

# College of Science and Engineering (CSE)

Dean: Sabra S. Anderson, 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.

Some programs (chemical engineering, electrical and computer engineering, industrial engineering) 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.

## 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 majoring in biology, chemical engineering, chemistry, computer science, geology, mathematics, or physics through the department honors programs.

Candidates are selected on the basis of coursework completed and potential for independent work. A research project is required for department honors.

More information about department honors is available through the departments.

## 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.), and bachelor of science in industrial engineering (B.S.I.E.) degrees.

### B.S. Majors

- Biochemistry/molecular biology
- Biology
- Cell biology
- Chemistry
- Computer science
- Geology
- Information systems and technology
- Mathematics
  - Applied mathematics
  - Computational mathematics
  - Double major
  - Statistics
  - Traditional mathematics
- 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
- Mathematics
- Mathematics, applied
- Physics

For other minors available to students receiving a B.S., see 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 (some programs require more than 120 degree credits; see program descriptions).
- Completion of at least 30 degree credits at UMD.
- Completion of at least 20 of the last 30 credits earned before graduation at UMD.

- 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 (excluding failing grades, nonpassing grades, and withdrawals) of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Policies and Procedures.
- Completion of a major for the B.S. and a minor or second major in a different program. Required for graduation is a 2.00 minimum GPA in the major, including supporting courses, and a 2.00 minimum GPA in the minor, including supporting courses. 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 of at least 20 of the last 30 credits earned before graduation at UMD.
- 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 (excluding failing grades, nonpassing grades, and withdrawals) of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Policies and Procedures. Students must take two courses with different course designators from Category 9 and no courses from Category 10 as part of their 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 131 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion of at least 20 of the last 30 credits earned before graduation at UMD.
- 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 (excluding failing grades, nonpassing grades, and withdrawals) of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Policies and Procedures. Students must take two courses with different course designators from Category 9 and no courses from Category 10 as part of their liberal education program.
- Completion of the electrical and computer engineering major. Admission to the upper division program of the electrical and computer 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 electrical and computer 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.I.E. Requirements

- Completion of at least 131 degree credits.
- Completion of at least 30 degree credits at UMD.
- Completion of at least 20 of the last 30 credits earned before graduation at UMD.
- 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 (excluding failing grades, nonpassing grades, and withdrawals) of 75 percent of all work attempted.
- Completion of UMD liberal education requirements. See Policies and Procedures. Students must take two courses with different course designators from Category 9 and no

courses from Category 10 as part of their liberal education program.

- 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.

## Master of Industrial Safety (M.I.S.)

*Professor:* B. J. DeRubeis, Director (218) 726-8117;  
*Associate Professor:* Hamid F. Fard; *Assistant Professor:* Dale Krageschmidt

The M.I.S. program prepares qualified personnel for industrial safety or industrial hygiene supervisory and management positions in business, government, and industry. 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 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 industrial 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.I.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.I.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 by April 1 of the year of anticipated entrance. Because enrollment is limited, applicants applying after April 1 may not get into the program. Information and applications are available from the master of industrial safety 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 500 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 Master of Industrial Safety include: 1) 36 course credits in either the industrial safety or industrial hygiene option 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 (30)

- 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 6111—Industrial Noise and Ventilation Control (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 6801—Conference Leading and Team Dynamics (2)
- Safe 6811—Behavioral Aspects of Safety (2)
- Safe 6821—Organization and Administration of Safety Programs (2)

#### Industrial Safety Option (9)

- Safe 6051—Construction Safety (2)
- Safe 6201—Fire Prevention and Emergency Preparedness (2)
- Safe 6211—Transportation Safety (2)
- Safe 6997—Internship in Industrial Safety (3)

#### Industrial Hygiene Option (9)

- Safe 6102—Advanced Industrial Hygiene and Health Physics (2)
- Safe 6112—Advanced Industrial Noise and Ventilation Control (2)
- Safe 6121—Epidemiology and Industrial Toxicology (2)
- Safe 6997—Internship in Industrial Safety (3)

### Final Project

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.I.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.

## 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, this 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.

### 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 for the next semester of day school 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.

## 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 one or two 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 see their advisers regularly to obtain current curriculum information, 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

*Adviser:* Holmstrand (Biol)

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)
- Comm 1112—Public Speaking (3)
- Comp 1120—College Writing (3)

Comp 3150—Advanced Writing: Science (3)  
 Math 1250—Precalculus Analysis (3)  
 Phys 1001—Introduction to Physics I (5)  
 Phys 1002—Introduction to Physics II (5)  
 Psy 1003—General Psychology (4)  
 Electives especially recommended are Acct 2005; Art 1002, 1009, 1012; Biol 1761, 2101, 2201, 4501, 4765, 4767, 5361, 5765; Chem 2222; Econ 1023; and Psy 2021, 3371.

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) must be taken before the student's application will be considered. The computerized DAT can be taken at any time, but students must first apply through the Dental Admission Testing Program.

## Pre-Engineering

*Advisers:* See individual engineering departments or contact CSE Student Affairs, (218) 726-7585, for referral.

Students who are undecided on the specific engineering program they would like to pursue may ask to be declared pre-engineering students. They should select a specific engineering program during their freshman year from either the Accreditation Board for Engineering and Technology (ABET)-accredited chemical engineering, electrical and computer engineering, or industrial engineering programs at UMD, or one of the preparatory engineering programs, such as pre-aerospace engineering, pre-civil engineering, or pre-mechanical 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 make a selection as early as possible because only mathematics, physics, and college writing courses are common in the first year. There are other required courses, such as chemistry, computer programming, economics, and engineering graphics, that 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—FORTRAN (3)  
 Engr 2015—Statics (2)  
 Engr 2016—Mechanics of Materials (3)  
 Engr 2026—Dynamics (3)  
 Math 1296—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3298—Calculus III (5)  
 Math 3280—Differential Equations and Linear Algebra (4)  
 Phys 1201—Mechanics (4)  
 Phys 1202—Heat and Electricity (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 (2)  
 Engr 2016—Mechanics of Materials (3)  
 Engr 2026—Dynamics (3)  
 Geol 1110—Introductory Geology (3)  
 Math 1296—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3298—Calculus III (5)  
 Math 3280—Differential Equations and Linear Algebra (4)  
 Phys 1201—Mechanics (4)  
 Phys 1202—Heat and Electricity (4)  
 Stat 3611—Introduction to Probability and Statistics (4)  
 Liberal education courses that complete Minnesota Transfer Curriculum or meet requirements of transfer institution

### Pre-Mechanical Engineering

Chem 1151—General Chemistry I (5)  
 Comp 1120—College Writing (3)  
 CS 1511—Computer Science I (5)  
 Engr 2015—Statics (2)

- Engr 2016—Mechanics of Materials (3)
- Engr 2026—Dynamics (3)
- IE 1105—Introduction to Engineering Design (3)
- IE 1205—Introduction to Manufacturing Engineering (3)
- Math 1296—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3298 —Calculus III (5)
- Math 3280—Differential Equations and Linear Algebra (4)
- Phys 1201—Mechanics (4)
- Phys 1202—Heat and Electricity (4)
- Liberal education courses that complete Minnesota Transfer Curriculum or meet requirements of transfer institution

**Other Engineering Specialties**

Consult CSE Student Affairs Office,  
140 Engineering Building.

**Junior-Level Admission**

UMD and transfer students must apply for admission at the end of their sophomore year 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 of the chosen engineering program. 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 the Minnesota state community college system 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.

