

This is the College of Science and Engineering section of the 1997-1999 University of Minnesota, Duluth Catalog

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: to help each student develop a foundation for a career by learning the substance and methods of an academic discipline; to participate fully in the liberal education mission of the campus; to foster significant scholarly research; and to 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 masters 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, 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.

Collegiate Honors

The Campus Assembly has established a policy that a maximum of 15 percent of the graduating class can graduate with collegiate honors. In CSE, the top 3 percent of the graduating class will be designated *summa cum laude*, the next 5 percent *magna cum laude*, and the next 7 percent *cum laude*.

At the beginning of each year, the GPAs necessary to achieve these honors are posted in the Student Affairs Office, 140 Engineering Building. The GPAs are established on the basis of the record of the previous spring quarter 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 45 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.

Requirements for the B.Ch.E.

- 1) Completion of a total of 196 or more degree credits.
- 2) Completion of at least 45 degree credits at UMD.
- 3) Completion of at least 30 of the last 45 credits earned before graduation at UMD.
- 4) A minimum GPA of 2.00 (C) in all work attempted at UMD, successful completion (with grades of A through D, or S) of 75 percent of all work attempted, and a minimum GPA of 2.00 (C) overall (including transfer credits).
- 5) Completion of composition requirement. See Policies and Procedures.
- 6) Completion of the liberal education distribution requirements: at least 48 credits must be in approved courses distributed in the four categories of knowledge defined by the UMD liberal education program.
- 7) Completion of the chemical engineering major. Admission to the upper division program is competitive and on a space-available basis. A minimum GPA of 2.00 in all courses taken in the major, including required courses in related fields, is required for graduation. This average applies to all courses in the major taken at UMD and calculated separately and also to all courses in the major when transfer credits are included.
- 8) Completion of a minimum of 80 credits in upper division courses (numbered 3xxx and above).
- 9) Filing an Engineering Degree Requirement Form (or APAS equivalent). Students who fail to file this form before completing 105 credits may not be permitted to register.
- 10) Compliance with the general regulations governing the granting of degrees. See All-University Degree Requirements in Policies and Procedures.

Requirements for the B.E.C.E.

- 1) Completion of a total of 196 or more degree credits.
- 2) Completion of at least 45 degree credits at UMD.
- 3) Completion of at least 30 of the last 45 credits earned before graduation at UMD.
- 4) Completion of the electrical and computer engineering major. Admission to the upper division program is competitive and on a space-available basis. A minimum GPA of 2.50 in all work attempted at UMD, successful completion (with grades of A through D, or S) of 75 percent of all work attempted, and a minimum GPA of 2.50 (C+) overall (including transfer credits) are required for admission to the ECE upper division program.
- 5) Completion of composition requirement. See Policies and Procedures.
- 6) Completion of the liberal education distribution requirements: at least 48 credits must be in approved courses distributed in the four categories of knowledge defined by the UMD liberal education program.
- 7) A minimum GPA of 2.00 in all courses taken in the major, including required supporting courses is required for graduation. This average applies to all courses in the major taken at UMD and calculated separately and also to all courses in the major when transfer credits are included.
- 8) Completion of a minimum of 80 credits in upper division courses (numbered 3xxx and higher).
- 9) Filing an Engineering Degree Requirement Form (or APAS equivalent). Students who fail to file this form before completing 105 credits may not be permitted to register.
- 10) Compliance with the general regulations governing the granting of degrees. See All-University Degree Requirements in Policies and Procedures.

Requirements for the B.I.E.

- 1) Completion of a total of 196 or more degree credits.
- 2) Completion of at least 45 degree credits at UMD.
- 3) Completion of at least 30 of the last 45 credits earned before graduation at UMD.
- 4) A minimum GPA of 2.00 (C) in all work attempted at UMD, successful completion (with grades of A through D, or P) of 75 percent of all work attempted, and a minimum GPA of 2.00 (C) overall (including transfer credits).
- 5) Completion of composition requirement. See Policies and Procedures.
- 6) Completion of the liberal education distribution requirements: at least 48 credits in approved courses distributed in the four categories of knowledge defined by the UMD liberal education program.
- 7) Completion of the industrial engineering major. Admission to the upper division program is competitive and on a space-available basis. A minimum GPA of 2.00 in all courses taken in the major, including required courses in related fields, is required for graduation. This average 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.
- 8) Completion of a minimum of 92 credits in upper division courses (numbered 3xxx and above).
- 9) Filing an Engineering Degree Requirement Form (or APAS equivalent). Students who fail to file this form before completing 105 credits may not be permitted to register.
- 10) Compliance with the general regulations governing the granting of degrees. See All-University Degree Requirements in Policies and Procedures.

Requirements for the B.S.

