



This is the College of Science and Engineering section of the 2005-2007 Duluth Catalog for the University of Minnesota

Contents

College of Science and Engineering (CSE) 175

Admission 175

Dean’s List of Academic Excellence 175

College Honors 175

Honors Programs 175

Academic Standing 176

Student Affairs Office 176

Baccalaureate Degrees 176

 B.S. Requirements 176

 B.S.Ch.E. Requirements 177

 B.S.E.C.E. Requirements 177

 B.S.I.E. Requirements 177

 B.S.M.E. Requirements 178

Collegiate Graduate Program 178

 Master of Environmental Health and Safety 178

Preprofessional Programs 179

 Pre-Dentistry 179

 Pre-Medicine 180

 Pre-Optometry 180

 Pre-Pharmacy 181

 Pre-Veterinary Medicine 181

 Pre-Engineering 181

 Pre-Fisheries and Wildlife Management 182

Degree Programs 183

 Aerospace Studies 183

 Aerospace Minor Only 183

 Astronomy 184

 Biochemistry and Molecular Biology B.S. 184

 Biology 185

 B.A.—CLA 185

 B.S. 185

 Cell Biology B.S. 186

 Chemical Engineering B.S.Ch.E. 187

Chemistry 188

 B.A.—CLA 189

 B.S. 189

Computer Science B.S. 190

Computer Science—Applied Minor Only 191

Electrical and Computer Engineering

 B.S.E.C.E. 191

Environmental Engineering Minor Only ... 193

Geological Sciences 193

 B.A.—CLA 193

 B.S. 194

Industrial Engineering B.S.I.E. 194

Information Systems and Technology B.S. 197

Limnology Minor Only 197

Mathematics 198

 B.A.—CLA 198

 Mathematics—Applied Mathematics

 B.S. 198

 Mathematics—Computational Mathematics B.S. 199

 Mathematics—Double Major B.S. 200

 Mathematics—Statistics and Actuarial Science B.S. 200

 Mathematics—Traditional Mathematics

 B.S. 201

Mechanical Engineering B.S.M.E. 201

Physical Science 203

Teaching Physical Science Major (B.A.S.) 203

Physics 203

 B.A.—CLA 203

 B.S. 204

 Applied Physics B.S. 205

 Teaching Physics, 9-12 205

Statistics 205

The College of Science and Engineering is committed to providing opportunities to learn through participation in research, honors programs, individual study, and special seminars.

College of Science and Engineering (CSE)

Dean: James Riehl, 140 Engineering Building, 218-726-6397

Associate Dean: Timothy B. Holst, 140 Engineering Building, 218-726-7585

The College of Science and Engineering has a fourfold mission: help each student develop a foundation for a career by learning the substance and methods of an academic discipline; participate fully in the liberal education mission of the campus; foster significant scholarly research; and serve the well-being of the community, state, and region. The college offers students a broad range of curricula covering the natural sciences, mathematical sciences, engineering, and technology.

Each student is provided the opportunity to develop competence in a special field of knowledge by learning its principles and perspectives, mastering its methods, and acquiring much of its accumulated knowledge.

In addition to offering formal coursework, the college is committed to providing students with opportunities to learn through participation in research, honors programs, individual study, and special seminars. Such programs, which emphasize undergraduate education, are enhanced and complemented by high quality graduate programs. These graduate programs form an integral component of our commitment to scholarship.

Several departments also offer master's degrees through the Graduate School.

Admission

The college has no specific secondary school preparation requirements for admission beyond the preparation standards of the University of Minnesota. However, secondary school students contemplating a baccalaureate degree in a physical or biological science, mathematics, computer science, or engineering are strongly urged to complete a college preparatory program that includes four years (grades 9-12) each of English, mathematics, and science.

The engineering programs have specific college-level course requirements and minimum GPAs that must be satisfied before students can be admitted into the upper division (junior and senior level) program.

For general admission information, see Policies and Procedures.

Dean's List of Academic Excellence

Each semester, CSE students are recognized for high academic achievement by being placed on the CSE Dean's List of Academic Excellence. A memo is placed on their transcript indicating this achievement. To be eligible for this honor, students must have a 3.50 minimum term GPA and 12 graded credits. Incompletes and grades of N or F disqualify students from eligibility.

College Honors

At UMD a maximum of 15 percent of the graduating class can graduate with college honors. In CSE the top 3 percent of the graduating class is designated *summa cum laude*, the next 5 percent *magna cum laude*, and the next 7 percent *cum laude*.

At the beginning of each year, GPAs necessary to achieve these honors are posted in the Student Affairs Office, 140 Engineering Building. The GPAs are based on the previous spring semester graduating class. In addition, students receiving honors must have a coefficient of course completion of at least 90 percent. To be eligible for honors, students must earn at least 30 credits at UMD. For more information, contact the Office of the Associate Dean, 140 Engineering Building.

Honors Programs

The objective of the CSE honors programs is to offer superior ability, highly motivated students a greater challenge than is available through the traditional curriculum. Honors opportunities provide for closer student-faculty relationships, emphasize writing and speaking skills, and offer active learning in the disciplinary and interdisciplinary components.

In the lower division, honors opportunities include seminars and special sections of lecture and lab courses. Students may participate in these by invitation or by consent of the instructor.

Honors opportunities in the upper division are available for students in all departments. Department honors candidates are selected on the basis of coursework completed and potential for independent work. A research project is required.

More information about department honors is available through the departments.

Academic Standing

Good Academic Standing

CSE requires that its students maintain a minimum cumulative GPA to be in good academic standing. For students who have attempted 20 or more credits the minimum cumulative GPA is 2.00. Because some students have difficulty adjusting to the standards of a university education, students who have attempted fewer than 20 credits (at UMD or elsewhere) must maintain a minimum cumulative GPA of 1.80 to remain in good academic standing.

Probation

Students with a cumulative GPA lower than that required for good academic standing are placed on academic probation. If at the end of a semester on academic probation the cumulative GPA is at or above 2.00, the student will be returned to good academic standing. In addition, any student with a GPA of less than 2.00 for two successive terms, even if the cumulative GPA is above 2.00, will be on academic probation.

Dismissal

If, after a semester of probation, a student fails to attain the required minimum cumulative GPA for good academic standing, the student is subject to dismissal. Dismissal decisions are made in the college office following fall and spring semester final exams. Dismissed students are notified immediately and their registration as a CSE student for the next semester is canceled. Students failing to attain the minimum GPA, yet making academic progress, may be granted an additional semester of probation at the discretion of the college.

Readmission

Students who have been academically dismissed from CSE must present evidence of improved academic capability to the college to justify readmission. Petition forms for readmission and information concerning academic standing are available in the CSE Student Affairs Office, 140 Engineering Building.

Student Affairs Office

Information on academic matters, including academic standing; admission; advising; academic programs; change of major, college, or adviser; grievance and appeals procedures; honors programs; undergraduate research;

student clubs; and tutoring is available in the CSE Student Affairs Office, 140 Engineering Building.

Baccalaureate Degrees

CSE offers the bachelor of science (B.S.), bachelor of science in chemical engineering (B.S.Ch.E.), bachelor of science in electrical and computer engineering (B.S.E.C.E.), bachelor of science in industrial engineering (B.S.I.E.), and bachelor of science in mechanical engineering (B.S.M.E.) degrees.

B.S. Majors

Biochemistry/molecular biology
Biology
Cell biology
Chemistry
Computer science
Geological sciences
Information systems and technology
Mathematics
 Applied mathematics
 Computational
 Double major
 Statistics and actuarial science
 Traditional
Physics
Applied physics

Minors

Aerospace studies
Biology
Chemistry
Computer science
Computer science, applied
Electrical and computer engineering
Environmental engineering
Geological sciences
Information systems and technology
Limnology
Mathematics
Mathematics, applied
Physics

For other minors available to students receiving a B.S., see Labovitz School of Business and Economics, School of Fine Arts, College of Education and Human Service Professions, and College of Liberal Arts.

B.S. Requirements

- Completion of at least 120 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion at UMD of at least 20 of the last 30 degree credits immediately before graduation.
- Completion of a major for the B.S. and a minor or second major in a different program. A 2.00 minimum GPA in the major, including supporting courses, and a 2.00 minimum GPA in the minor, including supporting courses.

- Completion of UMD liberal education requirements. See Liberal Education Program
- A 2.00 minimum GPA in all work attempted at UMD; a 2.00 minimum GPA in all work, including transfer credits; and successful completion of 75 percent of all work attempted.
- If there are multiple majors and/or minors, this requirement holds for each major and minor, calculated separately.

For students completing two or more majors:

- A minor is not required.
- If the majors are for different degrees (e.g., a B.S. and a B.A.), the majors must be in different programs (e.g., a student may not receive a B.S. in chemistry and a B.A. in chemistry) and students must complete requirements for both degrees.
- Compliance with general regulations governing granting of degrees.

B.S.Ch.E. Requirements

- Completion of at least 130 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion at UMD of at least 20 of the last 30 degree credits immediately before graduation.
- A 2.00 minimum GPA in all work attempted at UMD; a 2.00 minimum GPA in all work, including transfer credits; and successful completion of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Liberal Education Program.
- Completion of the chemical engineering major. Admission to the upper division program of the chemical engineering major is competitive and on a space-available basis. Application for admission to upper division must be filed with the department upon completion of lower division requirements.
- A 2.00 minimum GPA in all courses taken in the chemical engineering major, including required courses in related fields. This GPA requirement applies to all courses in the major taken at UMD calculated separately and also to all courses in the major when transfer credits are included.
- Compliance with general regulations governing granting of degrees.

B.S.E.C.E. Requirements

- Completion of at least 130 degree credits.
- Completion of at least 30 degree credits at UMD.

- Completion at UMD of at least 20 of the last 30 degree credits immediately before graduation.
- Completion of the electrical and computer engineering major. Admission to the upper division program is competitive and on a space available basis. A minimum GPA of 2.00 in all work attempted at UMD, successful completion (with grades of A through D, or S) of 75 percent of all work attempted, and a minimum GPA of 2.00 (C) overall (including transfer credits) are required for admission to the electrical and computer engineering (ECE) upper division program.
- Completion of UMD and ECE liberal education requirements.
- A minimum GPA of 2.00 for all courses taken in the major, including required supporting courses. This average applies to all courses in the major taken at UMD and calculated separately and also to all courses in the major when transfer credits are included.
- Compliance with general regulations governing granting of degrees.

B.S.I.E. Requirements

- Completion of at least 127-131 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion at UMD of at least 20 of the last 30 degree credits immediately before graduation.
- Grades of C- or better are required in all program courses. Transfer grades must be a C or better.
- A 2.00 minimum GPA (C) in all work attempted at UMD; a 2.00 minimum GPA in all work, including transfer credits; and successful completion of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Liberal Education Program. Courses for Categories 9 and 10 must have different designators.
- Completion of the industrial engineering major. Admission to the upper division program of the industrial engineering major is competitive and on a space-available basis. Application for admission to upper division must be filed with the department upon completion of lower division requirements.
- A 2.00 minimum GPA in all courses taken in the industrial engineering major, including required courses in related fields. This GPA requirement applies to all courses in the major taken at UMD calculated separately and also to all courses in the major when transfer credits are included.

- Compliance with general regulations governing granting of degrees.

B.S.M.E. Requirements

- Completion of at least 126-129 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion at UMD of at least 20 of the last 30 degree credits immediately before graduation.
- Grades of C- or better is required in all program courses. Transfer grades must be a C or better.
- A 2.00 minimum GPA (C) in all work attempted at UMD; a 2.00 minimum GPA in all work, including transfer credits; and successful completion of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Liberal Education Program. Courses for Categories 9 and 10 courses must have different designators.
- Completion of the mechanical engineering major. Admission to the upper division program of the mechanical engineering major is competitive and on a space-available basis. Application for admission to upper division must be filed with the department upon completion of lower division requirements.
- A 2.00 minimum GPA in all courses taken in the mechanical engineering major, including required courses in related fields. This GPA requirement applies to all courses in the major taken at UMD calculated separately and also to all courses in the major when transfer credits are included.
- Compliance with general regulations governing granting of degrees.

Collegiate Graduate Program

Master of Environmental Health and Safety

Professor: David A. Wyrick; *Associate Professors:* Hamid Fonooni, Director, 218-726-8117, Dale Krageschmidt; *Assistant Professor:* Daniel N. Pope

The M.E.H.S. program prepares graduates for professional careers in environmental health and safety, which include occupational safety, industrial hygiene, ergonomics, risk management, and environmental health. The coursework includes analysis of occupational safety and health problems; accompanying problem-

solving and decision-making techniques; and the application of established principles and practices of accident prevention, control, and reduction in occupational settings.

Admission Requirements

Applicants must have a baccalaureate degree from an accredited college or university, preferably with a major in technology, engineering, science, or another appropriate field. Baccalaureate degree holders with different majors who have relevant backgrounds or qualifications are also considered. A general chemistry course with laboratory, a statistics course, and a first aid course must be completed before admission. If other deficiencies exist, candidates may be accepted into the program contingent upon successful completion of courses designed to correct them. All applicants must take the Graduate Record Examination (GRE) General Test and have an official report of the results sent to the master of environmental health and safety program office as part of their application for admission. Because this test is given at limited times and places during the year, applicants are advised to register early for the examination. Applicants must furnish official transcripts showing that they have completed their baccalaureate degree before they will be admitted or allowed to enroll in any M.E.H.S. courses. Students may apply for admission during their last semester of undergraduate work, but they will not be formally admitted or allowed to begin M.E.H.S. coursework until the baccalaureate degree is completed.

Application Procedure

Admission is restricted to fall semester entry and is limited to thirty students. A completed admission application should be submitted prior to the year of anticipated enrollment. Information and applications are available from the M.E.H.S. program office, 229 Voss-Kovach Hall. The admission decision is based on an evaluation by the applicant screening committee of the undergraduate scholastic record, past work experience, GRE results, and letters of recommendation. International students must present a TOEFL score of 550 or above. Applicants are responsible for obtaining information on all admission deadlines and requirements and for submitting all required admission materials before the first day of fall semester classes or they will be denied admission and must reapply to the program the following year.

