field, including mobile phone systems and global positioning systems. Electrical engineers also work in remote sensing to infer characteristics of a re-

gion of the earth from the air or from space to study the environment and climate change. They design, manufacture, test and market the microprocessor, analog and RF integrated circuits from which computers, digital movie and still cameras, the internet, communication systems, and many other modern conveniences are made. Electrical engineers develop signal processing algorithms and hardware for multimedia devices and develop control algorithms and electronics for mechanical systems such as automobiles, robotics, planes and spacecraft. They embed microprocessors in everything from entertainment gadgets to industrial plants. Electrical engineers develop optical fiber communication systems and laser technology for applications ranging from astrophysics to eye surgery. Electrical engineers use semiconductor fabrication technology to make high-efficiency solar cells, light emitting diodes for lighting, and miniature machines called microelectromechanical devices. The signal processing algorithms, optical devices, and miniature systems invented and developed by electrical engineers are providing breakthrough technologies in the biomedical world for health and wellness and the diagnosis and treatment of diseases. A common effort of electrical engineers is to make components smaller, faster, more energy efficient and less costly.

## Requirements

Candidates for the Bachelor of Science in Engineering in Computer Engineering - B.S.E. in C.E., the Bachelor of Science in Engineering degree in Computer Science - B.S.E. in C.S., and Bachelor of Science in Engineering in Electrical Engineering - B.S.E. in E.E. must complete the respective degree requirements. The following Sample Schedules are examples that lead to graduation in eight terms. Candidates for the Bachelor of Science or Bachelor of Arts degree in Computer Science through the College of Literature, Science, and the Arts should consult the LS&A Bulletin for degree requirements.

## C- Rule

Among science, engineering and mathematics courses, a grade of C- or below is considered unsatisfactory.

## Declaration Requirements

The EECS Department follows the College of Engineering rules for Program Selection (i.e., Declaration). For more information see the Academic Rules, Declaring (or Changing) Major section of the bulletin.

## Sample Schedules

### B.S.E. in Computer Engineering

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET,

<http://www.abet.org>. Additional information can be found on the department advising website,

<http://www.eecs.umich.edu/eecs/undergraduate/staff.html>.

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215 and 216	16	4	4	-	4	4	-	-	-
Engineering 100, Introduction to Engineering	4	-	4	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	4	-	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	-	4	-	4	-	-
<b>Program Subjects (32 hours)</b>									
EECS 203, Discrete Mathematics	4	-	-	4	-	-	-	-	-
EECS 215, Introduction to Circuits <sup>3</sup>	4	-	-	-	4	-	-	-	-
EECS 216, Introduction to Signals and Systems	4	-	-	-	-	4	-	-	-
EECS 270, Introduction to Logic Design	4	-	-	4	-	-	-	-	-
EECS 280, Programming and Elementary Data Structures	4	-	-	-	4	-	-	-	-
EECS 370, Introduction to Computer Organization	4	-	-	-	-	4	-	-	-
EECS 301, MATH 425, or STATS 412	3	-	-	-	-	-	3	-	-
TCHNCLCM 300 <sup>4</sup>	1	-	-	-	-	1	-	-	-
TCHNCLCM 496 and EECS 496 <sup>5</sup>	4	-	-	-	-	-	-	-	4
<b>Technical Electives (28 hours)<sup>6, 11</sup></b>									
Flexible Technical Electives <sup>7</sup>	7	-	-	-	-	-	-	5	2
EECS Elective <sup>8</sup>	3	-	-	-	-	-	-	3	-
Core Electives <sup>9</sup>	8	-	-	-	-	-	8	-	-
Upper Level CE Electives <sup>10</sup>	10	-	-	-	-	-	-	4	6
<b>General Electives (13-16 hours)</b>	13-16	-	-	3	-	3	-	4	3
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>15</b>	<b>16</b>	<b>15</b>

Candidates for the Bachelor of Science in Engineering in Computer Engineering - B.S.E. in Compt. E. must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

C- Rule: Among science, engineering and mathematics courses, a grade of C- or below is considered unsatisfactory.

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> EECS 215 must be preceded or accompanied by Physics 240.

<sup>4</sup> TCHNCLCM 300 can be taken independently of any EECS course, but it is a prerequisite for TCHNCLCM 496.

<sup>5</sup> TCHNCLCM 496 and EECS 496 must be elected concurrently with a Major Design Experience (MDE) course.

<sup>6</sup> Technical Electives: At least one of these classes must be an approved Major Design Experience Course. (See the EECS Undergraduate Advising Office for a current list.)

<sup>7</sup> Unused credits from Upper Level CE Electives or EECS Elective courses may be used to satisfy this requirement.

<sup>8</sup> Unused credits from Upper Level CE Elective courses may be used to satisfy this requirement.

<sup>9</sup> Core Electives: 8 hours from the following list: EECS 281, EECS 312, EECS 373, EECS 451.

<sup>10</sup> Upper Level CE Electives: At least 10 hours Contact the EECS Undergraduate Advising Office for the current list. Must include at least one Major Design Experience course taken concurrently with EECS 496 and TCHNCLCM 496.

<sup>11</sup> A maximum of 4 hours of EECS 499 may be applied to Technical Elective requirements and only in the area of Flexible Technical Electives. Anything beyond 4 hours will be applied toward General Electives.

## B.S.E. in Computer Science

The Computer Science program is accredited by the Computing Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <https://www.eecs.umich.edu/eecs/academics/academics.html>.

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, and 214 <sup>3</sup>	12	4	4	-	4	-	-	-	-
Mathematics 215 or 216 <sup>4</sup>	4	-	-	-	-	4	-	-	-
Engineering 100, Introduction to Engineering	4	-	4	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	4	-	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	-	4	4	-	-	-
<b>Program Subjects (24 hours)</b>									
EECS 203 Discrete Mathematics <sup>5</sup>	4	-	-	4	-	-	-	-	-
EECS 280, Programming and Elementary Data Structures	4	-	-	4	-	-	-	-	-
EECS 281, Data Structures and Algorithms	4	-	-	-	4	-	-	-	-
EECS 370, Introduction to Computer Architecture	4	-	-	-	-	4	-	-	-
STATS 250 or STATS 412 or STATS 426 or EECS 301/401 or IOE 265 <sup>6</sup>	3	-	-	-	-	-	3	-	-
EECS 376, Foundations of Computer Science	4	-	-	-	-	-	4	-	-
TCHNCLCM 300	1	-	-	-	-	-	1	-	-
<b>Major Design Experience (8 hours)</b>									
Approved CS MDE course <sup>7</sup>	4	-	-	-	-	-	-	4	-
EECS 496 Major Design Experience Professionalism	2	-	-	-	-	-	-	2	-
TCHNCLCM 497	2	-	-	-	-	-	-	2	-
<b>Technical Electives (26 hours)</b>									
Upper Level CS Technical Electives <sup>8</sup>	16	-	-	-	-	-	4	4	8
Flexible Technical Electives <sup>9,10</sup>	10	-	-	-	4	4	-	-	2
<b>General Electives (15 hours)</b>									
	15	-	-	3	-	-	4	4	4
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>14</b>

Candidates for the Bachelor of Science in Engineering in Computer Science - B.S.E. in C.S. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

C- Rule: Among science, engineering and mathematics courses, a grade of C- or below is considered unsatisfactory.

Credits from a course may only be used to fulfill a single requirement (no double counting).

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> The requirements for Math 214 can be satisfied by Math 217, 417, or 419.

<sup>4</sup> If both Math 215 and Math 216 are taken, Math 216 will be counted as a Flexible Technical Elective.

<sup>5</sup> Math 465 can be used to satisfy this requirement.

<sup>6</sup> Stats 250, EECS 301, and IOE 265 are 4 hour courses; if this is elected, the extra hour is counted toward General Electives.

<sup>7</sup> An approved Computer Science (CS) Major Design Experience (MDE) course; see the appropriate CS Program Guide for the current list. Must be taken in the same term as EECS 496 and TCHNCLCM 497. A 3-credit CS MDE course can be used if a total of 27 credits of Technical Electives are elected.

<sup>8</sup> Upper Level CS Technical Electives (ULCS): approved Computer Science courses at the 300-level or higher. See the appropriate CS Program Guide for the current list.

<sup>9</sup> Flexible Technical Electives (FTEs): Approved courses at the 200 or higher level. See the appropriate CS Program Guide for the current list.

<sup>10</sup> A maximum of 4 hours of EECS 499 (or other upper-level directed/independent study) may be applied to Flexible Technical Electives. Anything beyond 4 hours will be applied toward the General Electives.

## B.S.E. in Electrical Engineering

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://www.eecs.umich.edu/eecs/undergraduate/staff.html>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
Subjects Required by All Programs (55 hours)									
Mathematics 115, 116, 216, and 215 <sup>3</sup>	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	4	-	-	-	-
Program Subjects (29 hours)									
EECS 215, Introduction to Circuits	4	-	-	4	-	-	-	-	
EECS 216, Introduction to Signals and Systems	4	-	-	-	4	-	-	-	-
EECS 230, Electromagnetics I	4	-	-	-	-	4	-	-	-
EECS 280, Programming and Elementary Data Structures	4	-	-	-	4	-	-	-	-
EECS 320, Introduction to Semiconductor Device Theory	4	-	-	-	-	4	-	-	-
EECS 301, Probabilistic Methods in Engineering <sup>4</sup>	4	-	-	-	-	-	4	-	-
TCHNCLCM 300 <sup>5</sup>	1	-	-	-	1	-	-	-	-
TCHNCLCM 496 and EECS 496 <sup>5</sup>	4	-	-	-	-	-	-	-	4
Technical Electives (33 hours) <sup>9</sup>									
Flexible Technical Electives <sup>6</sup>	10	-	-	-	-	3	-	4	3
Upper-Level EE Technical Electives <sup>7</sup>	19	-	-	-	-	4	8	7	-
Major Design Experience <sup>8</sup>	4	-	-	-	-	-	-	-	4
General Electives (11 hours)	11	-	-	-	-	-	4	4	3
Total	128	17	17	17	17	15	16	15	14

Candidates for the Bachelor of Science in Engineering in Electrical Engineering - B.S.E. in E.E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

C- Rule: Among science, engineering and mathematics courses, a grade of C- or below is considered unsatisfactory.

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/12 5/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> EE students are advised to take MATH 216 before MATH 215 since EECS 216 is to be preceded or accompanied by MATH 216.

<sup>4</sup> EE students may select only EECS 301 to fulfill this requirement. No more than 4 credits of undergraduate probability may be applied toward EE program requirements. (Additional credits will appear as General Electives.)

<sup>5</sup> Technical Communications: TCHNCLCM 300 can be taken independently of any EECS course, but it is a prerequisite for TCHNCLCM 496. It is advisable to take TCHNCLCM 496 with a Major Design Experience (MDE) course.

<sup>6</sup> Flexible Technical Electives: The flexible technical elective requirement may be fulfilled by taking selected course in EECS, other engineering departments, biology, chemistry, economics, math, or physics. See the ECE Undergraduate Advising Office for the current list. All other courses must be approved by the EE Chief Program Advisor.

<sup>7</sup> Upper-Level EE Technical Electives: Minimum 19 credits. Courses must be chosen from at least two categories; at least 7 credits must be at the 400-level or higher. See the ECE Undergraduate Advising Office for the current list. Credit hours in excess of 19 can be applied toward FTE.

<sup>8</sup> Major Design Experience: Pre-approved courses are EECS 411, 413, 425, 427, 430, 438, 452, 470, 473; other courses that are MDEs in other engineering programs may be acceptable with prior approval of the EE Chief Program Advisor. Students are advised to enroll concurrently in EECS 496, TCHNCLM 496 and MDE course.

<sup>9</sup> A maximum of 4 credits of EECS 499 may be applied to Technical Elective requirements and only in the area of Flexible Technical Electives. Anything beyond 4 credits will be applied toward General Electives.

## Sequential Undergraduate/ Graduate Study (SUGS)

### **B.S.E. or B.S. in one of the EECS programs or Computer Science/M.S.E. or M.S. in one of the Electrical Engineering and Computer Science (EECS) Programs**

There are two separate SUGS programs available through Rackham open to EECS and Computer Science undergraduates (depending on major/minor, etc.) who have completed 85 or more credit hours with a cumulative GPA of at least 3.6. Please see the individual program options and contact the EECS Department Graduate Advisors for more complete program information.

### **B.S.E. in Electrical Engineering/M.S. in Biomedical Engineering**

This SUGS program is open to all undergraduate students from Electrical Engineering who have achieved senior standing (85 credit hours or more) and have an overall cumulative GPA of 3.2 or higher. Please contact the Department of Biomedical Engineering for more complete program information.

## Graduate

### **Graduate Degrees in Computer Science and Engineering:**

- Master of Science (M.S.) in Computer Science and Engineering
- Master of Science in Engineering (M.S.E.) in Computer Science and Engineering
- Doctor of Philosophy (Ph.D.) in Computer Science and Engineering

### **Graduate Degrees in Electrical Engineering:**

- Master of Science (M.S.) in Electrical Engineering
- Master of Science in Engineering (M.S.E.) in Electrical Engineering

- Doctor of Philosophy (Ph.D.) in Electrical Engineering

### **Graduate Degrees in Electrical Engineering: Systems**

- Master of Science (M.S.) in Electrical Engineering: Systems
- Master of Science in Engineering (M.S.E.) in Electrical Engineering: Systems
- Doctor of Philosophy (Ph.D.) in Electrical Engineering: Systems

### **Graduate Degrees in Electrical and Computer Engineering:**

*\*Students admitted prior to Fall 2016 have the option of electing the new Electrical and Computer Engineering program.*

- Master of Science (M.S.) in Electrical and Computer Engineering
- Master of Science in Engineering (M.S.E.) in Electrical and Computer Engineering
- Doctor of Philosophy (Ph.D.) in Electrical and Computer Engineering

Electrical Engineering and Computer Science (EECS) is one of the highest-ranking EECS departments in the country, and many of the faculty are recognized as leaders in their field.

The department's size and scope mean that students may choose from a variety of research areas and participate in integrated research projects. This system provides for multidisciplinary studies, allows students to tailor a program to their needs, and is responsive to changes in rapidly emerging fields. Also, students may have an opportunity to take advantage of other excellent programs at the University of Michigan. Faculty members in EECS have joint projects in other engineering departments and in a wide range of non-engineering programs including medicine, music, physics, information and library science, education, and others.

## **Master of Science / Master of Science in Engineering**

Generally, the M.S.E. and M.S. degree programs in a given area are identical except for admission requirements. Application procedures and individual degree requirements for the M.S. and M.S.E. degree programs are available on the EECS website listed below. The principal requirements for the specific M.S.E. and M.S. degrees are listed below. (A more complete statement on master's degree requirements is available on the Web: <http://www.eecs.umich.edu/eecs/graduate/index.html>.)

### **M.S. and M.S.E. in Computer Science and Engineering**

The graduate program in CSE is organized into five broad areas.

A student must satisfy the regulations of the Rackham School of Graduate Studies, the College of Engineering, and the regulations as specified by the program brochure(s) and the program office.

A student must earn at least 30 credit hours of graduate level coursework, of which at least 24 hours must be technical courses, at least 15 hours must be CSE coursework at the 500-level or higher (excluding credit hours earned in individual study, research or seminar courses). The student must also satisfy course requirements in "breadth" areas of software, hardware, artificial intelligence, and theory. A maximum of six credit hours of individual study, research and seminar courses will be accepted toward the master's degree. The VLSI concentration has slightly different course requirements; please refer to the CSE Brochure available on the web for details.

The program requires that the grade point average received in CSE coursework must be at least 3.0 (based on Rackham's 4.0 scale). An individual course grade of "B-" or better is required for the credit hours received in any course to be counted towards any master's degree requirement. A master's thesis is optional. Credit hours transferred may be applied to meet any master's degree requirement except the 15 credit hours of 500-

level CSE coursework required. (Rackham specifies limitations to the circumstances under which credits may be transferred. See the Rackham Student Handbook.) Courses of an insufficiently advanced level, or which substantially duplicate in level and/or content courses already completed by the student, may not be counted as meeting any master's degree requirements.

### **M.S. and M.S.E. in Electrical Engineering**

The Graduate Program in Electrical Engineering covers topics such as circuits and microsystems, electronics, VLSI, applied electromagnetics and RF circuits, optics and photonics, solid state materials, devices and integrated circuits. A student must earn at least 30 credit hours of graduate-level coursework, of which at least 24 credit hours must be in technical courses, at least 12 credit hours must be EECS coursework at the 500 level or higher (excluding credit hours earned in individual study, research, or seminar courses), and at least 3 credit hours must be in mathematics. The student must also choose a major area and satisfy the requirement in MEMS and microsystems, applied electromagnetics and RF circuits, optics and photonics, solid state, or integrated circuits and VLSI.

For each designated major area there is a set of core courses. The major requirements are to be satisfied by taking approved courses from the major area. Specifically, at least nine credit hours must be earned from the major area, with at least six of these at the 500-level or higher. A grade point average of "B" or higher is required overall and also in EECS coursework. Course grades must be "B-" or higher to earn credit toward the master's degree.

A maximum of four credit hours of individual study, research, and seminar courses (EECS 599 and similar courses) will be accepted toward the master's degree. A master's thesis is optional.

Up to six credit hours may be transferred from other universities if the department grants approval. The student must also satisfy the regulations of the Rackham School of Graduate Studies and the College of Engineering.

Courses of an insufficiently advanced level, or which substantially duplicate in level and content courses already completed by the student, may not be counted as meeting any master's degree requirements.

### **M.S. and M.S.E. in Electrical Engineering: Systems**

The Graduate Program in Electrical Engineering: Systems is identified with the disciplines of communications, control, signal and image processing. Systems theory, stochastic systems, information theory, modulation and coding, estimation and detection, robotics, networks, manufacturing, bioelectrical science, and other disciplines in which the emphasis is on the design and analysis of systems of interacting components or devices, rather than on the physical components or devices themselves, comprise the essential nature of the program.

A student must earn at least 30 credit hours of graduate-level coursework of which at least 24 credit hours must be in technical courses; at least 12 credit hours must be in EECS coursework at the 500-level or higher (excluding credit hours earned in individual study, research or seminar courses). The student must also choose major and minor areas, completing courses in each. The major area must be in communication, control, or signal processing. The minor area must be different from the major and must be chosen from either (i) the previous list, (ii) the following: biosystems, MEMS and microsystems, computers, applied electromagnetics and RF circuits, manufacturing, optics and photonics, or solid state, or (iii) an outside area of concentration.

At least nine credit hours must be earned from the major area, with at least six of these at the 500-level or higher. At least six credit hours must be earned from the minor area, with at least three of these at the 500-level or higher. Course grades must be "B-" or better in order to be counted towards any requirements. A grade point average of "B" or higher is required overall.

A maximum of four credit hours of individual study, research and seminar courses will be accepted toward the degree. A master's thesis is optional. Up to six cred-

it hours may be transferred if the department grants approval. The student must also satisfy the regulations of the Rackham School of Graduate Studies and the College of Engineering.

### **M.S. and M.S.E. in Electrical and Computer Engineering**

The Graduate Program in Electrical and Computer Engineering covers topics such as applied electromagnetics & RF circuits, communications, computer vision, control systems, embedded systems, integrated circuits & VLSI, MEMS & microsystems, optics & photonics, power & energy, robotics, signal and image processing & machine learning, and solid state & nanotechnology. A student must earn at least 30 credit hours of graduate-level coursework, of which at least 24 credit hours must be in technical courses, at least 12 credit hours must be EECS coursework at the 500 level or higher (excluding credit hours earned in individual study, research, or seminar courses, other departments or universities), and 9 credit hours from an ECE major area including at least 6 at the 500 level or above, and at least 6 credit hours in courses outside the major area, often outside of ECE. A maximum of 3 credit hours of S/U courses that are not directed study will be accepted toward the degree. At most 6 credit hours of directed study will be accepted. Course grades must be "B-" or better in order to be counted towards any requirements. A grade point average of "B" or higher is required overall. A master's thesis is optional.

### **Doctor of Philosophy**

Ph.D. in Computer Science and Engineering  
 Ph.D. in Electrical Engineering  
 Ph.D. in Electrical Engineering: Systems  
 Ph.D. in Electrical and Computer Engineering

The doctoral degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by the committee. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the result of the



investigation in the form of a dissertation.

A student becomes an applicant for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in a field of specialization. Candidacy is achieved when the student demonstrates competence in her/his broad field of knowledge through completion of a prescribed set of courses and passing a comprehensive examination.

In most areas, a student must complete required coursework, pass a comprehensive examination and any other program requirements and be recommended for candidacy for the doctorate. A special doctoral committee is appointed for each applicant to supervise the work of the student both as to election of courses and in preparation of the dissertation.

Requirements regarding foreign language and non-technical courses are left to individual departments or programs and to the Graduate School. A prospective doctoral student should consult the program advisor regarding specific details.

A pamphlet that describes the general procedure leading to the doctorate is available in the Graduate School office, 1004 Rackham Building, upon request.

### **The 3.4 Program for EECS and Computer Science majors only**

Students with at least a 3.4 G.P.A. in their major course work and overall G.P.A. at the time of application and graduation may apply to one of the EECS master's degree programs (see documentation online and in the undergraduate and graduate offices of EECS). See any Program Advisor for details.