Students in the joint admission program are admitted to CSE as juniors if they meet admission requirements (see Joint Admission Program in Engineering). They must complete a UMD Application for Undergraduate Admission and pay the application fee. UMD engineering students seeking admission to IT engineering programs on the Minneapolis campus must complete the change of college form for transfer to IT.

**Pre-Fisheries and Wildlife Management**

*Adviser:* Contact the Department of Biology

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 and Wildlife, College of Natural Resources on the St. Paul campus. Students planning to attend the 3<sup>1</sup>/<sub>2</sub>-week summer program at the Lake Itasca Forestry and Biological Station following their freshman or sophomore year must have a 2.00 minimum GPA, completed 40 credits, and completed Biol 1011-1012 with minimum grades of C. For more information, consult the College of Natural Resources section of the Twin Cities *Undergraduate Catalog*.

- Biol 1011—General Biology I (5)
- Biol 1012—General Biology II (5)
- Biol 2201—Genetics (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)
- 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)

**Pre-Medicine**

*Advisers:* Carlson, Firling, Hedman, Hicks, Karim, Magnuson, Poe, Siders, Thompson, Tsai (Chem)

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 check the 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)  
 Chem 3324—Biochemistry Laboratory (1)  
 Comp 1120—College Writing (3)  
 Comp 3150—Advanced Writing: Science (3)  
 Math 1296—Calculus I (5)  
 Math 1297—Calculus II (5) (for Phys 1201-1204)  
 Phys 1001—Introduction to Physics I (5)  
 Phys 1002—Introduction to Physics II (5)  
 or Phys 1201—Mechanics (4)  
 and Phys 1204—Electricity, Magnetism, and Optics (5)

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

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*. Complete 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

Adviser: Firling (Biol)

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. Taking courses pass-fail is discouraged. 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 (4-5)  
 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)  
 Psy 1003—General Psychology (4)  
 Stat 1411—Introduction to Statistics (3)

Additional recommended or required courses may include anatomy, biochemistry, communications, computer science, genetics, humanities, microbiology, physiology, and social sciences.

## Pre-Pharmacy

Adviser: Caple, Harriss (Chem)

Students wishing to enter the four-year doctor of pharmacy (Pharm.D.) program in the College of Pharmacy on the Minneapolis campus may complete their pre-pharmacy work on the Duluth campus. Students who have successfully completed the prerequisites below are considered for admission to the program.

Biol 1011—General Biology I (5)  
 Biol 1012—General Biology II (5)  
 Biol 2101—Cell Biology (3)  
 Biol 1761—Human Anatomy (4)  
 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: Microeconomics (3)  
 Math 1296—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Phys 1001—Introduction to Physics I (5)  
 Phys 1002—Introduction to Physics II (5)  
 Two courses dealing with human behavior in society (e.g., psychology, sociology, anthropology)

## Pre-Veterinary Medicine

*Adviser:* Karim (Biol)

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 (about one year before desired entry). The Graduate Record Examination (GRE) is also required for admission. Write to the Office of the Registrar—St. Paul, University of Minnesota, 130 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108.

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 3150—Advanced Writing: Science (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.

*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 major departments. Additional biology, chemistry, or mathematics coursework, for example, can lead to majors in these areas.

## Degree Programs Aerospace Studies (Air)

*Professor:* Lt. Col. Carol Wolosz (department head);  
*Assistant Professor:* John Hedenberg

Any student may enroll in aerospace studies courses. 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. Applying organizational leadership and management skills is the backbone of this professional development program. AFROTC prepares college students for Air Force leadership positions as they earn their academic degrees. Scholarships are available on a competitive basis. High school seniors and college students can compete for two-, three-, and four-year scholarships that cover all tuition, fees, book expenses, and a monthly stipend. Non-AFROTC-scholarship two-year participants receive a monthly stipend and may qualify for a \$3,450 per year tuition incentive. All aerospace studies courses must be taken A-F.

### 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 (12) (required of all candidates for commissions)**

Air 3101-3102—Air Force Leadership and Management (6)  
 Air 4101—U.S. Security Policy Process (3)  
 Air 4102—Preparation for Active Duty (3)  
 Leadership Lab—A 1.25 hour per week laboratory provides introductory and advanced hands-on leadership and management experience (P-F).  
 Pilot and navigator candidates are encouraged to take Air 2200—Introduction to Aviation (3).

### Minor Only

The aerospace studies minor (27-28 credits) 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

### Lower Division (9)

- Air 1101—The Air Force Today (1)  
 Air 1102—The Air Force Today (1)  
 Air 2101—The Air Force Way (1)  
 Air 2102—The Air Force Way (1)  
 Course requiring mathematical reasoning (2)  
 Comm 1112\*—Public Speaking  
 or Comm 1222\*—Interpersonal Communication (3)

### Upper Division (18-19)

- Air 3101—Air Force Leadership and Management (3)  
 Air 3102—Air Force Leadership and Management (3)  
 Air 4101—U.S. Security Policy Process (3)  
 Air 4102—Preparation for Active Duty (3)  
 Advanced or technical writing course (3)

*One of the following or an approved substitute:*

- Air 2200—Introduction to Aviation (3)  
 Air 3400—Project Management (3)  
 Hist 3384—American Foreign Relations I (3)  
 Pol 3400—Contemporary Issues in World Politics (4)  
 Pol 3402—American Foreign and Defense Policy (3)  
 Pol 3415—International Law (4)

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

## Astronomy (Ast)

See Course Descriptions.

## Biochemistry and Molecular Biology

### Department of Chemistry

*Professors:* Paul M. Anderson (Med), Ronald Caple, Robert M. Carlson, Lester R. Drewes (Med), John F. Evans, John E. Fulkrod, Donald K. Harriss, Vincent R. Magnuson, Donald P. Poe, Joseph R. Prohaska (Med), Larry C. Thompson, Bilin P. Tsai (department head), Kendall B. Wallace (Med); Viktor V. Zhdankin; *Associate Professors:* Thomas E. Huntley (Med), Paul D. Siders, *Assistant Professors:* Annette Boman (Med), Benjamin L. Clarke (Med), Cecilia Giuliui, Paul Kiprof, James McManus

### 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 provides classroom and laboratory learning opportunities and research experience across the discipline to meet the needs of students in liberal arts and preprofessional programs as well as of students who wish to pursue careers in the field.

### Honors Requirements

The chemistry department 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 three semesters of effort on a jointly developed project. Written reports and an oral presentation of the research are also required.

### Degree Requirements

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

- UMD liberal education requirements
- Advanced writing requirement—noted under the major requirements for “Year 3” (3 credits)
- Major requirements (82 credits)

### 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 Course: General Chemistry I (5)  
 Chem 1152—General Chemistry II  
 or Chem 1162—Honors Course: General Chemistry II (5)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)

#### Year 2

- Biol 2201—Genetics (3)  
 Chem 2222—Quantitative Analysis (4)  
 Chem 2521—Organic Chemistry I (4)  
 Chem 2522—Organic Chemistry II (4)  
 Phys 1201\*—Mechanics (4)  
 Phys 1204—Electricity, Magnetism, and Optics (5)

#### Year 3

- Biol 2101—Cell Biology (3)  
 Chem 4341—Biochemistry and Molecular Biology I (4)  
 Chem 4363—Biochemistry Laboratory (2)  
 Chem 4632—Physical Chemistry (5)  
 Comp 31xx—Advanced Writing (3)

#### Year 4

- Chem 3184—Undergraduate Seminar (2)  
 Chem 4242—Instrumental Analysis (2)  
 Chem 4342—Biochemistry and Molecular Biology II (4)  
 Chem 4364—Molecular Biology Laboratory (2)  
 Chem 4434—Inorganic Chemistry (4)