- 1) Completion of a total of 180 or more degree credits.
- 2) Completion of at least 45 degree credits at UMD.
- 3) Completion of at least 30 of the last 45 credits earned before graduation at UMD.
- 4) A minimum GPA of 2.00 (C) in all work attempted at UMD, successful completion (with grades of A through D, or S) of 75 percent of all work attempted, and a minimum GPA of 2.00 (C) overall (including transfer credits).
- 5) Completion of composition requirement. See Policies and Procedures.
- 6) Completion of the liberal education distribution requirements: at least 48 credits in approved courses distributed in the four categories of knowledge. See Policies and Procedures for a list of approved liberal education courses and requirements for course and grading option selection.
- 7) Completion of an academic major for the B.S. degree and completion of a minor or a second major in a different department. A minimum GPA of 2.00 in each major program and each minor program, including required supporting courses for each, is required for graduation. This minimum applies to all courses in the major and minor taken at UMD and calculated separately and also to all courses in the major and minor when transfer credits are included.
- 8) For students completing two or more majors:
 - a) A minor is not required.
 - b) If both majors are approved for the B.S. degree, only the Degree Requirement Form for the B.S. is required.
 - c) If the majors are for different degrees (e.g., a B.S. and a B.A.), the majors must be from different departments (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, must inform both collegiate offices responsible for each degree, and must complete the Degree Requirement Form (or APAS equivalent) for each degree.
- 9) Completion of a minimum of 80 credits in upper division courses (numbered 3xxx and above).
- 10) Filing a Degree Requirement Form (or APAS equivalent). Students who fail to file this form before completing 105 credits may not be permitted to register.
- 11) Compliance with the general regulations governing the granting of degrees. See All-University Degree Requirements in Policies and Procedures.

Baccalaureate Degrees

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

Majors for the B.S.

Biochemistry/Molecular Biology
 Biology
 Cell Biology
 Chemistry
 Computer Science
 Geology
 Mathematics
 Physics
 Applied Physics

Minors

Aerospace Studies
 Biology
 Chemistry
 Computer Science
 Electrical and Computer Engineering
 Geology
 Mathematics
 Physics

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

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

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

This 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 but with other relevant backgrounds or qualifications will also be considered. If deficiencies exist, candidates may be accepted into the program contingent upon the successful completion of certain 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. Since 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 quarter 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 quarter 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 may be obtained from the master of industrial safety program office, 229 Voss-Kovach Hall. The admission decision is based on the undergraduate scholastic record, past work experience, GRE results, letters of recommendation, and evaluation by the applicant screening committee. International students must present a TOEFL score of 500 or above. Applicants must obtain information on all admission deadlines and requirements and submit all required admission materials before the first day of fall quarter classes or they will be denied admission and must reapply to the program the following year.

Degree Requirements

Candidates for the degree must complete a minimum of 50 credits in either the industrial safety or industrial hygiene option and maintain an overall GPA of 3.00 or better. Three academic quarters is the minimum residence requirement for

the degree. In addition a three-credit industrial internship with a Plan B type project or field research project is required. Degree candidates must enroll in the internship or field research project in the first summer session after completing their coursework and must fulfill all course requirements within a six month period unless a formal extension is requested and granted.

Industrial Safety Option (53)

Required Core (47-48)

Ind 5953—Conf Leading Tech (3)
 Safe 5000—Loss Control (2)
 Safe 5001—OSHA Volun Comp (3)
 Safe 5002—Safe, Hlth Stand, Cod (3)
 Safe 5003—Leg Implic in Safe (2)
 Safe 5004—Org, Adm of Safe Pro (3)
 Safe 5005—System Safety (3)
 Safe 5006—Behavior Asp Safety (3)
 Safe 5105—Environ Hlth, Safety (2)
 Safe 5106—Physical Hazard Con (2)
 Safe 5107—Phy Haz Control Des (2)
 Safe 5108—Industrial Toxicol (3)
 Safe 5111—Traffic, Fleet Safe (2)
 Safe 5112—Elem of Indus Hyg (2)
 Safe 5121—Indus Noise Control (2)
 Safe 5122—Ergonomics (3)
 Safe 5123—Fire Preven, Contr (2)
 Safe 5127—Elem of Indus Vent (3)
 Safe 5900—Intern Indus Safe (3)
 or Safe 5901—Prob Indus Safe Hyg (2)

Electives

Safe 5100—Indus First Aid (2)
 Safe 5119—Air Sampling, Analysis (2)
 Safe 5120—Air Measurement Lab (1)
 Safe 5903—Ind Std Indus Hyg/S (1-3)
 Safe 5904—Special Topics (1-3)
 Safe 5905—Sem in Indus Safe (1)

Industrial Hygiene Option (53)

Required Core (51-52)

Ind 5953—Conf Leading Tech (3)
 Safe 5000—Loss Control (2)
 Safe 5001—OSHA Volun Comp (3)
 Safe 5002—Safe, Hlth Stand, Cod (3)
 Safe 5003—Leg Implic in Safe (2)
 Safe 5004—Org, Adm of Safe Pro (3)
 Safe 5005—System Safety (3)
 Safe 5006—Behavior Asp Safety (3)
 Safe 5105—Environ Hlth, Safety (2)
 Safe 5106—Physical Hazard Con (2)
 Safe 5108—Industrial Toxicol (3)
 Safe 5112—Elem of Indus Hyg (2)
 Safe 5114—Adv Indus Hygiene (2)
 Safe 5119—Air Sampling, Analysis (2)
 Safe 5120—Air Measurement Lab (1)
 Safe 5121—Indus Noise Control (2)
 Safe 5122—Ergonomics (3)
 Safe 5127—Elem of Indus Vent (3)
 Safe 5128—Adv Industrial Vent (3)
 Safe 5900—Intern Indus Safe (3)
 or Safe 5901—Prob Indus Safe Hyg (2)
 Safe 5902—Elem of Hlth Phys (2)

Electives

Safe 5100—Indus First Aid (2)
 Safe 5111—Traffic, Fleet Safe (2)
 Safe 5115—Sem in Indus Hyg (1)
 Safe 5123—Fire Preven. Contr (2)
 Safe 5903—Ind Std Indus Hyg/S (1-3)
 Safe 5904—Special Topics (1-3)

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 quarter. The I remains in effect for six weeks after the beginning of the next quarter 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 will 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 40 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 a total of 39 or fewer 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 will be placed on academic probation. Once on academic probation, a student will have two quarters of day school attendance to attain the required cumulative GPA and avoid dismissal. No credit load restrictions are imposed on students on academic probation. However, they should consider the possibility that a higher GPA might be more easily attained by carrying a lighter load and/or repeating courses in which a D or F was received. Students on probation are strongly encouraged to talk with their adviser and the associate dean in the college office.