## Data Science

Data Science has emerged as a major field of study that is at the intersection of Computer Science and Statistics. The collection, management, analysis, and interpretation of such data, with complex structures in the form of text, video, streaming data, are leading to exciting new research opportunities.

Huge amounts of data are being collected in all areas, made possible by rapid technological advances over the last few decades. This is further enabling the use of data-driven approaches to fundamentally transform the way corporations do business and is also leading to new discoveries in science and engineering. Data Science affects research and applications in many domains, including education, biological sciences, medical informatics, engineering, healthcare, social sciences, and the humanities.

The Data Science (DS) program at the University of Michigan draws on our expertise in Computer Science, Statistics, and Mathematics, complementing them with exposure to application domains to provide a multidisciplinary degree that develops future generations of data scientists.

The Data Science program for the College of Engineering is administered by the Computer Science Program in the Department of Electrical Engineering and Computer Science.

## Department Administration

### Contacts

#### CSE Undergraduate Advising Office:

EECS Department

2808 Beyster Bldg.

[ugadmin@eecs.umich.edu](mailto:ugadmin@eecs.umich.edu)

(734) 763-6563

**Department Website:** <http://www.eecs.umich.edu/eecs/undergraduate/datascience>

#### Chief Program Advisor:

[dsengadviser@umich.edu](mailto:dsengadviser@umich.edu)

## Mission

To provide a solid and current foundation to students in the data science area.

## Goals

To produce students with intellectual understanding of both statistical and computing principles for exploring methods and algorithms related to data science so as to enable knowledge creation and decision-making in various application domains.

## Objectives

- To provide the necessary foundation in the principles and methods of data science while preparing students for a broad range of responsible technical positions in industry and/or advanced graduate education.
- To provide the technical skills necessary to ingest, curate, manage, query, analyze, and transform data
- To provide an opportunity to communicate in written and oral form, to develop an appreciation of ethics, security, and privacy in the digital world, and to prepare graduates for successful careers and leadership positions.

## Outcomes

The outcome we desire is that our graduates demonstrate:

- An ability to apply knowledge of mathematics, science, and engineering to problem solving.
- Knowledge of probability and statistics, including applications appropriate to data science.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to select ways of storing and analyzing data to meet desired needs, both in memory and on persistent storage.
- An ability to design and implement automated or semi-automated methods to help curate, query, and transform data.
- An ability to apply machine learning and statistical techniques to help analyze large datasets and to create prediction models or decision models.
- An ability to analyze data in the context of an application domain.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of data science solutions in a global and societal context.

## Sample Schedules

### B.S.E. in Data Science

Not an ABET accredited program. Additional information can be found on the department advising website, <https://www.eecs.umich.edu/eecs/academics/academics.html>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, and 214, 215 <sup>3</sup>	12	4	4	-	4	4	-	-	-
Engineering 100, Introduction to Engineering	4	-	4	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	4	-	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	-	4	4	-	-	-
<b>Program Core (30 hours)</b>									
EECS 203 Discrete Mathematics, or MATH 465	4	-	-	4	-	-	-	-	-
EECS 280, Programming and Elementary Data Structures	4	-	-	4	-	-	-	-	-
EECS 281, Data Structures and Algorithms	4	-	-	-	4	-	-	-	-
STATS 412	3	-	-	-	-	3	-	-	-
STATS 500	3	-	-	-	-	-	3	-	-
EECS 484 or EECS 485, Databases & Applications	4	-	-	-	-	-	4	-	-
EECS 445 or STATS 415	4	-	-	-	-	4	-	-	-
Data Science Application Course <sup>4</sup>	4	-	-	-	-	-	-	4	-
<b>Technical Electives &amp; Capstone (12 hours)</b>									
Advanced DS Technical Elective <sup>5</sup>	8	-	-	-	-	-	-	4	4
Approved DS Capstone course	4	-	-	-	-	-	-	-	4
<b>Other Requirements (16 hours)</b>									
Flexible Technical Electives <sup>6,7</sup>	11	-	-	-	4	-	4	3	-
TCHNCLCM 300	1	-	-	-	-	-	1	-	-
EECS 496, Major Design Experience Professionalism	2	-	-	-	-	-	-	2	-
TCHNCLCM 497 or STATS 404 <sup>8</sup>	2	-	-	-	-	-	-	2	-
<b>General Electives (15 hours)</b>	<b>15</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>1</b>	<b>8</b>
<b>Total</b>	<b>124</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>16</b>	<b>15</b>	<b>15</b>	<b>16</b>	<b>16</b>

Candidates for the Bachelor of Science in Engineering in Data Science - B.S.E. in Data Science - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

C- Rule: Among science, engineering and mathematics courses, a grade of C- or below is considered unsatisfactory.

Credits from a course may only be used to fulfill a single requirement (no double counting).

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> The requirements for Math 214 can be satisfied by Math 217 as an alternative.

<sup>4</sup> List of approved courses for this requirement can be found through the DS-Eng section of the EECS website.

<sup>5</sup> Advanced DS Technical Electives: 300-level or higher from a pre-approved list of courses found through the DS-Eng section of the EECS website, or with Chief Program Advisor approval prior to taking the course.

<sup>6</sup> Flexible Technical Electives (FTEs): Approved courses at the 200+ level. See the EECS Undergraduate Advising Office for the current list.

<sup>7</sup> A maximum of 4 hours of EECS 499 (or other upper-level directed/independent study) may be applied to Flexible Technical Electives. Anything beyond 4 hours will be applied toward the General Electives.

<sup>8</sup> Another approved 400-level technical communications course may be used with Chief Program Advisor approval prior to taking the course.

# Graduate Certificate for Data Science

The University of Michigan Graduate Data Science Certificate Program provides graduate science, technology and skills training for data scientists. The program emphasizes the practice of modeling using modern technology to handle large, incongruent, and heterogeneous collections of data. The Graduate Certificate for Data Science is issued by the Rackham School for Graduate Studies. The Program provides interactive data-centered training and involves 9 credits of courses and 3 credits of experiential training that require a written report on data analytics. Michigan Institute for Data Science (MIDAS) faculty from different disciplines provide student mentorship and curriculum advising. MIDAS offers merit-based top-off scholarships for graduate students enrolled in the Certificate program. Completion of the program is expected in 3-4 semesters. The Data Science Certificate program aims to provide core experiences in:

- (Modeling) Understanding of core Data Science principles, assumptions & applications;
- (Technology) Data management, computation, information extraction & analytics;
- (Practice) Hands-on experience with modeling tools and technology using real data.

## Who is eligible?

University of Michigan graduate students from any field are eligible to enroll.

## Program Requirements

There are four fundamental requirements for earning a Graduate Data Science Certificate Program.

1. Nine (9) graduate credit hours of coursework in approved courses. These courses are designated as core and elective Methods, Technology or Applications — at six (6) course hours must be from the core Modeling and Technology courses. Only one course may be double-counted with another

Rackham degree program and all courses must be outside the main program of study (e.g., statistics students may need to take engineering courses, social-science students may need to take outside statistics and application courses).

2. Three (3) graduate credits in Data Science related experience that is approved by the MIDAS DS Program Committee. This can take the form of non-credit activity like an internship, practicum or professional project equivalent to a three credit hour course, or additional coursework of at least three credits from the approved course list. (This course may be double-counted with another Rackham degree program.) To satisfy this “Plus Requirement” with a data-related experience, students will have to complete and submit to the DS Certificate Program Chair a report describing their experience and results, which will be evaluated to ensure the project demonstrates Data Science content, relevance and applications.
3. Annual Graduate Research Symposium, which provides graduate students with an opportunity to present the results of their research in talks and poster sessions, will be required and will ensure the students’ interaction with MIDAS faculty. Ph.D. students will be encouraged to make an oral or poster presentation.

## Program Chair

Program Chair: Assoc. Prof. Ivo Dinov, <http://www.umich.edu/~dinov/>

The complete Data Science Certificate Program details are available online at <http://midas.umich.edu/certificate/academic-requirements/>

# Engineering Physics

## Overview

Basic physics is an integral part of every engineering curriculum. However, in many areas of engineering the sophistication of the field, coupled with the staggering rate of technological advance, has created a need for engineers with much stronger backgrounds in math and physics—people who can work in an engineering environment and who are capable of applying advanced physics concepts to bring innovations to the marketplace. For example, the development of the computer closely followed the invention of the transistor. Consider the number of other recently discovered physical phenomena (lasers, nuclear reactors, particle accelerators, etc.) that have been successfully brought to fruition by engineers.

Engineering Physics is particularly attractive to those students who may attend graduate school, even if they have not decided on a particular field. An advanced physics and mathematics background coupled with an engineering curriculum is excellent preparation for most graduate engineering programs and for traditional physics or applied physics programs.

Engineering Physics meets the stated needs by providing a thorough curriculum in basic and advanced engineering courses combined with sufficient physics and mathematics to be equivalent to a traditional degree in physics. A unique feature of the curriculum is the elective sequence of engineering courses that the student may select in a specialized field of engineering. This sequence of courses can be chosen by the student (with the faculty advisor's agreement) in any field of interest, such as microprocessor design, plasma processing, electro-optics, radiological health, computational methods or bioengineering, to name just a few. With 46 credit hours of electives in math, engineering and physics, the student has a high degree of flexibility and opportunity for exploring or specializing in fields of interest.

Engineering Physics is Administered by the Nuclear Engineering and Radiological Sciences Department.

## Department Administration

### Department Chair

Ronald M. Gilgenbach, Chair and Chihiro Kikuchi  
Collegiate Professor

## Contacts

Nuclear Engineering and Radiological Sciences  
Department

1906 Cooley Memorial Laboratory  
2355 Bonisteel Blvd.

Ann Arbor, MI 48109-2104

Email: [rongilg@umich.edu](mailto:rongilg@umich.edu)

Phone: (734) 764-4260

Fax: (734) 763-4540

## Undergraduate Contacts

### Faculty Program Advisor

Michael Atzmon

2933 Cooley

[atzmon@umich.edu](mailto:atzmon@umich.edu)

(734) 764-6888

### Student Advisor/Counselor

Rose Prince

1919 Cooley

[princer@umich.edu](mailto:princer@umich.edu)

(734) 936-3130

## Mission

To provide students with a high-quality education that prepares them for careers in engineering and science.

## Goals

To educate students in the scientific fundamentals as well as in an engineering discipline of their choice, to provide the depth and breadth required to adapt to changes in technology.

# Sample Schedule

## B.S.E. in Engineering Physics

Not an ABET accredited program. Additional information can be found on the department advising website, <http://eng.physics.engin.umich.edu/>

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects required by all programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engr 100, Intro to Engr	4	4	-	-	-	-	-	-	-
Engr 101, Intro to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	4	-	-	-	-
<b>Advanced Mathematics (6 hours)</b>									
Mathematics Electives <sup>3</sup>	6	-	-	-	-	-	3	3	-
<b>Related Technical Subjects (8 hours)</b>									
MATSCIE 250, Princ of Eng Materials or MATSCIE 220, Intro to Materials and Manf	4	-	-	4	-	-	-	-	-
EECS 314, Elect Cir, Sys, and Appl or EECS 215, Intro to Circuits	4	-	-	-	4	-	-	-	-
<b>Physics Technical Subjects (20 hours)</b>									
Physics 340, Waves, Heat and Light	3	-	-	-	3	-	-	-	-
Physics 390, Intro to Modern Physics or NERS 311, Ele of Nuc Engr & Rad Sci I	3	-	-	-	-	3	-	-	-
Physics 401, Int Mech <sup>4</sup>	3	-	-	-	-	-	3	-	-
Physics 405, Int Elect and Mag	3	-	-	-	-	-	-	3	-
Physics 406, Stat/thermal Physics	3	-	-	-	-	-	-	-	3
Physics Elective (300-level +)	3	-	-	-	-	-	-	-	3
Physics Lab Elective or Directed Study with Research Lab Component	2	-	-	-	-	2	-	-	-
<b>Engr Technical Electives (20 hours)</b>									
Engineering Electives <sup>5</sup>	16	-	-	-	-	4	4	4	4
Engineering Laboratory Elective (400-level or higher)	4	-	-	-	-	-	-	-	4
<b>Technical Electives (7 hours)<sup>6</sup></b>									
Mathematics, Physics or Engr Courses (300-level or higher)	7	-	-	-	-	3	4	-	-
<b>General Electives (12 hours)<sup>7</sup></b>									
	12	-	-	-	-	3	3	3	3
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>17</b>	<b>15</b>	<b>15</b>	<b>17</b>	<b>13</b>	<b>17</b>

Candidates for the Bachelor of Science in Engineering in Engineering Physics - B.S.E. in Eng Physics - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for CoE.

<sup>3</sup> Math Electives must be 300-level or higher.

<sup>4</sup> For students pursuing ME in Engr Technical Elecives, CEE 211 or ME 240 will be advised as a substitute for Physics 401.

<sup>5</sup> Engineering Electives are to be chosen in consultation with the faculty advisor to form a coherent sequence that clearly defines professional goals for the student. Sample elective sequences for a number of different subject areas are available from the academic or faculty advisors.

<sup>6</sup> For students pursuing ME in Engr Tech Elective, students will be advised to take ME 235 and ME 320 as Flexible Tech Electives.

<sup>7</sup> Students contemplating graduate studies in Physics should elect Physics 453, Quantum Mech and Physics 463, Solid State for a complete background.

# Industrial and Operations Engineering

## Overview

Industrial and Operations Engineering is concerned with integrated systems of people, machines, environments and information. Drawing upon their specialized skills in mathematical, physical and social sciences (together with principles and methods of engineering analysis), industrial and operations engineers specify, predict and evaluate systems. Applications arise in industrial and manufacturing systems as well as a variety of nonindustrial settings, ranging from health care and education to financial and governmental organizations. The wide range of tasks an industrial engineer is called upon to perform requires knowledge of operations research, ergonomics, management engineering, statistics, manufacturing engineering and computer information processing.

## Department Administration

### Department Chair

Mark Daskin

1877A Industrial and Operations Engineering Building

## Contacts

Industrial and Operations Engineering Department

Industrial and Operations Engineering Building

1205 Beal Avenue

Ann Arbor, Michigan 48109-2117

**Departmental Website:** <http://ioe.engin.umich.edu/>

## Mission

The Industrial and Operations Engineering Department aims to be an international leader in developing and teaching theory and methods for the design, analysis, implementation and improvement of integrated systems of people, materials, information, facilities and technology.

## Goals

In addition, the IOE Program also has the following goals:

- To recruit, educate and support excellent, diverse students and prepare them to be leaders in the practice and further development of industrial and operations engineering.
- To have one of the leading undergraduate programs in the world in industrial and operations engineering.
- To engender the skills and desire to continually learn and grow through a lifelong professional career.

## Objectives

- Launch a successful career by effectively practicing industrial and operations engineering or be successful in advanced graduate study in engineering, scientific, business or related disciplines; practicing something other than IOE
- Assume leadership roles in their first job or graduate program;
- Contribute to the social and economic environments of their communities; and
- Have the breadth of knowledge and motivation to continue to develop their career skills through ongoing learning.

## Outcomes

1. an ability to apply knowledge of mathematics, science and engineering;
2. an ability to design and conduct experiments, as well as analyze and interpret data;
3. an ability to design and improve integrated systems of people, materials, information, facilities and technology;
4. an ability to function as a member of a multidisciplinary team;
5. an ability to identify, formulate and solve industrial and operations engineering problems;
6. an understanding of professional and ethical responsibility;
7. an ability to communicate effectively;



8. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
9. a recognition of the need for, and an ability to engage in, life-long learning;
10. a knowledge of contemporary issues;
11. an ability to use updated techniques, skills and tools of industrial and operations engineering throughout their professional careers.

## Undergraduate

<http://www.engin.umich.edu/college/academics/bulletin/depts/ioe/ug>

## Degree Program

The program in Industrial and Operations Engineering at the University of Michigan is designed to prepare students for challenges in the areas described above or for continuing their academic work to acquire an M.S.E. or Ph.D. degree. Approximately 40 percent of the courses required for the B.S.E. in I.O.E. degree are common College of Engineering core requirements, in mathematics, basic physical sciences, digital computing, humanities and social sciences, along with a broad base in engineering fundamentals. Fundamental topics in industrial engineering are provided by the nine (9) 200- and 300-level IOE courses. A solid technical foundation is obtained through 12 credits of departmental IOE electives. In addition, students gain valuable experience applying their knowledge in a senior-level design course.

The opportunity for students to tailor their studies in pursuit of individual interests is provided by an additional six (6) credits of technical electives and nine (9) credits of general electives. The goal of the technical electives is to provide a background in areas related to industrial and operations engineering. This allows students to deepen their knowledge in specific areas of industrial and operations engineering and provides an opportunity to prepare for advanced studies in other engineering disciplines, or in medicine, law or business.

## Sample Schedule

### B.S.E. in Industrial and Operations Engineering

The Industrial and Operations Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://ioe.engin.umich.edu/degrees/ugrad/index.php>.

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects required by all programs (55 hours)</b>									
Mathematics 115, 116, 215, and 214	16	4	4	4	4	-	-	-	-
Engr 100, Intro to Engr	4	4	-	-	-	-	-	-	-
Engr 101, Intro to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	-	-	4	-	-
<b>Related Engineering Subjects (11-12 hours)</b>									
Non-IOE Engineering Courses (11-12 hours) <sup>3</sup>	12	-	-	-	4	4	-	-	4
<b>Required Program Subjects (34 hours)</b>									
IOE 201, Industrial, Operations Modeling	2	-	-	2	-	-	-	-	-
IOE 202, Operations Modeling	2	-	-	2	-	-	-	-	-
IOE 265, Engr Probability and Statistics	3	-	-	-	3	-	-	-	-
IOE 310, Intro to Optim Methods	4	-	-	-	-	4	-	-	-
IOE 333, Ergonomics	3	-	-	-	3	-	-	-	-
IOE 334, Ergonomics Lab	1	-	-	-	1	-	-	-	-
IOE 316, Intro to Markov Processes	2	-	-	-	-	2	-	-	-
IOE 366, Linear Statistical Models	3	-	-	-	-	3	-	-	-
IOE 373, Data Processing	4	-	-	-	-	-	4	-	-
IOE 474, Simulation	4	-	-	-	-	-	-	4	-
IOE Senior Design Course IOE 424, 481, 499 <sup>4</sup>	4	-	-	-	-	-	-	-	4
TC 380, Technical Communication in IOE	2	-	-	-	-	-	2	-	-
<b>Technical Electives (18 hours)<sup>5</sup></b>	18	-	-	-	-	3	6	6	3
<b>General Electives (9-12 hours)</b>	9-12	-	-	-	-	-	-	6	3
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>17</b>	<b>15</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>14</b>

Candidates for the Bachelor of Science in Engineering in Industrial and Operations Engineering - B.S.E. in I.O.E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for CoE.

<sup>3</sup> Non-IOE Engineering Courses - Select 12 hours; 4 hours from any three different groups:

MECHENG 211 or CEE 211 or MECHENG 240

MECHENG 235 or CHE 230

MATSCIE 220 or MECHENG 382

BIOMEDE 458 or EECS 270 or EECS 314

CEE 265 or NERS 211

EECS 280

<sup>4</sup> IOE Senior Design courses are restricted to IOE undergraduate students only.

<sup>5</sup> Technical Electives - Select at least 12 hours from the following four groups; at least one course each from three of the following four groups:

IOE 413, 419, 440, 441, 447, 449

IOE 416, 460, 461\*, 465\*, 466\*

IOE 430, 432, 434, 436, 437, 438, 439, 463

IOE 421, 422, 425, 430, 452, 453

The remaining 6 hours may be selected from any 400-level IOE courses (except IOE 490, IOE 499, IOE 424, and IOE 481) and/or from the approved list of non-IOE courses ([http://ioe.engin.umich.edu/degrees/ugrad/ugdocs/nonIOE\\_technical\\_electives.pdf](http://ioe.engin.umich.edu/degrees/ugrad/ugdocs/nonIOE_technical_electives.pdf)).

\*Maximum of 6 hours allowed from IOE 461, 465, 466.

## Areas

### Operations Research

Operations research is an applied science devoted to describing, understanding, and predicting the behavior of systems, and guiding them towards better performance. Courses in this area cover the use of mathematics in constructing models to analyze and design operational systems. Students study a variety of model structures and their application to real-world processes such as production, maintenance, inspection, resource allocation, distribution and scheduling.

### Ergonomics

Ergonomics emphasizes the technical knowledge necessary to analyze and predict the performance of humans in human-machine systems. Basic courses cover the capabilities and limitations of major human subsystems including cardiovascular, muscular and cognitive (information processing) systems. Knowledge of these human subsystems is used to aid in the design of effective and safe working environments.

### Management Engineering

In the design and implementation of integrated systems, industrial engineers must be able to master the technology of new systems, to understand the technical change process, and to achieve the benefits of such systems. Management engineering courses emphasize the role of people acting as individuals, and in groups, in operating systems.

Theories of administration, group dynamics and human motivation are applied to specific managerial problems related to the establishment, clarification and modification of an organization's objectives.

They also cover the design, evaluation and improvement of human-machine systems for accomplishing these objectives.