Degree Requirements

Requirements for the M.E.H.S. include:

1) 36 course credits in the M.E.H.S. program and maintenance of an overall minimum GPA of 3.00; 2) a minimum of two semesters for the residence requirement; 3) an additional 3-credit industrial internship with a Plan B type project, which must be fulfilled within six months following completion of coursework, unless a formal extension is requested and granted.

Required Courses

Core (32 cr)

Safe 6001—OSHA and Other Regulatory Standards (3)

Safe 6011—System Safety and Loss Control Techniques (3)

Safe 6012—Risk Management and Workers' Compensation (2)

Safe 6021—Physical Hazard Control (3)

Safe 6101—Principles of Industrial Hygiene (3)

Safe 6212—Noise Control Engineering (3)

Safe 6213—Principles of Ventilation and Indoor Air Quality (3)

Safe 6301—Occupational Biomechanics and Work Physiology (2)

Safe 6302—Occupational Ergonomics and Injury Management (3)

Safe 6401—Environmental Safety and Legal Implications (2)

Safe 6802—Leadership, Teamwork, Behavior in EHS (3)

Safe 6821—Organization and Administration of Safety Programs (2)

Electives (4 cr)

Safe 6051—Construction Safety (2)

Safe 6102—Advanced Industrial Hygiene and Health Physics (2)

Safe 6121—Epidemiology and Industrial Toxicology (2)

Safe 6201—Fire Prevention and Emergency Preparedness (2)

Safe 6211—Transportation Safety (2)

Safe 6402—Environmental Control Operations and Design (2)

Final Project (3 cr)

Upon completing program coursework on campus, students are required to complete a cooperative internship in an industrial, governmental, or other organization that has an established safety program or is implementing one. Students are required to complete a Plan B type project for the firm.

Grading System

The M.E.H.S. program uses two grading systems, mandatory A-B-C-D-F and S-N. The course syllabus identifies the grading system used for each course. The temporary grade I (incomplete) is assigned only when a student has made an agreement with the instructor to complete the

requirements for a course before the time the instructor submits final grades for a semester.

The I remains in effect for nine weeks after the beginning of the next semester during which the student is in attendance, unless a different time period has been arranged between the student and instructor. At the end of this period, the I is changed to an N or F unless the instructor has submitted a change of grade or has agreed to an extension of the incomplete. If an extension is permitted, it is the responsibility of the student to get an Extension of Incomplete form, the instructor's signature, and submit the form to the program office before the deadline.

A student with an excessive number of incompletes may be denied further registration until some of them have been removed.

The program discourages retaking courses to improve grades. Permission from the course instructor and the major adviser is required to retake courses. If a course is retaken, all registrations for it remain on the student's record.

Preprofessional Programs

The college offers programs and special advising services for students who plan to enter professional schools. These programs offer preparation in preprofessional coursework as well as a broad background in mathematics, biological and physical sciences, humanities, and social science.

Some professional requirements can be fulfilled in two or three years; others take four years with the completion of a baccalaureate degree. In any case, students are encouraged to avoid narrow specialization during their undergraduate years.

The basic programs are described below. Variations in a curriculum may be arranged upon agreement among the student, preprofessional adviser, and office of admissions of the pertinent professional school. Students are encouraged to seek admissions details from the professional school of their choice, see their advisers regularly, learn of visits by representatives of various professional schools, and receive help with course planning. UMD also offers preparatory courses for other health sciences professions.

Pre-Dentistry

The University's School of Dentistry requires at least three years of college, including:

Biol 1011*—General Biology I (5)

Biol 1012—General Biology II (5)

Chem 1151*—General Chemistry I (5)

Chem 1152—General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4-5)
Chem 3322—Biochemistry (3)
Comp 1120*—College Writing (3)
Comp 3xxx—Advanced Writing (3)
Math 1250*—Precalculus Analysis (4)
Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)
Psy 1003*—General Psychology (4)
Electives especially recommended are art, cell biology, human anatomy, microbiology, and physiology. Additional electives can be selected from courses in business, biology, chemistry, social sciences, and the humanities.

It is also strongly recommended that students complete additional credits to achieve as broad and liberal an education as possible. About 80 percent of successful dental school candidates have a baccalaureate degree. Applicants to dental school must apply before December 1 for entry the following fall. The American Dental Association Admissions Test (DAT) is required and the official DAT score report must also be submitted by December 1 of the year before matriculation. The computerized DAT can be taken at any time, but students must first apply through the Dental Admission Testing Program.

** Courses that may be used to fulfill UMD liberal education program requirements.*

Pre-Medicine

Students admitted to medical school must complete four-year degrees before they begin medical studies. There is no prescribed pre-medical major—any recognized college major is acceptable. Admission requirements vary, however, and students should plan their academic programs with the assistance of a pre-medicine adviser. Students also should read and complete the specific admission requirements of the medical schools in which they are interested. The following courses are prerequisites for admission to many medical schools.

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Chem 1151*—General Chemistry I (5)
Chem 1152—General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4-5)
Chem 3322—Biochemistry (3)
Comp 1120*—College Writing (3)
Comp 3150—Advanced Writing: Science (3)
Math 1296*—Calculus I (5)
Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)

or Phys 2011*—General Physics I (4)

and Phys 2012—General Physics II (4)

Psy 1003—General Psychology (4)

Additional required or recommended courses may include cell biology, genetics, humanities, literature, microbiology, quantitative analysis, and social sciences.

** Courses that may be used to fulfill UMD liberal education program requirements.*

The Medical College Admission Test (MCAT) should be taken in the spring of the junior year or, at the latest, in the summer before the senior year. Students are advised to apply to medical school as early as possible after June 15 of the year preceding anticipated fall entrance. Most application deadlines are between October 1 and November 15.

Current information about admission requirements for all American medical schools can be found in *Medical School Admission Requirements*. Information on admission requirements for the three Minnesota medical schools is in the *Handbook on Pre-Medical Studies*, available from any pre-medicine adviser or the college's Student Affairs Office, 140 Engineering Building.

Pre-Optometry

Admission requirements for optometry colleges vary considerably. The following program satisfies pre-optometry requirements for most of these colleges. It is suggested that students begin application procedures during their third year of college study. Applicants are selected on a competitive basis and academic work is weighed heavily. In addition to GPA, admission is based on Optometry College Admission Test (OCAT) scores, letters of recommendation, volunteer or work experience in optometry, interview evaluations, and other supporting documents.

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Chem 1151*—General Chemistry I (5)
Chem 1152—General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4)
Comp 1120*—College Writing (3)
Comp 3xxx—Advanced Writing (3)
Math 1296*—Calculus I (5)
Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)
Psy 1003*—General Psychology (4)
Stat 1411*—Introduction to Statistics (3)

Additional required or recommended courses may include anatomy, biochemistry, communications, computer science, genetics, humanities, microbiology, physiology, and social sciences. Students should read and complete the specific admission requirements of the optometry school in which they are interested.

** Courses that may be used to fulfill UMD liberal education program requirements.*

Pre-Pharmacy

Students wishing to enter the four-year doctor of pharmacy (Pharm.D.) program in the College of Pharmacy on the Duluth or Minneapolis campus may complete their prerequisites with the coursework listed below. The Pharmacy College Admission Test (PCAT) is also required.

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 1761—Human Anatomy (4)
Biol 2101—Cell Biology (3)
Biol 4501—General Microbiology (4)
Chem 1151*—General Chemistry I (5)
Chem 1152—General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (5)
Comm 1112*—Public Speaking (3)
Comp 1120*—College Writing (3)
Comp 3150—Advanced Writing: Science (3)
Econ 1023*—Principles of Economics: Micro (3)
or Econ 1022—Principles of Economics: Macro (3)
Math 1296*—Calculus I (5)
Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)
Two courses dealing with human behavior in society (psychology or sociology courses)

** Courses that may be used to fulfill UMD liberal education program requirements.*

In addition to the prepharmacy course requirements, students must complete at least 30 credits of general education (nonscience, nonmathematics, nonprofessional) courses. Prepharmacy credits earned in behavioral sciences, English composition, economics, and public speaking apply toward this general education requirement.

Pre-Veterinary Medicine

The pre-veterinary program at UMD is part of the preparation for entry into the College of Veterinary Medicine on the St. Paul campus. Students may apply for entry after their third year at UMD. Required courses must be completed A-F.

Students should apply for admission to the veterinary college no later than November 1 for entry the following fall. The Graduate Record Examination (GRE) is also required for admission.

A recommended pre-veterinary program appears below for those who wish to enter veterinary college after their third year.

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Biol 2201—Genetics (3)
Biol 4501—General Microbiology (4)
Chem 1151*—General Chemistry I (5)
Chem 1152—General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4-5)
Chem 3322—Biochemistry (3)
Comp 1120*—College Writing (3)
Comp 3xxx—Advanced Writing (3)
Math 1250*—Precalculus Analysis (4)
Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)

Arts and humanities electives

History and social sciences electives

Additional recommended electives include courses in business management, communications, economics, public speaking, and statistics.

** Courses that may be used to fulfill UMD liberal education program requirements.*

Note: Students who choose to complete a degree at UMD before transferring to a veterinary college may do so within the usual four-year enrollment if they carefully select electives to fulfill pre-veterinary requirements and the requirements of their chosen major. Additional biology, chemistry, or mathematics coursework, for example, can lead to majors in these areas.

Pre-Engineering

Students who are undecided on the specific engineering program they would like to pursue may be declared pre-engineering students. They should select a specific engineering program during their freshman year from UMD's chemical engineering, electrical and computer engineering, industrial engineering, or mechanical engineering, or from one of UMD's preparatory engineering programs such as pre-aerospace engineering or pre-civil engineering. Students selecting one of the preparatory programs may transfer to the Institute of Technology (IT) on the Minneapolis campus or other baccalaureate degree-granting institutions at the end of their sophomore year to complete their studies in those engineering fields.

Students are encouraged to select their engineering program as early as possible because only mathematics, physics, and college writing courses are common in the first year. Other required courses, such as chemistry, computer programming, economics, and engineering graphics differ between engineering programs even in the first year. After selecting a specified field, students are assigned advisers with the appropriate background who can advise them to take the proper courses. Students should choose a field of engineering before the beginning of their sophomore year.

Recommended Courses for First Two Years for Students Who Wish to Transfer to IT or Another University

The course recommendations below have been designed to closely match the lower division programs (i.e., the first two years) at the University's Institute of Technology (IT). Students who wish to transfer to another engineering school can, with the aid of their engineering adviser, plan a program fulfilling the basic requirements of the first two years. Programs in engineering specialties at other schools normally do not differ markedly from those listed below; they usually concentrate on mathematics and the basic sciences.

Pre-Aerospace Engineering

Chem 1151*—General Chemistry I (5)
Comp 1120*—College Writing (3)
CS 1131*—Introduction to Programming in FORTRAN (3)
or CS 1511*—Computer Science I (5)
Engr 2015—Statics (3)
Engr 2016—Mechanics of Materials (3)
Engr 2026—Dynamics (3)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)
Math 3280—Differential Equations With Linear Algebra (4)
Math 3298—Calculus III (4)
ME 2105—Introduction to Material Science for Engineers (3)
Phys 2011*—General Physics I (4)
Phys 2012—General Physics II (4)
Phys 2021—Relativity and Quantum Physics (4)
Liberal education courses that complete Minnesota Transfer Curriculum or meet requirements of transfer institution

Pre-Civil Engineering

Chem 1151*—General Chemistry I (5)
Chem 1152—General Chemistry II (5)
Comp 1120*—College Writing (3)
Engr 2015—Statics (3)
Engr 2016—Mechanics of Materials (3)
Engr 2026—Dynamics (3)
Math 1296*—Calculus I (5)

Math 1297—Calculus II (5)
Math 3298—Calculus III (4)
Math 3280—Differential Equations With Linear Algebra (4)
Phys 2011*—General Physics I (4)
Phys 2012—General Physics II (4)
Stat 3611—Introduction to Probability and Statistics (4)
Liberal education courses that complete Minnesota Transfer Curriculum or meet requirements of transfer institution
* Courses that may be used to fulfill UMD liberal education program requirements.

Other Engineering Specialties

Consult CSE Student Affairs Office, 140 Engineering Building.

Upper Division

Upon completion of lower division requirements, students must apply for admission to the upper division of the engineering program in which they are interested. A minimum cumulative GPA, determined by the department, is required in the lower division courses. Students from other colleges wishing to transfer into UMD engineering programs should have completed the equivalent lower division courses with the required cumulative GPA. The completed application is evaluated on the basis of GPA, curriculum completed, and space availability. Students transferring from Minnesota state community colleges should refer to the list of equivalent lower division courses for their college. This list is available from CSE or the community college engineering adviser. Courses in which a D has been earned at an institution other than the University cannot be used to meet the specified course requirements of the engineering degrees except when the D is earned in a sequence course and a C or better is earned in the following course.

Pre-Fisheries and Wildlife Management

This curriculum provides two years of study that fulfill many of the basic requirements for professional study in fisheries and wildlife management. UMD courses below are required for the fisheries and wildlife management degree and have equivalents in the Department of Fisheries, Wildlife, and Conservation Biology in the College of Natural Resources on the St. Paul campus.

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2201—Genetics (3)
Biol 2801—General Ecology (3)
Chem 1151*—General Chemistry I (5)

Chem 1152—General Chemistry II (5)
Comm 1112*—Public Speaking (3)
Comp 1120*—College Writing (3)
Math 1296*—Calculus I (5)
 and Math 1297—Calculus II (5)
or Math 1160*—Finite Mathematics and Introduction to
 Calculus (5)

Phys 1001*—Introduction to Physics I (5)
Phys 1002—Introduction to Physics II (5)
Stat 2411—Statistical Methods (3)
Liberal education courses that complete the Minnesota
Transfer Curriculum or meet requirement of transfer
institution.

* Courses that may be used to fulfill UMD liberal
education program requirements.