Dismissal

If a student fails to attain the required minimum cumulative GPA after two quarters of day school attendance following the quarter when the student's cumulative GPA fell below the minimum required, the student is subject to dismissal. Dismissal decisions are made in the college office following finals week of fall, winter, and spring quarters. Students below the required minimum cumulative GPA, yet making progress and very close to the minimum, may be granted an additional quarter of probation at the discretion of the college. Students who are dismissed will be notified immediately and their registration for the next quarter of day school canceled.

Readmission

Students who have been academically dismissed must present evidence of improved academic capability to the college to justify readmission. Petitions for readmission are considered at any time. However, readmission is not normally considered before one year has passed from the date of dismissal, unless circumstances clearly support a decision for early readmission. Readmission is granted whenever the required minimum cumulative GPA for good academic standing has been attained through University College or summer school. Petition forms and information about academic standing are available in the CSE Student Affairs Office, 140 Engineering Building.

Student Affairs Office

Information on academic matters, including academic standing; admission; advisement; academic programs; change of major, college, or adviser; and 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 in alphabetical order on the following pages. Variations in a curriculum may be arranged upon agreement between 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 science professions such as chiropractic medicine, mortuary science, osteopathic medicine, and podiatry.

Pre-Dentistry

Adviser: Holmstrand (Biol)

The following courses, for a minimum of 130 credits, must be completed during the freshman, sophomore, and junior years:

Biol 1111-1112-1113—General, Animal, Plant Biology (15)
 Chem 1110-1111-1112—General Chemistry (15)
 Chem 3512-3513—Organic Chemistry (10)
 Comm 1112—Public Speaking (4)
 Comp 1120—College Writing (5)
 Comp 3150—Adv Writ: Science (4)

Math 1250—Pre-Calc Analysis

or Stat 1565—Elementary Stat (4)

Phys 1101-1102-1103—Intro to Physics (15)

Psy 1003—General Psychology (5)

Electives—Especially recommended are Acct 1995, 5501; Art 1002, 1010, 1012; Biol 1012, 3154, 3245, 5237, 5403, 5517, 5518; Chem 3210, 3311 or 5336, 5337; Econ 1004; Psy 3331 or 3371

It is also strongly recommended that students complete additional credits to achieve as broad and liberal an education as possible.

Applicants should apply before December 1 and before the fall quarter in which they desire to enroll in a school of dentistry. The American Dental Association Admission Test (usually given in April and October) must be taken before the student's application can be considered.

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 within 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.

Freshman-Level Courses for UMD Engineering Programs and Recommended Courses for First Two Years for Students Who Wish to Transfer to IT or Another University

Students interested in the chemical engineering, electrical and computer engineering, and industrial engineering programs at UMD should refer to the appropriate department in this bulletin for appropriate lower division courses.

The course recommendations listed below have been designed to closely match the lower division programs (i.e., the first two years) at 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.

Aerospace Engineering

Chem 1110-1111—General Chemistry (10)
Comp 1120—College Writing (5)
CS 1501—FORTRAN Programming (3)
Engr 3015—Statics (4)
Engr 3016—Deform Body Mech (4)
Engr 3036—Dynamics (4)
IE 1025—Intro to Engr Design (4)
Math 1296-1297-3298-3350—Calculus I-II-III-IV (20)
Math 3320—Vectors, Matrices (4)
Math 3380—Differ Equat I (5)
Phys 1107-1108-1109—General Physics (15)
Phys 3500—Modern Physics (4)
Liberal education electives to make a total of 95 credits

Civil Engineering

Chem 1110-1111—General Chemistry (10)
Comp 1120—College Writing (5)
CS 1501—FORTRAN Programming (3)
Engr 3015—Statics (4)
Engr 3016—Deform Body Mech (4)
Engr 3036—Dynamics (4)
Engr 3100—Intro Surv, Mapping (4)
Geol 1110—Introductory Geol (5)
IE 1025—Intro to Engr Design (4)
Math 1296-1297-3298-3350—Calculus I-II-III-IV (20)
Math 3320—Vectors, Matrices (4)
Math 3380—Differ Equat I (5)
Phys 1107-1108-1109—General Physics (15)
Stat 3562—Intro Probab, Statis (4)
Liberal education electives to make a total of 95 credits

Mechanical Engineering

Chem 1110-1111—General Chemistry (10)
Comp 1120—College Writing (5)
ECE 3005—Elec Circuit Analysis (4)
CS 1501—FORTRAN Programming (3)

Engr 3015—Statics (4)
Engr 3016—Deform Body Mech (4)
Engr 3036—Dynamics (4)
IE 1025—Intro to Engr Design (4)
Math 1296-1297-3298-3350—Calculus I-II-III-IV (20)
Math 3320—Vectors, Matrices (4)
Math 3380—Differ Equat I (5)
Phys 1107-1108-1109—General Physics (15)
Stat 3562—Intro Probab, Statis (4)
Liberal education electives to make a total of 95 credits

Other Engineering Specialties

Consult CSE Student Affairs Office, 140 Engineering Building.