### Production, Distribution, and Logistics

How does one add maximum value to an organization through world-class operations in the service and the manufacturing sectors? One needs highly effective production/transformation, inventory/sales and delivery/

fulfillment operations that are cost effective as well. The PDL area educates engineers and managers to lead through operational excellence. Emphasis is placed on global supply chain design, inventory management, production planning and control, facilities layout and planning, material handling, manufacturing strategy and related issues.

### Quality Engineering

Industrial and Operations Engineering graduates understand how to cope with uncertainty in the design of engineered systems. In particular, they design quality control systems and apply reliability analysis and experimental design techniques to design better products and processes.

### Computer and Information Processing

Computers and information systems are important components in most modern systems. Students are introduced to the basic terminology and concepts of information system design, construction and usage. The values and limitations of computing capabilities are explored. Emphasis is placed on the use of computer hardware and software systems in information processing and on the interface of information systems with management in helping to achieve the objectives of an organization.

## Sequential Undergraduate/ Graduate Study (SUGS)

<http://www.engin.umich.edu/college/academics/bulletin/depts/ioe/sugs>

### B.S.E in Industrial and Operations Engineering / M.S.E in Industrial and Operations Engineering

The IOE SUGS program is open to College of Engineering undergraduate students who have achieved senior standing (85 credit hours) with a minimum cumulative G.P.A. of 3.5. SUGS students are allowed to "double count" six (6) credit hours of graduate courses toward the B.S.E and M.S.E degrees. Students considering the SUGS program must "reserve" at least six (6) undergraduate elective credit hours for courses that are

eligible for credit in the IOE Masters degree program. SUGS students must enroll in Rackham for at least two (nine (9) credit) terms, paying full Rackham tuition with no other U of M registration.

### **B.S.E in Industrial and Operations Engineering / M.S. in Biomedical Engineering**

This SUGS program is open to all undergraduate students from Industrial and Operations Engineering who have achieved senior standing (85 credit hours) and have an overall cumulative G.P.A. of 3.5 or higher. Please contact the Department of Biomedical Engineering for more complete program information, <http://www.bme.umich.edu>.

## **Graduate**

### **Graduate Degrees**

- Master of Science (M.S.) in Industrial and Operations Engineering
- Master of Science in Engineering (M.S.E.) in Industrial and Operations Engineering
- Dual M.S. in Industrial and Operations Engineering/ Master of Business Administration (M.B.A.)
- Doctor of Philosophy (Ph.D.) in Industrial and Operations Engineering

### **M.S. and M.S.E. in Industrial and Operations Engineering**

The Master of Science degree in Engineering in Industrial and Operations Engineering is available to students who complete the M.S.E. course requirements and have a bachelor's degree from a recognized program in engineering. The Master of Science degree in Industrial and Operations Engineering is available to students with a bachelor's degree from a recognized program in physics, mathematics or other field related to engineering. Students who hold bachelor's degrees from other fields and who wish to receive an M.S. in Industrial and Operations Engineering should consult with the program advisor as specialized programs

(usually involving additional credit hours over basic requirements) can be developed.

The basic requirements include 30 credit hours of approved graduate courses subject to the following restrictions:

1. At least 18 credit hours of IOE courses
2. At least five (5) courses (equal or greater than 14 credit hours) must be at a 500-or greater level; with at least three (3) IOE courses (equal or greater than 8 credit hours) at a 500-or greater level. Directed study courses, courses graded S/U and one- and two-credit seminar classes may not be used to satisfy 500-level requirements.
3. At least two cognate courses (equal or greater than 4.5 credit hours) from outside the IOE Department.
4. No more than six (6) credit hours of independent study.

Students are required to make up deficiencies in their preparation in probability, statistics, computer programming, linear algebra and English. An overall grade point average of "B" or higher in graduate courses taken in the program is required.

Special options, for which recommended courses have been defined, include:

1. Operations Research
2. Ergonomics, Human Performance, and Occupational Safety
3. Production/Manufacturing/Distribution Systems
4. Quality Engineering and Applied Statistics
5. Management Engineering

### **Health Engineering and Patient Safety Concentration:**

The HEPS Concentration is a three semester program with its own requirements, which is conducted while simultaneously fulfilling the IOE Masters requirements. It has its own additional application procedure after admission to the Master's program.

### Requirements for Concentration in HEPS:

1. Fulfill all requirements for IOE master's program
2. Three (3) semesters (Fall, Winter, Fall)
3. Complete year long, program-designed, hands-on project (three (3) credits in the second semester, full-time in the summer, three (3) credits in the 3rd semester)
4. Satisfy the following course requirements:
  - IOE 813: Seminars in Healthcare Systems
  - Engineering — must be taken first semester (Fall):
    - Statistics/Data Analysis: 1 course
    - Intro to Healthcare: 2 courses
    - Technical Core: 2 courses
    - Methodology: 2 courses
    - Program Focus: 2 courses
5. Students may petition for special permission to count additional courses towards the HEPS requirements
6. Additional description is available at [http://sitemaker.umich.edu/cheps/about\\_cheps](http://sitemaker.umich.edu/cheps/about_cheps)
7. Material describing these options and other details of the graduate programs are available online at <http://ioe.engin.umich.edu/degrees/grad/index.php>.

### Ph.D. in Industrial and Operations Engineering

The doctoral degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by the committee. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the result of the investigation in the form of a dissertation.

A student becomes an applicant for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in a field of specialization. There is no general course or credit requirement for the doctorate.

At the end of the first year in the program, a student must pass a qualifying examination to continue in the

program. This exam is given in six (6) courses, chosen with the consent of the student's advisor. Most students, at the end of their second year, take a preliminary examination in their chosen area of concentration. At present there are five (5) such areas. The student must also satisfy a breadth requirement before taking the exam. After successfully passing this exam, the student is admitted to candidacy and selects a doctoral committee to supervise preparation of the dissertation. A defense of the dissertation in the presence of this committee is required.

Information that describes the general procedure leading to the doctorate is available on the Rackham Graduate School website, <http://www.rackham.umich.edu>.

### Dual M.B.A. / M.S. in Industrial and Operations Engineering

The School of Business Administration and the College of Engineering Department of Industrial and Operations Engineering offer a dual degree program enabling a student to pursue concurrent work in Business Administration and Industrial and Operations Engineering leading to the M.B.A and M.S. in I.O.E. degrees. The program is arranged so that all requirements for the degrees are completed in two and one-half years of enrollment with the required 65 credit hours completed.

Students interested in the M.B.A./M.S. in I.O.E dual program must apply to, and be admitted by, both schools, using their respective application forms and indicating that application is being made to the joint program. Only one application fee is necessary. Students are expected to meet the prerequisites for each program. In particular, the statistics requirement for the I.O.E. program should be discussed with an advisor prior to beginning either program. This program is not open to students who have earned either the M.B.A. or M.S. in I.O.E. degrees. However, students registered in the first year of either program may apply.

Students admitted to this joint program must satisfy the following degree requirements:

1. The M.B.A 60-credit-hour degree program including:
  1. the 31.5-credit-hour M.B.A core (no credit is awarded for Business Administration core courses successfully waived; credit must be earned with Business electives);
  2. 13.5 elective hours in Business Administration (12 of the 13.5 must be approved by I.O.E.);
  3. 15 credit hours of transferable electives from the Department of Industrial and Operations Engineering.
2. The 18 hours of graduate-level I.O.E. courses, including at least eight (8) credit hours in courses numbered 500 or above. Directed study courses and seminar classes may not be counted toward the I.O.E. 500-level or above requirement.
3. A two-credit independent study in I.O.E. or the Business School which would lead to a paper integrating business and I.O.E. perspectives on a particular area of interest.

The total credit hours for the joint degree program will be at least 65.

The dual program can begin with studies in either school; however, because of the sequential nature of the core courses in the M.B.A program, most students will find it advantageous to start the first year in the Business School. Students who wish to begin with Industrial Operations Engineering should consult a counselor in the Business School to work out an appropriate plan of study.

# Materials Science and Engineering

## Overview

Materials Science and Engineering is widely recognized as one of the most promising technical fields of the 21st century.

Materials scientists and engineers specialize in the characterization, development, processing and use of metallic, ceramic, polymeric and electronic materials that are employed in all fields of technology.

Materials scientists and engineers are developing important new materials to meet the needs of our modern technological society. These include high-temperature superconductors; ultra-high-purity semiconductors for solid-state electronic devices; high-strength alloys for use at the extreme temperatures encountered in jet and rocket engines; strong, light alloys and composites for aerospace applications; specialized glasses and ceramics with high thermal, mechanical and chemical stability; and a host of polymeric materials: some with unique functional characteristics and others which replace metal, glass, wood and natural fibers in dozens of applications.

The future role of materials scientists and engineers promises to be even more important and challenging. It is widely recognized that the world is facing a critical energy shortage. Materials scientists and engineers are rising to this challenge in a variety of ways. One method is reducing the weight of automobiles and other transportation systems for fuel savings. They are also actively engaged in reducing the impact of modern society on our environment. They are at the forefront of recycling technologies and more energy-efficient ways of processing materials. New materials and processes are being developed to replace environmentally unfriendly ones currently in use. Sputtering or vapor deposition instead of plating, and biodegradable plastics are examples.

Materials science and engineering graduates are em-

ployed in research, development and manufacturing. They support the creation of new materials and processes or the improvement of old ones with the aim of tailoring properties to applications. Often the work involves cooperating with mechanical, chemical, aeronautical, automotive and other types of engineers in selecting appropriate materials in the design of various devices; evaluating the performance of materials in service; and, particularly, determining the causes and cures for in-service failures; as well as various kinds of supervisory, research, teaching and management activities. A tremendous range of materials science and engineering opportunities exists in metals, polymers, ceramics and electronic materials.

The undergraduate program in Materials Science and Engineering at the University of Michigan has been carefully designed to prepare students for the broad range of activities as described previously; or for continuing their academic work to acquire a master's or doctoral degree.

Introductory courses (either MATSCIE 220 or MATSCIE 250) and MATSCIE 242, and a second-level course (MATSCIE 350) provide a foundation of basic principles applicable to all classes of materials. Other courses include thermodynamics, transport phenomena and mechanical behavior.

Two required laboratory courses give our students a working knowledge of equipment used and methods practiced in the materials industry including processing that uses thermal, chemical and mechanical methods; characterization using mechanical testing machines, microscopy and diffraction instruments; and analysis of experimental data using statistical and digital methods.

A required course in organic chemistry (Chem 210) may be used to satisfy the engineering chemistry requirement or the technical elective requirement. Introduction to Solid Mechanics (MECHENG 211) is also required.

Students have an opportunity to tailor their program of study to their own interests. They choose three senior-level courses from a group of six. These courses cover electrical, magnetic or optical properties of materials,

metals, polymers, ceramics, biomaterials, and materials characterization. They also choose one additional MSE course, plus 10 hours of technical electives and 12 hours of general electives.

All engineering students are required to take 16 credits of intellectual breadth to broaden their education. One of the courses must be macro- or micro-economics (Econ 101 or 102).

## Department Administration

### Department Chair

Amit Misra  
3062B HH Dow Building

Materials Science and Engineering Department  
3062 H.H. Dow  
2300 Hayward St.  
Ann Arbor, MI 48109-2136  
Phone: (734) 763-2445  
Website: <http://www.mse.engin.umich.edu>

## Mission

To provide internationally recognized leadership in education, research and service in the field of materials science and engineering. This is achieved through educational programs that produce students with a strong background in scientific and engineering problem-solving methods as well as communication and teamwork skills.

## Goals

- To provide excellent, diverse students with the knowledge and engineering skills in a quality learning environment that will enable them to become flexible, effective, life-long learners and leaders in materials-related industries, government agencies and academia.
- To have a leading undergraduate program in materials science and engineering, one that integrates a strong scientific base with engineering experience.

## Objectives

The undergraduate program in the Department of Materials Science and Engineering at the University of Michigan will graduate students who:

- possess an understanding of the structure, properties, performance and processing of materials.
- adapt to the rapidly changing scientific and technological landscape and drive the development of future technologies.
- communicate effectively with their colleagues and the general public.
- contribute substantively to science, technology, the environment, and society.

## Outcomes

All Materials Science and Engineering graduates should have:

- an ability to apply knowledge of mathematics, science and engineering within their chosen field.
- an ability to formulate engineering problems and develop practical solutions.
- an initial ability to design products and processes applicable to their chosen field.
- an ability to design, conduct, analyze and interpret the results of engineering experiments.
- an ability to work effectively in diverse teams and provide leadership to teams and organizations.
- an ability for effective oral, graphic and written communication.
- a broad education necessary to understand the impact of engineering decisions in a global/society/economic/environmental context.
- an understanding of professional and ethical responsibility.
- a recognition of the need for and an ability to engage in life-long learning.
- a broad education necessary to contribute effectively beyond their professional careers.
- a sense of responsibility to make a contribution to society.



## Sample Schedule

### B.S.E. in Materials Science and Engineering

The Materials Science and Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://www.mse.engin.umich.edu/undergraduate/overview>.

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth (Includes Econ 101 and Econ 102)	16	4	4	-	4	-	4	-	-
<b>Science and Technical Subjects (14 hours)</b>									
ME 211, Introduction to Solid Mechanics	4	-	-	-	4	-	-	-	-
Science and Technical Electives (Must include CHEM 210 - if not already taken)	10	-	-	4	-	-	3	3	-
<b>Program Subjects (47 hours)</b>									
MSE 250, Principles of Engineering Materials or MSE 220, Introduction to Materials and Manufacturing	4	-	-	4	-	-	-	-	-
MSE 242, Physics of Materials	4	-	-	-	4	-	-	-	-
MSE 330, Thermodynamics of Materials	4	-	-	-	-	4	-	-	-
MSE 335, Kinetics and Transitions in Materials Engineering	4	-	-	-	-	-	4	-	-
MSE 350, Principles of Engineering Materials II	4	-	-	-	-	4	-	-	-
MSE 360, Materials Lab I	3	-	-	-	-	3	-	-	-
MSE 365, Materials Lab II	3	-	-	-	-	-	3	-	-
MSE 420, Mechanical Behavior of Materials	3	-	-	-	-	-	-	3	-
MSE 480, Materials and Engineering Design	3	-	-	-	-	-	-	-	3
MSE 489, Materials Processing Design	3	-	-	-	-	-	-	3	-
<b>Electives</b>									
Elect 3 MSE Slectives <sup>3</sup>	9	-	-	-	-	3	3	3	-
MSE Elective	3	-	-	-	-	-	-	-	3
<b>General Electives</b>	<b>12</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>9</b>
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>14</b>	<b>17</b>	<b>15</b>	<b>15</b>

Candidates for the Bachelor of Science Degree in Engineering in Materials Science and Engineering - B.S.E. in Matl. Sci. & E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or credit from another institution you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or credit from another institution you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> Elect 3 From the Following List:

- MSE 400, EMO Materials for Modern Device Technology (3 hours)
- MSE 410, Design and Applications of Biomaterials (3 hours)
- MSE 412, Polymeric Materials (3 hours)
- MSE 440, Ceramic Materials (3 hours)
- MSE 454, Computational Approaches in Materials (3 hours)
- MSE 465, Structure & Chemical Characteristics of Materials (3 hours)
- MSE 470, Physical Metallurgy (3 hours)
- MSE 514, Composite Materials (3 hours)

## Sequential Undergraduate/ Graduate Study (SUGS)

Students should apply to the program in the first term of their senior year for provisional admission into the program in order to be advised appropriately regarding planning for undergraduate and graduate course selections. No dual enrollment will be required. Other requirements include a minimum undergraduate grade point average of 3.2 for provisional admission and subsequent enrollment into the SUGS program in Materials Science and Engineering. A maximum of nine (9) credits of prior-approved course work may be double counted. Only technical electives and/or general electives may be double counted. None of the 47 required Materials Science and Engineering credits may be used for the graduate degree. A maximum of 15 credit hours that are double counted or transferred for graduate credit are allowed. Contact the prospective department for more complete program information.

## Graduate

### Graduate Degrees

- Master of Science in Engineering (M.S.E.) in Materials Science and Engineering
- Doctor of Philosophy (Ph.D.) in Materials Science and Engineering
- SUGS (M.S.E.) in Materials Science and Engineering

### Master of Science Programs

Two different types of M.S.E. degrees are offered: one with a primary focus on coursework (the Coursework M.S.E.) and one with an emphasis on research (the Research M.S.E.). Students supported with a G.S.R.A. or research fellowship, must pursue a Research M.S.E. rather than a Coursework M.S.E.

#### Coursework M.S.E. Degree

Students seeking a coursework M.S.E. degree must complete 30 credit hours of courses, which must be

approved by the student's advisor. Of the 30 credit hours, up to eight (8) credit hours may be satisfied by MATSCIE 690, and at least 15 credit hours of MATSCIE department courses (excluding MATSCIE 690) must be taken. At least two (2) cognate courses (a minimum of four (4) credit hours) must be taken.

Students taking MATSCIE 690 must submit a research report commensurate with the number of MATSCIE 690 credits taken. This report must be approved by the project supervisor. It may also be used as a document for the Ph.D. oral candidacy exam.

#### Research M.S.E. Degree

Students seeking a Research M.S.E. degree must complete 30 credit hours of courses, which must be approved by the student's advisor. Students must take at least nine (9) credits of MATSCIE 690. Students must take at least 12 credit hours of MATSCIE department courses. Students must take at least two (2) cognate courses (a minimum of four (4) credit hours).

Students must submit a master's thesis to an examining committee of three faculty members, two of which must be from MATSCIE. This committee will include the research advisor and two other faculty selected by the advisor in consultation with the student and approved by the Graduate Committee Chair. The thesis may also be used as a document for the Ph.D. oral candidacy exam. The thesis must be defended orally before this committee and approved by a majority of the committee and the advisor. The oral defense may also serve as the Ph.D. oral exam at the committee's discretion. This thesis should contain a critical review of background information and relevant literature, a statement of objective, a results section and a thorough scientific analysis of these results. It should have a degree of originality suitable for publication. In the event that the student is not satisfied with the results of his/her examination(s), an appeal for arbitration can be made in sequence to the graduate committee chair, the Department chair, the Rackham Graduate School or the College of Engineering Ombudsman. Graduate students who pass the Ph.D. qualifying exam but still want a Masters Degree must also satisfy the above requirements.

---

## Ph.D. Programs

### Ph.D. in Materials Science and Engineering

Advancement to candidacy in the MATSCIE doctoral program is contingent on passing the written examination and the oral examination. A master's degree is not a prerequisite. Students must complete an additional nine (9) hours of formal coursework, above that required for the M.S.E. degree. Incoming students holding an M.S.E. degree (or equivalent) from another institution must complete an additional 18 hours of formal coursework to fulfill the residency and cognate requirements set forth by the Rackham Graduate School. In general, M.S. degrees from institutions outside the U.S. or Canada will be evaluated on an individual basis to determine if they meet the criteria for equivalency as set forth by the Graduate Committee of the MATSCIE department. The criteria for such a decision will be based on the academic standards of the foreign institution, the academic performance of the student at the institution and the fulfillment of course and research requirements similar to those required in the MATSCIE department. Reports, a thesis and publications may be submitted to the Graduate Committee for consideration in reaching decisions in such cases.

The Department will furnish details of requirements upon request. Also, a pamphlet that describes the general procedure leading to the doctorate is available in the Graduate School Office, 1004 Rackham Building, upon request.

# Mechanical Engineering

## Overview

The Department of Mechanical Engineering at the University of Michigan reflects the broad aspects of the mechanical engineering field. As exhibited by our internationally recognized leadership in traditional fields such as manufacturing and automotive engineering, to new enabling technologies of micro- and nanotechnology, biomechanics and biomaterials and environmentally friendly product design, our mechanical engineers are well positioned for the research, design, development and manufacture of a diverse set of systems and products.

The Mechanical Engineering program provides students with an excellent foundation in the core technical competencies of the discipline: thermal and fluid sciences, solid mechanics and materials and dynamics and control. Built upon these strengths is a very strong focus on application of these technical abilities through our design and manufacturing laboratory sequences. In addition, an array of technical electives is offered to enable students to tailor their mechanical engineering education to best suit their career goals.

There are numerous programs offered to enrich education, such as dual-degrees (M.E. degree and a second degree from another Engineering program), Sequential Undergraduate/Graduate Studies (SUGS), the Engineering Global Leadership Honors Program (EGL), Education Abroad (listed among CoE minors) and independent study opportunities with ME faculty. Students interested in any of these programs should contact the Mechanical Engineering Academic Services Office.

Students who do well in their undergraduate program are encouraged to consider graduate work and may take some of their electives in preparation for graduate study.

Information and assistance regarding fellowships and assistantships for graduate study may be obtained in the Academic Services Office of the Department of Mechanical Engineering.

# Department Administration

## Department Chair

Kon-Well Wang,  
Tim Manganello/BorgWarner Department Chair,  
Mechanical Engineering;  
Stephen P. Timoshenko Collegiate Professor of  
Mechanical Engineering  
2236 G.G. Brown

## Contacts

Mechanical Engineering Department  
2250 G.G. Brown Bldg.  
2350 Hayward St.  
Ann Arbor, MI 48109-2125  
**Departmental Website:** <http://me.engin.umich.edu/>

## Mission

To prepare the graduates for diverse careers in both mechanical engineering and related fields.