Degree Programs

Aerospace Studies

Professor: Lieutenant Colonel Michael McGoffin
(department head); *Assistant Professors:* Major Tim Allen,
Captain Eric Fraser

The Air Force Reserve Officer Training Corps (AFROTC) is a college-level educational program that gives students the opportunity to become Air Force officers while completing their degrees. Any student may enroll in aerospace studies courses. AFROTC offers post-collegiate opportunities in more than 100 career specialties. Air Force officers are challenged with organizational responsibilities and experiences not often available to new college graduates. This program is for students who want to challenge themselves as Air Force leaders and managers while serving their country in a professional, high-tech environment.

Active-duty Air Force officers provide a curriculum that gives students insight into the mission, organization, and operation of the U.S. Air Force. Students study Air Force history, leadership, management, professionalism, and U.S. foreign policy and its relationship to defense policy. Scholarships are available on a competitive basis. High school seniors and college students can compete for five-, four-, three-, two (and sometimes one-) year scholarships that cover tuition, fees, and book expenses. Participants may qualify to receive a tax-free allowance for each month in school.

Requirements

The following courses are required for both the two- and four-year commissioning programs (for more information about the commissioning programs, see Education, Service, and Research Centers):

Core Program—Professional Officer Course (16 cr) (required of all candidates for commissions)

Air 3101—Air Force Leadership Studies (3)
Air 3102—Air Force Leadership Studies(3)
Air 4101—National Security Affairs/Preparation for Active Duty (3)
Air 4102—National Security Affairs/Preparation for Active Duty (3)
Air 3000—AFROTC POC Leadership Lab (1)—A 1.5 hour per week laboratory provides introductory and advanced hands-on leadership and management experience. Some leadership lab requirements take place outside of the scheduled times. Taken in conjunction with the four lecture courses. Taken up to four times for credit (S-N).

Aerospace Minor Only

The aerospace studies minor provides preparation in areas studied by most officers early in their service careers. The minor increases future officers' performance potential in two areas in which all officers must eventually develop competence: communication skills and international affairs.

Requirements (32-33 cr)

Lower Division (10 cr)

Air 0100—AFROTC GMC Leadership Lab (0)
Air 1101—Foundations of the U.S. Air Force (1)
Air 1102—Foundations of the U.S. Air Force (1)
Air 2101—The Evolution of the U.S. Air Force Air and Space Power (1)
Air 2102—The Evolution of the U.S. Air Force Air and Space Power (1)
Course requiring mathematical reasoning (3)
Comm 1112*—Public Speaking
or Comm 1222*—Interpersonal Communication (3)

Upper Division (22-23 cr)

Air 3000—AFROTC POC Leadership Lab (1) (must be taken four times)
Air 3101—Air Force Leadership Studies (3)
Air 3102—Air Force Leadership Studies (3)
Air 4101—National Security Affairs/Preparation for Active Duty (3)
Air 4102—National Security Affairs/Preparation for Active Duty (3)
Advanced or technical writing course (3)

One of the following or an approved substitute:

Geog 4393—Political Geography (4)
A 2xxx or 3xxx history course with department head approval prior to taking the course.
A 3xxx political science course with department head approval prior to taking the course.

* Courses that may be used to fulfill UMD liberal
education program requirements.

Astronomy

See Course Descriptions.

Biochemistry and Molecular Biology

Department of Chemistry and Biochemistry

Professors: Robert M. Carlson, Lester R. Drewes (Med), John F. Evans, John E. Fulkrod, Vincent R. Magnuson, Donald P. Poe, Joseph R. Prohaska (Med), James P. Riehl, Bilin P. Tsai, Kendall B. Wallace (Med), Viktor V. Zhdankin; *Associate Professors:* Benjamin L. Clarke (Med), Thomas E. Huntley (Med), Paul Kiprof, Richard Markuszewski, Paul D. Siders; *Assistant Professors:* Leng Chee Chang, Robert Cormier (Med), Venkatram Mereddy, Victor Nemykin, Edward L. Perkins (Med), Jon N. Rumbley, Tatiana Sergeeva, Josef Werne; *Instructor:* Patricia R. Splan

B.S.

Biochemistry and molecular biology is the study of life at the molecular level. This field is both a life science and a chemical science, exploring the chemistry of living organisms and the molecular basis for the processes that occur in living cells. The Department of Chemistry and Biochemistry provides classroom and laboratory learning opportunities and research experience across the discipline to meet the needs of students in engineering, liberal arts, and preprofessional programs as well as of students who wish to pursue careers or graduate studies in chemistry or related disciplines.

Honors Requirements

The Department of Chemistry and Biochemistry honors program helps outstanding biochemistry and molecular biology majors develop into competent, independent research workers, encourages student interest in the discipline, and aids students in their transition to scientists. Qualified majors may apply after the first semester of their sophomore year. Participants choose a research adviser and complete two semesters on a jointly developed project. Written reports and an oral presentation of the research are also required.

Students earning a B.S. degree who wish to have their program certified by the American Chemical Society must take advanced courses that include additional hours of laboratory work.

Degree Requirements

Requirements for the B.S. degree in biochemistry and molecular biology (120 cr) include:

- Liberal education requirements
- Advanced writing requirement
- Major requirements (82 cr)

Required Courses

Year 1

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Chem 1151*—General Chemistry I
or Chem 1161*—Honors: General Chemistry I (5)
Chem 1152—General Chemistry II
or Chem 1162—Honors: General Chemistry II (5)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)

Year 2

Biol 2101—Cell Biology (3)
Chem 2222—Quantitative Analysis (3)
Chem 2223—Quantitative Analysis Laboratory (1)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4)
Phys 2011*—General Physics I (4)
Phys 2012—General Physics II (4)

Year 3

Biol 2201—Genetics (3)
Chem 4341—Biochemistry (4)
Chem 4363—Biochemistry Laboratory (2)
Chem 4632—Physical Chemistry (4)
Chem 4633—Physical Chemistry Laboratory (1)
Comp 31xx—Advanced Writing (3)

Year 4

Chem 4184—Undergraduate Seminar I (1)
Chem 4185—Undergraduate Seminar II (1)
Chem 4242—Instrumental Analysis (3)
Chem 4342—Molecular Biology (4)
Chem 4364—Molecular Biology Laboratory (2)
Chem 4434—Inorganic Chemistry (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Students who earn a B.S. degree in biochemistry and molecular biology (BMB) will have met the requirements for the B.A. in chemistry and for the chemistry minor. However, neither the BMB major/B.A. chemistry major combination nor the BMB major/chemistry minor combination satisfies the college degree requirement for a second major or minor. The B.S. BMB major/B.S. chemistry major combination does satisfy the college degree requirement.

Biology

Professors: Matthew T. Andrews, Stephen C. Hedman, Randall E. Hicks, M. Reza-Ul Karim, Andrew R. Klemer, Gerald J. Niemi, John J. Pastor, Carl Richards; *Associate Professors:* Timothy P. Craig, Linda L. Holmstrand, David J. Schimpf; *Assistant Professors:* Donn K. Branstrator, Julie R. Etterson, Thomas R. Hrabik, Allen F. Mensinger, Anna S. Rachinsky; *Instructors:* Colleen M. Belk, Virginia M. Borden, Lyle J. Shannon

The Department of Biology provides instruction and research experience for undergraduate and graduate students as part of a liberal education, preparation for graduate school, or a sound basis for professional training in the biological and health sciences.

B.A.—CLA

The B.A. degree is for students completing a liberal arts degree in biology.

Degree Requirements

Requirements for the B.A. in biology (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (59-70 cr): 24 core biology credits, which include coursework in general biology, genetics, cell biology, ecology, evolution, and seminar; 17-28 credits of supporting courses in mathematics, statistics, and chemistry; 18 credits of biology electives at 2xxx or above to provide flexibility in pursuing personal interests or career preparation
- A minor or a second major from another area of study
- Elective credits to total 120 credits

Required Courses

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Biol 2201—Genetics (3)
Biol 2801—General Ecology (3)
Biol 2802—Ecology Laboratory (2)
Biol 3997—Seminar I (0.5)
Biol 3998—Seminar II (0.5)
Biol 4801—Evolution (2)

Required Courses From Other Programs

Chem 1113*—Introduction to General, Organic, and Biological Chemistry I (5)
and Chem 1114—Introduction to General, Organic, and Biological Chemistry II (5)
or Chem 1151*—General Chemistry I (5)

and Chem 1152—General Chemistry II (5)
and Chem 2521—Organic Chemistry I (4)
and Chem 2522—Organic Chemistry II (4-5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
and Chem 2521—Organic Chemistry I (4)
and Chem 2522—Organic Chemistry II (4-5)

Choose math from Option A or B

Option A

Math 1250*—Precalculus Analysis (4)
and Stat 1411*—Introduction to Statistics (3)
or Stat 2411*—Statistical Methods (3)

Option B

Math 1296*—Calculus I *or* Math 1290*—Calculus for the Natural Sciences (5)
and Math 1297—Calculus II (5)
or Stat 1411*—Introduction to Statistics (3)
or Stat 2411*—Statistical Methods (3)
or Stat 3611—Introduction to Probability and Statistics (4)

Electives (18 cr)

Biol 2xxx or higher must include a minimum of two laboratory courses or courses with a laboratory component
Two of the following may be used:
MdBc 5501—Neurobiochemistry (2)
MicB 5545—Immunobiology (3)
MicB 5555—Molecular Pathogenesis: Current Concepts (3)
Phsl 5601—Physiology of Organ Systems I (4)
Phsl 5602—Physiology of Organ Systems II (2)
** Courses that may be used to fulfill UMD liberal education program requirements.*

B.S.

Degree Requirements

Requirements for the B.S. in biology (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (76-81 cr): 24 core biology credits, which include general biology, cell biology, genetics, ecology, evolution, and seminar; supporting coursework in mathematics, chemistry, and physics; 18 credits of biology electives at 2xxx or higher
- A minor or second major from another area of study; the cell biology major may not be used to meet this requirement.
- Exit interview

Required Courses

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Biol 2201—Genetics (3)
Biol 2801—General Ecology (3)

Biol 2802—Ecology Laboratory (2)
Biol 3997—Seminar I (0.5)
Biol 3998—Seminar II (0.5)
Biol 4801—Evolution (2)

Required Courses From Other Programs

Chem 1151*—General Chemistry I (5)
and Chem 1152—General Chemistry II (5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4-5)
Math 1296*—Calculus I or Math 1290—Calculus for the
Natural Sciences (5)
and Math 1297—Calculus II (5)
or Stat 2411*—Statistical Methods (3)
or Stat 3611—Introduction to Probability and Statistics (4)
Phys 1001*—Introduction to Physics I (5)
and Phys 1002—Introduction to Physics II (5)
or Phys 2011*—General Physics I (4)
and Phys 2012—General Physics II (4)

* Courses that may be used to fulfill UMD liberal
education program requirements.

Electives (18 cr)

Biol 2xxx or higher must include a minimum of two
laboratory courses or courses with a laboratory component

Two of the following may be used:

MdBc 5501—Neurobiochemistry (2)
MicB 5545—Immunobiology (3)
MicB 5555—Molecular Pathogenesis: Current Concepts (3)
Phsl 5601—Physiology of Organ Systems I (4)
Phsl 5602—Physiology of Organ Systems II (2)

Biology Minor

Requirements (44-55 cr)

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Biol 2201—Genetics (3)
Biol 2801—General Ecology (3)
Biol 4801—Evolution (2)
Biol electives at 2xxx or above (6 cr) (may include two of
the following: MicB 5545, MicB 5555, Phsl 5601, Phsl
5602)

Chem 1113*—Introduction to General, Organic, and
Biological Chemistry I (5)
and Chem 1114—Introduction to General, Organic, and
Biological Chemistry II (5)
or Chem 1151*—General Chemistry I (5)
and Chem 1152—General Chemistry II (5)
and Chem 2521—Organic Chemistry I (4)
and Chem 2522—Organic Chemistry II (4-5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
and Chem 2521—Organic Chemistry I (4)
and Chem 2522—Organic Chemistry II (4-5)

Choose math from Option A or B

Option A

Math 1250*—Precalculus Analysis (4)
and Stat 1411*—Introduction to Statistics (3)
or Stat 2411*—Statistical Methods (3)

Option B

Math 1296*—Calculus I or Math 1290*—Calculus for the
Natural Sciences (5)
and Math 1297—Calculus II (5)
or Stat 1411*—Introduction to Statistics (3)
or Stat 2411*—Statistical Methods (3)
or Stat 3611—Introduction to Probability and Statistics (4)
* Courses that may be used to fulfill UMD liberal
education program requirements.

Cell Biology

Department of Biology

Professors: Matthew T. Andrews, Stephen C. Hedman,
Randall E. Hicks, M. Reza-Ul Karim, Andrew R. Klemmer,
Gerald J. Niemi, John J. Pastor, Carl Richards; *Associate
Professors:* Timothy P. Craig, Linda L. Holmstrand, David
J. Schimpf; *Assistant Professors:* Donn K. Branstrator,
Julie R. Etterson, Thomas R. Hrabik, Allen F. Mensinger,
Anna S. Rachinsky; *Instructors:* Colleen Belk, Virginia M.
Borden, Lyle J. Shannon

B.S.

Cell biology is one of the most rapidly growing
areas of modern biology. The cell biology major
prepares students for graduate school and careers
in cell biology, genetics, developmental biology,
physiology, immunology, and biotechnology. The
major is also appropriate for students considering
entry into professional schools of medicine,
dentistry, pharmacy, and veterinary medicine.
The program is administered by the Department
of Biology and involves faculty in both the
College of Science and Engineering and the
University of Minnesota Medical School Duluth.

Degree Requirements

The B.S. in cell biology allows students to
satisfy requirements for a chemistry minor by
completing the courses listed in the major.