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

## Biology (Biol)

*Professors:* Conrad E. Firling, Stephen C. Hedman, M. Reza-Ul Karim, Andrew R. Klemer, Gerald J. Niemi, John J. Pastor, Melbourne C. Whiteside; *Associate Professors:* Randall E. Hicks, Linda L. Holmstrand, David J. Schimpf; *Assistant Professors:* Arun Goyal, Qinqin Liu, Merry Jo Oursler

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 credits) include:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (59-70 credits): 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 the 2xxx level or above to provide flexibility in pursuing personal interests or career preparation
- Minor requirements

### 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)

Biol electives at 2xxx or above (18), must include a minimum of two laboratory courses or courses with a laboratory component

### 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 Course: General Chemistry I (5)

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

and Chem 2521—Organic Chemistry I (4)

and Chem 2522—Organic Chemistry (4-5)

Math 1250\*—Precalculus Analysis (4)

and Stat 1411\*—Introduction to Statistics (3)

or Math 1290\*—Calculus for Modeling (5)

and Stat 2411\*—Statistical Methods (3)

or Stat 3611—Introduction to Probability and Statistics (4)

or Math 1296\*—Calculus I (5)

and Stat 2411\*—Statistical Methods (3)

or Stat 3611—Introduction to Probability and Statistics (4)

### Electives

*Two of the following may be applied toward biology elective credits noted above:*

MicB 5545—Immunobiology (3)

Phsl 5601—Physiology of Organ Systems I (3)

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 credits) include:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (77-81 credits): 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 level or higher

### 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)

Biol electives at 2xxx or above (18), must include a minimum of two laboratory courses or courses with a laboratory component

**Required Courses From Other Programs**

- Chem 1151\*—General Chemistry I (5)  
and Chem 1152—General Chemistry II (5)
- or Chem 1161\*—Honors Course: General Chemistry I (5)  
and Chem 1162—Honors Course: General Chemistry II (5)
- Chem 2521—Organic Chemistry I (4)  
Chem 2522—Organic Chemistry II (4-5)
- Math 1296\*—Calculus I (5)  
and Math 1297—Calculus II (5)
- or Math 1296\*—Calculus I (5)  
and Stat 2411\*—Statistical Methods (3)  
or Stat 3611—Introduction to Probability and Statistics (4)
- or Math 1290—Calculus for Modeling (5)  
and 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 1201—Mechanics (4)  
and Phys 1204—Electricity, Magnetism, and Optics (5)

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

**Electives**

Two of the following may be applied to biology elective credits noted above:

- MicB 5545—Immunobiology (3)  
Phsl 5601—Physiology of Organ Systems I (3)  
Phsl 5602—Physiology of Organ Systems II (2)

**Minor Requirements (44-55)**

- 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) (may include two of the following: MicB 5545, 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 Course: General Chemistry I (5)  
and Chem 1162—Honors Course: General Chemistry II (5)  
and Chem 2521—Organic Chemistry I (4)  
and Chem 2522—Organic Chemistry II (4-5)
- Math 1250\*—Precalculus Analysis (4)  
and Stat 1411\*—Introduction to Statistics (3)

- or Math 1290\*—Calculus for Modeling (5)  
and Stat 2411\*—Statistical Methods (3)  
or Stat 3611—Introduction to Probability and Statistics (4)
- or Math 1296\*—Calculus I (5)  
and 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:* Conrad E. Firling, Stephen C. Hedman, M. Reza-Ul Karim, Andrew R. Klemer, Gerald J. Niemi, John J. Pastor, Melbourne C. Whiteside; *Associate Professors:* Randall E. Hicks, Linda L. Holmstrand, David J. Schimpf; *Assistant Professors:* Arun Goyal, Qinqin Liu, Merry Jo Oursler

**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 UMD School of Medicine.

**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 credits):

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (84-90 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 4501—General Microbiology (4)  
Biol 4801—Evolution (2)  
Biol 5231—Molecular Biology (3)  
Biol 5232—Molecular Biology Laboratory (2)  
Biol 5331—Plant Development (2)  
and Biol 5332—Plant Development Laboratory (2)
- or Biol 5361—Developmental Biology (4)

- Biol 5601—Plant Physiology (2)  
*and* Biol 5602—Plant Physiology Laboratory (2)  
 or Phsl 5601—Physiology of Organ Systems I (3)  
*and* Phsl 5602—Physiology of Organ Systems II (2)

*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—Topics in Biology (program approved) (1-5)  
 Biol 3994—Undergraduate Research (1-3)  
 Biol 5121—Plant Biochemistry and Molecular Biology (4)  
 Biol 5133—Mechanisms of Cell Communication (4)  
 Biol 5199—Frontiers in Cell Biology (1)  
 Biol 5331—Plant Development (2)  
 Biol 5332—Plant Development Laboratory (2)  
 Biol 5361—Developmental Biology (4)  
 Biol 5511—Virology (3)  
 Biol 5513—Experimental Immunology (4)  
 Biol 5601—Plant Physiology (2)  
 Biol 5602—Plant Physiology Laboratory (2)  
 Biol 5765—Histology (4)  
 Biol 5801—Microbial Ecology (2)  
 Biol 5802—Microbial Ecology Laboratory (2)  
 Biol 5990—Topics in Biology (program approved) (1-5)  
 MicB 5545—Immunobiology (3)  
 Phsl 5601—Physiology of Organ Systems I (3)  
 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 Course: General Chemistry I (5)  
*and* Chem 1162—Honors Course: General Chemistry II (5)  
 Chem 2222—Quantitative Analysis (4)  
*and* 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 and Molecular Biology I (4)  
*and* Chem 4363—Biochemistry Laboratory (2)  
 Math 1296\*—Calculus I (5)  
*and* Math 1297—Calculus II (5)  
 or Math 1296\*—Calculus I (5)  
*and* Stat 2411\*—Statistical Methods (3)  
 or Stat 3611—Introduction to Probability and Statistics (4)  
 or Math 1290\*—Calculus for Modeling (5)  
*and* 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 1201—Mechanics (4)  
*and* Phys 1204—Electricity, Magnetism, and Optics (5)

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

## Chemical Engineering (ChE)

*Professor:* Dianne Dorland (department head); *Associate Professor:* Richard A. Davis; *Assistant Professors:* Keith Lodge, Steven Sternberg

### 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. By the end of the program, the student must demonstrate the ability to solve engineering problems, a sensitivity to the 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 and deformable body mechanics of materials; 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. The program emphasizes hazardous waste processing engineering, communication skills, safety, ethics, and the use of computers. 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 and students who have been granted joint admission in engineering with the Minnesota State Community College System should refer to the Pre-Engineering 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:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering (3 credits)
- 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)

- ChE 1011\*—Introduction to Chemical Engineering (3)  
 ChE 2011—Design of Engineering Experiments (3)  
 ChE 2111—Material and Energy Balances (3)  
 ChE 2121—Chemical Engineering Thermodynamics (3)

#### Upper Division (36)

- ChE 3111—Fluid Mechanics (3)  
 ChE 3112—Heat and Mass Transfer (3)  
 ChE 3211—Chemical Engineering Laboratory I (2)  
 ChE 3231—Properties of Engineering Materials (3)  
 ChE 4111—Separations (3)  
 ChE 4211—Chemical Engineering Laboratory II (2)  
 ChE 4301—Chemical Reaction Engineering (3)  
 ChE 4401—Process Control (3)  
 ChE 4501—Chemical Engineering Design I (4)  
 ChE 4502—Chemical Engineering Design II (4)  
 Two ChE electives at 4xxx or 5xxx (6)