## Goals

To have students graduate with outstanding problem solving skills and a superb knowledge of mechanical engineering that allows them to continue their education throughout their careers and to become leaders in their fields.

## Program Educational Objectives

The Mechanical Engineering Program is designed to prepare students for continued learning and successful careers in industry, government, academia and consulting. Our alumni are expected to:

1. Apply their engineering knowledge, critical thinking and problem solving skills in professional engineering practice or in non-engineering fields, such as law, medicine or business.

2. Continue their intellectual development via graduate education or professional development courses, for example.
3. Embrace leadership roles in their careers.

## Outcomes

The outcomes that we desire our graduates demonstrate are:

- An ability to apply knowledge of mathematics, science and engineering to mechanical engineering problems.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design systems, components or processes to meet desired needs.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to effectively communicate via written, oral and visual means.
- The broad education necessary to understand the impact of engineering solutions in a global and societal context.
- A recognition of the need for and an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use modern engineering techniques, skills and computing tools necessary for engineering practice.
- An ability to work professionally in both thermal and mechanical systems areas.

# Sample Schedule

## B.S.E. in Mechanical Engineering

The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://abet.org>. Additional information can be found on the department advising website, <http://me.engin.umich.edu/academics/ugsh>

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by all Programs (55 hours)</b>									
Mathematics 115, 116, 215, 216+	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering+	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers+	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup> +	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth (including one course in economics or financials <sup>4</sup> )	16	3	4	-	-	-	3	-	6
<b>Related Program Subjects (7 hours)</b>									
Advanced Mathematics <sup>3</sup>	3	-	-	-	-	-	3	-	-
EECS 314, Elect Cir, Sys, and Appl or EECS 215, Intro to Circuits	4	-	-	-	-	4	-	-	-
<b>Program Subjects (45 hours)</b>									
ME 211, Introduction to Solid Mechanics +	4	-	-	4	-	-	-	-	-
ME 235, Thermodynamics I+	3	-	-	-	3	-	-	-	-
ME 240, Introduction to Dynamics and Vibrations+	4	-	-	-	4	-	-	-	-
ME 250, Design and Manufacturing I +	4	-	-	-	4	-	-	-	-
ME 320, Fluids I+	3	-	-	-	-	3	-	-	-
ME 335, Heat Transfer	3	-	-	-	-	-	3	-	-
ME 350, Design and Manufacturing II +	4	-	-	-	-	4	-	-	-
ME 360, Systems and Controls +	4	-	-	-	-	-	4	-	-
ME 382, Engineering Materials +	4	-	-	-	-	4	-	-	-
ME 395, Laboratory I +	4	-	-	-	-	-	4	-	-
ME 450, Design and Manufacturing III	4	-	-	-	-	-	-	-	4
ME 495, Laboratory II	4	-	-	-	-	-	-	4	-
<b>Electives (Minimum 21)</b>									
Technical Electives <sup>3</sup>	9	-	-	-	-	-	-	6	3
Specialization Elective <sup>5</sup>	3	-	-	-	-	-	-	-	3
General Electives	9	-	-	3	-	-	-	6	-
<b>Total</b>	<b>128</b>	<b>16</b>	<b>17</b>	<b>16</b>	<b>15</b>	<b>15</b>	<b>17</b>	<b>16</b>	<b>16</b>

Candidates for the Bachelor of Science Degree in Engineering in Mechanical Engineering - B.S.E. in Mech. E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 or Chemistry 210/211, you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and/or Physics 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> Advanced Mathematics, and Technical Electives: A list of approved courses is available on the ME Department's Website & in the Academic Services Office (ASO).

<sup>4</sup> The ME department requires each student to take at least 3 credit hours economic or financial course as part of their Intellectual Breadth requirements. Any course on the supplied list within LS&A fulfills the Intellectual Breadth as a LAC. Any course on the supplied list outside of LS&A fulfills the Intellectual Breadth as a Professional & Creative Development Courses (PCDC). A list of ME approved courses is available on the ME Department's Website & in the Academic Services Office (ASO).

<sup>5</sup> A specialization elective is any 3 credit hour course that meets the requirement of either: 1) have a 300-level or higher prerequisite; or 2) be any 300-level or higher ME course.

(+) "D+" rule: Students must earn a "C-" or better in prerequisite courses indicated by the (+) symbol; anything less must be repeated prior to taking a subsequent class for which this class is required.

"D" Rule: No grade less than a "D" shall be earned in any course used for degree credit.

The Mechanical Engineering program offers several dual and joint degree programs. \* A 3.0 cumulative and math, science, and engineering grade point average is required for admissions to one of these programs. As well, minors through LS&A (see CoE Bulletin) and a Concentration in Manufacturing Systems Design or in Energy Systems is available. Refer to the ME Department's Website or consult with staff in the ASO.

\* There are dual degree programs with other Engineering Departments and Joint (MDDP) degrees with other Schools such as Music and LS&A.

## M.E. Program Specific Course Requirements

Within the M.E. program, there are five categories of program specific courses. These include M.E. Core courses, Technical Electives, Specialization Elective, Advanced Math and EECS 314/215.

### M.E. Core Courses

The M.E. Core courses consist of five categories: Design and Manufacturing, Mechanics and Materials, Dynamics and Controls, Thermal Sciences and Laboratories and Technical Communication. In total, there are 45 credits of required M.E. Core courses; and together these subjects represent the fundamental technical competencies every mechanical engineering student must learn. The list below outlines the courses from each of the core categories:

- Design and Manufacturing: ME250, ME350, ME450
- Mechanics and Materials: ME211, ME382
- Dynamics and Controls: ME240, ME360
- Thermal Sciences: ME235, ME320, ME335
- Labs and Technical Communication: ME395, ME495

### Technical Electives (T.E.s)

All M.E. students are required to take nine (9) credits of advanced technical electives (a grade of at least "D" must be obtained in each course). It is the intent of the advanced technical elective requirement that students take a number of "core technical electives" to develop a deeper technical knowledge in specific areas of mechanical engineering.

The nine (9) credits of advanced TEs required are broken down into two (2) categories. The categories are:

1. One class (at least three (3) credit hours) must be a 400-level or higher class in Mechanical Engineering. This may include 400-level classes off the core TE list but does not have to. Note that ME490 or ME491 can fulfill this requirement.

2. Two (2) core TE classes (totaling at least six (6) credit hours) must come from the following list:

- Design and Manufacturing: ME452, ME481, ME483, ME487
- Mechanics and Materials: ME424, ME440, ME461\*
- Dynamics and Controls: ME305, ME311, ME406, ME412, ME451
- Thermal Sciences: ME336, ME420, ME432, ME433
- General: ENGR350\*\*

\*EECS460 may be elected as a non-M.E. class, fulfilling a CORE or a Specialization Elective requirement (see guidelines below), but students may not take both EECS460 and ME461 for T.E. and Specialization Elective credit.

\*\*ENGR350 is offered at Technical University of Berlin during the summer only. For ENGR350 to be counted as an M.E. Technical Elective, the required sophomore-level M.E. courses (ME211, ME235, ME240, ME250) must be taken before ENGR350. Otherwise, ENGR350 counts as a general elective.

### Specialization Elective

A Specialization Elective is any course intended to allow students to explore deeply any dimension of intellectual endeavor that they elect, in both technical (including engineering) and non-technical fields (across the University). A Specialization Elective is any three (3) hour credit course that meets the requirement of either 1) have a 300-level or higher prerequisite; or 2) be any 300-level or higher M.E. course.

### Advanced Math

In addition to the CoE Core math courses, the M.E. department requires students to complete an Advanced Math course (3-4 credits). Students must earn a "D" grade or better to receive credit for the Advanced Math requirement, and it cannot be taken Pass/Fail. The approved list of Advanced Math courses recommended for ME students is provided on the department advising website.

## Electrical Circuits

Also as part of the undergraduate ME degree, students must complete EECS 314 (4) - Electrical Circuits, Systems and Applications. Students must earn a "D" grade or better in EECS 314, and cannot take it Pass/Fail. Students that wish to complete an Electrical Engineering minor would enroll in EECS 215 (4) - Introduction to Electronic Circuits, which would count in place of EECS 314 and follow the same grading rules. Students who are interested in the Electrical Engineering minor should contact the EE department for more information.

## Economics

The M.E. department requires each student to take at least three (3) credit hours economic or financial course as part of their Intellectual Breadth requirements. Any course on the supplied list within LSA fulfills the Intellectual Breadth as a LAC. Any course on the supplied list outside of LSA fulfills the Intellectual Breadth as a Professional & Creative Development Courses (PCDC). The approved list of economic/financial courses recommended for ME students is provided on the department advising website.

## General Electives (G.E.s)

The M.E. B.S.E. degree requires 128 credits to graduate. 119 credits are completed via the CoE Core courses, Intellectual Breadth courses, and ME Program Specific courses. General Electives complete the balance of the credits to reach the 128 total credits, which usually amounts to 9 to 12 credits of G.E. coursework.

For transfer students, students who received credit by exam, or students who transferred one or more courses from another institution, the total number of credits from the other categories may not equal 119 credits. As a result, some students will need to enroll in more or less than 9 general elective credits, depending on how many credits are needed to reach the 128 credits required for graduation.

For the description of what courses count as General Electives, please see the CoE Bulletin.

## Sequential Undergraduate/Graduate Study (SUGS)

Students need to apply to the program at the end of the junior year for provisional admission into the respective program in order to be advised appropriately regarding planning for undergraduate and graduate course selections. This is known as the Intent Form. Requirements differ from one SUGS program to another and include: (1) a minimum undergraduate grade point average of 3.2 to 3.6, (2) a maximum of six (6) to nine (9) credits of previously approved course work may be double counted, (3) only technical electives, advanced mathematics or general electives may be double counted. Go to Contacts to find the prospective department liaison with whom to discuss complete program information.

## Join Institute - Sequential Undergraduate/Graduate Study (JI-SUGS)

This program is designed for students who receive an undergraduate M.E. B.S.E. degree from the UM - Shanghai Jiao Tong University's Joint Institute and wish to pursue a Mechanical Engineering Master's degree at U.M. Students that participate in the joint undergraduate program and receive two undergraduate degrees from U.M. and S.J.T.U. are not eligible for this program. Students that have received only a M.E. bachelor's from S.J.T.U. and have maintained a 3.6 G.P.A. throughout their tenure may apply to the program through the Rackham Admissions Application. Requirements include: (1) a M.E. B.S.E. degree from S.J.T.U., (2) a minimum undergraduate grade point average of 3.6, (3) a maximum of six (6) credits of previously approved course work may be double counted, and (4) only technical electives, advanced mathematics or general electives may be double counted. Go to Contacts to find the prospective department liaison with whom to discuss complete program information.



---

# Graduate

## Graduate Degrees

- Master of Science in Engineering (M.S.E.) in Mechanical Engineering
- Doctor of Philosophy (Ph.D.) in Mechanical Engineering

### M.S.E. in Mechanical Engineering

The requirement for this degree is 30 credit hours of approved graduate course work. At least 18 hours must be taken in mechanical engineering, six (6) hours in mathematics, and six (6) cognate credits. Up to six (6) credit hours of research or nine (9) credit hours of thesis can be taken as part of a 30 credit hour requirement. Details of degree requirements may be found at <http://me.engin.umich.edu/academics/gsh/masters>.

### Ph.D. in Mechanical Engineering

A doctoral committee is appointed for each applicant to supervise the investigative work of the student and election of graduate courses of instruction and passing the qualifying examination. Candidacy is achieved when the student demonstrates competence in his/her field of knowledge through completion of courses and passing the preliminary examination.

The doctoral degree is conferred after the student presents the result of their investigation in the form of a dissertation and in recognition of marked ability and scholarship in a relatively broad field of knowledge. For more information, please go to <http://me.engin.umich.edu/academics/overview/phd>.

# Naval Architecture and Marine Engineering

## Overview

More than 70 percent of the surface of our planet is covered by water. Engineering for the marine environment covers the design and production of all types of systems to operate successfully in this often harsh and demanding environment. In addition to traditional naval architecture and marine engineering, instruction is offered in offshore engineering, coastal engineering and marine environmental engineering. Recent graduates are active in design and research related to offshore oil and gas exploration and production platforms. Others are involved in overcoming water-borne pollution transport in the Great Lakes and the oceans, and coastal erosion predictions, as well as the design of traditional ships, submersibles, high-speed vessels and recreational craft.

Since the design of modern marine systems encompasses many engineering fields, graduates of this department are called upon to handle diverse professional responsibilities; therefore the program includes study in the fundamentals of the physical sciences and mathematics as well as a broad range of engineering aspects that constitute design for the marine environment. To provide the appropriate educational breadth, students are required to complete at least 16 credits of Intellectual Breadth requirements from an approved list of courses. It is recognized that the undergraduate program cannot, in the time available, treat all important aspects of engineering for the marine environment that may be desired by the student; therefore, graduate work is encouraged.

Ship and offshore platform analysis and design require knowledge of hull geometry, vessel arrangements, hydrostatic stability, structures, resistance, propulsion, maneuvering and seakeeping. Other areas of concern are the economic aspects of design and operation, production, model testing, propeller and control theory, vibration problems and piping and electrical system analysis and design.

The undergraduate degree program is arranged to give the student a broad engineering mechanics education by requiring basic courses in the areas of structural mechanics, hydrodynamics, marine power systems and marine dynamics. These courses cover engineering fundamentals and their application to the design and construction of marine vehicles and systems. Courses in marine structures deal with the design and analysis of marine vehicles and platforms including static strength, fatigue, dynamic response, safety and production. Resistance, maneuvering and seakeeping characteristics of vessels in the marine environment are the subject matter for courses in marine hydrodynamics. Marine power systems involve all the mechanical systems on a marine vehicle with particular emphasis on the selection and arrangement of the main propulsion system. In marine dynamics, the student studies the vibrations of marine structures and engines and the responses of the vessel to wind and waves. Through the use of technical and general electives, students may decide to focus their education in areas such as:

- Marine Structures
- Ship Production and Management
- Sailing Yachts
- High Speed Craft
- Marine Power Systems

An integration and demonstrations of the material covered in earlier courses takes place in the junior and senior laboratory courses and in the two-semester, final design sequence. In the first course of the design sequence, the student works on a class design project using state-of-the-art computer-aided design tools. In the second semester, the students form design teams and work on projects of their choosing. Recent final design projects included a mega yacht, an offshore wind farm repair vessel, a cruise ship rescue vessel, an offshore well intervention vessel, a neo-Panamax containership, a naval vessel for high-energy weapons and an offshore racing trimaran. The department works closely with the marine industry and is able to assist graduates in obtaining positions in the field. The department is in regular contact with the country's marine design offices, shipyards, ship operators, government agencies and other organizations concerned with naval architecture and marine engineering. A successful summer intern-

ship program allows students to work in the industry. Students who meet the academic requirements of both departments may earn an additional B.S.E. degree in another engineering program, or in combined programs with other engineering departments. The combined programs allow substantial substitution of courses required in one regular program for those required in the other, and typically can be completed in one extra term.

## Department Administration

### Department Chair

Steven Louis Ceccio  
212 Naval Architecture & Marine Engineering  
Building

### Contacts

Naval Architecture and Marine Engineering  
Department  
222 Naval Architecture and Marine Engineering  
2600 Draper Drive  
Ann Arbor, MI 48109-2145  
Email: [nooner@engin.umich.edu](mailto:nooner@engin.umich.edu)  
Phone: (734) 764-6471  
Fax: (734) 936-8820  
**Departmental Website:** [http://  
name.engin.umich.edu/](http://name.engin.umich.edu/)

## Mission

The mission of the Naval Architecture and Marine Engineering (NA&ME) Department, University of Michigan, is to be a world leader in the education of engineers in the application of engineering principles for the marine environment by:

- providing the leading bachelor's program in naval architecture and marine engineering, with emphasis on the conceptual design, engineering, manufacture and life cycle management of marine vehicles, structures and complex systems;
- providing the leading graduate education and research program in engineering for the marine environment, one which spans a broad range of inquiry;
- providing leadership and service to the state, national and international marine community.

## Goals

In addition, the N.A.&M.E. Program also has the following goals:

- to recruit, educate and support exceptional, diverse students and engage them in lifelong learning and achievement while preparing them for a sustained career of engineering leadership in the marine related industries, government service and academia.
- to maintain and enhance the leading undergraduate program in the world in naval architecture and marine engineering; one which provides a rigorous and effective preparation for a lifelong career of engineering leadership and service.

## Objectives

The Educational Objectives of the N.A.&M.E. Program are to produce graduates that, in 3-5 years' time, are:

1. designing and manufacturing vehicles and structures that operate in the marine environment
2. working effectively in teams
3. practicing professionally in the marine industries, enrolling in graduate study, and engaging in life-long learning.

## Outcomes

The student outcomes of the N.A.&M.E. Program are:

- an ability to apply knowledge of mathematics, science and engineering within naval architecture and marine engineering; [ABET: 3A]
- an ability to formulate engineering problems and develop practical solutions; [ABET: 3e, 3k]
- an ability to design products and processes applicable to naval architecture and marine engineering; [ABET: 3c]
- an ability to design, conduct, analyze and interpret the results of engineering experiments in a laboratory; [ABET: 3c]
- an ability to work effectively in diverse teams and

provide leadership to teams and organizations;  
[ABET: 3d]

- an ability for effective oral, graphic and written communication; [ABET: 3g]
- a broad education necessary to understand the impact of engineering decisions in a global/societal/economic/environmental context; [ABET: 3h]
- an understanding of professional and ethical responsibility; [ABET: 3f]
- a recognition of the need for and an ability to engage in life-long learning; [ABET: 3i]
- a broad education necessary to contribute effectively beyond their professional careers; [ABET: 3j]
- a sense of responsibility to make a contribution to society; [ABET: 3f]
- an ability to apply probability and statistical methods to naval architecture and marine engineering problems; [ABET: 3a, Program: i]
- an ability to apply basic knowledge in fluid mechanics, dynamics, structural mechanics, material properties, hydrostatics, stochastic mechanics and energy/propulsion systems in the context of marine vehicles, and/or ocean structures; [ABET: 3a, Program: ii]
- a familiarity and experience with instrumentation appropriate to naval architecture and marine engineering including experiment design, data collection, data analysis and formal laboratory report writing; [ABET: 3b, Program: iii]
- an understanding of the organization, methods and techniques of marine system manufacture and the use of concurrent marine design; [ABET: 3k]
- an understanding of and experience in marine system conceptual and preliminary design using industrial capability design software, including a team design experience with formal written and oral presentation. [ABET: 3c, 3g]

## Undergraduate

### Degree Program

The undergraduate degree program is arranged to give the student a broad engineering mechanics education by requiring basic courses in the areas of structural mechanics, hydrodynamics, marine power systems and marine dynamics. These courses cover engineering fundamentals and their application to the design and construction of marine vehicles and systems. Courses in marine structures deal with the design and analysis of marine vehicles and platforms including static strength, fatigue, dynamic response, safety and production. Resistance, maneuvering and seakeeping characteristics of vessels in the marine environment are the subject matter for courses in marine hydrodynamics. Marine power systems involve all the mechanical systems on a marine vehicle with particular emphasis on the selection and arrangement of the main propulsion system. In marine dynamics, the student studies the vibrations of marine structures and engines and the rigid body responses of the vessel to the wind and waves.

## Sample Schedule

### B.S.E. in Naval Architecture and Marine Engineering

The Naval Architecture and Marine Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department's undergraduate advising website, <http://name.engin.umich.edu/academics/undergraduateprogram/>

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
<b>Subjects Required by All Programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engineering 100, Introduction to Engineering	4	4	-	-	-	-	-	-	-
Engineering 101, Introduction to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	3	3	-	-	2	-	4	4
<b>Related Technical Core Subjects (11 hours)</b>									
ME 211, Introduction to Solid Mechanics	4	-	-	-	4	-	-	-	-
ME 240, Introduction to Dynamics	4	-	-	-	4	-	-	-	-
ME 235, Thermodynamics I	3	-	-	3	-	-	-	-	-
<b>Program Subjects (46 hours)</b>									
NA 270, Marine Design	4	-	-	4	-	-	-	-	-
NA 260, Marine Systems Manufacturing	2	-	-	-	2	-	-	-	-
NA 280, Probability for Marine Engineers	2	-	-	-	2	-	-	-	-
NA 310, Marine Structures I	4	-	-	-	-	4	-	-	-
NA 320, Marine Hydrodynamics I	4	-	-	-	-	4	-	-	-
NA 321, Marine Hydrodynamics II	4	-	-	-	-	-	4	-	-
NA 331, Marine Engineering I	3	-	-	-	-	3	-	-	-
NA 332, Marine Electrical Engineering	3	-	-	-	-	-	3	-	-
NA 340, Marine Dynamics I	4	-	-	-	-	-	4	-	-
NA 391, Marine Engineering Laboratory I	3	-	-	-	-	-	3	-	-
NA 461, Marine Structures Construction	3	-	-	-	-	-	-	-	3
NA 470, Foundations of Ship Design	4	-	-	-	-	-	-	4	-
NA 475, Marine Design Team Project	4	-	-	-	-	-	-	-	4
NA 492, Marine Engineering Laboratory II	2	-	-	-	-	-	-	2	-
<b>Electives (15 - 18 hours)</b>									
Technical Electives <sup>3</sup>	7	-	-	-	-	-	-	4	3
General Electives	9	-	-	-	-	3	2	2	2
<b>Total</b>	<b>128</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>

Candidates for the Bachelor of Science Degree in Engineering in Naval Architecture and Marine Engineering - B.S.E. in N.A.M.E. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 125/126/130 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and Physics 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> Technical Electives - Choose 2 from the following list. At least one must come from the first four on the list:

- NA 410, Marine Structure II
- NA 420, Environmental Ocean Dynamics
- NA 431, Marine Engineering II
- NA 440, Marine Dynamics II
- NA 401, Small Craft Design
- NA 403, Sailing Craft Design Principles
- NA 416, Theory of Plates and Shells
- NA 423 Introduction to Numerical Hydrodynamics
- NA 483 Marine Control Systems
- NA 525 Drag Reduction Techniques
- NA 562, Marine Systems Production Strategy Operations Management
- Advanced Mathematics: Math 450, Math 454, or Math 471
- Other courses as approved by the department.