Degree requirements include (120 cr):

- Liberal education requirements
- Advanced writing requirement: Comp
3150—Advanced Writing: Science (3)
- Major requirements (84-90 cr)
- A minor or second major from another area of
study; biology may not be used to satisfy this
requirement.
- Exit interview

Required Courses

Biol 1011*—General Biology I (5)
Biol 1012—General Biology II (5)
Biol 2101—Cell Biology (3)
Biol 2102—Cell Biology Laboratory (2)
Biol 2201—Genetics (3)
Biol 3703—Animal Diversity (3)
Biol 3997—Seminar I (.5)
Biol 3998—Seminar II (.5)
Biol 4231—Molecular Genetics (3)
Biol 4232—Molecular Biology Laboratory (2)
Biol 4361—Developmental Biology (4)
Biol 4501—General Microbiology (4)
Biol 4801—Evolution (2)
Biol 5233—Genomics (3)

Minimum of 6 credits—select at least one course with laboratory or a laboratory course not selected above:

Biol 2801—General Ecology (3)
Biol 3990—Special Topics: (Various Titles to be Assigned) (1-5) (program approval required)
Biol 3994—Undergraduate Research (1-3)
Biol 4199—Frontiers in Cell Biology (2)
Biol 5240—Ecological Genetics (3)
Biol 5365—Developmental Physiology (2)
Biol 5511—Virology (3)
Biol 5513—Experimental Immunology (4)
Biol 5760—The Physiology of Fishes (3)
Biol 5772—Mechanisms of Neural Behavior (3)
Biol 5801—Microbial Ecology (2)
Biol 5802—Microbial Ecology Laboratory (2)
Biol 5990—Special Topics: (Various Titles to be Assigned) (1-5) (program approval required)
MdBc 5501—Neurobiochemistry (2)
MicB 5545—Immunobiology (3)
MicB 5555—Molecular Pathogenesis: Current Concepts (3)
Phsl 5601—Physiology of Organ Systems I (4)
Phsl 5602—Physiology of Organ Systems II (2)

Required Courses From Other Programs

Chem 1151*—General Chemistry I (5)
and Chem 1152—General Chemistry II (5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
Chem 2521—Organic Chemistry I (4)
and Chem 2522—Organic Chemistry II (4-5)
Chem 3322—Biochemistry (3)
and Chem 3324—Biochemistry Laboratory (1)
or Chem 4341—Biochemistry (4)
and Chem 4363—Biochemistry Laboratory (2)
Math 1296*—Calculus I
or Math 1290*—Calculus for the Natural Sciences (5)
Stat 2411*—Statistical Methods (3)
or Stat 3611—Introduction to Probability and Statistics (4)
Phys 1001*—Introduction to Physics I (5)
and Phys 1002—Introduction to Physics II (5)

or Phys 2011*—General Physics I (4)

and Phys 2012—General Physics II (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Chemical Engineering

Professors: Richard A. Davis, A. Rashid Hasan (department head); *Associate Professors:* Keith Lodge, Steven Sternberg; *Assistant Professors:* Michael Rother, Gregory Rutkowski; *Instructors:* Renee DeWitte, Hossain Khorroosi

B.S.Ch.E.

This four-year baccalaureate (B.S.Ch.E.) degree program emphasizes the development of the student's ability to analyze and design chemical processing systems and to effectively communicate. By the end of the program, the student must demonstrate the ability to solve engineering problems, a sensitivity to the economic, social, and environmental impacts of the engineering profession, and the ability to maintain a high level of competency.

Chemical engineering graduates are qualified for employment in diverse industries, ranging from those that manufacture inorganic chemicals, petrochemicals, plastics, synthetic fibers, paper and pulp, and pharmaceuticals to those that process hazardous and nuclear wastes. Graduates are qualified for assignments that include plant operations, process development, process control, project engineering, or sales, and frequently pursue engineering management later in their careers. They are also well qualified to continue with professional or graduate education.

The chemical engineering curriculum is based on fundamental sciences such as physics, chemistry, and mathematics; engineering sciences such as statics; traditional chemical engineering sciences such as material and energy balance, transport phenomena, and thermodynamics; and chemical engineering design courses, with a capstone plant design course during the senior year. Students have a unique opportunity to become involved in research, through either the Undergraduate Research Opportunities Program or the department honors program.

Admission Requirements

Students may declare a chemical engineering major as freshmen or sophomores. Students must complete the lower division level before applying to the upper division level (junior and senior years) of the program. Admission is competitive and applicants are admitted on a space-available basis, determined by the cumulative GPA in composition, physics, mathematics, engineering

statics, and chemistry through Chem 2521. Transfer students should refer to the Pre-Engineering Junior-Level Admission section. Students must complete the upper division courses to complete the degree.

Honors Requirements

To graduate with department honors, students must have a minimum 3.50 GPA and be nominated by the chemical engineering faculty.

Degree Requirements

Requirements for the B.S.Ch.E. in chemical engineering (130 credits) include:

- Liberal education requirements
- Completion of the lower division level before applying to the upper division level (junior and senior years) of the program

Required Courses

Lower Division (12 cr)

ChE 1011*—Introduction to Chemical Engineering
or ChE 2001*—Introduction to Environmental Engineering
or ChE 3xxx (or higher) elective—subject to ChE department approval (3)

ChE 2011—Design of Engineering Experiments (3)

ChE 2111—Material and Energy Balances (3)

ChE 2121—Chemical Engineering Thermodynamics (3)

Upper Division (41 cr)

ChE 3031—Computational Methods in Chemical Engineering (3)

ChE 3111—Fluid Mechanics (3)

or ME 3111—Fluid Mechanics (3)

ChE 3112—Heat and Mass Transfer (3)

ChE 3211—Chemical Engineering Laboratory I (3)

ChE 3231—Properties of Engineering Materials (3)

ChE 3241—Principles of Particle Technology (3)

ChE 4111—Separations (3)

ChE 4211—Chemical Engineering Laboratory II (3)

ChE 4301—Chemical Reaction Engineering (3)

ChE 4402—Process Dynamics and Control (3)

ChE 4501—Chemical Engineering Design I (4)

ChE 4502—Chemical Engineering Design II (4)

ChE 4xxx (or higher) elective (3)

Required Courses From Other Programs

Lower Division (52 cr)

Chem 1151*—General Chemistry I

or Chem 1161*—Honors General Chemistry I (5)

Chem 1152—General Chemistry II

or Chem 1162—Honors General Chemistry II (5)

Chem 2222—Quantitative Analysis (3)

Chem 2223—Quantitative Lab (1)

Chem 2521—Organic Chemistry I (4)

Comp 1120*—College Writing (3)

CS 11xx (or higher)—Introduction to Programming (2)

Engr 2015—Statics (3)

Math 1296*—Calculus I (5)

Math 1297—Calculus II (5)

Phys 2011*—General Physics I (4)

Phys 2012—General Physics II (4)

Liberal education electives

Upper Division (25 cr)

Chem 25xx (or higher) advanced chemistry electives (4)
may not be satisfied with Chem 3184 or 4632

Engr 4001—Engineering Professionalism (3)

Math 3280—Differential Equations with Linear Algebra (4)

Advanced science or engineering elective: 3xxx or higher course in the College of Science and Engineering (3)

Liberal education electives: 1 each Category 6-10, except where an option is provided for Category 10, another course from Category 9 may be taken.

* Courses that may be used to fulfill UMD liberal education program requirements.

Chemistry

Professors: Robert M. Carlson, Lester R. Drewes (Med), John F. Evans, John E. Fulkrod, Vincent R. Magnuson, Donald P. Poe, Joseph R. Prohaska (Med), James P. Riehl, Bilin P. Tsai, Kendall B. Wallace (Med), Viktor V. Zhdankin; *Associate Professors:* Benjamin L. Clarke (Med), Thomas E. Huntley (Med), Paul Kiprof, Richard Markuszewski, Paul D. Siders; *Assistant Professors:* Leng Chee Chang, Robert Cormier (Med), Venkatram Mereddy, Victor Nemykin, Edward L. Perkins (Med), Jon N. Rumbley, Tatiana Sergeeva, Josef Werne; *Instructor:* Patricia R. Splan

Chemistry is a body of knowledge that helps explain the physical world and its processes. Chemists study substances: their composition, structures, properties, and reactions. The Department of Chemistry and Biochemistry provides classroom and laboratory learning opportunities and research experience across the discipline to meet the needs of students in engineering, liberal arts, and preprofessional programs as well as of students who wish to pursue careers or graduate studies in chemistry or related disciplines.

Honors Requirements

The Department of Chemistry and Biochemistry honors program helps outstanding chemistry majors develop into competent, independent research workers, encourages student interest in the discipline, and aids students in their transition to scientists. Qualified majors may apply after the first semester of their sophomore year. Participants choose a research adviser and complete two semesters of effort on a jointly developed project. Written reports and an oral presentation of the research are also required.

B.A.—CLA

The B.A. degree is for students completing a liberal arts degree in chemistry.

Degree Requirements

Requirements for the B.A. degree in chemistry (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 31xx (3 cr)
- Major requirements (53-55 cr)
- A minor or second major from another area of study
- Elective credits to total 120 credits

Required Courses

Year 1

Chem 1151*—General Chemistry I
or Chem 1161*—Honors: General Chemistry I (5)
Chem 1152—General Chemistry II
or Chem 1162—Honors: General Chemistry II (5)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)

Year 2

Chem 2222—Quantitative Analysis (3)
Chem 2223—Quantitative Analysis Laboratory (1)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4)
Phys 2011*—General Physics I (4)
and Phys 2012—General Physics II (4)
or Phys 1001*—Introduction to Physics I (5)
and Phys 1002—Introduction to Physics II (5)

(Students are strongly encouraged to take Phys 2011-2012.)

Year 3

Chem 3322—Biochemistry (3)
Chem 3324—Biochemistry Laboratory (1)
Chem 4632—Physical Chemistry (4)
Chem 4633—Physical Chemistry Laboratory (1)
Comp 31xx—Advanced writing (3 credits)

Year 4

Chem 4434—Inorganic Chemistry (4)
** Courses that may be used to fulfill UMD liberal education program requirements.*

B.S.

Students earning a B.S. degree who wish to have their program certified by the American Chemical Society must take advanced courses that include additional hours of laboratory work.

Degree Requirements

Requirements for the B.S. degree (120 cr) in chemistry include:

- Liberal education requirements
- Advanced writing requirement
- Major requirements (69 cr)

Required Courses

Year 1

Chem 1151*—General Chemistry I
or Chem 1161*—Honors: General Chemistry I (5)
Chem 1152—General Chemistry II
or Chem 1162—Honors: General Chemistry II (5)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)

Year 2

Chem 2222—Quantitative Analysis (3)
Chem 2223—Quantitative Analysis Laboratory (1)
Chem 2521—Organic Chemistry I (4)
Chem 2532—Organic Chemistry II for B.S. Chem Majors (5)
Math 3280—Differential Equations with Linear Algebra (4)
Phys 2011*—General Physics I (4)
Phys 2012—General Physics II (4)

Year 3

Chem 3322—Biochemistry (3)
Chem 3324—Biochemistry Laboratory (1)
Chem 4641—Physical Chemistry I (3)
Chem 4643—Physical Chemistry Laboratory I (1)
Chem 4642—Physical Chemistry II (3)
Chem 4644—Physical Chemistry Laboratory II (1)
Comp 31xx—Advanced writing (3 credits)

Year 4

Chem 4184—Undergraduate Seminar I (1)
Chem 4185—Undergraduate Seminar II (1)
Chem 4242—Instrumental Analysis (3)
Chem 4243—Instrumental Chemistry Laboratory (2)
Chem 4434—Inorganic Chemistry (4)
Chem 4435—Inorganic Chemistry Laboratory (1)

** Courses that may be used to fulfill UMD liberal education program requirements.*

Chemistry Minor

Requirements (29-31 cr)

Chem 1151*—General Chemistry I
or Chem 1161*—Honors: General Chemistry I (5)
Chem 1152—General Chemistry II
or Chem 1162—Honors: General Chemistry II (5)
Chem 2222—Quantitative Analysis (3)
Chem 2223—Quantitative Analysis Laboratory (1)
Chem 2521—Organic Chemistry I (4)
Chem 2522—Organic Chemistry II (4)
Chem 3322—Biochemistry (3)
or Chem 4632—Physical Chemistry (4)
Math 1250—Precalculus Analysis (4)
or Math 1290—Calculus for the Natural Sciences (5)
or Math 1296—Calculus I (5)

** Courses that may be used to fulfill UMD liberal education program requirements.*

Computer Science

Professors: Donald B. Crouch (department head), Douglas J. Dunham; *Associate Professors:* Timothy R. Colburn, Carolyn J. Crouch, Linda L. Deneen, Richard Maclin, Theodore D. Pedersen, Gary M. Shute, Masha Sosonkina, C. Hudson Turner; *Assistant Professor:* Christopher Prince

B.S.

Computer science is a discipline that requires understanding the design of computers and computational processes. The B.S. in computer science is an accredited, four-year program that provides a solid foundation in mathematics and statistics, computational problem solving, software design and analysis, computer theory, programming languages, algorithms, data structures, and computer organization and architecture. The program also requires that students acquire significant knowledge in several subdisciplines of computer science, thus enabling them to apply and situate their knowledge of computer science fundamentals. Goals of the learning process include highly developed programming skills, an understanding of the context in which computing activities occur, and an ability to communicate effectively. The program provides the necessary foundational studies for students preparing for graduate school as well as those seeking careers in industry. The program is accredited by the Computing Accreditation Commission of the Accreditation Board for Engineering and Technology.

Honors Requirements

Program candidates submit an application to the department honors committee. Participants must maintain a 3.00 cumulative GPA and a 3.30 GPA in the major and complete an honors research project supervised by a faculty member; credit for the project can be earned in CS 4994—Honors Project.