### Required Courses From Other Programs

#### Lower Division (56)

- Comp 1120\*—College Writing (3)  
 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 (4)  
 Chem 2521—Organic Chemistry I (4)  
 CS 1135\*—Introduction to Programming in FORTRAN 77 (2)  
 Engr 2015—Statics (2)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4)

- Phys 1201\*—Mechanics (4)  
 Phys 1202—Heat and Electricity (4)  
 Liberal education electives\*\* (9)

#### Upper Division (23)

- Advanced chemistry elective, such as Chem 2522—Organic Chemistry II (4)  
 or Chem 4642—Physical Chemistry II (4)  
 Chem 4641—Physical Chemistry I (4)  
 Engr 2016—Mechanics of Materials (3)  
 Engr 3201—Electrical Power (3)  
 Liberal education electives\*\* (6)

Advanced liberal education elective—any 2xxx course or above in the humanities, social sciences, or behavioral sciences for which the student has already completed a category 6, 7, 8, or 9 prerequisite course (3)

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

\*\* Liberal education electives: one course each from categories 6, 7, and 8; two courses from category 9.

## Chemistry (Chem)

*Professors Emeritus:* Thomas J. Bydalek, Edward J. Cowles, James C. Nichol; *Professors:* Paul M. Anderson (Med), Ronald Caple, Robert M. Carlson, Lester R. Drewes (Med), John F. Evans, John E. Fulkrod, Donald K. Harriss, Vincent R. Magnuson, Donald P. Poe, Joseph R. Prohaska (Med), Larry C. Thompson, Bilin P. Tsai (department head), Kendall B. Wallace (Med), Viktor V. Zhdankin; *Associate Professors:* Thomas E. Huntley (Med), Paul D. Siders; *Assistant Professors:* Annette Boman (Med), Benjamin L. Clarke (Med), Cecilia Giulivi, Paul Kiprof, James McManus

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 provides classroom and laboratory learning opportunities and research experience across the discipline to meet the needs of students in liberal arts and preprofessional programs as well as of students who wish to pursue careers in the field.

### Honors Requirements

The chemistry department honors program helps outstanding chemistry majors develop into competent, independent research workers, and 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 three semesters of effort on a jointly developed project. Written reports and an oral presentation of the research are also required.

**B.A.—CLA****Degree Requirements**

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

- UMD liberal education requirements
- Advanced writing requirement—listed under the major requirements for “Year 3” (3 credits)
- Major requirements (54 credits)
- Minor requirements

**Required Courses****Year 1**

Chem 1151\*—General Chemistry I

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

Chem 1152—General Chemistry II

or Chem 1162—Honors Course: General Chemistry II (5)

Math 1296\*—Calculus I (5)

Math 1297—Calculus II (5)

**Year 2**

Chem 2222—Quantitative Analysis (4)

Chem 2521—Organic Chemistry I (4)

Chem 2522—Organic Chemistry II (4)

Phys 1201\*—Mechanics (4)

Phys 1204—Electricity, Magnetism, and Optics (5)

**Year 3**

Chem 3322—Biochemistry (3)

Chem 3324—Biochemistry Laboratory (1)

Chem 4434—Inorganic Chemistry (4)

Chem 4632—Physical Chemistry (5)

Comp 31xx—Advance writing (3 credits)

\* 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 credits) in chemistry include:

- UMD liberal education requirements
- Advanced writing requirement—noted under the major requirements for “Year 3” (3 credits)
- Major requirements (71 credits)

**Required Courses****Year 1**

Chem 1151\*—General Chemistry I

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

Chem 1152—General Chemistry II

or Chem 1162—Honors Course: General Chemistry II (5)

Math 1296\*—Calculus I (5)

Math 1297—Calculus II (5)

**Year 2**

Chem 2222—Quantitative Analysis (4)

Chem 2521—Organic Chemistry I (4)

Chem 2522—Organic Chemistry II (5)

CS 1135\*—Introduction to Programming in FORTRAN 77 (2)

Math 3280—Differential Equations with Linear Algebra (4)

Phys 1201\*—Mechanics (4)

Phys 1204—Electricity, Magnetism, and Optics (5)

**Year 3**

Chem 3322—Biochemistry (3)

Chem 3324—Biochemistry Laboratory (1)

Chem 4242—Instrumental Analysis (4)

Chem 4641—Physical Chemistry I (4)

Chem 4642—Physical Chemistry II (4)

Comp 31XX—Advanced writing (3 credits)

**Year 4**

Chem 3184—Undergraduate Seminar (2)

Chem 4434—Inorganic Chemistry (5)

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

**Minor Requirements (26)**

Chem 1151\*—General Chemistry I

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

Chem 1152—General Chemistry II

or Chem 1162—Honors Course: General Chemistry II (5)

Chem 2222—Quantitative Analysis (4)

Chem 2521—Organic Chemistry I (4)

Chem 2522—Organic Chemistry II (4)

College-level math course (4)

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

## Computer Science (CS)

*Professors:* Donald B. Crouch (department head); *Associate Professors:* Timothy R. Colburn, Carolyn J. Crouch, Linda L. Deneen, Douglas J. Dunham, Gary M. Shute; *Assistant Professors:* Maria Sosonkina Driver, Richard F. Maclin, C. Hudson Turner

### B.S.

Computer science is a discipline that involves understanding the design of computers and computational processes, and ranges from the theoretical study of algorithms to the design and implementation of software at the systems and applications levels.

The B.S. degree in computer science is a four-year accredited program that provides a solid base of fundamental knowledge in the following areas: design and implementation of computer software systems, fundamental principles of computer hardware operation, and theoretical computer science. In addition, students are expected to develop outstanding programming skills. The program provides the necessary foundational studies for students seeking careers in the computing industry or preparing for graduate study in computer science. This program is accredited by the Computer Science Accreditation Commission of the Computing Sciences Accreditation Board.

### Admission Requirements

Same as admission criteria for the College of Science and Engineering.

### 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, presenting the results of this research at a colloquium; credit for the project can be earned in CS 4994—Honors Project. Students must also attend 10 computer science research colloquia.

### Degree Requirements

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

- UMD liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering *or* Comp 3150—Advanced Writing: Science (3 credits)
- The computer science segment of the program contains a broad-based core of fundamental material required of all students (18 credits). In addition,

24 credits of advanced computer science courses, with at least 12 of these chosen from courses that provide depth in the discipline, are included in the major requirements.

- Mathematics and science are particularly important for the study of computer science. The curriculum includes 18 credits of mathematics/statistics courses and 12-14 credits of science courses, including a 2-semester science sequence.
- To broaden students' backgrounds, the major includes courses chosen from communication, composition, the humanities, the social sciences, and the arts.
- An ethics course is included, as well as a fundamental course in digital system design chosen from electrical and computer engineering.
- A minor or a second major in another department is required.