## Focus of Study

In the fourth year, students are required to select two (2) technical electives from an approved list. These electives allow students to focus their education in specific areas. Example focus areas and possible courses are as follows:

- Marine Structures: NA 410 and NA 440
- High Speed Craft Design: NA 401 and NA 431 or NA 440
- Marine Power Systems: NA 431 and NA 401
- Marine Manufacturing: NA 410 and NA 562
- Sailing Yachts: NA 403 and NA 410, NA 431, or NA 440

These and other combinations of general and technical electives should be selected in consultation with the Undergraduate Program Advisor.

Students are strongly encouraged to review the possible options prior to their senior year.

## Sequential Undergraduate/ Graduate Study (SUGS)

### B.S.E./M.S.E. in Naval Architecture and Marine Engineering

This program permits outstanding Naval Architecture and Marine Engineering students to receive the B.S.E. and M.S.E. degrees. The student benefits from the continuity of study and the inefficiencies of transferring from an undergraduate to a graduate program are eliminated. The program allows students with a 3.2 or better G.P.A., to apply early in the first semester of their senior year (once 85 credit hours have been completed), for a Sequential Undergraduate/Graduate program, which allows them to double count up to nine (9) credits and transfer up to six (6) credits of technical or general electives. In consultation with their advisor, students select technical electives that will be relevant to the master's program of study. Students are admitted using the normal department graduate admission process, with the admission standards required for ex-

pected successful completion of the program. Please contact the Naval Architecture and Marine Engineering department for more complete program information.

## Graduate

### Graduate Degrees

- Master of Science (M.S.) in Naval Architecture and Marine Engineering
- Master of Science in Engineering (M.S.E.) in Naval Architecture and Marine Engineering
- Joint Master of Science in Engineering (M.S.E.)/Master of Business Administration (M.B.A.) in Naval Architecture and Marine Engineering
- Doctor of Philosophy (Ph.D.) in Naval Architecture and Marine Engineering

### Masters Programs

#### M.S. and M.S.E. in Naval Architecture and Marine Engineering

Applicants for the M.S. or M.S.E. degrees normally hold a Bachelor of Science degree in naval architecture and marine engineering with an average grade of 3.5 on a 4.0 scale. However, the graduate program has been structured so that students with a bachelor's degree in other engineering disciplines that require knowledge of basic mechanics—such as mechanical engineering, applied mechanics, aerospace or civil engineering—may also start directly on their master's program. Students with a bachelor's degree from another field without knowledge of basic mechanics and only want to pursue a master's degree will be required to take NA 470 (Foundation of Ship Design) or NA 491 (Marine Engineering Laboratory I) they might also need to take several undergraduate-level courses which will be determined on a case-by-case basis.

#### Joint M.S.E. / M.B.A. in Naval Architecture and Marine Engineering

The Department of Naval Architecture and Marine Engineering and the School of Business Administration

offer a joint degree program for qualified persons to pursue concurrent work in business administration and naval architecture and marine engineering studies leading to the M.B.A. and M.S.E. degrees. The program is arranged so that all requirements for both degrees can be completed in two years of enrollment, depending on undergraduate NAME background and the specialty area of the NAME master's program. The degrees are awarded simultaneously.

The program can begin with studies in either school. However, because of the sequential nature of the core courses in the M.B.A. program, most students will find it advantageous to start with year one in the Business School. During the remainder of the program, courses might be taken in both schools. Students who wish to begin in NAME should consult a counselor in the Business School to formulate an appropriate plan of study. Interested students must file separate applications and be admitted to both schools. Students admitted to this joint program must satisfy the following degree requirements:

1. The MBA 57 credit hour degree program including:
  - 45 Business Administration Credits, made up of:
    - Roughly 30 credit hours M.B.A. core
    - Roughly 15 elective hours in business administration
  - MBA communication requirement
    - Up to 12 credit hours of transferable electives from the Department of Naval Architecture and Marine Engineering
2. The N.A.&ME 30 credit hour degree program including:
  - 18 hours of graduate-level N.A.M.E. courses  
15 of the 18 N.A.&M.E. credits required need to be 500 level N.A.&M.E. courses or higher.
  - 2 cognate courses must include one (1) Mathematics course

## Ph.D. Programs

### Doctor of Philosophy (Ph.D.) in Naval Architecture and Marine Engineering

The doctoral degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by the committee. In addition, the student must conduct an independent investigation in a subdivision of the selected field, and must present the results of the investigation in the form of a dissertation.

A student becomes a pre-candidate for the doctorate when admitted to the Horace H. Rackham School of Graduate Studies and accepted in a field of specialization. Candidacy is achieved when the student demonstrates competence in her/his broad field of knowledge through the completion of course work, passing comprehensive exams and successful presentation of a Ph.D. prospectus.

There is no general course requirement for the doctorate. However, during the course of a student's graduate study, three (3) math classes and 50 total classroom credit hours are expected as a minimum (with an approved M.S. degree earned before admission to the Ph.D. program, the total classroom credit hours could be reduced to 20). The comprehensive exam consists of a Part I, written exam covering general mechanics; and a Part II, oral exam and prospectus presentation describing the proposed Ph.D. dissertation. A special doctoral committee is appointed for each applicant to supervise the work of the student both in election of courses and in the preparation of the dissertation.

A pamphlet describing the general procedure leading to the doctorate is available from the Rackham Graduate School upon request.

# Nuclear Engineering and Radiological Sciences

## Overview

Nuclear engineering and radiological sciences are concerned with the direct technological use of atomic and subatomic particles. These applications have become an inseparable part of much of modern technological life: smoke detectors, nuclear power reactors, nondestructive evaluation of turbine blades, hardening of artificial hip joints, treatment of radioactive waste, medical CT and PET imaging, treatment of cancer using radiotherapy—all of these rely on the direct manipulation and measurements of parts of atoms or their emitted energy. These are the kinds of technologies that nuclear engineering and radiological sciences encompasses. The Undergraduate Program in Nuclear Engineering and Radiological Sciences leads to the Bachelor of Science in Engineering (B.S.E.) in N.E.R.S..

## Department Administration

### Department Chair

Ronald M. Gilgenbach, Chair and Chihiro Kikuchi  
Collegiate Professor

Nuclear Engineering and Radiological Sciences Department

1906 Cooley Memorial Laboratory

2355 Bonisteel Blvd.

Ann Arbor, MI 48109-2104

Email: [rongilg@umich.edu](mailto:rongilg@umich.edu)

Phone: (734) 764-4260

Fax: (734) 763-4540

## Contacts

**Departmental Website:** <http://www.engin.umich.edu/ners>

## Mission

To provide a superior education for engineers and scientists in nuclear engineering and radiological sciences and to develop future leaders in industry, government and education.

## Goals

The program provides students with:

- skills and tools necessary for industrial, medical, governmental and environmental applications of nuclear processes and radiation; and
- insights and skills that will prepare them to be leaders in research and the practice of nuclear engineering and radiological sciences.

## Objectives

Our alumni:

- are expected to engage in entry-level professional practice in industry, government or health care practice, where, within the initial phase (few years) of employment, they will be performing analysis and measurements related to radiation and radiation interactions with matter, including nuclear power system and health physics and analysis; or,
- enter graduate studies and earn M.S. or Ph.D. degrees in nuclear engineering and related fields;
- are expected to have successful careers and assume leadership roles building upon their strong background in fundamental engineering analysis, teamwork and communication skills and ability to engage in life-long learning for their continual improvement of their skills and knowledge.

## Outcomes

Graduates of the program will have:

- an ability to apply mathematics, science and engineering, including atomic and nuclear physics, to the study of radiation interactions with matter and



nuclear processes;

- an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;
- an ability to identify, formulate and solve engineering problems and develop practical solutions;
- an ability to design a system, component, or process applicable to nuclear engineering and radiological science, to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability;
- an ability to design and conduct engineering experiments, as well as to analyze and interpret data, including the characteristic attributes of nuclear processes and radiation;
- an ability to function effectively on diverse multidisciplinary teams and provide leadership to teams and organizations;
- an ability to communicate effectively in oral, graphic and written communication;
- the broad education necessary to understand the impact of engineering solutions and biological effects of radiation in a global, economic, environmental and societal context;
- an understanding of professional and ethical responsibility;
- a recognition of the need for, and an ability to engage in life-long learning;
- a knowledge of contemporary issues.

## Sample Schedule

### B.S.E. in Nuclear Engineering and Radiological Sciences

The Nuclear Engineering and Radiological Sciences program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Additional information can be found on the department advising website, <http://www.engin.umich.edu/ners/academics/undergrad>

	Total Credit Hours	Term:							
		1	2	3	4	5	6	7	8
<b>Subjects required by all programs (55 hours)</b>									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engr 100, Intro to Engr	4	4	-	-	-	-	-	-	-
Engr 101, Intro to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211 <sup>1</sup>	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241 <sup>2</sup>	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	-	-	4	-	-
<b>Related Technical Subjects (11 hours)</b>									
MATSCIE 250, Princ of Eng Materials or MSE 220, Intro to Materials and Manf	4	-	-	-	4	-	-	-	-
EECS 215, Intro to Circuits or EECS 314, Electrical Circuits, Systems, and Applications	4	-	-	-	-	4	-	-	-
MECHENG 235, Thermodynamics I	3	-	-	-	-	3	-	-	-
<b>Program Subjects (45 hours)</b>									
NERS 250, Fundamentals of Nuclear Eng and Rad Sci	4	-	-	-	4	-	-	-	-
NERS 311, Ele of Nuc Eng & Rad Sci I	3	-	-	-	-	3	-	-	-
NERS 312, Ele of Nuc Eng & Rad Sci II	3	-	-	-	-	-	3	-	-
NERS 315, Nuclear Instr Lab	4	-	-	-	-	-	4	-	-
NERS 320, Prob in nucl Engr & Rad Sci	4	-	-	-	-	4	-	-	-
NERS 344, Fluid Mech Nucl Eng	3	-	-	-	-	-	3	-	-
NERS 441, Nuclear Reactor Theory I	4	-	-	-	-	-	-	4	-
NERS 444, Therm-hyd Nucl Sys	3	-	-	-	-	-	-	3	-
Laboratory Course (above NERS 315) <sup>3</sup>	4	-	-	-	-	-	-	-	4
Design Course <sup>4</sup>	4	-	-	-	-	-	-	-	4
NERS Electives <sup>5</sup>	9	-	-	-	-	-	-	6	3
<b>Technical Electives (5 hours)<sup>6</sup></b>	5	-	-	-	-	2	-	-	3
<b>General Electives (12 hours)</b>	12	-	-	3	3	-	3	3	-
<b>Total</b>	<b>128</b>	<b>17</b>	<b>17</b>	<b>16</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>16</b>	<b>14</b>

Candidates for the Bachelor of Science Degree in Engineering in Nuclear Engineering and Radiological Sciences - B.S.E. in N.E.R.S. - must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

#### Notes:

<sup>1</sup> If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 125/126/130 you will have met the Chemistry Core Requirement for the College of Engineering.

<sup>2</sup> If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and Physics 240/241 you will have met the Physics Core Requirement for the College of Engineering.

<sup>3</sup> Laboratory Course, (above NERS 315) select one from the following: NERS 425, 535, 575, 586. (NERS 535 and 575 require program advisor's consent.)

<sup>4</sup> Design Course, select one: NERS 442, 554.

<sup>5</sup> One course must be selected from the following: NERS 421, NERS 471 and NERS 484. A maximum of 3 credit hours of independent study (NERS 499) can count as a NERS elective. All additional NERS 499 credits beyond those 3 can only be counted as a general elective.

<sup>6</sup> Technical electives are defined as: 300-level and above Mathematics, Physics or non-NERS Engineering courses. Course content must be technical. All substitutions must be approved by the faculty advisor.

## Sequential Undergraduate/Graduate Study (SUGS)

The five-year Sequential Undergraduate/Graduate Study (SUGS) Program permits students who enter the program in the first term of their senior year to receive the B.S.E. and M.S.E. degrees (or the B.S.E. and M.Eng. degrees) upon completion of a minimum of 149 credit hours. Students should speak with the department advising office to learn more about the SUGS application process and procedures. SUGS admissions requirements will vary. Please go to our website for more information: <http://www.engin.umich.edu/ners>

Available programs include:

- B.S.E in Nuclear Engineering and Radiological Sciences/M.S. in Nuclear Engineering and Radiological Sciences
- B.S.E in Nuclear Engineering and Radiological Sciences/M.S. in Biomedical Engineering

## Graduate

### M.S. and M.S.E. Programs

#### M.S. in Nuclear Science and M.S.E. in Nuclear Engineering and Radiological Sciences

- **Undergraduate Preparation:** Entrance requirements are NERS 311, 312, and Math 454 (or their equivalents) and may NOT be applied towards the 30 hours for the Master's Degree.
- **Bachelor of Science (B.S.):** Apply for the Master's of Science (M.S.) diploma
- **Bachelor of Science in Engineering (BSE):** Apply for the Master's of Science in Engineering (M.S.E.) diploma

Please review the "Checklist for Master's Degree Requirements" available in the department office and online.

### Nuclear Engineering and Radiological Sciences, M.S.E.

Students entering the program must have a bachelor's degree from an accredited engineering program.

### Nuclear Science, M.S.

The nuclear science program is available to those with bachelor's degrees from recognized programs in physics, chemistry or mathematics who wish to work in the field of nuclear engineering and radiological sciences.

## Master's Graduation Requirements

The Master's degree in Nuclear Engineering and Radiological Sciences requires 30 hours of coursework at the graduate level, including 20 hours from N.E.R.S. (of which four (4) courses must be at the 500-level or above). Rackham requires a minimum of four (4) credit hours of cognate graduate-level coursework. N.E.R.S. requires that the cognate courses be related to the student's degree program and should be chosen with the advice of the student's graduate advisor. A student must also take at least one 400-level or higher laboratory course for the M.S. degree while a graduate student. The average grade in N.E.R.S. courses must be a "B" (a grade point of 3.0/4.0) or better, and the average grade for all courses must also be a "B" or higher. Undergraduates who earned the following degrees should apply for the corresponding diplomas.

### Master's Project: (Optional)

The student, with approval of the student's graduate advisor, may substitute a master's project report for two (2) to six (6) credit hours of graduate coursework (NERS 599). In addition to a written final report, the student will be required to make a seminar presentation on the master's project.

Minimum Number of Credits Required: 30 credit hours.

## Ph.D. Programs

### Nuclear Engineering and Radiological Sciences, Ph.D. Nuclear Science, Ph.D.

The doctoral degree is conferred in recognition of marked ability and scholarship in some relatively broad field of knowledge. A part of the work consists of regularly scheduled graduate courses of instruction in the chosen field and in such cognate subjects as may be required by Rackham and the advisor. In addition, the student must pursue independent investigation in a subdivision of the selected field and must present the result of the investigation in the form of a dissertation. The selected fields (options) are:

- Fission Systems and Radiation Transport
- Materials
- Plasmas and Fusion
- Radiation Measurements and Imaging

### Ph.D. Candidacy and Graduation Requirements

- Laboratory course requirement
- Breadth course requirements
- NERS candidacy requirements
- Thesis prospectus
- Dissertation and dissertation defense

#### Laboratory Course Requirement

All Ph.D. students must take NERS 515, Nuclear Measurements Laboratory, and obtain a grade of “B” (5.00) or better. Students who have taken N.E.R.S. 315 or an equivalent as an undergraduate must instead take one of NERS 425, NERS 535, NERS 575, or NERS 586. The student’s advisor and graduate program chair must approve in writing any variances and substitutions.

#### Breadth Course Requirements

All Ph.D. students must take and obtain a grade of “B” (3.0/4.0) or better in six (6) credit hours of N.E.R.S. courses selected from outside the student’s option, as defined by the following lists of courses. Courses not listed do not satisfy this requirement; the

student’s advisor and graduate chair must approve any variances in writing. The purpose of this requirement is to ensure the breadth of nuclear engineering and radiological science education of our Ph.D. students and to ensure that the student is exposed to the quantitative analytical methods used in other specialties in the field. A laboratory course used to satisfy this breadth requirement cannot be used to satisfy the laboratory requirement (above). Breadth courses are not required for candidacy; however, they are required for final degree approval.

#### Breadth Requirement Courses and Option Classification:

Fission Systems and Radiation Transport: NERS 441, 442, 444, 462, 543, 544\*, 546, 551, 554\*, 561, 590\*\*, 644

Materials: NERS 521, 522, 524, 531, 622

Measurements: NERS 481, 484, 518, 535, 580, 582, 583, 585, 586, 587

Plasmas and Fusion: NERS 471, 571, 572, 573, 574, 575, 576, 577, 578

\*Students in the Measurements Option cannot elect these courses as breadth courses

\*\*590 Computational Fluid Dynamics (CFD) for Nuclear Applications

\*\*590 Computational Transport Methods

\*\*590 Solvers for Nuclear Applications

#### NERS and Rackham Candidacy Requirements

- Time to Candidacy - A student must achieve candidacy within 2.0 years after the first enrollment in the N.E.R.S. Ph.D. program.
- Coursework In Residence - A precandidate must complete at least 18 credit hours of graded (including the grade of “S” for Satisfactory) graduate coursework registered as a Rackham student while in residence on the Ann Arbor campus.
- Courses elected as visit (audit) do not meet this requirement, nor do any doctoral courses (those designated as 990, etc.).
- Cognate Requirement - Before advancing to candidacy, students must complete four (4) credit hours of cognate coursework with a grade of B or better according to the NERS graduation requirements.

Additional Rackham requirements can be found at:  
**<http://www.rackham.umich.edu/current-students/policies/academic-policies/section5#52>**

- All courses in Responsible Conduct of Research and Scholarship (RCRS) for Ph.D. students must be completed. **<http://rcrs.engin.umich.edu/>**

## Advancement to Candidacy

The entire NERS faculty will decide a student's advancement to candidacy based on a broad assessment of the student's performance on a written examination, the student's academic and research record, and the recommendation of the student's advisor.

The written examination is a six-hour test in a specific option: 1) Fission Systems and Radiation Transport; 2) Plasmas and Fusion; 3) Materials; 4) Measurements; or 5) an alternative area approved in advance by the NERS Executive Committee. The exam will cover topics at the graduate level. Students are encouraged to access the NERS CTOOLS website for copies of old examinations, and to discuss with their research advisor specific topics covered and relevant courses. The written exam is prepared by the examination committee in each Option and is given twice a year, in January and May.

To take the written exam, a student must be a doctoral precandidate in good standing with the graduate school, have identified a thesis advisor, and have a minimum graduate G.P.A. of 3.3 (B+) at the time of the exam. Exceptions will be considered by petition to the Departmental Graduate Committee. Also, a student must receive the written approval of their advisor and the NERS Graduate Chair.

The written exam will be graded anonymously, and the scores will be communicated to the student within two (2) weeks of the exam. The student will be considered by the Option Faculty for advancement to candidacy within a month of the written exam, taking into account the score on the written exam, the student's academic and research record, and the input of the student's advisor. A recommendation on advancement to candidacy will be prepared by the Option Faculty for the full N.E.R.S. faculty, who will decide each case. If the fac-

ulty decision is not to advance the student to candidacy, the student will be informed of the reasons for the decision and the specific recommendations of the faculty. A student may be considered for candidacy a second time, but attempts beyond the second will require approval of the department faculty.

Note on advancement to candidacy: before the student advances to candidacy, the department will audit the student's Ph.D. checklist to ensure that all candidacy requirements have been met. The breadth courses are not required for candidacy, but they must be taken before completion of the doctoral degree.

## Dissertation Prospectus

A thesis prospectus exam is required for completion of the Ph.D. degree. This exam must be taken within 12 months of achieving candidacy status, and after the candidate has formed a dissertation committee.

The exam will consist of a presentation by the candidate on his or her proposed research program, lasting about 30 minutes, followed by questioning. After questions covering the presentation material, questions of a more fundamental but related nature may be introduced. These questions may cover material found in standard undergraduate or introductory graduate N.E.R.S. courses. This question period is nominally expected to last 60 minutes.