Degree Requirements

Requirements for the B.S. in computer science (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering or Comp 3150—Advanced Writing: Science (3)
- Major requirements (106-109 cr)
- A minor or a second major from another department; computer science majors may not minor in mathematics

Required Courses

Core

CS 1511*—Computer Science I
or CS 1581—Honors: Computer Science I (5)

CS 1521—Computer Science II (5)
CS 2511—Software Analysis and Design (4)
CS 2521—Computer Organization and Architecture (4)
ECE 1315—Digital System Design (4)

Advanced Courses

CS 3111—Computer Ethics (4)
or Phil 3242*—Values and Technology (3)
CS 3511—Computer Science Theory (3)
CS 4993—Seminar (1)
CS 5631—Operating Systems (4)
CS 5621—Computer Architecture (4)
or CS 5651—Computer Networks (4)

Three additional courses, including at least one breadth course:

Breadth

CS 4511—Computability and Complexity (4)
CS 4521—Algorithms and Data Structures (4)
CS 4531—Software Engineering (4)
CS 4611—Database Management Systems (4)
CS 5541—Artificial Intelligence (4)
CS 5551—User Interface Design (4)
CS 5621—Computer Architecture (4)**
CS 5641—Compiler Design (4)
CS 5651—Computer Networks (4)**

Electives

CS 4821—Computer Security (4)
CS 5721—Computer Graphics (4)
CS 5741—Object-Oriented Design (4)
CS 5751—Introduction to Machine Learning (4)
CS 5761—Introduction to Natural Language Processing (4)
CS 5831—Information and Text Processing (4)

** Courses that may be used to fulfill UMD liberal education program requirements.*

*** CS 5621 or CS 5651 must be taken for this major. If both courses are taken, the second course fulfills the requirement of one additional breadth course.*

Other Required Courses

Comm 1112*—Public Speaking (3)
Comp 1120*—College Writing (3)
Comp 3130—Advanced Writing: Engineering
or Comp 3150—Advanced Writing: Science (3)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)
Math 3355—Discrete Mathematics (4)
Stat 3611—Introduction to Probability and Statistics (4)

One of the following science sequences:

Biol 1011*—General Biology I (5)
and Biol 1012—General Biology II (5)
or Chem 1151*—General Chemistry I (5)
and Chem 1152—General Chemistry II (5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
or Geol 1110*—Geology and Earth Systems (4)
and Geol 2311—Mineralogy (4)
and Geol 2312—Petrology (4)

or Phys 2011*—General Physics I (4)

and Phys 2012—General Physics II (4)

Additional approved courses from physics, chemistry, biology, astronomy, and geology (4 cr)**

Electives in the humanities, social sciences, and arts (21 cr)

* Courses that may be used to fulfill UMD liberal education program requirements.

** Complete an additional science course that either is in Category 4 of the liberal education program or has a Category 4 course as a prerequisite. The total number of credits for this additional course and the science sequence must be at least 12 credits.

Computer Science Minor Requirements (30 cr)

CS 1511*—Computer Science I

or CS 1581—Honors: Computer Science (5)

CS 1521—Computer Science II (5)

CS 2511—Software Analysis and Design (4)

Electives from CS 2521 or ECE 2325, CS courses at 35xx or above, ECE 3341, 4305 (11 cr)

Math 1296*—Calculus I (5)

* Courses that may be used to fulfill UMD liberal education program requirements.

Computer Science—Applied Minor Only

The computer science—applied minor provides a thorough introduction to the use of computers as tools and complements studies in other disciplines.

Requirements (27 cr)

CS 1511*—Computer Science I (5)

or CS 1581—Honors: Computer Science (5)

CS 1521—Computer Science II (5)

CS 2511—Software Analysis and Design (4)

Electives in CS courses at 2xxx or above (7 cr)

Approved electives from computer science or other departments with a significant computing component (6 cr).

* Courses that may be used to fulfill UMD liberal education program requirements.

Note: The computer science minor and computer science—applied minor are not available to information systems and technology majors.

Electrical and Computer Engineering

Professors: Stanley Burns (department head), Taek Mu Kwon, Marian Stachowicz, Jiann-Shiou Yang; *Associate Professors:* Christopher Carroll, Mohammed Hasan, Imran Hayee; *Assistant Professors:* Rocio Alba-Flores, Fernando Rios-Gutierrez, Bassam Shaer

B.S.E.C.E.

The mission of the Department of Electrical and Computer Engineering is to provide a high quality educational opportunity in electrical and computer engineering for students in the region by delivering a program with a strong hands-on laboratory and design component in conjunction with a thorough foundation in theory, and to provide students with the tools and skills to be a life-long major contributor to their profession and society as a whole.

The electrical and computer engineering B.S.E.C.E. program combines traditional electrical engineering topics with current computer design and analysis topics. The program is concerned with the theory, design, and application of electrical phenomena and digital computers, including electronic circuits, signal analysis, system design, and computer architecture. The department displays strengths in such diverse areas as electronics, signal processing, electromagnetics, digital computer systems, communications, and controls. Individual faculty members specialize in areas such as VLSI design, microprocessor systems, image processing, robust control, solid state devices, robotics, instrumentation, neural networks, and fuzzy logic. The program balances theoretical and practical experience in electrical and computer engineering through analysis, synthesis, and experimentation, using facilities that include ten major instructional laboratories and three research laboratories.

Admission Requirements

Freshman-level Admission—Students who enter the electrical and computer engineering program as freshmen must follow the lower division program listed under Required Courses below.

Junior-level Admission—Students should complete the lower division ECE program before applying to the upper division (junior and senior years) program. Admission is competitive and on a space-available basis. A minimum GPA of 2.00 is required for admission to the upper division program. See department for further details.

Honors Requirements

To receive department honors upon graduating, students must finish the program with an overall GPA of at least 3.50, satisfactorily complete a research project under the guidance of a faculty member, and convey the results in an oral and written presentation to the department.

Advising

ECE majors are required to meet with their adviser each semester to discuss their academic plans for the upcoming semester and to obtain a registration hold release. Students are encouraged to meet as often as needed to discuss curriculum choices, professional interests, and any other topics that will be of assistance as they pursue their electrical and computer engineering education. Students who have questions about any part of the ECE program should see their adviser.

Note: Completion of the ECE program as outlined below satisfies the requirements for a computer science minor.

Degree Requirements

Requirements for the B.S.E.C.E. (130 cr) include:

- Liberal education requirements (35 cr; 37 cr for ECE majors)
- Advanced writing requirement: Engr 4001—Engineering Professionalism (3)
- 9 technical elective credits to achieve breadth and depth in the major
- Enough required math, science, engineering science, engineering design, and composition credits to meet or exceed accreditation requirements

Required Courses

Lower Division (22 cr)

ECE 1001—Introduction to Electrical and Computer Engineering (2)

ECE 1315—Digital System Design (4)

ECE 2006—Electrical Circuit Analysis (4)

ECE 2111—Linear Systems and Signal Analysis (4)

ECE 2212—Electronics I (4)

ECE 2325—Microcomputer System Design (4)

Upper Division (30 cr)

ECE 3151—Control Systems (3)

ECE 3235—Electronics II (4)

ECE 3341—Digital Computer Circuits (4)

ECE 3445—Electromagnetic Fields (3)

ECE 3611—Introduction to Solid State Semiconductors (3)

ECE technical electives (9 cr) must include at least one course selected from the following list:

ECE 4305—Computer Architecture (4)

ECE 5315—Multiprocessor-Based System Design (3)

ECE 4899—Senior Design Project I (1)

and ECE 4999—Senior Design Project II (3)

or ECE 4951—Design Workshop (4)

Required Courses From Other Programs

Lower Division (46 cr)

Chem 1151—General Chemistry I (5)

Comp 1120*—College Writing (3)

CS 1511*—Computer Science I (5)

CS 1521—Computer Science II (5)

CS 2511—Software Analysis and Design (4)

Econ 1023*—Principles of Economics: Micro (3)

ME 2105**—Introduction to Materials Science for Engineers (3)

or Engr 2015—Statics (3)

Math 1296*—Calculus I (5)

Math 1297—Calculus II (5)

Phys 2011*—General Physics I (4)

Phys 2012—General Physics II (4)

Upper Division (19 cr)

CS 5631—Operating Systems (4)

Engr 4001—Engineering Professionalism (3)

Math 3280—Differential Equations with Linear Algebra (4)

Math 3298—Calculus III (4)

Stat 3611—Introduction to Probability and Statistics (4)

Liberal education elective in addition to Econ 1023 must include the following

- At least one course from Category 7
- At least one course from Category 8
- At least two courses from Category 9 with different designators
- At least one course emphasizing international perspective
- At least one course emphasizing cultural diversity
- A total of at least 16 credits in Categories 6 through 9.
- Two courses with the same designator from the humanities or social sciences—the first one from Categories 6 through 9 numbered 1xxx and the second one numbered 2xxx or higher.

** Courses that may be used to fulfill UMD liberal education program requirements.*

Final Project

Electrical and computer engineering students must complete a capstone team design project integrating the knowledge from their academic career. This project must involve the design of hardware or software to meet specifications agreed upon by the student and the faculty project adviser. Oral and written reports are required.

Electrical and Computer Engineering Minor

Requirements (42 cr)

Lower Division (38)

ECE 1315—Digital System Design (4)

ECE 2006—Electrical Circuit Analysis (4)

ECE 2111—Linear Systems and Signal Analysis (4)

ECE 2212—Electronics I (4)

ECE 2325—Microcomputer System Design (4)**

Math 1296*—Calculus I (5)

Math 1297—Calculus II (5)

Phys 2011*—General Physics I (4)

Phys 2012—General Physics II (4)

Upper Division (4 cr)

Math 3280—Differential Equations and Linear Algebra (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

** For computer science majors: CS 2521—Computer Organization and Architecture (4) may be substituted for ECE 2325—Microcomputer System Design (4)

Environmental Engineering Minor Only

Department of Chemical Engineering

The environmental engineering minor develops a student's ability to understand and address environmental concerns. Coursework provides broad-based science and engineering knowledge suited to pollution prevention and waste management. The minor enhances degrees in science or other engineering fields.

Requirements (46-47 cr)

Lower Division (40-41 cr)

ChE 1011*—Introduction to Chemical Engineering
or ChE 2001*—Introduction to Environmental Engineering (3)

Stat 3611—Introduction to Probability and Statistics (4)

or Stat 2411*—Statistical Methods (3)

or ChE 2011—Design of Engineering Experiments (3)

ChE 2111—Material and Energy Balances (3)

Chem 1151*—General Chemistry I (5)

and Chem 1152—General Chemistry II (5)

or Chem 1161*—Honors: General Chemistry I (5)

and Chem 1162—Honors: General Chemistry II (5)

Chem 2222—Quantitative Analysis (3)

Chem 2223—Quantitative Analysis Lab (1)

Engr 2015—Statics (3)

Math 1296*—Calculus I (5)

Math 1297—Calculus II (5)

Phys 2011*—General Physics I (4)

Upper Division

Electives (6 cr)

ChE 4601—Biochemical Engineering (3)

ChE 4613—Air Pollution Control (3)

Other upper division electives may be substituted subject to department approval.

* Courses that may be used to fulfill UMD liberal education program requirements.

Geological Sciences

Professors: Steven M. Colman, John W. Goodge, Vicki L. Hansen, Timothy B. Holst, Thomas C. Johnson, Howard D. Mooers, Ronald L. Morton; *Associate Professors:* Erik T. Brown, Penelope Morton (department head), Nigel J. Watturs; *Assistant Professors:* Timothy M. Demko, Christina D. Gallup, John B. Swenson

The Department of Geological Sciences offers three undergraduate programs: a B.S. program providing training for a career as a professional geologist, which usually requires graduate study; a B.A. liberal arts program; and a program for those interested in teaching earth sciences (see Earth Sciences). Minors in geological sciences and limnology are also available.

Honors Program

The honors program in geological sciences has been established to recognize the achievements of undergraduate students who pursue independent research in geological sciences. To attain departmental honors, students must undertake an independent research project (typically two semesters) and maintain a cumulative overall GPA of 3.00. The research can be part of a UROP, directed research, independent study, or an internship with a faculty member. Students must make a brief oral presentation to the department summarizing their results and produce a research paper (maximum 10 pages).

B.A.—CLA

Degree Requirements

Requirements for the B.A. in geological sciences (120 cr) include:

- Liberal education requirements
- Completion of an advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (54-56 cr)
- A minor or second major from another area of study
- Elective credits to total 120 credits.

Required Courses

Geology Core (33 cr)

Geol 1110*—Geology and Earth Systems (4)

Geol 2110—Earth History, with lab (4)

Geol 2120—The Earth's Dynamic Interior (3)

Geol 2311—Mineralogy (4)

Geol 2312—Petrology (4)

Geol 3420—Sedimentology and Stratigraphy (4)

Geol 4450—Structural Geology (4)

Geol 4500—Field Geology (6)

Advanced Electives (8 cr)

Geol electives, 3xxx and above

With the exception of Geol 4110—Advanced Earth Science for Teachers, electives (3xxx and above) are selected from our yearly geological sciences offerings. Six credits of limnology classes may be substituted for geological sciences classes. Geog 4563 and 4564 (5 credit total) may be substituted for 3 credits of geological sciences electives.

Required Courses From Other Programs

Chem 1113*—Introduction to General, Organic, and Biological Chemistry I (5)

and Chem 1114—Introduction to General, Organic, and Biological Chemistry II (5)

or Chem 1151*—General Chemistry I (5)

and Chem 1152—General Chemistry II (5)

or Chem 1161*—Honors: General Chemistry I (5)

and Chem 1162—Honors: General Chemistry II (5)

Math 1250*—Precalculus Analysis (4)

or Math 1290*—Calculus for the Natural Sciences (5)

or Math 1296*—Calculus I (5)

or Stat 2411*—Statistical Methods (3)

* Courses that may be used to fulfill UMD liberal education program requirements.

B.S.

Degree Requirements

Requirements for the B.S. in geological sciences (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (76 cr)

Required Courses

Geology Core (33 cr)

Geol 1110*—Geology and Earth Systems (4)

Geol 2110—Earth History, with lab (4)

Geol 2120—Earth's Dynamic Interior (3)

Geol 2311—Mineralogy (4)

Geol 2312—Petrology (4)

Geol 3420—Sedimentology and Stratigraphy (4)

Geol 4450—Structural Geology (4)

Geol 4500—Field Geology (6)

Advanced Electives (15 cr)

Geol electives, 3xxx and above

With the exception of Geol 4110—Advanced Earth Science for Teachers, electives (3xxx and above) are selected from yearly geological sciences offerings. Six credits of limnology classes may be substituted for geological sciences classes. Geog 4563 and 4564 (5 credit total) may be substituted for 3 credits of geological sciences electives.