Junior Level Admission

All UMD and transfer students must apply for admission at the end of their sophomore year to the upper division level of the engineering program in which they are interested. A minimum cumulative GPA, as determined by the department, is required in the lower division courses of the chosen engineering program. Students from other colleges wishing to transfer to the UMD engineering programs should have completed the equivalent lower division courses for those programs with the required cumulative GPA. The completed application will be evaluated on the basis of GPA, curriculum completed, and space available. Students transferring from the Minnesota state community college system should refer to the list of equivalent lower division courses for their college for the engineering programs at UMD. This list is available from CSE or the community college engineering adviser or counselor. Courses in which a grade of 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 for a grade of D earned in a sequence course, which will be counted if a grade of C or better is earned in the following course.

Students in the joint admission program will be admitted as juniors to CSE if they meet the admission requirements (see Joint Admission Program in Engineering). They will still have to 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 proper change of college form for transfer to IT.

Pre-Fishery 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. The UMD courses listed 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 3½-week summer program at the Lake Itasca Forestry and Biological Station following their freshman or sophomore year must have a minimum GPA of 2.00; completed 40 credits; and completed, with grades of C or better, Biol 1111-1112-1113. For more information, consult the *College of Natural Resources Bulletin*.

Biol 1111-1112-1113—General, Animal, Plant Biology (15)
 Biol 3774—General Ecology Lab (2)
 Biol 3775—General Ecology (4)
 Biol 5461—Plant Taxonomy (5)
 Chem 1105-1106-1107—Gen, Organ, Biol Chem (15)
 Comm 1112—Public Speaking (4)
 Comm 3020—Group Communication (4)
 Comp 1120—College Writing (5)
 Econ 1002—Intro to Economics
 or Econ 1005—Prin Econ: Macro (4)
 Geol 1110—Introductory Geol (5)
 Math 1296-1297-3298—Calculus I-II-III (15)
 or Math 1156, 1160, and Phil 1018 (12)
 Phys 1101-1102—Intro to Physics (10)
 Pol 1011—American Govt. Pol (4)
 Stat 1565—Elementary Stat (4)
 Biology electives—Consult adviser

Pre-Medicine

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

Most students admitted to medical school 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.

Biology: One year of biology or zoology with lab
 Chemistry: Two years with lab, including organic chemistry Composition Program

Mathematics: Calculus (1-2 qtrs)

Physics: One year with lab

Social and Behavioral Sciences and Humanities: Most medical schools require or recommend a well-balanced program with courses in such areas as anthropology, economics, history, the humanities, language, literature, psychology, and sociology. For example, the UMD School of Medicine requires at least 12 quarter cr in the behavioral sciences and 12 quarter cr in the humanities, and requires that at least one course in each of these groups be at the upper division level.

The Duluth medical school provides the first two years of medical education, and students can then transfer to the University's Medical School in Minneapolis.

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-med adviser or the college's Student Affairs Office, 140 Engineering Building.

Pre-Optometry

Adviser: Firling (Biol)

Admission requirements for colleges of optometry vary considerably. The following program will satisfy the pre-optometry requirements for most colleges of optometry. 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.

Freshman Year

Biol 1111-1112-1113—General, Animal, Plant Biology (15)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Comp 1120—College Writing (5)
 Comp 3150—Adv Writ: Science (4)
 Math 1250—Pre-Calc Analysis (5)

Sophomore Year

Biol 3245—Cellular Biology (4)
 Chem 3311—Biochemistry (4)
 Chem 3512-3513—Organic Chemistry (10)
 Math 1296-1297—Calculus I-II (10)
 Phys 1101-1102-1103—Intro to Physics
 or Phys 1107-1108-1109—General Physics (15)
 Stat 1565—Elementary Stat
 or Stat 3562—Intro Probab, Statis (4)
 or Psy 3020—Basic Stat Methods (5)

Junior Year

Biol 1012—Human Anatomy
 or Biol 5517—Compar Anat Vertebr (5)
 Biol 5403—General Micbiol (5)
 Hlth 1905—Prin Hum Physiol (5)
 Psy 1003—General Psychology (5)
 Psy 3331—Developmental Psych (5)
 Electives (10-12)—Recommended are Biol 3154, 5518;
 Hlth 1104, 3101; MgtS 3304; MicB 5545; Psy 3061;
 and courses in the humanities/classics, social sciences,
 and foreign language

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 Twin Cities campus of the University may complete their pre-pharmacy work on the Duluth campus. Students who have successfully completed the prerequisite courses below will be considered for admission to the program.