This examining committee will consist of at least three (3) members of the student's dissertation committee (the full committee will be invited), and one randomly selected N.E.R.S. faculty member from outside the candidate's dissertation committee. The chair of the examining committee will be the student's dissertation committee chair. Following the questioning the examining committee will discuss the proposed research and prospectus, and vote on passing or failing the student; their decision will be communicated to the student as soon afterwards as practicable, generally along with suggestions for the direction of the research, and to the N.E.R.S. faculty as a whole at the next faculty meeting.

This exam may be attempted twice; the second attempt must occur within 12 months of the first. Additional

attempts beyond the second will require approval of the N.E.R.S. faculty.

The thesis prospectus will be scheduled at the advisor's request. The student should then submit his or her name, option, research topic and an abstract to the departmental Graduate Coordinator, along with some dates that both the advisor and student find convenient. The Graduate Coordinator will then set the committee, schedule the exam, and reserve the room for the exam. Additionally, the student is required to send an electronic abstract to the full examining committee and departmental graduate coordinator. After consulting with the student's advisor, a paper, publication, report, and/or slides are encouraged in addition to the abstract.

## **Dissertation and Dissertation Defense**

Ph.D. students must complete a written dissertation describing an original, substantive, and scholarly contribution to their field of study. A dissertation committee, chaired by the student's research advisor(s), will read this dissertation and its abstract and judge their adequacy. The committee may require changes to the dissertation. Each student must also present and successfully defend the dissertation work at a public meeting.

# Military Officer Education Programs

## Overview

The University of Michigan, in cooperation with the armed services of the United States, provides an opportunity for eligible male and female students to earn a commission from the Army, Navy, Marine Corps and Air Force upon completion of the degree and commissioning requirements. This opportunity is available through enrollment in the Military Officer Education Program (M.O.E.P.), which is known nationally as the Reserve Officers Training Corps (R.O.T.C.).

All three officer education programs (Army, Navy, and Air Force) offer four- and two-year program options, financial benefits, and scholarship opportunities. Minor variations, however, do exist among the programs and students should consult the specific information under the applicable program.

## Financial Benefits

All students enrolled in advanced (junior and senior year) officer education courses, whether or not on scholarship, receive a monthly stipend for the academic year. Uniforms, required books and equipment are furnished to students. Additionally, pay and travel allowances are provided for attendance at summer field training courses.

## Scholarships

In addition to the financial benefits provided for all students contracted in the advanced courses, two-, three- and four-year merit-based scholarships are awarded on a competitive basis by each of the Officer Education Programs. These scholarships provide tuition, laboratory fees, payment for required books and a monthly stipend.

## Course Election by Non-Program Students

Officer education courses are also open to University students not enrolled in the program with the permission of the instructor.

## Army

### Army Officer Education Program

Upon graduation and completion of program requirements, students receive a commission as Second Lieutenant in the United States Army Reserve or in the Active Army.

### Career Opportunities

Graduates may request active duty in the Army as commissioned officers or choose reserve duty service in the Army National Guard or Army Reserve in order to pursue a civilian career or graduate schooling.

Active duty officers are available for worldwide assignment. Service in one of the Army's 17 branches and the possibility for educational delay provides an opportunity for extensive leadership experience.

### Four-Year, Three-Year, and Two-Year Programs

Students may choose one of three program options as described in the general introduction to the Military Officer Education Programs. All programs include a four-week Cadet Leaders Course (C.L.C.) at Fort Knox, KY, which is taken as part of the advanced course sequence between the junior and senior years. The first two years of the four-year program can be taken without an obligation to the Army.

Students who intend to enroll in the two-year program should contact the Scholarship and Enrollment Officer by February of their sophomore year in order to discuss enrollment options before the following fall term. Two-year candidates must have a total of two years of school remaining at the undergraduate and/or graduate level. Students with prior military service (or prior R.O.T.C. training) may enroll in the program with advanced standing.

## Financial Benefits and Scholarships

Army R.O.T.C. scholarships are merit-based and provide full tuition plus books and fees. All scholarship students receive a monthly stipend to help cover additional expenses. The stipend is \$300/month for first-year students, \$350/month for second-year students, \$450/month for third-year students and \$500/month for fourth-year students. Engineering students may request an additional year of scholarship benefits if they are enrolled in a five-year program. Two, three & four year scholarships are available.

## Simultaneous Membership Program

Non-scholarship students can choose to join a Reserve or National Guard unit of their choice while enrolled at the University. The student trains as an officer trainee, gaining valuable leadership training as a member of the Reserve Forces and can collect over \$1,000 a month.

## Branch Assignments

In their senior year, cadets are assessed for branch assignments to one of the following 17 branches of the Army in accordance with their personal preference, aptitude, academic background, and the needs of the Army: Corps of Engineers, Cyber, Signal Corps, Aviation, Armor, Field Artillery, Air Defense Artillery, Adjutant General's Corps, Military Intelligence, Finance Corps, Infantry, Medical Service Corps, Military Police Corps, Ordnance Corps, Quartermaster Corps, Transportation Corps and Chemical Corps.

## Course of Study

Students enroll in one Military Science (MS) class during each term of participation in the program for a total of 12 credit hours distributed as follows:

- Basic Course sequence (first and second years):  
Military Science 101, 102, 201, 202  
(4 hours total).
- Advanced Course sequence (third and fourth years):  
Military Science 301, 302, 401, 402  
(8 hours total).

The complete course of instruction includes professional ethics, professional writing and briefing, principles of military leadership, staff management principles,

military justice, and tactics. In addition to the classroom courses, students participate in Leadership Laboratories (one 120 minute period per week). Training includes orienteering, rappelling, marksmanship, land navigation and physical training. In addition, courses in effective writing and military history are required for completion of the program.

## Military Obligation

Students may request active duty or non-active duty assignments in the Army Reserve or National Guard. All Advanced Course students are obligated to four years of service which may be served in an active or reserve status depending on individual preference and Army needs and an additional four years of I.R.R. (on call) status. No obligation is incurred during the freshman and sophomore years, unless the student is on scholarship.

**Note:** A Leadership Laboratory (0 credit), meeting for two hours each week, accompanies each of the above listed MS courses.

## Army Officer Education Course Listings

(Subject = MILSCI)

Course descriptions are found on the College of Engineering web site at <http://courses.engin.umich.edu/>

### 101. Introduction to Officership

Prerequisite: none. (1 credit)

### 102. Introduction to Leadership

Prerequisite: none. (1 credit)

### 103. Leadership Laboratory

Prerequisite: none. (0 credit)

### 201. Innovative Tactical Leadership

Prerequisite: none. (1 credit)

### 202. Leadership in Changing Environments

Prerequisite: none. (1 credit)

### 301. Leading Small Organizations I

Prerequisite: permission of Chairman. (2 credits)

### 302. Leading Small Organizations II

Prerequisite: permission of Chairman. (2 credits)

### 401. Leadership and Management

Prerequisite: permission of Chairman. (2 credits)

### 402. Military Professionalism and Professional Ethics

Prerequisite: permission of Chairman. (2 credits)



## **Military Obligation**

Newly commissioned officers incur a minimum of four years of active duty service obligation.

Professor of Military Science: Lieutenant Colonel

William Wade

Scholarship and Enrollment Officer: Mr. Peter Drake

Program Office

930 N. University Ave, Room 1090

Phones: (734) 764-4200

Scholarships: (734) 936-2839

Website: [www.army.rotc.umich.edu](http://www.army.rotc.umich.edu)

## **Air Force**

### **Air Force Officer Education Program**

Students who enroll as cadets in the Air Force Officer Education Program, which is known nationally as the Air Force Reserve Officers Training Corps (A.F.R.O.T.C.), successfully complete the program and receive a University degree are commissioned as Second Lieutenants in the United States Air Force.

### **Career Opportunities**

Men and women can serve in a wide range of technical fields such as meteorology, research and development, communications and electronics, engineering, transportation, logistics and intelligence as well as in numerous managerial and training fields such as administrative services, accounting and finance, personnel, statistics, manpower management, education and training, investigation and information services. There are also opportunities in the pilot, combat systems officer, space operations and missile career fields. Advanced education or technical training for these career areas may be obtained on active duty at Air Force expense.

### **Four-Year and Three-Year Programs**

Students may choose one of two program options as described in the general introduction to Military Officer Education Programs. The four-year and three-year program options include a summer four-week field training course at Maxwell Air Force base between the sophomore and junior years. Students electing to take the three-year program will be required to take the

basic course sequence in one year instead of two years. No military obligation is incurred during the freshman year for scholarship recipients and none during the freshman or sophomore years for non-scholarship recipients.

### **Financial Benefits and Scholarships**

For a detailed description of the available financial benefits and scholarships, consult the appropriate sections in the general introduction to the Military Officer Education Programs.

### **Course of Study**

Students enroll in one course in Aerospace Studies (AS) during each term of participation in the program for a total of 16 credit hours.

- Basic course sequence (first and second year):  
Aerospace Studies 101, 102, 201, 202 (4 hours).
- Advanced course sequence (third and fourth years):  
Aerospace Studies 310, 311, 410, 411 (12 hours).

This sequence of courses attempts to develop an understanding of the global mission and organization of the United States Air Force, of the historical development of air power and its support of national objectives, of concepts of leadership, management responsibilities and skills, of national defense policy and of the role of the military officer in our society.

### **Military Obligation**

After being commissioned, graduates of the program will be called to active duty with the Air Force in a field usually related to their academic degree program. The period of service is four years for non-flying officers, six years for combat systems officers and air battle managers after completion of their training and ten years for pilots after completion of flight training.

### **Air Force Officer Education Course Listings**

(Subject = AERO)

Course descriptions are found on the College of Engineering web site at <http://courses.engin.umich.edu/>

#### **101. The Air Force Today**

Prerequisite: none. I (1 credit)

**102. The Air Force Today**

Prerequisite: AERO 101. II (1 credit)

**201. Evolution of U.S. Air Power**

Prerequisite: AERO 102. I (1 credit)

**202. Evolution of U.S. Air Power**

Prerequisite: AERO 201. II (1 credit)

**310. Air Force Leadership and Management**

Prerequisite: AERO 202. I (3 credits)

**311. Air Force Leadership and Management**

Prerequisite: AERO 310. II (3 credits)

**410. National Security Forces in Contemporary American Society**

Prerequisite: AERO 311. I (3 credits)

**411. National Security Forces in Contemporary American Society**

Prerequisite: AERO 410. II (3 credits)

**Note:** A Leadership Laboratory (0 credit), meeting for two-hours each week, accompanies each of the above-listed courses.

## Navy

### Navy Officer Education Program

Students enrolled as Midshipmen in the Navy Officer Education Program, also known as the Naval Reserve Officers' Training Corps (N.R.O.T.C.), who receive a scholarship or advanced standing placement and successfully complete required courses and receive a degree from either the University of Michigan (Ann Arbor) or Eastern Michigan University will be commissioned as officers in the United States Navy or Marine Corps.

### Career Opportunities

Graduates of the program have a wide range of job and career opportunities. Navy officers may choose duty assignments in the surface, aviation, submarine, special warfare or nursing communities. Marine Corps officers may choose any duty assignment to include those in aviation, infantry, armor or artillery specialties. After graduation, all commissioned officers receive additional training in their prospective fields.

### Program Length

The program normally includes eight terms of course

work. A military obligation is incurred at the beginning of the sophomore year for scholarship students. Non-scholarship students may enroll in the College Program and take ROTC courses without incurring a military obligation. College Program students may be considered for scholarship in their first- or second-year in the program. Students must first be nominated by their respective N.R.O.T.C. advisor, endorsed by the Professor of Naval Science, and approved by Naval Service Training Command. All scholarships are funding-dependent, and are based upon academic and athletic performance, as well as military aptitude and the competition is with the other N.R.O.T.C. units nationwide. If not selected for a scholarship or advanced standing by the end of the second-year in the program, students must be disenrolled from the R.O.T.C. program.

### Financial Benefits and Scholarships

Scholarships cover tuition, lab fees, books, uniforms, and provide a monthly stipend for a length of two- to five-years of study. For a more detailed description of the available financial benefits and scholarships consult the following websites: <http://navy.rotc.umich.edu> and <http://www.nrotc.navy.mil/>. Most students who enter the program as freshmen have received four-year scholarships based on national competition. As mentioned above, any other student may join the program through the College Program. These students will participate in the same way as the scholarship students. The only exception will be the absence of financial benefits. Additionally, the Navy offers several other scholarship opportunities. Immediate scholarships for up to 3.5 years may be awarded to students pursuing degrees in engineering and related fields. College program students may earn 3.5, 3 or 2 year scholarships through the Navy Officer Education Program at the University along with continuing to apply through the national selection board. Finally, students who wish to join the program for two years may apply for two-year scholarships during the winter of their sophomore year. Criteria for eligibility vary based upon program; details are available from the program chair.

### Course of Study

Students enroll in Naval Science (NS) courses during each term of participation in the program. Additionally, all Navy-option scholarship students are required to

complete course work in calculus, calculus-based physics and other required courses. Students also participate in a four- to six-week summer training exercises during periods between academic years.

**Note:** The courses listed herein are offered primarily for the students participating in the program; however, they are open to, and may be taken by, any University - enrolled student. **Not all of them are accredited.**

### **Military Obligation**

Newly commissioned officers incur a minimum of five years of active duty service obligation. Aviation officers incur minimum active duty of up to 10 years.

### **Navy Officer Education Course Listings**

(Subject = NAVSCI)

Course descriptions are found on the College of Engineering web site at <http://courses.engin.umich.edu/> (Electrical Engineering), and at <http://www.lsa.umich.edu/cg/default.aspx> (NavSci)

#### **101. Introduction to Naval Science**

Prerequisite: none. (2 credits)

#### **102. (UC 101). Seapower and Maritime Affairs**

Prerequisite: none. (2 credits)

#### **201. (NAVARCH 102). Introduction to Ship Systems**

Prerequisite: none. (3 credits)

#### **202. (EECS 250). Electronic Sensing Systems**

Prerequisite: Prior or concurrent enrollment in Physics 240 (or 260) or EECS 230. (3 credits)

#### **203. (UC 205). Leadership and Management**

Prerequisite: NavSci 101 & 102 or Permission of Instructor. (3 credits)

#### **301. (Astro 261). Navigation**

Prerequisite: none. (3 credits)

#### **302. Naval Operations**

Prerequisite: NavSci 301. (3 credits)

#### **310. (UC 310). Evolution of Warfare**

Prerequisite: none (3 credits)(Offered Fall of even years)

#### **402. (UC 403). Leadership and Ethics**

Prerequisite: NavSci 203 or Permission of Instructor II (2 credits)

#### **410. (UC 410). Amphibious Warfare**

Prerequisite: none. (3 credits)(Offered Fall of odd years)

# Applied Physics

## Program Administration

### Contacts

**Program Director**

Cagliyan Kurdak

Phone: (734) 647-4650

Applied Physics Program

University of Michigan

450 Church ST.

1425 Randall Laboratory

Ann Arbor, MI 48109-1040

Website: <http://www-applied.physics.lsa.umich.edu/>

### Overview

The quickening pace of development at the frontier between physics and engineering creates a need for interdisciplinary training and research which is not readily accommodated by traditional single-focus graduate programs. The University of Michigan Applied Physics Program is designed to fill this gap, providing students with the opportunity to gain a solid base in the fundamentals of modern physics while exploring applications in the context of various branches of engineering.

The program, which spans the Physical Science Division of the College of Literature Science and the Arts and the College of Engineering, as well as several other units of the University of Michigan, offers graduate studies leading to the Doctor of Philosophy (Ph.D.) degree in Applied Physics. Coursework and research are structured to meet individual goals so that the program is appropriate for students intending to pursue careers in industry, academia or government service.

From nonlinear optics to the latest developments in ultramicroscopy, Michigan has a distinguished record of innovation in applied physics. With a broad range of multidisciplinary research and access to the most ad-

vanced facilities, the program offers a dynamic environment for graduate training. Doctoral research may be performed in any appropriate department under the supervision of any of the 120+ faculty participating in the Applied Physics Program. The opportunities and challenges for bridging science and technology have never been more exciting, nor the potential impact on our society's needs greater. The University of Michigan Applied Physics Program is committed to a leading role in this endeavor.

### Graduate

#### Admission Criteria for the Applied Physics Ph.D. Degree

The Applied Physics Program is designed for students intending to pursue coursework and research leading to the Ph.D. degree. Our students are usually eligible to receive a Masters degree in Applied Physics or Electrical Engineering at the time they become candidates for the Ph.D. degree.

A completed application and transcripts of all previous academic records must be on file.

The admission committee will take into account the applicant's background in the physical sciences, engineering physics and related disciplines. A good grounding in basic physics is expected with at least 15 hours of introductory and intermediate coursework in classical mechanics, statistical physics, electricity and magnetism and quantum physics. Graduate Record Examination general scores are required. Three letters of recommendation must be submitted. At least two of the letters must be from an academic institution. Students from non-English-speaking countries are required to demonstrate proficiency in English via the T.O.E.F.L. examination.

Applications will be processed for Fall Term admission. The deadline for applications for financial aid consideration is February 1.

## **Requirements for the Applied Physics Ph.D. Degree**

The curriculum leading to the Ph.D. degree in Applied Physics combines coursework in the fundamentals of physical theory, its applications to modern technology and practical "hands-on" training in the research laboratories.

Applied Physics is administered as an intercollegiate degree program with participating faculty in the College of Literature Science and the Arts and the College of Engineering and several other units of the University. General admission and degree requirements are administered by the Horace Rackham Graduate School.

The program is normally four to five years with an emphasis on coursework during the first two years. Students are encouraged to become involved in research at the earliest opportunity and are required to complete a supervised research project in their first year. When students complete the basic academic core, have satisfied the qualification procedure (see below), have formed a Dissertation Committee and have obtained approval for their Dissertation Prospectus, they are eligible for admission to Candidacy for the Ph.D. Candidacy is normally achieved after two or three semesters of graduate work.

### **Candidacy**

In order to achieve candidacy and form a dissertation committee, seven (7) prescribed 500-level courses must be passed with a grade "B" or better. In addition, four (4) elective courses (chosen in consultation with the program advisor according to the student's research needs) must be completed satisfactorily. Satisfactory completion of one (1) four-credit hour course on non-thesis research is also required, under the supervision of a faculty member. Prior approval by the program committee must be obtained before beginning this supervised research course. All first-, second- and third-year students are required to enroll in the weekly seminar course (AP 514).

## **Qualifying Procedure**

The decision to qualify a student for Ph.D. study is based on the student's academic record, performance in a four-credit hour supervised research project and the results of a qualifying examination. The qualifying examination is an oral examination, beginning with a brief presentation of the student's supervised research followed by questions on standard undergraduate-level physics. The student is expected to qualify within two years of entering the graduate program.

## **Preliminary Examination**

A preliminary examination of the plans for dissertation research will be made by the student's Dissertation Committee. The preliminary examination will take the form of a presentation to the committee of a Dissertation Prospectus stating the objectives and proposed methods of investigation. Over the signatures of the Dissertation Committee, the program committee will authorize the student to proceed with the thesis research.

Students normally will have formed their Dissertation Committee by the end of their fifth term in graduate school. Approval of the Dissertation Prospectus is a program requirement prior to Candidacy.

# Environmental Sustainability

## Administration Contact

ConsEnSus Program Coordinator  
Omolola Eniola-Adefeso  
B28-G046W NCRC  
(734) 936-0856  
[lolaa@umich.edu](mailto:lolaa@umich.edu)

## Overview

### Concentrations in Environmental Sustainability (ConsEnSus)

Implementation of sustainable engineering practices in industry has created a demand for engineers skilled in both rigorous disciplinary background (i.e. Civil, Chemical, Electrical, Mechanical, etc. engineering) and working knowledge of environmental regulations, policies and practices. The Concentrations in Environmental Sustainability (ConsEnSus) Program is designed to prepare students to meet this demand by providing the opportunity to pursue an MSE degree in a traditional engineering discipline coupled with advanced study in issues relating to engineering practices that will ensure environmental sustainability. The concentration comprises a coherent sequence of courses designed to enhance general environmental literacy and prepare students to integrate environmental principles into professional practice.

### Who is eligible?

Students must be enrolled in one of the participating five (5)\* College of Engineering departments to receive credit for the ConsEnSus Program. Participating departments include:

- Climate and Space Sciences and Engineering  
(A.O.S.S. department name change effective 9/1/15)

- Civil and Environmental Engineering
- Chemical Engineering
- Mechanical Engineering
- Naval Architecture and Marine Engineering

\*Additional departments may offer ConsEnSus at a later date.

### Program Requirements

Successful completion of the ConsEnSus Program requires twelve credits of coursework in environmental sustainability. Two (2) specific courses comprising six (6) credit hours are required of all ConsEnSus participants: CEE 586/NRE 557 Industrial Ecology or ME 599 Eco-Design and Manufacturing and CEE 686/ChE 686 Case Studies in Environmental Sustainability (or equivalent). The remaining six (6) of the credit hours may be selected from a list of approved courses. Courses are divided into three categories:

- Environmental Law and Regulations
- Environmental Assessment and Policy
- Environmental Science and Technology

The six (6) elective credit hours required for completion of the ConsEnSus concentration must be selected from at least two of the three (3) course categories, with a maximum of three credits from Environmental Law and Regulations and up to six (6) from Environmental Assessment and Policy.