Required Courses From Other Programs

Chem 1151*—General Chemistry I (5)

and Chem 1152—General Chemistry II (5)

or Chem 1161—Honors: General Chemistry I (5)

and Chem 1162—Honors: General Chemistry II (5)

Math 1290*—Calculus for the Natural Sciences (5)

or Math 1296*—Calculus I (5)

and Math 1297—Calculus II (5)

Phys 2011*—General Physics I (4)

and Phys 2012—General Physics II (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Geological Sciences Minor

The geological sciences minor enhances the student's understanding of and familiarity with earth materials and processes, and provides valuable background for many environmental careers and applications.

Requirements (21 cr)

Geol 1110*—Geology and Earth Systems (4)

Geol 2110—Earth History, with lab (4)

Geol 2300—Basic Mineralogy and Petrology (4)

Geol electives 2xxx or above (9)

* Courses that may be used to fulfill UMD liberal education program requirements.

Industrial Engineering

Professors: Mark A. Fugelso, Richard R. Lindeke, David A. Wyrick (department head); *Associate Professors:* Hamid Fonooni, Dale A. Krageschmidt, Ryan G. Rosandich; *Assistant Professors:* Emmanuel U. Enemuoh, William E. Pedersen, Daniel N. Pope, John C. Voss

B.S.I.E.

The industrial engineering B.S.I.E. program integrates topics from manufacturing, management, and traditional design. Industrial engineers are proficient in the design, improvement, and management of complex systems of people, materials, equipment, and energy. They study and adapt product designs and the associated plant facilities to optimize production. In the process, they consider economic, technical, and human factors. The curriculum rounds out the learning experience by providing skills in the mathematical and physical sciences, economics, composition, and humanities and social sciences.

The industrial engineering program is accredited by the Accreditation Board for Engineering and Technology (ABET). The program emphasizes manufacturing engineering and engineering management.

The international engineering option requires a senior year exchange with the Department of Materials and Manufacturing Engineering at Luleå University of Technology in Sweden and provides students with the opportunity to learn about engineering in the global community.

Upper Division Admission Requirements

Admission to the program is competitive and on a space-available basis. A C- or better is required in all program courses. Transfer credits must be completed with a C or better. An application may be submitted when the student has completed the following courses:

- Chem 1151—General Chemistry I (5)
- CS 1121—Introduction to Programming in Visual BASIC (3)
or CS 1131—Introduction to Programming in FORTRAN (3)
- or CS 1211—Introduction to Programming in C (3)
- or CS 1511—Computer Science I (5)
- or CS 2121—Introduction to Programming in Java (3)
- Comp 1120—College Writing (3)
- Engr 2015—Statics (3)
- IE 1225—Introduction to Design and Manufacturing Engineering (4)
- ME 2105—Introduction to Material Science for Engineers (4)
- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations With Linear Algebra (4)
- Phys 2011*—General Physics I (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Honors Requirement

To graduate with department honors, a student must graduate with a 3.40 GPA, be an active member of Tau Beta Pi or a professional engineering society (ASME or IIE), and be nominated by a department faculty member.

Degree Requirements

Requirements for the B.S.I.E. in (127-131 cr) include:

- Liberal education requirements.
- Completion of at least 30 degree credits at UMD
- At least 20 of the last 30 degree credits taken immediately before graduation must have been taken at UMD
- Successful completion (with grades of C- or better or S) of all required courses and of 75 percent of all work attempted. Transfer credits must be completed with a C or better.
- Completion of the composition requirement
- Completion of the major program. A minimum GPA of 2.00 in all courses taken in the major, including required courses in related fields
- Filing of an upper division application and Academic Progress Audit (APAS). Students who fail to file this form by the time they have completed 75 credits may not be permitted to register.

Automated Systems Program (127-131 cr)

B.S.I.E.

Required Courses (47cr)

- EMgt 4110—Engineering Professionalism and Practice (2)
- IE 1225—Introduction to Design and Manufacturing Engineering (4)
- IE 3105—Human Factors (4)
- IE 3115—Operations Research (4)
- IE 3125—Engineering Economic Analysis (3)
- IE 3135—Materials Processing (4)
- IE 3255—Statistical Quality Control (3)
- IE 3265—Production and Operations Management (4)
- IE 4115—Facility Planning and Simulation (4)
- IE 4235—Manufacturing Systems Integration (4)
- IE 4255—Multidisciplinary Senior Design (4)
- ME 2105—Introduction to Material Science for Engineers (3)
- ME 4135—Robotics and Controls (4)

Required Courses From Other Programs (65 cr)

- Chem 1151*—General Chemistry I (5)
- Comp 1120*—College Writing (3)
- Comp 31xx (or higher)—Advanced Writing
or Comp 5220—Document Design and Graphics
or Comp 5230—Web Pages, Applications, and Presentations (3)
- Econ 1022*—Principles of Economics: Macro (3)
or Econ 1023*—Principles of Economics: Micro (3)
- Engr 2015—Statics (3)
- Engr 2016—Mechanics of Materials (3)
- Engr 2026—Dynamics (3)
- ECE 2006—Electrical Circuit Analysis (4)
- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Phys 2011*—General Physics I (4)
- Phys 2012—General Physics II (4)
- Stat 3611—Introduction to Probability and Statistics (4)

Required Science and Information Systems Electives

Choose two from (6-10 cr):

- CS 1511*—Computer Science I (5)
 - CS 1121—Introduction to Programming in Visual BASIC (3)
 - CS 1131—Introduction to Programming in FORTRAN (3)
 - CS 1211—Introduction to Programming in C (3)
 - CS 1521—Computer Science II (5)
 - CS 2121—Introduction to Programming in JAVA (3)
- One course each from liberal education categories 7, 8, and 9 and one course from 9 or 10 (12 cr); courses from categories 9 and 10 must have different designators.

* Courses that may be used to fulfill UMD liberal education program requirements.

Automated Systems Electives

at least three courses from the list of courses below (9 cr):

- IE 4196—Cooperative Education (1)
- IE 4495—Special Topics: (Various Titles to be Assigned) (1-4)
- IE 4993—IE Seminar (1)
- IE 5305—Supply Chain Management (3)
- IE 5315—Organizational Control Methods (3)
- IE 5325—Advanced Engineering Economics (3)
- IE 5335—Engineered Products and Services (3)
- ChE 2111—Material and Energy Balances (3)
- ChE 5895—Special Topics: (Various Titles to be Assigned) (1-4)
- CS 1521—Computer Science II (5) (cannot apply twice)
- CS 2121—Introduction to Programming JAVA (3) (cannot apply twice)
- ECE 1315—Digital Systems Design (4)
- ECE 2111—Linear Systems and Signal Analysis (4)
- ECE 2325—Microcomputer Systems Design (4)
- ECE 3151—Control Systems (3)
- ECE 5995—Special Topics: (Various Titles to be Assigned) (1-3)
- FMIS 3222—Systems Analysis and Design (3)
- MgtS 4472—Entrepreneurship (3)
- Math 3298—Calculus III (4)
- Math 3355—Discrete Math (4)
- Math 5260—Dynamical Systems (3)
- Math 5270—Modeling with Dynamical Systems (3)
- ME 3111—Fluid Mechanics
or ChE 3111—Fluid Mechanics (3)
- ME 3211—Thermodynamics (3)
- ME 4112—Heat and Mass Transfer
or ChE 3112—Heat and Mass Transfer (3)
- ME 4122—Heat Transfer, Thermodynamics and Fluid Mechanics Lab (2)
- ME 4145—CAD/CAM (4)
- ME 4175—Machine Design (3)
- ME 4245—Machining and Machine Tools (4)
- ME 4495—Special Topics: (Various Titles to be Assigned) (1-4)
- Safe 6001—OSHA and Other Regulatory Standards (3)
- Stat 5411—Analysis of Variance (3)
- Stat 5511—Regression Analysis (3)

International Engineering Program (127-130 cr)

B.S.I.E.

Required Courses (56 cr)

- IE 1225—Introduction to Design and Manufacturing Engineering (4)
- IE 3105—Human Factors (4)
- IE 3115—Operations Research (4)
- IE 3125—Engineering Economic Analysis (3)
- IE 3135—Materials Processing (4)

- IE 3255—Statistical Quality Control (3)
- IE 3265—Production and Operations Management (4)
- IE 4801—International Engineering Report (1) *must be taken twice* (2)
- IE 4803—Simulation of Swedish Manufacturing (3)
- IE 4812—Computer Integrated Manufacturing (4)
- IE 4823—Project Management and Swedish Industrial Design Project (6)
- IE 4827—Manufacturing Systems Project (8)
- IE 4870—Advanced Manufacturing Processes (4)
- ME 2105—Introduction to Material Science for Engineers (3)

Required Courses From Other Programs (72-74 cr)

- Chem 1151*—General Chemistry I (5)
- Comp 1120*—College Writing (3)
- Comp 3xxx (or higher)—Advanced Writing
or Comp 5220—Document Design and Graphics
or Comp 5230—Web Pages, Applications, and Presentation (3)
- CS 1511*—Computer Science I (5)
or CS 1121—Introduction to Programming in Visual BASIC (3)
or CS 1131—Introduction to Programming in FORTRAN (3)
or CS 1211—Introduction to Programming in C (3)
or CS 2121—Introduction to Programming in Java (3)
- ECE 2006—Electrical Circuit Analysis (4)
- Econ 1022*—Principles of Economics: Macro
or Econ 1023*—Principles of Economics: Micro (3)
- Engr 2015—Statics (3)
- Engr 2016—Mechanics of Materials (3)
- Engr 2026—Dynamics (3)
- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- ME 4145—CAD/CAM (4)
- Phys 2011*—General Physics I (4)
- Phys 2012—General Physics II (4)
- Stat 3611—Introduction to Probability and Statistics (4)
- IntS 1070*—An Introduction to Scandinavia (Category 8) (3)

One course from liberal education categories 7 and 9; and one course from 9 or 10 (9 credits); courses from categories 9 and 10 must have different designators.

* Courses that may be used to fulfill UMD liberal education program requirements.

Final Project

Students are required to complete a final team design project in the capstone design courses EMgt 4110—Engineering Professionalism and Practice and IE 4255—Multidisciplinary Senior Design. Completion of the junior year curriculum is a prerequisite for this course. The course requires publication of a final report and a formal presentation to the project sponsors. Students

taking the senior year at Luleå University of Technology must take its equivalent capstone design course.

Information Systems and Technology

Computer Science

B.S.

Professionals in the field of information systems work with information technology and must have sound technical knowledge of computers, software and communications. Since they operate within an organizational framework, they must also understand business and business functions. The B.S. in information systems and technology is a four-year program that includes formal courses in information technology (including system architecture, operating systems, interactive multimedia computing, and networking), management information systems, project organization and management, and business organizational functions. The program also includes supporting courses in communications, mathematics and statistics, and the economic, social, and ethical implications of computing. Goals of the learning process include the development of good programming and communication skills and the ability to work effectively in team environments. This program provides both the necessary foundational studies for students seeking entry-level positions in information systems and a strong basis for continued career growth.

Degree Requirements

Requirements for the B.S. in information systems and technology (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (73 cr)
- A minor in business administration for non-LSBE students is required.

Required Courses

Core

CS 1511*—Computer Science I (5)
or CS 1581—Honors: Computer Science (5)
CS 1521—Computer Science II (5)
CS 2511—Software Analysis and Design (4)
CS 3011—Information Technology Hardware and Software (4)
FMIS 2201—Information Technology in Business (3)

Advanced Courses

CS 3111—Computer Ethics (4)
CS 3121—Interactive Multimedia Technology (4)
CS 3211—Database System Concepts (4)
CS 3221—Operating Systems Practicum (4)
CS 4411—Data Communications and Network Technology (4)
CS 4531—Software Engineering (4)
CS 4993—Seminar (1)

Additional Requirements

Business administration minor for non-LSBE students
Comm 1112*—Public Speaking (3)
Comp 1120*—College Writing (3)
Comp 3150—Advanced Writing: Science (3)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)
Math 3355—Discrete Mathematics (4)
Stat 3611—Introduction to Probability and Statistics (4)
General education electives, including additional liberal education requirements (21)

* Courses that may be used to fulfill UMD liberal education program requirements.

Information Systems and Technology Minor Requirements (29 cr)

CS 1511*—Computer Science I (5)
CS 1521—Computer Science II (5)
CS 2511—Software Analysis and Design (4)
CS 3011—Information Technology and Hardware and Software (4)
LSBE 1101—The Business Environment (3)

Choose two courses from the following (8 cr):

CS 3121—Interactive Multimedia Technology (4)
CS 3211—Database Systems Concepts (4)
CS 3221—Operating Systems Practicum (4)
CS 4411—Data Communications and Network Technology (4)
CS 4531—Software Engineering (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Note: The information systems and technology minor is not available to computer science majors.

Limnology Minor Only

Department of Geological Sciences

Limnology is the scientific study of lakes, rivers, and wetlands. It is an interdisciplinary science encompassing the biology, chemistry, geology, and physics of these aquatic systems.