Biol 1012—Human Anatomy (5)
 or Biol 5517—Compar Anat Vertebr (5)
 Biol 1111, 1112, 1113—General, Animal, Plant Biology (15)
 Biol 5403—Microbiology (5)
 Chem 1110-1111-1112—General Chemistry (15)
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Chem 3512-3513—Organic Chemistry (10)
 Chem 3514—Intermediate Organic Chemistry (4)
 Comm 1112—Public Speaking (4)
 Comp 1120—College Writing (5)
 Comp 3150—Adv Writ: Science (4)
 Econ 1004—Prin Econ: Micro (4)
 Math 1296-1297—Calculus I-II (10)
 Phys 1101-1102-1103—Intro to Physics (15)
 Electives such as Psy 1003, Soc 1100; course in the arts and humanities/classics or behavioral and social sciences

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. Some students can apply for entry after their third year at UMD but most secure a four-year degree in a major of their choice. Degree requirements are listed elsewhere in this bulletin and pre-veterinary requirements are listed below. All required courses must be completed on A-F grading.

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 directly 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.

First Year (45)

Biol 1111-1112-1113—General, Animal, Plant Biology (15)
 Chem 1110-1111-1112—General Chemistry (15)
 Comp 1120—College Writing (5)
 Math 1250—Pre-Calc Analysis (5)
 Econ 1002 or 1004 or 1005 (highly recommended)
 Electives from Category III, The Individual and Society, or Category IV, Literary and Artistic Expression

Second Year (45)

Biol 3154—Prin of Genetics (4)
 Chem 3311—Biochemistry (4)
 Chem 3512-3513—Organic Chemistry (10)
 Phys 1101-1102-1103—Intro to Physics
 or Phys 1107-1108-1109—General Physics (15)
 Electives from Category III, The Individual and Society, or Category IV, Literary and Artistic Expression

Third Year (45)

Biol 5403—General Micbiol (5)
 Approved Advanced Writing (4)
 Chem 3210—Intro Quant Analysis (5) (highly recommended)
 Electives* (31)

* *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 their electives to fulfill the pre-veterinary requirements and the requirements of their major departments. Additional biology, chemistry, or mathematics coursework, for example, could lead to majors in these departments.*

Aerospace Studies (Air)

Professor: Lt. Col. Marc Miller (department head); *Assistant Professors:* Maj. Richard Lindberg, Maj. Richard Runchey, Capt. Kevin Warzynski

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. Students must take all aerospace studies courses A-F. 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. All non-AFROTC scholarship two-year participants receive \$2,000 per year for tuition plus a monthly stipend. (For more information about the two commissioning programs, see Education, Service, and Research Centers.)

The following courses are required for both the two- and four-year commissioning programs:

Core Program—Professional Officer Course

The core program (21 credits) is required of all candidates for commissions.

Air 3310-3311-3312—Air Force Leadership and Mgt (9)
A department-approved course requiring mathematical reasoning (3)

Air 3410-3411-3412—National Security Policy Process (9)
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 3482—Introduction to Aviation. Students on an AFROTC scholarship have additional mathematical reasoning and composition requirements.

Minor

The Aerospace Studies minor (39 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.

Lower Division (13)

Air 1101-1102-1103—The Air Force Today (3)

Air 1201-1202-1203—The Air Force Way (3)

A course requiring mathematical reasoning (3)

Comm 1112—Public Speaking (4)

or Comm 1222—Interpersonal Comm (4)

or approved substitute

Upper Division (26)

Air 3310-3311-3312—Air Force Leadership Management (9)

Air 3410-3411-3412—National Security Policy Process (9)

Upper division advanced or technical writing course (4)

Pol 3415—International Law

or approved substitute (4)

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 E. Fulkrod, Donald K. Harris, Vincent R. Magnuson, Donald P. Poe, Joseph R. Prohaska (Med), Larry C. Thompson, Bilin P. Tsai (department head); *Associate Professors:* Thomas E. Huntley (Med), Paul D. Siders, Kendall B. Wallace (Med), Viktor V. Zhdankin; *Assistant Professors:* Benjamin L. Clarke (Med), Paul Kipf

The Department of Chemistry's mission is to provide coursework and research experience in this field 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.

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. These include mechanisms of differentiation, heredity, and even learning and memory.

Honors Program

The department honors program helps outstanding biochemistry/molecular biology majors develop into competent, independent research workers, encourages these students in their study of and interest in biochemistry/molecular biology, and aids them in their transition from students to scientists. Qualified biochemistry/molecular biology majors may apply to participate in the honors program at any time after the winter quarter of their sophomore year.

Major (B.S.)

This biochemistry/molecular biology major (116 credits) prepares students for graduate school and professional program study and for industrial and health science careers in the molecular bio-sciences.

Students should take the required courses in the sequence shown.

Lower Division (78)

First Year (40)

Biol 1111—General Biology (5)
 Biol 1112—Animal Biology (5)
 Biol 1113—Plant Biology (5)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Math 1296—Calculus I (5)
 Math 1297—Calculus II (5)

Second Year (38)

Biol 3154—Prin of Genetics (4)
 Biol 3245—Cellular Biology (4)
 Chem 3210—Intro Quant Analysis (5)
 Chem 3512-3513—Organic Chemistry (10)
 Phys 1107-1108-1109—General Physics (15)

Upper Division (38)

Third Year (25.5)

Chem 3181—Undergraduate Sem (0.5)
 Chem 5336-5337—Biochemistry (8)
 Chem 5338—Molecular Biology (4)
 Chem 5361—Biochemistry Lab (2)
 Chem 5610-5611—Physical Chemistry (7)
 Comp 3xxx—Advanced Writing (4)

Fourth Year (12.5)

Chem 3181—Undergraduate Sem (1.5)
 Chem 5230—Instrumental Analysis (3)
 Chem 5362—Advanced Biochemistry Lab (2)
 Chem 5420-5421—Inorganic Chemistry (6)

Biology (Biol)

Professors: Conrad E. Firling, Stephen C. Hedman, Anne E. Hershey, M. Reza-Ul Karim, Andrew R. Klemer, Gerald J. Niemi, John 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 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.