---

# Engineering Sustainable Systems

## **Dual Degree: Master of Science in Natural Resources and the Environment and Master of Science in Engineering**

This dual-degree program between the College of Engineering and the School of Natural Resources and the Environment is a 54-credit program that provides graduate engineers with a comprehensive understanding of major sustainability challenges facing society in the 21st century including global climate changes, energy scarcity, ecological degradation, environmental threats to human health and resource scarcity. Students will achieve scientific literacy related to air, water and land pollution as well as ecological systems, energy systems and important regional/global cycles (e.g., material, nutrient, carbon, hydrologic). The program educates students in engineering design approaches for products, processes and services that facilitate the sustainable application of technology, and also provides students with the scientific knowledge and methods required to evaluate the sustainability of engineered systems. Currently three tracks exist in the fields of sustainable energy systems (M.E. and Ch.E.), sustainable design and manufacturing (M.E.) and sustainable water resources (C.E.E.).

## **Administration Contact**

Please go directly to the dual-degree website at S.N.R.E. to find out more about the program: [http://www.snre.umich.edu/degrees/masters/sustainable\\_systems/overview](http://www.snre.umich.edu/degrees/masters/sustainable_systems/overview)

# Integrative Systems + Design Division (ISD)

## Overview

Engineering is critically important in today's technology-driven society. Globalization, changing demographics, and rapidly evolving technologies are dramatically changing the nature of engineering practice, demanding broader skills than mastery of scientific and technological disciplines. These complex challenges call for an integrative approach that goes beyond a deep expertise in a single discipline and that blends engineering with the behavioral, business, and social sciences. Integrative Systems + Design (ISD) addresses these challenges by providing versatile, interdisciplinary educational programs for lifelong learning, including graduate degrees, short courses and certificates, with emphasis on systems and design thinking. ISD's programs horizontally integrate disciplinary knowledge across traditional fields of engineering with business and leadership skills. An important element is the capstone project that students complete individually or in teams, locally or through virtual global collaborations. Sponsoring companies offer project topics and work is conducted under faculty supervision. For students without significant work experience, the capstone project can be expanded into a practicum, a 3- to 6-month-long work-study at the sponsor's location guided by a faculty member and a local mentor. ISD programs are offered on campus and some degrees are available through online learning, creating a diverse learning community of students on campus and at locations around the world. ISD offers four Master's degree programs that can be completed entirely online. They are taught by the same U-M faculty using the same syllabi and offering the same content that is available to students on the Ann Arbor campus. ISD's graduates possess deep strengths in their engineering discipline, greater breadth in relevant engineering and science, and the ability to lead and innovate technical and design solutions for complex systems in a wide range of organizations and industries. Please visit the ISD website at [isd.engin.umich.edu](http://isd.engin.umich.edu).

## Department Administration

### Division Chair, Integrative Systems + Design

Professor Panos Papalambros  
2210 SI-North 1075 Beal Ave  
Ann Arbor, MI 48109-2112

### Associate Director

Diane Landsiedel  
2401 Plymouth Rd, Suite A-B  
Ann Arbor, MI 48109  
[dianelan@umich.edu](mailto:dianelan@umich.edu)

**Department Website:** <http://isd.engin.umich.edu/>

## Automotive Engineering

### Degree Programs

- Master of Engineering in Automotive Engineering
- Sequential Undergraduate/Graduate Study (SUGS)
  - B.S.E. Mechanical Engineering
  - M. Eng. in Automotive Engineering

### Master of Engineering in Automotive Engineering

The Master of Engineering in Automotive Engineering (M. Eng. in Auto. Eng.) blends engineering fundamentals and practice with an emphasis on systems thinking and the latest advances in technologies. The program provides students with a systems perspective and breadth of knowledge that cuts across departments, drawing upon many different engineering disciplines, such as mechanical engineering, chemical engineering, electrical engineering, computer science engineering, materials science, and industrial engineering. Students will deepen their knowledge of traditional mechanical engineering, but they can also take courses in electric machines, electronics, control systems, software development, and business. An important element of the program is a capstone project which offers students the opportunity to solve a real world problem with their new knowledge. The culminating project can be completed individually or on a team, virtually or locally, and in close interaction with faculty and industry lead-



ers. Graduates of the Automotive Engineering program are prepared to move the automotive industry further into the 21st Century and beyond. The M.Eng. in Automotive Engineering degree is available for on campus or online study.

For more information, please visit the ISD Automotive Engineering website at [isd.engin.umich.edu/AutoEng](http://isd.engin.umich.edu/AutoEng).

### **Sequential Undergraduate / Graduate Study**

*B.S.E. Mechanical Engineering*

*M. Eng. in Automotive Engineering*

This Sequential Undergraduate/Graduate Study (SUGS) program leads to a Master of Engineering in Automotive (M. Eng. in Auto. Eng.) sequentially with a Bachelor of Science (B.S.E.) in Mechanical Engineering. University of Michigan students who are pursuing a B.S.E. in Mechanical Engineering and who meet all the SUGS requirements may apply to the Automotive Engineering program to pursue the five-year SUGS program.

For more detailed information about the program, please visit the ISD website at: [isd.engin.umich.edu/degree-programs/automotive-engineering/sugs](http://isd.engin.umich.edu/degree-programs/automotive-engineering/sugs).

### **Online Learning**

The Master of Engineering in Automotive Engineering can be earned entirely online by qualified students from around the world. ISD has built upon the University of Michigan's experience in offering "distance learning" courses over several decades. Courses in ISD's programs are reengineered as Online-By-Design (OBD) where instructors and support staff deliver learning materials that purposefully take advantage of online tools to enrich the learning experience of students independently of their location on campus or remotely. To learn more about online learning with ISD, please visit the links below:

- Online Learning with ISD:  
[isd.engin.umich.edu/online-grad-programs](http://isd.engin.umich.edu/online-grad-programs)
- Latest Online Graduate Courses:  
[isd.engin.umich.edu/online-learning](http://isd.engin.umich.edu/online-learning)
- Online Learning FAQs:  
[isd.engin.umich.edu/online-faqs](http://isd.engin.umich.edu/online-faqs)

## **Design Science**

### **Degree Programs**

- Master of Science in Design Science
- Doctoral Program in Design Science

The new field of Design Science studies the creation of artifacts and their embedding in our physical, psychological, economic and social environment. Traditional science studies the world as we found it; design science studies the world as we make it. In an increasingly designed world, good design is the means to improving this world through innovative, sustainable products and services, creating value and reducing or eliminating the negative unintended consequences of technology deployment. The Design Science program is offered on campus in Ann Arbor.

#### **Master of Science in Design Science**

The Master of Science in Design Science was launched in 2015 to address modern product development that integrates engineering with the behavioral, business and social sciences. The program provides students flexibility in exploring across multiple disciplines to learn in-depth rigorous design methods and theory that drive the design process. Each student defines a custom program of study tailored to his or her background and design interests in consultation with a program advisor that includes at least two disciplines. This path integrates disciplines from top programs at the University of Michigan to balance rigorous coursework, trend-setting research and practica. In one year, graduates of the design science program are uniquely positioned to build bridges between key stakeholders bringing future employers in advanced industries and government settings the skills needed to meet the challenges of innovation in today's workplace.

#### **Doctoral Program in Design Science**

The Design Science Ph.D. is interdisciplinary in nature. In consultation with faculty advisors and the program committee, the student defines a custom program of study that has the right mix of disciplinary depth and interdisciplinary breadth and is tailored to his or her background and interests. At least two disciplines per-

meate the program of study. Students are required to take a core set of classes that teaches them integrative design processes and research methods, and then deepen their knowledge in two or more disciplines by leveraging courses available across the university. Advised by two faculty in their respective fields, students integrate their disciplines through cutting-edge research to advance the field of design science in their dissertations. Students are expected to complete a one-semester equivalent of practicum with an industrial or academic partner to further deepen their learning experience.

For more information about both degree programs, please visit the ISD Design Science website at: [isd.engin.umich.edu/design-science](http://isd.engin.umich.edu/design-science).

## Energy Systems Engineering

### Degree Programs

- Master of Engineering in Energy Systems Engineering
- Sequential Undergraduate/Graduate Study (SUGS)  
B.S.E. Chemical Engineering  
Master of Engineering in Energy Systems Engineering

**Master of Engineering in Energy Systems Engineering**  
The Master of Engineering in Energy Systems Engineering (ESE) degree program is designed for students who are ready to accept the grand challenge of energy in all its diverse forms and applications. It provides critical engineering skills in interlocking energy disciplines. Energy Systems is a multidisciplinary specialization that includes science, engineering, and the development of policies that promote sustainable systems. Students select from a wide array of courses to create an individual plan of study with a concentration in one of three areas: Energy Generation, Distribution and Usage; Transportation Power; or Sustainable Chemical Conversion. The program also covers basic management issues and enables students to develop their ability to lead project teams. There is a significant and industrially relevant capstone project supervised by faculty and with industry or government participation. ESE graduates possess strengths in their engineering discipline, breadth in relevant engineering and science and

understanding of the critical role of the environment in energy systems, including economic factors. The degree is available for on campus and online study. For more information, please visit the ISD Energy Systems Engineering website at: [isd.engin.umich.edu/ESE](http://isd.engin.umich.edu/ESE).

### Sequential Undergraduate/Graduate Study

*B.S.E. Chemical Engineering*

*Master of Engineering in Energy Systems Engineering*

This Sequential Undergraduate/Graduate Study (SUGS) program leads to a Master of Engineering in Energy Systems Engineering sequentially with a Bachelor of Science in Engineering (B.S.E.) in Chemical Engineering. University of Michigan students who are pursuing a B.S.E. in Chemical Engineering and who meet all the SUGS requirements may apply to the Energy Systems Engineering program to pursue the five-year SUGS program.

For more information, please visit the ISD website at: [isd.engin.umich.edu/ESE/sugs](http://isd.engin.umich.edu/ESE/sugs).

### Online Learning

The Master of Engineering in Energy Systems Engineering program can be earned entirely online by qualified students from around the world. ISD has built upon the University of Michigan's experience in offering "distance learning" courses over several decades. Courses in ISD programs are reengineered as Online-By-Design (OBD) where instructors and support staff deliver learning materials that purposefully take advantage of online tools to enrich the learning experience of students independently of their location on campus or remotely. To learn more about online learning with ISD, please visit the links below:

- Online Learning with ISD:  
[isd.engin.umich.edu/online-grad-programs](http://isd.engin.umich.edu/online-grad-programs)
- Latest Online Graduate Courses:  
[isd.engin.umich.edu/online-learning](http://isd.engin.umich.edu/online-learning)
- Online Learning FAQs:  
[isd.engin.umich.edu/online-faqs](http://isd.engin.umich.edu/online-faqs)

# Global Automotive and Manufacturing Engineering

## Degree Program

- Master of Engineering in Global Automotive and Manufacturing Engineering

### Master of Engineering in Global Automotive and Manufacturing Engineering

The Master of Engineering in Global Automotive and Manufacturing Engineering program (G.A.M.E.) is a one-of-a-kind engineering master's program that blends product development and manufacturing into a curriculum to address the integration challenges arising from the globalization of the automotive industry. The aim of the program is to develop technical leaders who have a holistic understanding of product creation and manufacturing, breadth across relevant engineering disciplines, depth in a key specialty area, and a global business sense with cross-cultural management and leadership skills. In collaboration with a faculty advisor, students will develop a custom plan of study composed of courses in systems integration, engineering, and business. Students select from a wide selection of courses for their specialization in areas such as advanced powertrains, vehicle manufacturing, advanced materials, electrification, intelligent vehicle systems and design, and vehicle performance and controls. Students must successfully satisfy a global component requirement through a capstone project that is either completed through a virtual, global collaboration or, in an industry setting in a location outside the student's native country. Sponsoring companies offer project topics and work is conducted under faculty supervision. GAME graduates possess a comprehensive knowledge in the product development and manufacturing of vehicles; a technical proficiency in automotive systems, systems integration, or manufacturing; an ability to apply sound global business concepts to engineering applications; and competence in building and leading diverse teams in terms of culture, business environment, and disciplinary perspective. The GAME degree is available for on campus and online study.

For more information, please visit the ISD GAME website at: [isd.engin.umich.edu/game](http://isd.engin.umich.edu/game)

### Online Learning

The Master of Engineering in Global Automotive and Manufacturing Engineering program can be earned entirely online by qualified students from around the world. ISD has built upon the University of Michigan's experience in offering "distance learning" courses over several decades. Courses in ISD's programs are reengineered as Online-By-Design (OBD) where instructors and support staff deliver learning materials that purposefully take advantage of online tools to enrich the learning experience of students independently of their location on campus or remotely. To learn more about online learning with ISD, please visit the links below:

- Online Learning with ISD:  
[isd.engin.umich.edu/online-grad-programs](http://isd.engin.umich.edu/online-grad-programs)
- Latest Online Graduate Courses:  
[isd.engin.umich.edu/online-learning](http://isd.engin.umich.edu/online-learning)
- Online Learning FAQs:  
[isd.engin.umich.edu/online-faqs](http://isd.engin.umich.edu/online-faqs)

## Manufacturing

### Degree Programs

- Master of Engineering in Manufacturing
- Dual Degree: Master of Engineering in Manufacturing / MBA
- Doctor of Engineering in Manufacturing
- Sequential Undergraduate/Graduate Study

### Master of Engineering in Manufacturing

The Master of Engineering in Manufacturing (MEM) is a graduate professional program designed for engineers who have already earned a B.S. in Engineering in any engineering discipline. The objective of the degree is to prepare these engineers for leadership roles in manufacturing. Students can choose from more than 80 courses offered through departments in the College of Engineering and the Ross School of Business. The degree can be earned in one calendar year, including a four-month team project in industry.

For more information, please visit the ISD MEM website at: **[isd.engin.umich.edu/mfgeng](http://isd.engin.umich.edu/mfgeng)**.

### *Team Project*

Students admitted to the MEM program must conduct an industry-relevant project related to manufacturing. There are several options for part-time and full-time students to complete the project requirement. Project opportunities will be discussed and developed upon admission to the program. One option for applicants planning to pursue the MEM program full-time is to apply to the Tauber Institute for Global Operations. The Tauber Institute assists students in finding projects in industry. To learn more about the Tauber Team Project option, please visit their website at: [tauber.umich.edu/prospective-students/elements-program/team-project](http://tauber.umich.edu/prospective-students/elements-program/team-project).

### **Online Learning**

The Master of Engineering in Manufacturing (MEM) program can be earned entirely online by qualified students from around the world. ISD has built upon the University of Michigan's experience in offering "distance learning" courses over several decades. Courses in ISD's programs are reengineered as Online-By-Design (OBD) where instructors and support staff deliver learning materials that purposefully take advantage of online tools to enrich the learning experience of students independently of their location on campus or remotely. To learn more about online learning with ISD, please visit the links below:

- Online Learning with ISD:  
**[isd.engin.umich.edu/online-grad-programs](http://isd.engin.umich.edu/online-grad-programs)**
- Latest Online Graduate Courses:  
**[isd.engin.umich.edu/online-learning](http://isd.engin.umich.edu/online-learning)**
- Online Learning FAQs:  
**[isd.engin.umich.edu/online-faqs](http://isd.engin.umich.edu/online-faqs)**

### **Dual Master of Engineering in Manufacturing/M.B.A.**

In this dual degree program, qualified students can pursue concurrent work in manufacturing engineering and business administration that leads to both a Master of Engineering in Manufacturing (MEM) from the College of Engineering and a Master of Business Admin-

istration (MBA) from the Ross School of Business. The program is arranged so that all requirements are satisfied simultaneously. The dual degree can be earned in two and one-half years by full-time students. It is also offered part-time through the Ross School of Business Evening Program.

Please visit the ISD website for more information at: **[isd.engin.umich.edu/mem-mba](http://isd.engin.umich.edu/mem-mba)**.

### **Doctor of Engineering in Manufacturing**

The Doctor of Engineering in Manufacturing (D. Eng. in Mfg.) is a graduate professional degree in engineering for students who already have earned a B.S.E. degree and an M.S.E. degree in any field of engineering or, a Master of Business Administration (MBA). Students work with a faculty advisor to develop a custom plan of study that blends engineering disciplines with management and business. An important element of the program is an industrially relevant, engineering practice-oriented dissertation that is supervised by a dissertation committee. Graduates of this doctoral program possess a depth of knowledge in manufacturing systems and the skills to carry out high quality engineering research and development.

To learn more, please visit the ISD Doctoral Program in Manufacturing at: **[isd.engin.umich.edu/mfgeng-doctorate](http://isd.engin.umich.edu/mfgeng-doctorate)**

## Sequential Undergraduate/Graduate Study (SUGS)

Sequential Undergraduate/Graduate Study programs (SUGS) are offered through the Manufacturing Engineering Program. This program leads to the Master of Engineering in Mfg. (MEM.) sequentially with a Bachelor of Science in Engineering (B.S.E.) through one of the following departments:

1. Aerospace Engineering (AERO)
2. Chemical Engineering (ChE)
3. Civil and Environmental Engineering (CEE)
4. Electrical Engineering and Computer Science (EECS)
5. Industrial and Operations Engineering (IOE)
6. Materials Science and Engineering (MSE)
7. Mechanical Engineering (ME)
8. Naval Architecture and Marine Engineering (NAME)

The eight engineering departments above participate in this program. Each department is represented on the Manufacturing Program Committee by a faculty member.

For more detailed information about the SUGS program, please visit the ISD website at:  
[isd.engin.umich.edu/degree-programs/mfgeng/sugs](http://isd.engin.umich.edu/degree-programs/mfgeng/sugs).

## Pharmaceutical Engineering

### Master of Engineering in Pharmaceutical Engineering

The Master of Engineering in Pharmaceutical Engineering is an interdisciplinary program of the College of Engineering and the College of Pharmacy at the University of Michigan. This program is dedicated to educate and train a new generation of scientists and engineers with an emphasis on fundamental scientific, technical and regulatory expertise. The program provides comprehensive training in medical product formulation and delivery, innovation and technologies; quality by design and engineering in product and process development; laboratory and process automation; science based regulatory requirements; and the application of computational tools and decision analysis. Opportunities and

expertise are provided to students through one of four core areas: Pharmaceutical Development Science, Biopharmaceutical Manufacturing Science, e-Clinical Science and Regulatory Science within the Pharmaceutical Engineering Program. Practical training is a key component. **Please note:** The Master of Engineering in Pharmaceutical Engineering degree is currently under review and revision by the College of Engineering. It is currently closed to applications for the Fall 2015 and beyond.

## Systems Engineering + Design

### Master of Engineering in Systems Engineering + Design

Complex systems require specialized knowledge and training on how to design and deploy engineered systems. The Master of Engineering in Systems Engineering + Design degree (SE+D) closes the gap between design and systems engineering in complex product development. The program couples creative synthesis (design domain) and systems analysis (systems engineering domain) in a multidisciplinary approach that prepares students to lead and discover innovative solutions for complex engineered systems. It blends design and engineering with human factors, organizational strategy, and social science thinking. All students in the SE+D program conduct a substantive, interdisciplinary and applied internship at a company location during their final semester. These internships, also called practicums, provide students the opportunity to apply their knowledge of the analysis, design, and operation of complex engineering systems and develop solutions for the integration issues involving cross-functional areas and multiple disciplines. Students will work on projects that are aligned with the company's business-critical needs and specifications involving areas such as products and processes.

University of Michigan faculty advisors guide and oversee the student's practicum and engage with the company project team before and during the internship. Usually, students work on an interdisciplinary project team directly under the supervision of the company sponsor. Taking on a pivotal role as the integrator and magnet for multidisciplinary resources, the student de-

velops practical experience in teamwork, along with a greater understanding of how to deploy discipline-related knowledge in complex systems. The scope and duration of the practicum depends on the company's expectations for deliverables. The internship can range from three to nine months and six to nine semester credit hours and can be paid or unpaid. SE+D students typically do their practicum from May to December at the conclusion of their degree program.

Graduates of the Systems Engineering and Design program leverage and augment their core engineering discipline expertise, possess a broad systems engineering perspective, have knowledge and capabilities in the analysis, design and operation of complex engineered systems, and are able to answer complex questions, deal with uncertainty, and integrate the social and human aspects in modern engineered systems. For more information, please visit the ISD SE+D website at: **[isd.engin.umich.edu/se+d](http://isd.engin.umich.edu/se+d)**.

# Macromolecular Science and Engineering

## Overview

Macromolecular Science and Engineering is an interdisciplinary program that provides the academic and research basis for studies in the science and technology of synthetic and natural macromolecules. Such large molecules exhibit unusual and specific properties as compared to small molecules and a large field has developed in unraveling the scientific foundations of this behavior, both in the synthetic and the biological areas.

The Program at UM is one of the very few where students can achieve competence in both the traditional discipline of their choice and the interdisciplinary field of Macromolecular Science and Engineering. It is a unique graduate program structure that allows a tailor fitting by the students to their individual interests while permitting the faculty to train the students in the Program to a high level of competence. A Ph.D. is offered in Macromolecular Science and Engineering with concentrations in the areas of Biomaterials Engineering, Biomedical Engineering, Chemistry, Chemical Engineering, Materials Science and Engineering, Organic Electronics or Physics. Other areas of interest include Electrical Engineering and Computer Science and Mechanical Engineering. The focus is mainly on the Ph.D., but Master's degrees are also granted.