### 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 Development (4)  
 CS 2521—Computer Organization (4)

**Advanced Courses—six courses, including at least three breadth courses (24)**

#### 1. Breadth

CS 4511—Automata, Computability, and Formal Languages (4)  
 CS 4521—Advanced Data Structures and Algorithms (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 5631—Operating Systems (4)  
 CS 5641—Compiler Design (4)  
 CS 5651—Computer Networks (4)

#### 2. Electives

CS 4711—Computer Security (4)  
 CS 4811—Systems Software (4)  
 CS 5721—Computer Graphics (4)  
 CS 5731—Information and Text Processing (4)  
 CS 5741—Object-Oriented Design (4)  
 CS 5751—Machine Learning (4)

#### Required Courses From Other Programs

Comp 1120\*—College Writing (3)  
 Comm 1112\*—Public Speaking (3)  
 ECE 1315—Digital System Design (4)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3355—Discrete Mathematics (4)  
 Phil 3242—Values and Technology (3)  
 Stat 3611—Introduction to Probability and Statistics (4)

One of the following science sequences:

- Biol 1011\*—General Biology I  
and Biol 1012—General Biology II (10)
- or Chem 1151\*—General Chemistry I  
and Chem 1152—General Chemistry II (10)
- or Chem 1161\*—Honors Course: General Chemistry I  
and Chem 1162—Honors Course: General Chemistry II (10)
- or Geol 1110\*—Introductory Geology (3)  
and Geol 2210—Geomorphology (3)  
and Geol 2300—Basic Mineralogy and Petrology (4)
- or Phys 1201\*—Mechanics (4)  
and Phys 1202—Heat and Electricity (4)  
or Phys 1204—Electricity, Magnetism, and Optics (5)
- Additional approved courses from physics, chemistry, biology, astronomy, and geology (4)\*\*

Electives in the humanities, social sciences, and arts (18)\*\*

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

\*\* A complete list of eligible courses is available from the department.

### Minor Requirements

The computer science minor requires 31 credits:

- CS 1511\*—Computer Science I  
or CS 1581\*—Honors: Computer Science (5)  
CS 1521—Computer Science II (5)  
CS 2511—Software Development (4)  
Electives in CS courses at 4xxx or above, ECE 3341, ECE 4305 (12)

Math 1296\*—Calculus I—(5)

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

## Computer Science—Applied

### Minor Only

The applied computer science minor (29–34 credits) provides a thorough introduction to the use of computers as tools and complements studies in other disciplines.

### Requirements (29)

Two of the following courses (5–10):

- CS 1111\*—Introduction to Programming in Pascal (3)  
CS 1121\*—Introduction to Programming in Visual BASIC (3)  
CS 1131\*—Introduction to Programming in FORTRAN (3)  
or CS 1135\*—Introduction to Programming in FORTRAN 77 (2)  
CS 1211\*—Introduction to Programming in C (3)  
or CS 1511\*—Computer Science I (5)  
CS 1581\*—Honors: Computer Science (5)  
CS 2111—Introduction to Programming in C++ (3)  
CS 1521—Computer Science II (5)

Electives in CS courses at 25xx or above (16)

Approved electives from computer science or other departments with a significant computing component (8)\*\*

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

\*\* A complete list of eligible courses is available from the department.

## Electrical and Computer Engineering (ECE)

*Professors:* Stanley Burns (department head), Nazmi Shehadeh, Marian Stachowicz; *Associate Professors:* Christopher Carroll, Taek Mu Kwon, Jiann-Shiou Yang; *Assistant Professors:* Mohammed Hasan, Bassam Shaer

### B.S.

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, 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 eight major instructional laboratories and three research laboratories.

### 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.

### Degree Requirements

Requirements for the B.S.E.C.E. in electrical and computer engineering (131 credits) include:

- UMD liberal education requirements (35 credits; 37 credits for ECE majors)—courses listed within the major or minor indicated by \* may be used to fulfill this requirement

- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering (3 credits)
- 6 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

ECE 1001—Introduction to ECE (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)  
 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 4305—Computer Architecture (4)  
 ECE 4899—Senior Project I (1)  
 ECE 4999—Senior Project II (3)  
 ECE technical electives (6)

### Required Courses From Other Programs

Chem 2172\*—General Chemistry (4)  
 Comp 1120\*—College Writing (3)  
 Comp 3130—Advanced Writing: Engineering (3)  
 CS 1511\*—Computer Science I (5)  
 CS 1521—Computer Science II (5)  
 CS 2511—Software Development (4)  
 CS 5631—Operating Systems (4)  
 Econ 1023\*—Principles of Economics: Micro (3)  
 IE 2105—Material Science (3)  
 or Engr 2015—Statics (2)  
 and Engr 2026—Dynamics (3)  
 or Engr 2015—Statics (2)  
 and ChE 3111—Fluid Mechanics (3)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4)  
 Math 3298—Calculus III (4)  
 Phil 3242\*—Values and Technology (3)  
 Phys 1201\*—Mechanics (4)  
 Phys 1204—Electricity, Magnetism, and Optics (5)  
 Stat 3611—Introduction to Probability and Statistics (4)  
 Liberal education electives (13)\*  
 Liberal education elective choices (plus 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 prefixes
- At least one course emphasizing international perspective

- At least one course emphasizing cultural diversity
- At least 16 credits in categories 6 through 9
- At least one course numbered 2000 or higher *and* one 1xxx course with the same prefix, both from categories 6 through 9 (or any course that specifies as a prerequisite any course in categories 6 through 9)

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

### Final Project

Electrical and computer engineering students must complete a capstone design project integrating the knowledge from their academic career. This project, completed individually or in a small group, must involve the design of hardware or software to meet specifications agreed upon by the student and the faculty project adviser.

### Minor Requirements (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)  
 Math 3280—Differential Equations with Linear Algebra (4)  
 Phys 1201\*—Mechanics (4)

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

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

## Engineering

### College of Science and Engineering

See Chemical Engineering, Electrical and Computer Engineering, Environmental Engineering, Industrial Engineering, or Pre-Engineering Program.

## Environmental Engineering

### Department of Chemical Engineering

#### Minor Only

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 (48)****Lower Division (42)**

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

ChE 2011—Design of Engineering Experiments  
 or Stat 2411\*—Statistical Methods (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 Course: General Chemistry I (5)

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

Chem 2222—Quantitative Analysis (4)

Engr 2015—Statics (2)

Geol 1110\*—Introductory Geology (3)

Math 1296\*—Calculus I (5)

Math 1297—Calculus II (5)

Phys 1201\*—Mechanics (4)

**Upper Division (3)**

ChE 4612—Hazardous Waste Processing Engineering (3)

**Elective (3)**

ChE 4601—Biochemical Engineering (3)

ChE 4611—Advanced Wastewater Treatment (3)

Geol 4211—Applied Hydrogeology (3)

Lim 5601—Limnology I: Physics and Chemistry (4)

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

**Geological Sciences (Geol)**

*Professors:* James A. Grant, Timothy B. Holst, Thomas C. Johnson, Charles L. Matsch, Ronald L. Morton, Richard W. Ojakangas, George R. Rapp, Jr.; *Associate Professors:* Erik T. Brown, Howard D. Mooers, Penelope Morton (department head), Nigel J. Watrous

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).

**Admission Requirements**

Students must have a minimum GPA of 2.00.

**Honors Requirements**

Students must maintain a GPA of 3.00 or higher, participate in the CSE honors program, and conduct independent research under the supervision of a geological sciences faculty member or other member of the scientific community approved by the department honors coordinator.