Core Courses

The following courses (30 credits) are the required core for all B.A. and B.S. majors and minors in biology.

Lower Division (15)

Biol 1111—General Biology (5)
 Biol 1112—Animal Biology (5)
 Biol 1113—Plant Biology (5)

Upper Division (15)

Biol 3154—Prin of Genetics (4)
 Biol 3245—Cellular Biology (4)
 Biol 3775—General Ecology (4)
 Biol 5155—Evolutionary Biology (3)

Major (B.A.—CLA)

Lower Division (35-47)

Core (15)
 Chem 1105-1106—Gen, Organ, Biol Chem (10)
 or Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Chem 1107—Gen, Organ, Biol Chem (5)
 or Chem 3512-3513—Organic Chemistry (10)
 Math 1250 (5), or Math 1210 and Stat 1565 (7), or Math 1296 (5)

Upper Division (47)

Core (15)
 Biol 3774—General Ecology Lab (2)
 Biol 3959—Seminar Evaluation (1)
 Biol 3960—Seminar (1)
 Comp 3150—Adv Writ: Science (4)
 Biol electives numbered 3xxx or above (24)
 (May include up to two courses from the following:
 MicB 5545; Txcl 5214; Phsl 5541, 5542)

Major (B.S.)

Lower Division (50)

Core (15)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Math 1296—Calculus I (5)
 Phys 1101-1102-1103—Intro to Physics
 or Phys 1107-1108-1109—General Physics (15)

Upper Division (57)

Core (15)
 Biol 3774—General Ecology Lab (2)
 Biol 3959—Seminar Evaluation (1)
 Biol 3960—Seminar (1)
 Biol electives numbered 3xxx or above (24)
 (May include up to two courses from the following:
 MicB 5545; Txcl 5214; Phsl 5541, 5542)
 Chem 3512-3513—Organic Chemistry (10)
 Comp 3150—Adv Writ: Science (4)

Minor

Lower Division (35-47)

Core (15)
 Chem 1105-1106—Gen, Organ, Biol Chem (10)
 or Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Chem 1107—Gen, Organ, Biol Chem (5)
 or Chem 3512-3513—Organic Chemistry (10)
 Math 1250 (5), or Math 1210 and Stat 1565 (7), or
 Math 1296 (5) (must be taken A-F)

Upper Division (23)

Core (15)
 Biol electives numbered 3xxx or above (8)

Cell Biology (B.S.)

(Department of Biology)

Professors: Conrad E. Firling, Stephen C. Hedman, Anne E. Hershey, M. Reza-Ul Karim, Andrew R. Klemer, Gerald J. Niemi, John 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 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.

Cell biology is one of the most rapidly growing areas of modern biology and is regarded as a distinct biological field.

Major (B.S.)

The cell biology major (136 credits) prepares students for graduate school and careers in cell biology, genetics, developmental biology, physiology, immunology, and biotechnology. This major also is appropriate for students planning to attend professional school in dentistry, medicine, pharmacy, or veterinary medicine. The cell biology program involves faculty from both CSE and the UMD School of Medicine.

Completion of approximately 78 credits of required courses should be attempted during the first two years of the program. By completing the following courses, students satisfy requirements for a chemistry minor as well as the cell biology major.

First Two Years (78)

Biol 1111—General Biology (5)
 Biol 1112—Animal Biology (5)
 Biol 1113—Plant Biology (5)
 Biol 3154—Prin of Genetics (4)
 Biol 3245—Cellular Biology (4)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Chem 3210—Introductory Quantitative Analysis (5)
 Chem 3512-3513—Organic Chemistry (10)
 Math 1296-1297—Calculus I-II (10)
 Phys 1107-1108-1109—General Physics (15)

Second Two Years (58)

Biol 3774—General Ecology Lab (2)
 Biol 3775—General Ecology (4)
 Biol 3959—Seminar Evaluation (1)
 Biol 3960—Seminar (1)
 Biol 5155—Evolution Biology (3)
 Biol 5237—Devel Biology
 or Biol 5214—Plant Development (5)
 Biol 5255—Mol Biol, Genetics (5)

Biol 5256—Mol Biol Genet Lab (3)
 Biol 5259—Frontiers in Cell Biology (2)
 Biol 5403—General Microbiol (5)
 Biol 5443—Plant Physiology (3)
 Biol 5444—Plant Phys Lab (2)
 Chem 5336-5337—Biochemistry (8)
 Chem 5361—Biochemistry Lab (2)
 Comp 3150—Adv Writ: Human Serv (4)
 MicB 5545—Immunobiology (3)
 Phsl 5601—Physiology of Organ System (5)

Broad Area Science

Teaching Middle School-Junior High School Science Major (B.A.S.)

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

Chemical Engineering (ChE)

Professors: Dorab N. Baria, Dianne Dorland (department head), Michael E. McDonald; *Associate Professor:* Kewen Yin; *Assistant Professors:* Richard A. Davis, Keith Lodge

This four-year baccalaureate degree program (196-198 credits) 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.