Requirements (34-36 cr)

Math 1296*—Calculus I (5)
Phys 2011*—General Physics I (4)
and Phys 2012—General Physics II (4)

or Phys 1001*—Introduction to Physics I (5)
and Phys 1002—Introduction to Physics II (5)
Chem 1151*—General Chemistry I (5)
and Chem 1152—General Chemistry II (5)
or Chem 1161*—Honors: General Chemistry I (5)
and Chem 1162—Honors: General Chemistry II (5)
Lim 5004—Field Limnology (2)

Three of the following:

Lim 5101—Physical Limnology (3)
Lim 5102—Chemical Limnology (3)
Lim 5103—Geological Limnology (3)
Biol 5861—Lake Ecology (3)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics

Department of Mathematics and Statistics

Professors: Joseph A. Gallian, Richard F. Green, Barry R. James, Kang L. James, Zhuangyi Liu, Ronald R. Regal, Harlan W. Stech (department head); *Associate Professors:* Dalibor Froncek, John R. Greene, Kathryn E. Lenz, Robert L. McFarland, Bruce B. Peckham, James W. Rowell, Steven A. Trogon; *Assistant Professors:* Michael Cheng, Guihua Fei, Carmen M. Latterell, Yongcheng Qi; *Instructors:* Erik W. Brohaugh, Anna C. Jacobson, Karl K. Kruppstadt, Thilagavathi Murugesan, Chad Pierson, Deanna L. Riley, Angela M. Sharp, Amanda Thralow

Honors

To graduate with department honors students must finish the program with an overall and department GPA of 3.50, satisfactorily complete a research project under the guidance of a faculty member, and convey the results of their research in a public presentation.

B.A.—CLA

This major prepares students for careers in business, industry, and government and for graduate school.

Degree Requirements

Requirements for the B.A. in mathematics (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering *or* Comp 3150—Advanced Writing: Science (3)
- Major requirements (46-51 cr)
- Minor or second major from another area of study
- Elective credits to total 120 credits

Required Courses

Math 1296*—Calculus I
or Math 1596*—Honors: Calculus I (5)
Math 1297—Calculus II

or Math 1597—Honors: Calculus II (5)
Math 3280—Differential Equations with Linear Algebra (4)
Math 3298—Calculus III (4)
Math 3299—Intermediate Analysis (3)
Math 3355—Discrete Mathematics (4)
Math 3941—Undergraduate Colloquium (1)
Math 4326—Linear Algebra (3)
Math 5371—Abstract Algebra I (3)
Stat 3611—Introduction to Probability and Statistics (4)

One of the following options (7-12 cr):

1. Math 5201—Real Variables (4)
and Math 5372—Abstract Algebra II (3)
2. Math 5201—Real Variables (4)
and two 5xxx courses approved by the Department of Mathematics and Statistics (6-8)
3. Math 5372—Abstract Algebra II (3)
and two 5xxx courses approved by the Department of Mathematics and Statistics (6-8)

Required Courses From Other Programs

One CS course above 1010 (3)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics—Applied Mathematics

B.S.

This major prepares students for careers in business, industry, and government and for graduate school. A working knowledge of a programming language is required for some of the higher level numerical courses.

Degree Requirements

Requirements for the B.S. in mathematics—applied mathematics (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering *or* Comp 3150—Advanced Writing: Science (3)
- Major requirements (51-54 credits)

Required Courses

Math 1296*—Calculus I
or Math 1596*—Honors: Calculus I (5)
Math 1297—Calculus II
or Math 1597—Honors: Calculus II (5)
Math 3280—Differential Equations with Linear Algebra (4)
Math 3298—Calculus III (4)
Math 3299—Intermediate Analysis (3)
Math 3941—Undergraduate Colloquium (1)
Math 4326—Linear Algebra (3)
Stat 3611—Introduction to Probability and Statistics (4)

One of the following (2-3 cr):

- Math 3097—Internship (2)
- Math 5270—Modeling with Dynamical Systems (3)
- Math 5991—Independent Study (2)
- Math or Stat course above 3xxx for UROP participants (2)

At least one course from each of the following groups (10-14 cr)—students who take CS 1521 select three courses; others select four courses:

Group 1

- Math 4230—Applied Mathematics: Complex Variables (3)
- Math 4240—Applied Mathematics: Operational Methods (3)

Group 2

- Math 5220—Optimization and Control (3)
- Math 5260—Dynamical Systems (3)
- Math 5280—Partial Differential Equations (3)
- Math 5810—Linear Programming (3)

Group 3

- Math 5830—Numerical Analysis: Approximation and Quadrature (4)
- Math 5840—Numerical Analysis: Systems and Optimization (4)
- Math 5850—Numerical Differential Equations (4)

Required Courses From Other Programs

CS 1511*—Computer Science I (5)

One of the following (3-5 cr):

- CS 1121*—Introduction to Programming in Visual BASIC (3)
- CS 1131*—Introduction to Programming in FORTRAN (3)
- CS 1211*—Introduction to Programming in C (3)
- CS 1521—Computer Science II (5)
- CS 2121*—Introduction to Programming in Java (3)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics Applied Minor Requirements (21 cr)

- Math 1296*—Calculus I
- or Math 1290*—Calculus for the Natural Sciences
- or Math 1596*—Honors: Calculus I (5)
- Math 1297—Calculus II
- or Math 1597—Honors: Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Electives from the following (7 cr):
- Math 3298—Calculus III (4)
- Math 3355—Discrete Mathematics (4)
- Math 4230—Applied Mathematics: Complex Variables (3)
- Math 4240—Applied Mathematics: Operational Methods (3)
- Math 4326—Linear Algebra (3)
- Math 5810—Linear Programming (3)
- Math 5830—Numerical Analysis: Approximation and Quadrature (4)
- Math 5840—Numerical Analysis: Systems and Optimization (4)

- Math 5850—Numerical Differential Equations (4)
- Stat 3611—Introduction to Probability and Statistics (4)
- Stat 5411—Analysis of Variance (3)
- Stat 5511—Regression Analysis (3)

The student's program of study must include either 1) at least one course at 4xxx or 5xxx selected from the above electives, or 2) beyond the 7 elective credits, an additional approved 4xxx or 5xxx course containing strong mathematical content but with a course designator outside of Math or Stat.

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics—Computational Mathematics B.S.

This major prepares students for careers in business, industry, and government and for graduate school. A working knowledge of a programming language is required for some of the higher level numerical courses.

Degree Requirements

Requirements for the B.S. in mathematics—computational mathematics (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering or Comp 3150—Advanced Writing: Science (3)
- Major requirements (58-60 credits)

Required Courses

- Math 1296*—Calculus I
- or Math 1596*—Honors: Calculus I (5)
- Math 1297—Calculus II
- or Math 1597—Honors: Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Math 3298—Calculus III
- or Math 3355—Discrete Mathematics (4)
- Math 3941—Undergraduate Colloquium (1)
- Math 4326—Linear Algebra (3)
- Stat 3611—Introduction to Probability and Statistics (4)
- Two of the following (7-8 cr):
- Math 5810—Linear Programming (3)
- Math 5830—Numerical Analysis: Approximation and Quadrature (4)
- Math 5840—Numerical Analysis: Systems and Optimization (4)
- Math 5850—Numerical Differential Equations (4)

Required Courses From Other Programs

- CS 1511*—Computer Science I (5)
- CS 1521—Computer Science II (5)
- CS 2511—Software Analysis and Design (4)

Three courses from the following, with at least two courses from Group 2 (11-12 cr):

Group 1

- CS 1121*—Introduction to Programming in Visual BASIC (3)
- CS 1131*—Introduction to Programming in FORTRAN (3)
- CS 1211*—Introduction to Programming in C (3)
- CS 2121*—Introduction to Programming in Java (3)

Group 2

- CS 4511—Computability and Complexity (4)
- CS 4521—Algorithms and Data Structures (4)
- CS 4531—Software Engineering (4)
- CS 4611—Database Management Systems (4)
- CS 4821—Computer Security (4)
- CS 5541—Artificial Intelligence (4)
- CS 5551—User Interface Design (4)
- CS 5621—Computer Architecture (4)
- CS 5631—Operating Systems (4)
- CS 5641—Compiler Design (4)
- CS 5651—Computer Networks (4)
- CS 5721—Computer Graphics (4)
- CS 5741—Object-Oriented Design (4)
- CS 5751—Introduction to Machine Learning (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics—Double Major

B.S.

This major prepares students for careers in business, industry, and government and for graduate school.

Degree Requirements

Requirements for the B.S. in mathematics—double major (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 31xx—Advanced writing course (3)
- Major requirements (48-58 credits)

An individualized program may be designed for students who have received a degree or are working on a degree from outside the Department of Mathematics and Statistics.

Required Courses

- Math 1296*—Calculus I
- or Math 1596*—Honors: Calculus I (5)
- Math 1297—Calculus II
- or Math 1597—Honors: Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Math courses above 3280 and/or Stat courses above 3xxx (23 cr); substitution courses from other programs must contain substantial mathematical or statistical content and be approved by the Department of Mathematics and Statistics in consultation with the participating department.

Substitution Option 1—Substitute up to 10 credits for up to 10 credits: 4xxx and/or 5xxx courses. Selected courses cannot be used for any major or minor outside the Department of Mathematics and Statistics.

Substitution Option 2—Usually substitute up to 20 credits for up to 10 credits: 4xxx and/or 5xxx courses. The substitution rate is higher because the credits apply to two majors/minors.

Math and/or Stat courses above 5xxx (8 cr)

* Courses that may be used to fulfill UMD liberal education program requirements.

Required Courses From Other Programs

One CS course above 1010 (3 cr)

Mathematics—Statistics and Actuarial Science

Advisers: R. Green, B. James, K. James, Y. Qi, R. Regal

B.S.

The science of statistics is concerned with generating and analyzing data. The mathematics and statistics major trains students in theoretical, applied, and computational statistics used in a wide variety of disciplines. Advisers have information on the national actuarial examinations.

Degree Requirements

Requirements for the B.S. in mathematics—statistics and actuarial science (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 31xx—Advanced writing course (3)
- Major requirements (49-50 credits)

Required Courses

- Math 1296*—Calculus I
- or Math 1596*—Honors: Calculus I (5)
- Math 1297—Calculus II
- or Math 1597—Honors: Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Math 3298—Calculus III (4)
- Math 3941—Undergraduate Colloquium (1)
- Stat 3611—Introduction to Probability and Statistics (4)
- Stat 5511—Regression Analysis (3)
- Stat 5531—Probability Models (4)
- Stat 5571—Probability (4)
- Stat 5572—Statistical Inference (4)
- Two of the following (6-7 cr):*
- Math 3299—Intermediate Analysis (3)
- Math 3355—Discrete Mathematics (4)
- Math 4326—Linear Algebra (3)

Required Courses From Other Programs

CS 1511*—Computer Science I (5)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics—Traditional Mathematics

B.S.

This major prepares students for careers in business, industry, and government and for graduate school.

Degree Requirements

Requirements for the B.S. in mathematics—traditional mathematics (120 cr) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering or Comp 3150—Advanced Writing: Science (3)
- Major requirements (48-53 cr)

Required Courses

Math 1296*—Calculus I

or Math 1596*—Honors: Calculus I (5)

Math 1297—Calculus II

or Math 1597—Honors: Calculus II (5)

Math 3280—Differential Equations with Linear Algebra (4)

Math 3298—Calculus III (4)

Math 3299—Intermediate Analysis (3)

Math 3355—Discrete Mathematics (4)

Math 3941—Undergraduate Colloquium (1)

Math 4326—Linear Algebra (3)

Math 5371—Abstract Algebra I (3)

Stat 3611—Introduction to Probability and Statistics (4)

One of the following (7-12 cr):

1. Math 5201—Real Variables (4)

and Math 5372—Abstract Algebra II (3)

2. Math 5201—Real Variables (4)

and two 5xxx courses approved by the Department of Mathematics and Statistics (6-8 cr)

3. Math 5372—Abstract Algebra II (3)

and two 5xxx courses approved by the Department of Mathematics and Statistics (6-8 cr)

Required Courses From Other Programs

CS 1511*—Computer Science I (5)

* Courses that may be used to fulfill UMD liberal education program requirements.

Mathematics Traditional Minor Requirements (22 cr)

Math 1296*—Calculus I

or Math 1596*—Honors: Calculus I (5)

Math 1297—Calculus II

or Math 1597—Honors: Calculus II (5)

Math 3280—Differential Equations with Linear Algebra (4)

Math and/or Stat courses above 3099, with not more than one credit from Math 3120—Mathematics Tutorial Project and with at least one course above 4xxx (8 cr).

* Courses that may be used to fulfill UMD liberal education program requirements.

Mechanical Engineering

B.S.M.E.

Professors: Mark A. Fugelso, Richard R. Lindeke, David A. Wyrick (department head); *Associate Professors:* Hamid Fonooni, Dale A. Krageschmidt, Ryan G. Rosandich; *Assistant Professors:* Emmanuel U. Enemuoh, William E. Pedersen, Daniel N. Pope, John C. Voss

The B.S.M.E. program integrates topics from chemistry, physics, advanced mathematics and statistics, and core engineering science to prepare graduates to work professionally in both thermal and mechanical systems, from design through realization of these systems. Mechanical engineers are proficient in the design, development, manufacture, and use of products involving mechanical and thermal elements.

The program emphasizes the production engineering approach to mechanical and thermal systems design and development. Upper division courses provide students with a strong understanding of mechanical and thermal systems, and the skills to design, develop, and implement these systems.

Mechanical engineering graduates are qualified for employment in a wide variety of industries including design, manufacturing, materials, aerospace, transportation, natural resources, and energy. Graduates may pursue assignments in design, development, manufacturing, operations, project engineering, or sales, and frequently move into engineering management. They are also well qualified to continue with or graduate education.

Students in the B.S.M.E. program have the opportunity to put their design and entrepreneurial skills to use in ASME design competitions, projects sponsored by regional companies, and research projects in the Undergraduate Research Opportunities Program.

Admission Requirements

Admission to the B.S.M.E. program is competitive and on a space-available basis. A C- or better is required in all program courses. Transfer credits must be completed with a C or better. An application for upper division may be submitted when the student has completed the following courses:

Chem 1151—General Chemistry I (5)
 CS 1121—Introduction to Programming in Visual BASIC (3)
 or CS 1131—Introduction to Programming in FORTRAN (3)
 or CS 1211—Introduction to Programming in C (3)
 or CS 1511—Computer Science I (5)
 or CS 2121—Introduction to Programming in Java (3)
 Comp 1120—College Writing (3)
 Engr 2015—Statics (3)
 IE 1225—Introduction to Design and Manufacturing Engineering (4)
 ME 2105—Introduction to Material Science for Engineers (3)
 Math 1296*—Calculus I (5)
 Math 1297—Calculus II (5)
 Math 3280—Differential Equations With Linear Algebra (4)
 Phys 2011*—General Physics I (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Honors Requirements

To graduate with department honors, a student must have a 3.40 GPA, be an active member of Tau Beta Pi or a professional engineering society (ASME or IIE), and be nominated by a department faculty member.