**B.A.—CLA****Degree Requirements**

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

- UMD liberal education requirements
- Completion of an advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (51-53 credits)
- Minor requirements

**Required Courses**

Geol 1110\*—Introductory Geology (3)

Geol 2100—Geological Computer Applications (1)

Geol 2210—Geomorphology (3)

Geol 2311—Mineralogy and Petrology I (4)

and Geol 2312—Mineralogy and Petrology II (4)

or Geol 2300—Basic Mineralogy and Petrology (4)

Geol 2315—Mineral Resource Geology (2)

Geol 3110—Environmental Geology (2)

Geol 3410—Stratigraphy-Sedimentation (3)

Geol 3520—Structural Geology (4)

Geol 3530—Field and Computer Methods (3)

Geol 4500—Field Geology (6)

Geol electives 3xxx or higher (3-7)

**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 Course: General Chemistry I (5)

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

Math 1250\*—Precalculus Analysis (4)

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 credits) include:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (76 credits)

**Required Courses**

Geol 1110\*—Introductory Geology (3)

Geol 2100—Geology Computer Applications (1)

Geol 2210—Geomorphology (3)

Geol 2311—Mineralogy and Petrology I (4)

Geol 2312—Mineralogy and Petrology II (4)  
 Geol 2315—Mineral Resource Geology (2)  
 Geol 3110—Environmental Geology (2)  
 Geol 3410—Stratigraphy-Sedimentation (3)  
 Geol 3520—Structural Geology (4)  
 Geol 3530—Field and Computer Methods (3)  
 Geol 3710—Introduction to Geochemistry (3)  
 Geol 4500—Field Geology (6)  
 Geol 4810—Global Geophysics (3)  
 Geol electives, upper division (9)

### Required Courses From Other Programs

Chem 1151\*—General Chemistry I  
 or Chem 1161\*—Honors Course: General Chemistry I (5)

Chem 1152—General Chemistry II  
 or Chem 1162—Honors Course: General Chemistry II (5)

Math 1290\*—Calculus for Modeling I  
 or Math 1296\*—Calculus I (5)

Phys 1201\*—Mechanics (4)

Phys 1202—Heat and Electricity (4)

Stat 2411\*—Statistical Methods (3)

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

### Minor Requirements (20)

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.

Geol 1110\*—Introductory Geology (3)

Geol 2300—Basic Mineralogy and Petrology (4)

Geol 2410—Geology of North America (2)

Geol electives 2xxx or above (11)

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

## Industrial Engineering (IE)

*Professors:* Bernard J. DeRubeis, Mark A. Fugelso, Thys B. Johnson (NRRI), L. Alden Kendall, Richard R. Lindeke;  
*Associate Professors:* Hamid Fard, Lester W. Garber, David A. Wyrick (department head); *Assistant Professors:* Dale A. Krageschmidt, Ryan G. Rosandich, 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.

Students have an opportunity to learn about engineering in the global community. This option requires a senior year exchange with the Department of Materials and Manufacturing Engineering at Luleå University of Technology in Sweden.

### Admission Requirements

Admission to the program is competitive and on a space-available basis. A minimum overall GPA of 2.00 is required on all program courses taken at the time an application to the program is submitted. An application may be submitted when the student has completed the following courses:

Math 1296—Calculus I (5)

Math 1297—Calculus II (5)

Math 3280—Differential Equations with Linear Algebra (4)

Phys 1201—Mechanics (4)

Phys 1202—Heat and Electricity (4)

Engr 2015—Statics (2)

IE 1105—Introduction to Engineering Design (3)

IE 1205—Introduction to Manufacturing Engineering (3)

The department will use a summary of the grades on the above courses as another criteria for accepting students into the B.S. program.

### Degree Requirements

Requirements for the B.S.I.E. in industrial engineering (132 credits) include:

- UMD liberal education program requirement—courses listed within the major or minor indicated by \* may be used to fulfill this requirement. Students must take two courses with different designators from category 9, and no courses from category 10, as part of this requirement.
- Completion of at least 30 degree credits at UMD
- Completion at UMD of at least 20 of the last 30 credits earned before graduation
- A minimum GPA of 2.00 (C) overall (including transfer credits) and in all major work attempted at UMD, and successful completion (with grades of A-D, or P) of all required courses and of 75 percent of all work attempted
- 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, is required for graduation.
- Completion of 65 credits in upper division courses (at 3xxx or above)
- Students should file an Academic Progress Audit System (APAS) report by the time they have completed 60 credits, or they may not be permitted to register.

### Required Courses

- IE 1105—Introduction to Engineering Design (3)  
 IE 1205—Introduction to Manufacturing Engineering (3)  
 IE 2105—Introduction to Material Science for Engineers (3)  
 IE 3105—Human Factors (4)  
 IE 3115—Operations Research (4)  
 IE 3125—Engineering Economic Analysis (3)  
 IE 3135—Manufacturing Processes I (4)  
 IE 3205—Project Management (3)  
 IE 3245—Manufacturing Processes II (4)  
 IE 3255—Statistical Quality Control (3)  
 IE 3265—Production and Operations Management (4)  
 IE 4115—Facility Planning and Simulation (4)  
 IE 4135—Automation and Robotics (3)  
 IE 4145—CAD/CAM (4)  
 IE 4175—Machine Design (3)  
 IE 4235—Manufacturing Systems Integration (4)  
 IE 4255—Design of Industrial Systems (3)

### Required Courses From Other Programs

- Chem 1151\*—General Chemistry I (5)  
 Comp 1120\*—College Writing (3)  
 Comp 3130—Advanced Writing: Engineering\*\*  
 or Comp 3150—Advanced Writing: Science (3)\*\*  
 CS 1511\*—Computer Science I (5)  
 Econ 1022\*—Principles of Economics: Macro  
 or Econ 1023\*—Principles of Economics: Micro (3)  
 Engr 2015—Statics (2)  
 Engr 2016—Mechanics of Materials (3)  
 Engr 2026—Dynamics (3)  
 Engr 3201—Electrical Power (3)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4)  
 Phys 1201\*—Mechanics (4)  
 Phys 1202—Heat and Electricity (4)  
 Stat 3611 Introduction to Probability and Statistics (4)  
 One course each from liberal education categories 7 and 8;  
 two courses from category 9 (12)  
 Advanced (3xxx level or greater) humanities/social science  
 approved elective (3)  
 Approved technical elective (2)

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

\*\* Fulfills the advanced composition requirement.

### Final Project

Students are required to complete a final team design project in the capstone design course IE 4255—Design of Industrial Systems. 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.

The B.S. in information systems and technology prepares a student for graduate school and careers in information systems, and provides a basis for continued career growth. This is a multidisciplinary program that emphasizes the study of systems development methodology and technology for our rapidly changing information society. Professionals in this area must be capable of designing and developing information systems that utilize the latest in computer technology. They must possess good communication skills, both oral and written, and also be aware of the societal and ethical implications of the systems they develop. The goal is to develop project leaders and information resource managers who can address organizational needs with technical solutions. Graduates of this program are prepared for positions in the design and development of information systems as project managers, information systems center specialists, network administrators, and database managers. This major also is appropriate for students considering information systems graduate programs or MBA professional programs.

### Degree Requirements

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

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150—Advanced Writing: Science (3 credits)
- The computer science segment of the program consists of a core of fundamental material required of all students (17 credits). In addition, 32 credits of advanced computer science courses are required for the major.

- Mathematics courses are particularly important for the study of information systems and technology. The curriculum includes 9 credits in mathematics/statistics, and 6 credits in advanced FMIS courses, and 6 credits in economics and accounting.
- A minor or second major in another department is required.