The faculty members are drawn from the Colleges of Engineering, Literature Science and the Arts, the Dental School and the Medical School. The Macro Program is an interdisciplinary endeavor, permitting students to acquire a broad understanding of macromolecular science. The faculty believe the approach taken permits the students to eventually make a more significant contribution to macromolecular science. It also allows the students to develop the self-confidence needed to adapt to the changes inherent in modern research and development. The specific Program requirements include completing most of the course requirements prescribed in each option by the end of the second year, passing a two part comprehensive written examination, selection

of a research area and a Research Supervisor and Dissertation Committee.

There are also some general Ph.D. degree requirements set by the Rackham Graduate School.

Counseling on both the general and specific requirements is provided by an advisor representing the Executive Committee of the Macromolecular Science and Engineering Program. The advisor is designated through a selection process during the student's first month. The student then chooses among several major options: Biomaterials Engineering, Biomedical Engineering, Chemistry (organic or physical), Chemical Engineering, Materials Science and Engineering, Organic Electronics or Physics. An individualized option is also available.

The progress to a Ph.D. is normally four- to five-years with coursework being emphasized during the first two years. Students are approved for candidacy after they have completed the basic prescribed courses satisfactorily, passed the comprehensive exam, formed a Dissertation Committee and passed a preliminary oral examination by that Committee. Candidacy is usually achieved within four terms.

## Program Administration Contact

**Program Director:** Richard M. Laine  
Professor of Materials Science and Engineering, Chemistry; Professor and Director of Macromolecular Science and Engineering  
Email: [talsdad@umich.edu](mailto:talsdad@umich.edu)

2300 Hayward Street  
3062C HH Dow Bldg.  
Ann Arbor, MI 48109  
Phone: 734-763-2316  
Fax: 734-763-0459

Website: <http://macromolecular.umich.edu/>

## Sequential Undergraduate Study (SUGS)

The Macro Program offers SUGS degrees in collaboration with several participating departments (BiomedE, ChemE, Chemistry, MSE, ME and Physics). These degrees make it possible for students to receive both a B.S.E. and M.S. degree in an accelerated fashion.

### Research

An early start in research is encouraged as soon as the students have demonstrated satisfactory progress in courses and have selected a Research Supervisor. The interdisciplinary nature of the Program allows for a wide range of research possibilities.

### Representative Ph.D. Course Programs

It is recommended that in all the options an introductory course such as MacroSE 412 be taken as part of these credits by all students who do not have a strong polymer background. The majority of the option courses taken should be 500- level or above. See "Course Descriptions" for individual course information at <http://www.engin.umich.edu/college/academics/bulletin/courses>. The following course plans are suggestions from Macro faculty for good academic training.

#### Biomaterials Engineering Option

A minimum of 30 hours of course work from Biomaterials Engineering and Macromolecular Science Courses. This must include a minimum of 12 hours from Biomaterials and 12 hours from MacroSE. These courses must include a graduate course in biomaterials, biochemistry and biophysics.

#### Biomedical Engineering Option

A minimum of 30 hours of course work from Biomedical Engineering and Macromolecular Science Courses. This must include a minimum of 12 hours from Biomedical Engineering and 12 hours from MacroSE.

These courses must include a graduate course in biomaterials, biochemistry and/or biophysics and biomedical engineering.

#### Chemistry Option (Synthetic or Physical)

A minimum of 30 hours of course work from Chemistry and Macromolecular Science Courses. This must include a minimum of 12 hours from Chemistry and 12 hours from MacroSE.

For a Synthetic option, these courses must include: MacroSE 790, MacroSE 800, MacroSE 536, MacroSE 538, two courses from Chem 507, 540, 541 or 543, and one from Chem 511, 542 or 616.

For a Physical option, these courses must include: MacroSE 790, MacroSE 800, MacroSE 536, Chem 571, Chem 576, Chem 580 and another approved Chemistry course.

#### Chemical Engineering Option

A minimum of 30 hours of course work from Chemical Engineering and Macromolecular Science courses. This must include a minimum of 12 hours from ChE and 12 hours from Macromolecular Science. These courses must include: MacroSE 790, MacroSE 800, MacroSE 535 or MSE 412 or 512, MacroSE 536, ChE 528, graduate courses in transport phenomena, numerical methods or mathematical modeling and polymer processing.

#### Materials Science and Engineering Option

A minimum of 30 hours of course work from Materials Science and Engineering and Macromolecular Science courses. This must include a minimum of 12 hours from MSE and 12 hours from MacroSE.

These courses must include: MacroSE 790, MacroSE 800, MacroSE 535 or MSE 412 or 512, MacroSE 536, a graduate course in metals and a graduate course in ceramics.



**Physics Option**

A minimum of 30 hours of course work from Physics and Macromolecular Science courses. This must include a minimum of 12 hours from Physics and 12 hours from MacroSE.

These courses must include: MacroSE 790, MacroSE 800, MacroSE 536, graduate Physics or Applied Physics courses, and an advanced course in physical properties of polymers.

**Individualized Options**

An individualized option may be proposed by students. Such students must submit a detailed program in writing to the Executive Committee for approval.

# The Robotics Program

## Overview

<http://robotics.umich.edu/academic-program/>

The Robotics program welcomed its first class of students in Fall 2014! Robotics is part of an interdisciplinary effort to bring together the many disciplines that contribute to research on robotics. Robotics is the design, creation, analysis, and use of embodied computational systems that interact with the physical and human environment. The study of robotics and its place in the world draws on many fields of engineering, including computer science, mechanical engineering, artificial intelligence, computer vision, electrical engineering, control systems, human-robot/computer interaction, and biomedical engineering. Robotics will integrate knowledge from these fields for applications to Robotics.

U-M Robotics currently offers Masters and Ph.D. degrees. Both programs share a common set of course requirements. Ph.D. students must additionally complete a set of qualifying exams to become Ph.D. candidates, and then complete a thesis.

This program will have three main core technical areas. These three areas are integrated in order to implement a functioning robot: (1) Sensing of the environment, external agents, and internal body information to determine state information, (2) Reasoning with that information to make decisions for guidance, control, and localization, and (3) Acting upon the body and environment to produce motion or other outputs that enable the robot to locomote or interact with the environment. Each of these areas may be considered a subplan for coursework and research study. The goal of the proposed Robotics Program is to train students to be independent researchers and engineers, and future leaders in robotics research, in academia, industry and government.

## Contact

General Email: [robotics@umich.edu](mailto:robotics@umich.edu)

Faculty: <http://robotics.umich.edu/faculty/>

## Course Requirements (Masters and Ph.D.)

The Robotics Masters (M.S.) degree program requires completion of 30 credits of letter-graded coursework including directed study for three (3) to six (6) credits. Ph.D. programs have very similar course requirements. Ph.D. students earn a Masters degree as part of their Ph.D. program. To complete the Ph.D., students will typically complete a minimum of six (6) additional credits to satisfy specific course requirements. The Rackham Residency requirement states that at least 18 of the 36 course credits required for a Ph.D. be earned at the University of Michigan, for those entering with M.S. degrees from other institutions.

The robotics program classifies most of its courses as belonging to one of three core subdisciplines:

- Sensing – Includes computer vision, mapping, signal processing
- Reasoning – Includes planning, multi-agent coordination, machine learning, artificial intelligence
- Acting – Includes control, kinematics, dynamics, mechanical, bio-mechanical systems design, manipulation, real-time systems

Note: For a list of approved courses go to:

<http://robotics.umich.edu/academic-program/>

The following table summarizes robotics program course requirements. The “Other Electives” course set is quite general and should be discussed with a student’s advisor and documented on the student’s course plan. Some suggested math and robotics courses hosted in traditional departments are listed at: <http://robotics.umich.edu/academic-program/requirements-obtain-ph-d-m-s-robotics/possible-elective-courses/>

Course / Category	Description	Requirement
ROB 501	Math for Robotics	3 credits
ROB 550	Robotic Systems Laboratory	4 credits
Breadth	One course from each core area: sensing, reasoning, acting	3 courses (9+ credits)
Cognate	One technical course from <i>outside</i> the core areas	4 credits
Directed Study	Research supervised by a robotics faculty member	3+ credits
Other Electives (PhD only)	400 level or higher (approved by a faculty advisor)	3+ credits

## 1st Year Students

All first-year M.S. and Ph.D. robotics students are advised to take three (3) courses in the first (fall) semester: Math for Robotics (ROB 501), Robotic Systems Laboratory (ROB 550), plus a third course related to their primary area of interest. In the second term, students are advised to take two (2) courses, e.g., from other breadth areas, plus a directed study course.

Each student is strongly encouraged to meet with his/her research advisor or the graduate chair soon after arrival on campus to discuss course options. The goal of this meeting is to develop a course plan that satisfies course requirements and student interests. It is ex-

pected that each student will identify and meet with a (directed study) research advisor by the beginning of their second term.

## Qualification Process (Ph.D.)

A major milestone for Ph.D. students is to pass the qualifying exams, which advances the student to Ph.D. candidate status. The qualification process is comprised of a review of academic performance, technical qualifying exam, and a research preliminary exam. A Ph.D. student is considered to have adequate performance in coursework if his/her grade-point average is 3.5 or above. Both components of the exam are typically completed after three semesters in the program.

### *Technical Qualifying Exam*

This is an oral exam in which the student is examined by two faculty members. The faculty will examine the student’s understanding of technical fundamentals gained from coursework.

### *Research Preliminary Exam*

The student delivers an oral presentation describing a research problem. Following the presentation (which may focus, for example, on a literature review, a replication study, or original research), two faculty members will question the student on their understanding of their subject.

## Thesis Proposal and Defense (Ph.D.)

Ph.D. students must propose, write, and defend a thesis on an original research topic. At least a year prior to the final thesis defense, the student must defend a proposal to the Ph.D. committee.

# Michigan Engineering Offices

<b>Michigan Engineering Offices (area code 734)</b>	
General Information: <a href="http://www.engin.umich.edu">www.engin.umich.edu</a>	647-7000
Academic Records and Services (Withdrawal/Disenrollment), 145 A Chrysler Center	647-7111
CAEN, Main Office, 1315 Duderstadt Center	764-CAEN
CAPS Embedded Counselor, Engineering	764-8312
Center for Engineering Diversity and Outreach (CEDO), 1108 LEC	647-7120
Center for Entrepreneurship (CFE), 3350 Duderstadt Center	763-1021
Engineering Career Resource Center (students and alumni), 230 Chrysler Center	647-7160
Engineering Learning Center (ELC), 273 Chrysler Center	615-8438
Engineering Advising Center (EAC), 230 Chrysler Center	647-7106
Engineering Scholarship Office, 143 Chrysler Center	647-7113
Engineering Student Organizations, 143 Chrysler Center	647-7155
Integrative Systems + Design, 2214 SI-North	647-7024
Office of Graduate Education, 1240 LEC	647-7077
International Programs in Engineering Office (IPE), 245 Chrysler Center	647-7129
Multidisciplinary Design Program (MDP), 203 Gorguze Family Laboratory	763-7421
Office of Student Affairs (OSA), 143 Chrysler Center	647-7118
Office of Student Support and Accountability (OSSA)	615-1405
Recruitment and Transfer Admissions, 153 Chrysler Center	647-7101
Scholastic Standing Committee, 129 Chrysler Center	647-7106
Undergraduate Education, 1261 LEC	647-7150
Wilson Student Team Project Center	615-6400
Women in Science & Engineering Program (WISE), 3236 Undergraduate Science Building	615-4455

# University of Michigan

## University of Michigan Offices (area code 734)

Admissions, Undergraduate, 1220 Student Activities Bldg. (SAB)	764-7433
Campus Information Center	764-INFO
Career Center, 3200 Student Activities Building (SAB)	764-7460
Cashier's Office, 2226 Student Activities Building (SAB)	764-7447
Counseling and Psychological Services, 3100 Michigan Union	764-8312
English Language Institute, 555 S. Forrest Ave.	764-2413
Employment:	
Student, 2500 Student Activities Building (SAB)	763-4128
Hospital, 2901 Hubbard, Suite 1100	647-5538
Recruitment and Employment, G250 Wolverine Tower	615-2000
Temporary Staffing Services, 3003 S. State St. #250	763-5740
Financial Aid, 2500 SAB	763-6600
Graduate School, Rackham Bldg., 915 E. Washington Admissions	764-8129
Housing Information Services, 1011 Student Activities Building (SAB):	763-3164
International Center, Central Campus, 603 E. Madison	764-9310
International Institute, 1080 South University Ave., Suite 2660	
Ombuds, 6015 Fleming Bldg.	763-3545
Office of New Student Programs, 1100 LSA	764-6413
Orientation	
University Mentorship Program	
Arts at Michigan	
Welcome to Michigan	
Office of the President, 2074 Fleming Bldg.	764-6270
Office of the Provost, 3074 Fleming Bldg.	764-9290
Office of Student Conflict Resolution, 100 SAB	936-6308
Office of the Vice President and Secretary of the University, 2013 Fleming Bldg.	763-5553
Services for Students with Disabilities (SSD), G-664 Haven Hall	763-3000
Student Financial Operations (Room, Board, and Tuition), 2226 SAB	764-7447
Student Activities and Leadership, 2205 Michigan Union	763-5900
Student Legal Services, 715 N. University, Suite 202	763-9920
University Health Service, 207 Fletcher	764-8325
Appointments	764-8320
Information	
Veterans and Military Services Program (VMSP), 1100 LSA	764-6413
Veterans Benefits, Office of the Registrar, 1207 LSA	763-9066

# Index

<b>A</b>	
Academic Calendar .....	5
Academic Honors and Awards .....	28
Academic Rules, Rights and Responsibilities.....	15
General Standards of Conduct .....	15
Grievances Procedures .....	29
Honor Code .....	15
Registration, Grades and Policies (Policies: Add/Drop/Modify, Term Withdrawal, Optional Pass/Fail Course/Credit Limits, Academic Definitions, Declaring (or changing) Major, Repeating Courses) .....	18
Scholastic Standing Committee .....	29
Statement of Student Rights and Responsibilities .....	17
Accreditation.....	9
Aerospace Engineering .....	61
Contacts.....	61
Graduate Education.....	65
Sample Schedule .....	64
Sequential Undergraduate/Graduate Study (SUGS) .....	65
Undergraduate Education.....	62
Applied Physics .....	154
Contacts.....	154
Graduate Education.....	154
<b>B</b>	
Biomedical Engineering.....	68
Contacts.....	68
Concentrations .....	71
Graduate Education.....	72
Sample Schedule.....	70
Sequential Undergraduate/Graduate Study (SUGS) .....	71
Undergraduate Education .....	69
<b>C</b>	
Chemical Engineering .....	74
Contacts .....	74
Concentrations .....	77
Graduate Education .....	78
Sample Schedule.....	76
Sequential Undergraduate/Graduate Study (SUGS) .....	77
Undergraduate Education .....	74
Civil Engineering & Environmental Engineering....	79
Contacts .....	79
Civil Engineering Focus Areas .....	82
Civil Engineering Sample Schedule .....	84
Environmental Engineering Sample Schedule....	85
Graduate Education .....	86
Program in Sustainable Engineering.....	86
Sequential Undergraduate/Graduate Study (SUGS) .....	86
Undergraduate Education .....	79
Climate & Space Sciences Engineering.....	91
Contacts .....	91
Climate and Meteorology Sample Schedule.....	93
Concentrations .....	94
Graduate Education .....	97
Minor .....	96
Space Sciences & Engineering Sample Schedule.....	95
Sequential Undergraduate/Graduate Study (SUGS) .....	96

Undergraduate Education.....	91
Computer Engineering, Computer Science and Electrical Engineering.....	100
Contacts.....	100
Computer Engineering Sample Schedule .....	105
Computer Science Sample Schedule.....	106
Electrical Engineering Sample Schedule .....	107
Graduate Education.....	108
Sequential Undergraduate/Graduate Study (SUGS) .....	108
Undergraduate Education.....	103
Credits .....	3

## D

Data Science.....	112
Contacts.....	112
Sample Schedule .....	114
Graduate Education.....	115
Degree Requirements.....	32
Dismissal.....	31
Drop/Modify Deadlines .....	6

## E

Education Abroad .....	50
Engineering Physics.....	116
Contacts.....	116
Sample Schedule .....	117
Undergraduate Education.....	116
Engineering Sustainable Systems .....	157
Contact .....	157
Graduate Education.....	157
Enrollment Withheld.....	30
Environmental Sustainability (ConsEnSus).....	156
Contacts.....	156
Graduate Education.....	156

## G

General Information.....	7
Accreditation.....	9
Degree Programs .....	8
Departments .....	8
General Electives .....	41
Graduate Education .....	58
Admissions .....	58
Degree Options .....	59
Funding and Fellowships.....	60
Grievances Procedures.....	29

## I

Incompletes.....	27
Industrial and Operations Engineering .....	118
Contacts .....	118
Focus Areas .....	121
Graduate Education .....	122
Sample Schedule.....	120
Sequential Undergraduate/Graduate Study (SUGS) .....	121
Undergraduate Education .....	119
Integrative Systems + Design Division (IS+D) .....	158
Contacts .....	158
Automotive Engineering.....	158
Design Science.....	159
Energy Systems Engineering .....	160
Global Automotive and Manufacturing Engineering.....	161
Manufacturing.....	161
Pharmaceutical Engineering .....	163
Systems Engineering + Design .....	163
Undergraduate Education .....	158
Intellectual Breadth Requirements.....	38

Introduction.....	1
-------------------	---

## M

Macromolecular Science and Engineering.....	165
Contacts.....	165
Sequential Undergraduate/Graduate	
Study (SUGS) .....	166
Mandatory Leaves.....	31
Materials Science and Engineering.....	125
Contacts.....	126
Graduate Education.....	128
Sample Schedule .....	127
Sequential Undergraduate/Graduate	
Study (SUGS) .....	128
Mechanical Engineering .....	130
Contacts.....	130
Graduate Education.....	135
Sample Schedule .....	132
Sequential Undergraduate/Graduate	
Study (SUGS) .....	134
Undergraduate Education.....	133
Military Officer Education Programs .....	149
Air Force Office Education Program .....	151
Army Officer Education Program.....	149
Navy Office Education Program.....	152
Minors	
Art & Design Minor.....	57
Climate and Space Sciences and Engineering ....	51
Community Action and Social Change (School of	
Social Work .....	57
International Minors for Engineers .....	52
LSA Academic Minors .....	56
Minor in Business (Ross School of Business) ....	57
Minor in Electrical Engineering.....	52

Minor in Environmental Engineering .....	53
--	----

Minor in Naval Engineering .....	53
----------------------------------	----

Multidisciplinary Design Minor .....	54
--------------------------------------	----

## N

Naval Architecture and Marine Engineering .....	136
Contacts .....	137
Graduate Education .....	140
Sample Schedule.....	139
Sequential Undergraduate/Graduate	
Study (SUGS) .....	140
Undergraduate Education .....	138
Nuclear Engineering and Radiological	
Science .....	142
Contacts .....	142
Graduate Education .....	145
Sample Schedule.....	144
Sequential Undergraduate/Graduate	
Study (SUGS) .....	145
Undergraduate Education .....	142

## O

CoE Directory.....	170
University of Michigan Directory.....	171

## P

Probation.....	30
Program in Sustainable Engineering (PISE)	
(Supplemental Studies) .....	55,86

## R

Repeating Courses .....	27
Robotics Program .....	168
Contacts .....	168
Graduate Education .....	168



**S**

Scholastic Standing Committee .....	29
-------------------------------------	----

**T**

Transfer Credit Information .....	23
-----------------------------------	----

Transfers and Withdrawals, Readmission.....	24
---	----

**U**

Undergraduate Admissions .....	10
--------------------------------	----

Advanced Placement.....	10
-------------------------	----

Foreign Languages.....	11
------------------------	----

Readmission .....	13
-------------------	----

Special Student Status .....	13
------------------------------	----

Transfer Credit .....	11
-----------------------	----

Undergraduate Education.....	34
------------------------------	----

Combined BSE/Master's Programs .....	47
--------------------------------------	----

    Combined Degree in Art & Design

And Engineering .....	46
-----------------------	----

Combined Degree in Music and Engineering .....	46
--	----

Combined Degree Programs .....	43
--------------------------------	----

Cooperative Education.....	49
----------------------------	----

Core CoE Requirements.....	35
----------------------------	----

Definition of Liberal Arts Courses.....	40
---	----

Degree Options .....	42
----------------------	----

Dual Baccalaureate Degree .....	43
---------------------------------	----

Education Abroad .....	50
------------------------	----

    Engineering Global Leadership Honors

Program (EGL) .....	47
---------------------	----

Honors Programs .....	47
-----------------------	----

    Sequential Undergraduate/Graduate

Study (SUGS) .....	47
--------------------	----

    Undergraduate Research Opportunity

Program (UROP) .....	51
----------------------	----





2015-2016  
**BULLETIN**

**M** | MICHIGAN ENGINEERING  
UNIVERSITY OF MICHIGAN