Degree Requirements

Requirements for the B.S.M.E. in mechanical engineering (126-129 cr) include:

- Liberal education program requirements
- At least 30 degree credits must be taken at UMD
- At least 20 of the last 30 degree credits taken immediately before graduation must be taken at UMD
- Successful completion (with grades of C- or better or S) of all required courses and 75 percent of all work attempted.
- Transfer credits must be completed with C or better
- Composition requirement
- Major requirements. A minimum GPA of 2.00 in all courses taken in the major, including required courses in related fields
- Admission to upper division by submitting an application and APAS form. Students who fail to file these forms by the time they have completed 75 credits may not be permitted to register.

Required Courses (45 cr)

EMgt 4110—Engineering Professionalism and Practice (2)
 IE 1225—Introduction to Design and Manufacturing Engineering (4)
 IE 3125—Engineering Economic Analysis (3)

IE 3135—Materials Processing (4)
 IE 3255—Statistical Quality Control (3)
 ME 2105—Introduction to Materials Science for Engineers (3)
 ME 3111—Fluid Mechanics
 or ChE 3111—Fluid Mechanics (3)
 ME 3211—Thermodynamics (3)
 ME 4112—Heat and Mass Transfer
 or ChE 3112—Heat and Mass Transfer (3)
 ME 4122—Heat Transfer, Thermodynamics, and Fluid Mechanics Laboratory (2)
 ME 4145—CAD/CAM (4)
 ME 4175—Machine Design (3)
 ME 4245—Machining and Machine Tools (4)
 ME 4255—Multidisciplinary Senior Design (4)

Required Courses From Other Programs (81-84 cr)

Chem 1151*—General Chemistry I (5)
 Comp 1120*—College Writing (3)
 Comp 31xx (or higher)—Advanced Writing
 or Comp 5220—Document Design and Graphics
 or Comp 5230—Web Pages, Applications, and Presentation (3)
 CS 1121—Introduction to Programming in Visual BASIC (3)
 or CS 1131—Introduction to Programming in FORTRAN (3)
 or CS 1211—Introduction to Programming in C (3)
 or CS 1511—Computer Science I (5)
 or CS 2121—Introduction to Programming in Java (3)
 Econ 1022*—Principles of Economics: Macro (3)
 or Econ 1023*—Principles of Economics: Micro (3)
 ECE 2006—Electrical Circuit Analysis (4)
 Engr 2015—Statics (3)
 Engr 2016—Mechanics of Materials (3)
 Engr 2026—Dynamics (3)
 Math 1296*—Calculus I (5)
 Math 1297—Calculus II (5)
 Math 3280—Differential Equations with Linear Algebra (4)
 Math 3298—Calculus III (4)
 Phys 2011*—General Physics I (4)
 Phys 2012—General Physics II (4)
 Stat 3611—Introduction to Probability and Statistics (4)
 Liberal education Category 7 elective (3 cr)
 Liberal education Category 8 elective (3 cr)
 Liberal education Category 9 elective (3 cr)
 Liberal education Category 9 or 10 elective (3 cr); courses from categories 9 and 10 must have different designators.

Control Systems Elective

Choose at least one course (3-4 cr):
 ChE 4401—Process Control (3)
 or ECE 3151—Control Systems (3)
 or IE 4235—Manufacturing Systems Integration (4)
 or ME 4135—Robotics and Controls (4)

Mechanical Engineering Electives

Choose at least two courses (6 cr):

- ChE 2121—Chemical Engineering Thermodynamics (3)
- ChE 4111—Separations (3)
- ChE 4301—Chemical Reaction Engineering (3)
- ChE 4401—Process Control (3) (if not taken for control systems elective)
- ChE 4613—Air Pollution Control (3)
- ChE 4621—Particle Technology (3)
- ChE 5895—Special Topics: (Various Titles to be Assigned) (1-4)
- ECE 2111—Linear Systems and Signal Analysis (4)
- ECE 2212—Electronics I (4)
- ECE 3151—Control Systems (3) (if not taken for control systems elective)
- ECE 3235—Electronics II (4)
- ECE 3445—Electromagnetic Fields (3)
- ECE 3611—Introduction to Solid-State Semiconductors (3)
- ECE 4501—Power Systems (4)
- ECE 5801—Introduction to Artificial Neural Networks (3)
- ECE 5831—Fuzzy Set Theory and Its Applications (3)
- ECE 5995—Special Topics: (Various Titles to be Assigned) (1-3)
- IE 3105—Human Factors (4)
- IE 3115—Operations Research (4)
- IE 3265—Production and Operations Management (4)
- IE 4115—Facility Planning and Simulation (4)
- IE 4196—Cooperative Education (1)
- IE 4235—Manufacturing Systems Integration (4) (If not taken for control systems elective)
- IE 4495—Special Topics: (Various Titles to be Assigned) (1-4)
- IE 4993—Industrial Engineering Seminar (1)
- ME 4135—Robotics and Controls (4) (If not taken for control systems elective)
- ME 4196—Cooperative Education (1)
- ME 4491—Independent Study in Mechanical Engineering (1-4)
- ME 4495—Special Topics: (Various Titles to be Assigned) (1-4)
- ME 5991—Independent Study in Mechanical Engineering (1-4)
- MgtS 4472—Entrepreneurship (3)
- Phys 2021—Relativity and Quantum Physics (4)
- Phys 4001—Classical Mechanics (4)
- Phys 4021—Quantum Physics II (4)
- Phys 4031—Thermal and Statistical Physics (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

Final Project

Students are required to complete a final team design project in the capstone design courses EMgt 4110—Professionalism and Practice and ME 4255—Multidisciplinary Senior Design. Completion of the junior year curriculum is a prerequisite for this course. The course requires a final report and a formal presentation to the project sponsors.

Physical Science

Teaching Physical Science Major (B.A.S.)

See College of Education and Human Service Professions for program description.

Physics

Professors: John R. Hiller (department head), Michael Sydor; *Associate Professors:* Bo R. Casserberg, Elise A. Ralph; *Assistant Professors:* Alec T. Habig, Jonathan Maps; *Instructor:* Darrin E. Johnson

The Department of Physics offers two B.S. degrees that provide professional preparation in pure and applied physics and a liberal arts degree (B.A.). Students participate in research focused primarily on theoretical physics, instrumentation, experimental solid state and high energy physics, and physical oceanography. The department also offers courses required for such professional and pre-professional programs as engineering and medicine.

Honors Requirements

To graduate with honors, students must participate in the department honors program, complete a research project, and maintain a GPA above 3.00. They are also expected to attend department colloquia. Interested students should contact the physics honors program coordinator.

B.A.—CLA

The B.A. in physics is a liberal arts degree that allows considerable freedom in the planning of upper level courses and can easily be combined with other majors and interests. The physics courses emphasize conceptual foundations, problem-solving skills, and experimental techniques.

Degree Requirements

Requirements for the B.A. in physics (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing; Science (3)
- Major requirements (49 credits): 31 credits in physics courses, including 12 credits in physics and limnology electives; 18 credits in mathematics
- A minor or a second major from another area of study
- Elective credits to total 120 credits.

Required Courses

Core

- Phys 1021—Exploring Current Topics in Physics (1)
- Phys 2011*—General Physics I (4)**
- Phys 2012—General Physics II (4)**
- Phys 2021—Relativity and Quantum Physics (4)
- Phys 2022—Classical Physics (4)
- Phys 2033—Classical and Quantum Physics Laboratory (2)

Electives (12 cr)

- Lim 5101—Physical Limnology (3)
- Phys 3061—Instrumentation (3)
- Phys 4001—Classical Mechanics (4)
- Phys 4011—Electromagnetic Theory (4)
- Phys 4021—Quantum Physics II (4)
- Phys 4031—Thermal and Statistical Physics (4)
- Phys 5041—Optics (3)
- Phys 5052—Computational Methods in Physics (3)
- Phys 5053—Data Analysis Methods in Physics (3)
- Phys 5061—Experimental Methods (3)
- Phys 5531—Introduction to Solid State Physics (3)
- Phys 5541—Fluid Dynamics (3)

Required Courses From Other Programs

- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Math 3298—Calculus III (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

** The department also recommends the supplementary courses Phys 2111—Solving Physics Problems I and Phys 2112—Solving Physics Problems II

B.S.

The B.S. in physics is primarily for students planning to work toward an advanced degree in physics or a related area. The physics courses emphasize conceptual foundations, problem-solving skills, and experimental techniques.

Degree Requirements

Requirements for the B.S. in physics (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (67 credits): 42 credits in physics courses; 25 credits in chemistry, computer science, and mathematics
- A minor or a second major in a different program

Required Courses

- Phys 1021—Exploring Current Topics in Physics (1)
- Phys 2011*—General Physics I (4)**
- Phys 2012—General Physics II (4)**
- Phys 2021—Relativity and Quantum Physics (4)
- Phys 2022—Classical Physics (4)
- Phys 2033—Classical and Quantum Physics Lab (2)
- Phys 3061—Instrumentation (3)
- Phys 4001—Classical Mechanics (4)
- Phys 4011—Electromagnetic Theory (4)
- Phys 4021—Quantum Physics II (4)
- Phys 4031—Thermal and Statistical Physics (4)
- Phys 5061—Experimental Methods (3)
- Phys 5090—Physics Seminar (1)

* Courses that may be used to fulfill UMD liberal education program requirements.

** The department also recommends the supplementary courses Phys 2111—Solving Physics Problems I and Phys 2112—Solving Physics Problems II

Required Courses From Other Programs

- Chem 2172*—General Chemistry (4)***
- CS 1131*—Introduction to Programming in FORTRAN (3)****
- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Math 3298—Calculus III (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

*** One year of college-level chemistry may be substituted with department approval.

**** Any one-semester course in a programming language may be substituted with department approval.

Physics Minor

This minor program provides an introduction to classical and quantum physics.

Requirements (32 cr)

- Math 1296*—Calculus I (5)
- Math 1297—Calculus II (5)
- Phys 1021—Exploring Current Topics in Physics (1)
- Phys 2011*—General Physics I (4)
- Phys 2012—General Physics II (4)
- Phys 2021—Relativity and Quantum Physics (4)
- Phys 2022—Classical Physics (4)
- Phys 2033—Classical and Quantum Physics Lab (2)
- Phys electives at 3xxx or above (3)

* Courses that may be used to fulfill UMD liberal education program requirements.

Applied Physics

B.S.

The B.S. in applied physics is primarily for students planning to work in industry. The physics courses emphasize conceptual foundations, problem-solving skills, and experimental and computational techniques.

Degree Requirements

The requirements for the B.S. in applied physics (120 credits) include:

- Liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3)
- Major requirements (74 credits): 37 credits in physics courses, including 8 credits of physics electives in fundamental areas; 9 credits of technical electives in physics, limnology, or approved engineering courses; 28 credits in chemistry, computer science, and mathematics
- A minor or a second major in a different program

Required Courses

Core

Phys 1021—Exploring Current Topics in Physics (1)
Phys 2011*—General Physics I (4)**
Phys 2012—General Physics II (4)**
Phys 2021—Relativity and Quantum Physics (4)
Phys 2022—Classical Physics (4)
Phys 2033—Classical and Quantum Physics Lab (2)
Phys 3061—Instrumentation (3)
Phys 5052—Computational Methods in Physics
or Phys 5053—Data Analysis Methods in Physics (3)***
Phys 5061—Experimental Methods (3)
Phys 5090—Physics Seminar (1)

Electives (8 cr)

Phys 4001—Classical Mechanics (4)
Phys 4011—Electromagnetic Theory (4)
Phys 4021—Quantum Physics II (4)
Phys 4031—Thermal and Statistical Physics (4)

Technical Electives (9 cr)

Lim 5101—Physical Limnology (3)
Phys 5041—Optics (3)
Phys 5052—Computational Methods in Physics
or Phys 5053—Data Analysis Methods in Physics (3)***
Phys 5531—Introduction to Solid State Physics (3)
Phys 5541—Fluid Dynamics (3)
Engineering courses approved by the department

* Courses that may be used to fulfill UMD liberal education program requirements.

** The department also recommends the supplementary courses Phys 2111—Solving Physics Problems I and Phys 2112—Solving Physics Problems II

*** The computational course not selected in Required Courses may be used as a technical elective.

Required Courses From Other Programs

Chem 2172*—General Chemistry (4)**
CS 1131*—Introduction to Programming in FORTRAN (3)
CS 1211*—Introduction to Programming in C (3)
Math 1296*—Calculus I (5)
Math 1297—Calculus II (5)
Math 3280—Differential Equations with Linear Algebra (4)
Math 3298—Calculus III (4)

* Courses that may be used to fulfill UMD liberal education program requirements.

** One year of college-level chemistry may be substituted with department approval.

Teaching Physics, 9-12

Students seeking a B.A. or B.S. in physics may enroll concurrently in secondary education licensure requirements in the Department of Education. Requirements for the physics 9-12 license are listed at http://www.d.umn.edu/cehsp/licensure/post_bac.htm. Students must apply for admission to the Secondary Teacher Education Program. Instructions can be found at <http://www.d.umn.edu/educ/forms/index.html>.

Students completing the B.A. in physics and seeking licensure must include Phys 3061 as an elective.

Statistics

Department of Mathematics and Statistics

Advisers: R. Green, B. James, K. James, Y. Qi, R. Regal
The science of statistics is concerned with generating and analyzing data. The mathematics and statistics major trains students in theoretical, applied, and computational statistics used in a variety of disciplines. See Mathematics for a description of the mathematics—statistics and actuarial science B.S. major.