## Required Courses

### Core (17)

CS 1121\*—Introduction Programming in Visual BASIC  
or CS 2121\*—Introduction to Programming in Java (3)  
CS 1211\*—Introduction to Programming in C (3)  
CS 1311—Fundamentals of Information Systems (4)  
CS 2111—Introduction to Programming in C++ (3)  
CS 2311—Data, File, and Object Structures (4)  
*Note: CS 1511\*—Computer Science I (5) and CS 1521—Computer Science II (5) may be taken in lieu of CS 1211 (3), CS 2111 (3), and CS 2311 (4).*

### Advanced Courses (38)

CS 3011—Information Technology and Hardware (4)  
CS 3111—Computer Ethics (4)  
CS 3121—Introduction to Interactive Multimedia Technology (4)  
CS 3211—Introduction to Database Management Systems (4)  
CS 3221—Operating Systems Practicum (4)  
CS 4311—Human-Computer Interaction (4)  
CS 4411—Data Communications and Network Technology (4)  
CS 4711—Computer Security (4)  
FMIS 3201—Management Information Systems (3)  
FMIS 3222—Systems Analysis and Design (3)

## Required Courses From Other Programs

### Additional Requirements (21)

Acct 2005\*—Survey of Accounting (3)  
Comm 1112\*—Public Speaking (3)  
Comp 1120\*—College Writing (3)  
Comp 3150—Advanced Writing: Science (3)  
Econ 1003\*—Economics and Society (3)  
Stat 3611—Introduction to Probability and Statistics (4)  
Math 1296\*—Calculus I  
or Math 1160\*—Finite Math and Introduction to Calculus (5)

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

## Minor Requirements (32)

CS 1211\*—Introduction to Programming in C (3)  
CS 1311—Fundamentals of Information Systems (4)  
CS 2111—Introduction to Programming in C+ (3)  
CS 2311—Data, File and Object Structures (4)  
CS 3011—Information Technology and Hardware (4)  
CS 3121—Introduction to Interactive Multimedia Technology (4)  
CS 4411—Data Communications and Network Technology (4)

FMIS 3201—Management Information Systems (3)

FMIS 3222—Systems Analysis and Design (3)

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

*Note: CS 1511\*—Computer Science I (5) and CS 1521—Computer Science II (5) may be taken in lieu of CS 1211 (3), CS 2111 (3), and CS 2311 (4).*

# Mathematics (Math and Stat)

## Department of Mathematics and Statistics

*Professors:* Sabra S. Anderson, Joseph A. Gallian, Richard F. Green, Barry R. James, Ronald R. Regal, Harlan W. Stech (department head); *Associate Professors:* Duane E. Anderson, John R. Greene, Kang L. James, Clinton J. Kolaski, Kathryn E. Lenz, Zhuangyi Liu, Robert L. McFarland, James L. Nelson, Bruce B. Peckham, James W. Rowell, Steven A. Trogdon

## B.A.—CLA

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

## Degree Requirements

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

- UMD liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering or Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (45-51 credits)

## Required Courses

Math 1296\*—Calculus I (5)  
Math 1297—Calculus II (5)  
Math 3280—Differential Equations with Linear Algebra (4)  
or Math 3320—Introduction to Linear Algebra (3)  
Math 3298—Calculus III (4)  
Math 3299—Intermediate Analysis (3)  
Math 3355—Discrete Mathematics (4)  
Math 3941—Undergraduate Colloquium (1)  
Math 5326—Linear Algebra I (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.—CSE**

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

**Degree Requirements**

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

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

**Required Courses**

- Math 1296\*—Calculus I (5)
- Math 1297—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 5326—Linear Algebra I (3)
- Stat 3611—Introduction to Probability and Statistics (4)

*One of the following (2-3):*

- Math 3097—Internship (2)
- Math 5270—Modeling with Dynamical Systems (3)
- Math 5900—Team Modeling Project (3)
- Math 5991—Independent Study (2)
- Math or Stat course above 3000 for UROP participants (2)

*At least one course from each of the following groups (10-14)—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 Mathematics (3)
- Math 4820—Applied Mathematics: Numerical 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):*

- 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 2111—Introduction to Programming in C++ (3)
  - CS 2121\*—Introduction to Programming in Java (3)
- \* Courses that may be used to fulfill UMD liberal education program requirements.

**Minor Requirements (21)**

- Math 1296\*—Calculus I (5)
- Math 1297—Calculus II (5)
- Math 3280—Differential Equations with Linear Algebra (4)
- Two of the following (7):*
- 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 4820—Applied Mathematics: Numerical Methods (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)

The student's program of study must include at least one course 4xxx or 5xxx course selected from the above electives or an additional approved 4xxx or 5xxx course outside of Math or Stat containing strong mathematical content.

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

**Mathematics—Computational  
Mathematics  
B.S.—CSE**

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

**Degree Requirements**

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

- UMD liberal education requirements
- Advanced writing requirement: Comp 3130—Advanced Writing: Engineering or Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (57-60 credits)

**Required Courses**

Math 1296\*—Calculus I (5)  
 Math 1297—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 5326—Linear Algebra I (3)  
 Stat 3611—Introduction to Probability and Statistics (4)  
*Two of the following (6-8):*  
 Math 4820—Applied Mathematics: Numerical Methods (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)

**Required Courses From Other Programs**

CS 1511\*—Computer Science I (5)  
 CS 1521—Computer Science II (5)  
 CS 2511—Software Development (4)

*Three courses from either of the following, with at least two courses from Group 2 (11-12)—no course from Group 1 can duplicate a language covered in CS 1511—Computer Science I or CS 1521—Computer Science II:*

**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 2111—Introduction to Programming in C++ (3)  
 CS 2121\*—Introduction to Programming in Java (3)

**Group 2**

CS 4511—Automata, Computability and Formal Languages (4)  
 CS 4521—Advanced Data Structures and Algorithms (4)  
 CS 4531—Software Engineering (4)  
 CS 4611—Database Management Systems (4)  
 CS 4711—Computer Security (4)  
 CS 4811—Systems Software (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 5731—Information and Text Processing (4)  
 CS 5741—Object-Oriented Design (4)  
 CS 5751—Machine Learning (4)

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

**Mathematics—Double Major  
B.S.—CSE**

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

**Degree Requirements**

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

- UMD liberal education requirements
- Advanced writing requirement: Comp 31xx—Advanced writing course (3 credits)
- Major requirements (48 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 (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4)  
 Math courses above 3280 and/or Stat courses above 3000 (23); 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)

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

**Required Courses From Other Programs**

One CS course above 1010 (3)

**Mathematics—Statistics**

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

**B.S.—CSE**

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 (120 credits) include:

- UMD liberal education requirements
- Advanced writing requirements: Comp 3100—Advanced Writing: Language and Literature *or* Comp 3110—Advanced Writing: Arts and Letters *or* Comp 3121—Advanced Writing in Business and Organizations *or* Comp 3130—Advanced Writing: Engineering *or* Comp 3140—Advanced Writing: Human Services *or* Comp 3150—Advanced Writing: Science *or* Comp 3160—Advanced Writing: Social Sciences (3 credits)
- Major requirements (48-50 credits)

## Required Courses

- Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4) *or* Math 3320—Introduction to Linear Algebra (3)  
 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):*

- Math 3299—Intermediate Analysis (3)  
 Math 3355—Discrete Mathematics (4)  
 Math 5326—Linear Algebra I (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.—CSE

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

## Degree Requirements

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

- UMD liberal education requirements
- Advanced writing requirements: Comp 3130—Advanced Writing: Engineering *or* Comp 3150—Advanced Writing: Science (3 credits)
- Major requirements (45-51 credits)

## Required Courses

- Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4) *or* Math 3320—Introduction to Linear Algebra (3)  
 Math 3298—Calculus III (4)  
 Math 3299—Intermediate Analysis (3)  
 Math 3355—Discrete Mathematics (4)  
 Math 3941—Undergraduate Colloquium (1)  
 Math 5326—Linear Algebra I (3)  
 Math 5371—Abstract Algebra I (3)  
 Stat 3611—Introduction to Probability and Statistics (4)

*One of the following (7-12):*

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.