ChE graduates are qualified for employment in diverse industries, ranging from the manufacture of inorganic chemicals, petrochemicals, plastics, synthetic fibers, paper and pulp, and pharmaceuticals to the processing of hazardous and nuclear wastes. Graduates are qualified for assignments that may 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 additional professional or graduate education.

The ChE curriculum is based on the fundamental sciences such as physics, chemistry, and mathematics; engineering sciences such as statics and deformable body mechanics; traditional chemical engineering sciences such as stoichiometry, 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 in the ChE program have a unique opportunity to become involved in research, either in the Undergraduate Research Opportunities Program or in the department honors program.

Honors Program

The department honors program encourages and aids outstanding chemical engineering majors and helps develop participants into active independent researchers. Students in the honors program must maintain a high GPA, register for the honors research course, and conduct independent research under the supervision of a chemical engineering faculty member or other member of the scientific community approved by the department honors coordinator.

The chemical engineering department admits students to the honors program who have demonstrated potential for academic excellence and scholarly achievement. The department requires a 3.00 cumulative GPA, a 3.25 GPA in required chemical engineering courses, and a letter of recommendation from a chemical engineering faculty member. Qualified students may apply to participate in the ChE honors program after completing ChE 3110—Stoichiometry and ChE 3210—Fluid Mechanics, or ChE 3601-3602—Thermodynamics I-II. Applications are available from the ChE department honors coordinator and the department office.

Freshman-Level Admission

Freshman students must pursue the lower division B.Ch.E. program listed below.

Junior-Level Admission

Students must complete the lower division B.Ch.E. program 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 3513. 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.

Major (B.Ch.E.)

Lower Division (117)

ChE 1010—Intro to Chem Engr (4)
 ChE 3050—Computation Methods (2)
 ChE 3110—Stoichiometry (4)
 ChE 3526—Experimental Design (3)
 ChE 3601—Thermodynamics I (3)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Chem 3512-3513—Organic Chemistry (10)
 Chem 3210—Intro Quant Analysis (5)
 Comp 1120—College Writing (5)
 CS 1501—FORTRAN Programming (3)
 Engr 3015—Statics (4)
 Math 1296-1297-3298—Calculus I-II-III (15)
 Math 3320—Vectors, Matrices (4)
 Math 3380—Differ Equat I (5)
 Phys 1107-1108-1109—General Physics (15)
 Electives (20)*

Upper Division (79-81)

ChE 3210—Fl Flow, Heat Transf (4)
 ChE 3220—Heat Transfer (4)
 ChE 3230—Mass Transfer (4)
 ChE 3411-3412—Chem Engr Lab I-II (6)
 ChE 3602—Thermodynamics II (3)
 ChE 3611—Reactor Design (4)
 ChE 3621—Process Control (4)
 ChE 3631—Chem Engr Analysis (4)
 ChE 3651—Engineering Economy (4)
 ChE 3701-3702—ChE Design I-II (10)
 ChE 5534-5535—Haz Wst Pro Eng I-II (8)
 Chem 5620-5621-5622—Physical Chemistry (9)
 Comp 3130—Adv Writ: Engineer (4)
 Engr 3016—Deform Body Mech (4)
 Engr 3200—Electrical Power (3)
 or ECE 3006—Ele Circuit Analy (5)
 Advanced social science or humanities/classics elective (4)**

* Minimum of 12 cr in Category III and 8 cr in Category IVA in nonperformance courses

** Any 3xxx course or above in the humanities, social sciences, or behavioral sciences for which the student has already completed a Category III or IVA prerequisite course.

Chemistry (Chem)

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

The Department of Chemistry's mission is to provide coursework and research experience in the various fields of chemistry 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.

Under certain circumstances, some course substitutions for the various majors and minors are permitted with the department's consent. Students earning the B.S. degree who wish to have their programs certified by the American Chemical Society must also take advanced courses that include an additional 20 hours of laboratory work.

Honors Program

The chemistry department honors program helps outstanding chemistry majors develop into competent, independent research workers, encourages these students in their study of and interest in chemistry, and aids them in their transition from student to scientist. Qualified chemistry majors may apply to participate in the honors program at any time after the winter quarter of their sophomore year.

Major (B.S.)

This chemistry major (102-104 credits) is for students who wish to pursue careers in chemistry or chemistry-related professions. Students should attempt to take the required courses in the sequence specified.

Lower Division (71)

First Year (30)

Chem 1110-1111-1112—General Chem
or Chem 1130H-1131H-1132H—General Chem (15)
Math 1296-1297—Calculus I-II (10)
Math 3298—Calculus III (5)

Second Year (41)

Chem 3210—Intro Quant Analysis (5)
Chem 3512-3513-3514—Organic Chem (14)
CS 1501—FORTRAN Programming (3)
Math 3320—Vectors, Matrices (4)
Phys 1107-1108-1109—General Physics (15)

Upper Division (31)

Third Year (24.5)

Chem 3181—Undergraduate Sem (0.5)
Chem 5120—Advanced Chem Lab (1)
Chem 5121-5122—Advanced Chem Lab (4)
Chem 5420-5421—Inorganic Chemistry (6)
Chem 5620-5621-5622—Physical Chemistry (9)
Comp 3xxx—Advanced Writing (4)

Fourth Year (6.5)

Chem 3181—Undergraduate Sem (1.5)
Chem 5123—Advanced Chem Lab (2)
Chem 5230—Instrumental Analysis (3)

Major (B.A.—CLA)

This chemistry major (72-74 credits) is for students completing a liberal arts degree in chemistry.