## Minor Requirements (22)

- Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Math 3280—Differential Equations with Linear Algebra (4) *or* Math 3320—Introduction to Linear Algebra (3)  
 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 4000, to bring the total to 22 credits (8-9)

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

## Physical Science

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

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

## Physics (Phys)

*Professors:* John R. Hiller (department head), Thomas F. Jordan, Michael Sydor; *Associate Professors:* Bo R. Casserberg, John L. Kroening; *Assistant Professors:* Jonathan Maps, Elise A. Ralph, Mong Zhou

The Department of Physics offers two B.S. degrees, which provide professional preparation in pure and applied physics, and a liberal arts degree (B.A.). Students participate in research, which is focused primarily on theoretical physics, instrumentation, experimental solid state physics, and physical limnology. 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:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150 (3 credits)
- Major requirements (52 credits):  
32-credit core required for all physics majors and minors, 8 credits in mathematics in addition to required core, 12 credits of physics and limnology electives
- A minor or a second major in a different program

### Required Courses

#### Core

Phys 1201\*—Mechanics (4)  
 Phys 1202—Heat and Electricity (4)\*\*  
 Phys 1203—Magnetism, Waves, and Optics (4)\*\*  
 Phys 2001—Oscillations (2)  
 Phys 2021—Relativity and Quantum Physics (4)  
 Phys 2031—Quantum Physics Laboratory (1)

#### Electives (12)

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 5051—Computational Physics (4)  
 Phys 5061—Experimental Methods (3)  
 Phys 5062—Advanced Laboratory (2)  
 Phys 5531—Introduction to Solid State Physics (3)  
 Phys 5541—Fluid Dynamics (3)

### Required Courses From Other Programs

#### Core

CS 1131\*—Introduction to Programming in FORTRAN (3)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)

#### Additional Courses

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.

\*\* Phys 1204—Electricity, Magnetism, and Optics (5) and Phys 1205—Waves and Heat (3) may be substituted for the pair Phys 1202 and Phys 1203

### Electives

May be used toward 12 credits in electives:

Lim 5601—Limnology I: Physics and Chemistry (4)

### Minor Requirements

This minor program (35 credits) provides an introduction to classical and quantum physics.

#### Core (32)

CS 1131\*—Introduction to Programming in FORTRAN (3)  
 Math 1296\*—Calculus I (5)  
 Math 1297—Calculus II (5)  
 Phys 1201\*—Mechanics (4)  
 Phys 1202—Heat and Electricity (4)\*\*  
 Phys 1203—Magnetism, Waves, and Optics (4)\*\*  
 Phys 2001—Oscillations (2)  
 Phys 2021—Relativity and Quantum Physics (4)  
 Phys 2031—Quantum Physics Laboratory (1)

#### Additional Courses

Phys electives at 3xxx or above (3)

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

\*\* Phys 1204—Electricity, Magnetism, and Optics (5) and Phys 1205—Waves and Heat (3), may be substituted for the pair Phys 1202 and 1203

**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:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150 (3 credits)
- Major requirements (68 credits):  
32-credit core required for all physics majors and minors; 12 credits in mathematics and chemistry in addition to required core; 24 credits in advanced physics courses in the fundamental areas of mechanics, quantum physics, electromagnetism, statistical physics, and experimental methods; two semesters (1 credit each) of a seminar course to train students for oral presentation of work in physics
- A minor or a second major in a different program

**Required Courses****Core**

Phys 1201\*—Mechanics (4)  
Phys 1202—Heat and Electricity (4)\*\*  
Phys 1203—Magnetism, Waves, and Optics (4)\*\*  
Phys 2001—Oscillations (2)  
Phys 2021—Relativity and Quantum Physics (4)  
Phys 2031—Quantum Physics Laboratory (1)

**Additional Courses (24)**

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 (2)

**Required Courses From Other Programs****Core**

CS 1131\*—Introduction to Programming in FORTRAN (3)  
Math 1296\*—Calculus I (5)  
Math 1297—Calculus II (5)

**Additional Courses**

Chem 2172\*—General Chemistry (4)  
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.

\*\* Phys 1204—Electricity, Magnetism, and Optics (5) and Phys 1205—Waves and Heat (3) may be substituted for the pair Phys 1202 and Phys 1203

**Final Project**

No final projects, internships, or seminars are required, except as part of Phys 5090—Physics Seminar.

**Minor Requirements**

This minor program (35 credits) provides an introduction to classical and quantum physics.

**Core (32)**

CS 1131\*—Introduction to Programming in FORTRAN (3)  
Math 1296\*—Calculus I (5)  
Math 1297—Calculus II (5)  
Phys 1201\*—Mechanics (4)  
Phys 1202—Heat and Electricity (4)\*\*  
Phys 1203—Magnetism, Waves, and Optics (4)\*\*  
Phys 2001—Oscillations (2)  
Phys 2021—Relativity and Quantum Physics (4)  
Phys 2031—Quantum Physics Laboratory (1)

**Additional Courses**

Phys electives at 3xxx or above (3)

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

\*\* Phys 1204—Electricity, Magnetism, and Optics (5) and Phys 1205—Waves and Heat (3), may be substituted for the pair Phys 1202 and Phys 1203

**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:

- UMD liberal education requirements
- Advanced writing requirement: Comp 3150 (3 credits)
- Major requirements (76 credits):  
32-credit core required for all physics majors and minors; 15 credits in chemistry, computer science, and mathematics in addition to required core; 10 credits in computational and experimental methods; 17 credits in electives chosen from advanced physics courses and courses in other technical areas, such as limnology and engineering; two semesters (1 credit each) of a seminar to train students in oral presentation of work in physics
- A minor or a second major in a different program

**Required Courses****Core**

Phys 1201\*—Mechanics (4)

Phys 1202—Heat and Electricity (4)\*\*

Phys 1203—Magnetism, Waves and Optics (4)\*\*

Phys 2001—Oscillations (2)

Phys 2021—Relativity and Quantum Physics (4)

Phys 2031—Quantum Physics Laboratory (1)

\*\* *Phys 1204—Electricity, Magnetism, and Optics (5) and Phys 1205—Waves and Heat (3) may be substituted for the pair Phys 1202 and Phys 1203.*

**Additional Courses (12)**

Phys 3061—Instrumentation (3)

Phys 5051—Computational Physics (4)

Phys 5061—Experimental Methods (3)

Phys 5090—Physics Seminar (2)

**Electives (8)**

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)**

Phys 5041—Optics (3)

Phys 5062—Advanced Laboratory (2)

Phys 5531—Introduction to Solid State Physics (3)

Phys 5541—Fluid Dynamics (3)

**Required Courses From Other Programs****Core**

CS 1131\*—Introduction to Programming in FORTRAN (3)

Math 1296\*—Calculus I (5)

Math 1297—Calculus II (5)

**Additional Courses**

Chem 2172\*—General Chemistry (4)

CS 1211\*—Introduction to Programming in C (3)

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.*

**Electives**

*May be used toward 9 credits in technical electives:*

An approved set of Engr courses

Lim 5601—Limnology I: Physics and Chemistry (4)

**Final Project**

No final projects, internships, or seminars required, except as part of Phys 5090—Physics Seminar.

**Minor Requirements**

An applied physics minor is not available, but see the B.S. and B.A. degrees for a description of the physics minor.

**Teaching Physics Minor**

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

**Statistics (Math and Stat)****Department of Mathematics and Statistics**

*Advisers:* R. Green, B. James, K. James, 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 B.S. major.