Lower Division (50)

Chem 1110-1111-1112—General Chemistry
or Chem 1130H-1131H-1132H—General Chemistry (15)
Chem 3512-3513—Organic Chemistry (10)
Math 1296-1297—Calculus I-II (10)
Phys 1107-1108-1109—General Physics (15)

Upper Division (22-24)

Chem 3210—Intro Quant Analysis (5)
Chem 5420-5421—Inorganic Chemistry (6)
Chem 5610-5611—Physical Chemistry (7)
or Chem 5620-5621-5622—Physical Chemistry (9)
Comp 3xxx—Advanced Writing (4)

All students are encouraged to take Chem 3514 after completing Chem 3512-13, and those who are qualified are encouraged to substitute Chem 5620-5621-5622 for Chem 5610-5611. All students are also encouraged to take Chem 3311 and complete additional courses in mathematics.

Minor (35)

Chem 1110-1111-1112—General Chem
or Chem 1130H-1131H-1132H—General Chem (15)
Chem 3210—Intro Quant Analysis (5)
Chem 3512-3513—Organic Chem (10)
College level mathematics courses (5)

Chemistry Teaching Minor (B.A.S.)

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

Computer Science (CS)

Professors: Donald B. Crouch (department head), Keith R. Pierce; *Associate Professors:* Timothy R. Colburn, Carolyn J. Crouch, Linda L. Deneen, Douglas J. Dunham, Gary M. Shute; *Assistant Professors:* Richard F. Maclin, David W. Opitz

The Department of Computer Science's mission is to provide an instruction and research environment that leads to careers and research in computer science and supports computer applications in other disciplines.

Honors Program

The honors program of the UMD Department of Computer Science is directed toward outstanding computer science majors. The program encourages those students to function independently and to develop their study of and interest in their majors. These goals are primarily accomplished by participation in independent research under supervision of a faculty member, attendance at colloquia, and maintenance of a high GPA.

A student must earn the honors designation by showing conscientious and successful effort, interest, and ability in the classroom and in other scholarly activities while a student at

UMD. The computer science honors award signifies that the recipient is one of the most outstanding students who has majored in computer science at UMD.

Qualified majors may apply to participate in the honors program at any time after completion of two terms at UMD, preferably after completion of CS 1621 and 1622 or CS 1621H and 1622H. Applications are available in the department office.

Major (B.S.)

This computer science major (148-151 credits) provides a thorough foundation for careers in computing and for postgraduate studies in computer science.

This program has been accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB).

Lower Division (104-106)

CS 1621-1622-1623—Computer Science I-II-III
or CS 1621H-1622H-1623H—
Honors Comp Science I-II-III (15)

CS 3610—Machine Lang, Org (4) *

CS 3620—Intro Sys Software (4)

CS 3710—Theory of Comp Sci (4)

ECE 1315—Digital Sys Design (5)

Math 1296-1297—Calculus I-II (10)

Math 3320—Vectors, Matrices (4)

Stat 3562—Intro Probab, Statis (4)

One of the following science sequences:

Biol 1111—General Biology, Biol 1112—Animal

Biology, Biol 1113—Plant Biology (15)

or Chem 1110-1111-1112—General Chemistry (15)

or Chem 1130H-1131H-1132H—General Chemistry (15)

or Geol 1110 or 1110H—Introductory Geol

and Geol 3300—Basic Mineral, Pet

and either Geol 3150—Environmental Geol or Geol
3200—Geomorphology (14)

or Phys 1107-1108—General Physics

and either Phys 1109 or Phys 1109H-General Physics (15)

Additional approved courses from physics, chemistry,
biology, astronomy, or geology (8)**

Electives in humanities, social sciences, and the arts (32)****

Upper Division (44-45)

Comp 3130—Adv Writ: Engineer

or Comp 3150—Adv Writ: Science (4)

CS 5510—Computer Arch I (4)*

CS 5518—Adv Data Structures (4)

CS 5520—Operating Systems I (4)

CS 5529—Software Engineer (4)

CS 5544—Compar Progr Lang

or CS 5756—Compiler Design I (4)

CS 5766—Auto, Comput, Form La (4)

Math 3530—Numerical Methods (4)

Phil 3242—Values, Technology (4)

Electives either in CS courses numbered 5xxx or above or in
approved ECE courses (8)

* For ECE/CS double majors: ECE 3325—Microcomp Design may be substituted for CS 3610; ECE 5305—Computer Architecture may be substituted for CS 5510

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

*** Eligible courses are any courses listed under Category III or IV of liberal education; any other courses offered by CLA or SFA except certain composition courses and Phil 3242; any honors seminar courses; and selected courses from CEHSP. (A complete list of selected courses and exceptions is available from the department.) Must include minimum of 11 cr in lib ed Category III, 8 cr in lib ed Category IV, and 13 additional cr.

Minor

This computer science minor (39-41 credits) provides a thorough introduction to the central concepts of computer science.

Lower Division (31-33)

CS 1621-1622-1623—Computer Science I-II-III

or CS 1621H-1622H-1623H—

Computer Science I-II-III (15)

CS 3610—Machine Language Organization (4)

or ECE 3325—Microcomp System Design (5)

CS 3620—System Software (4)

Math 1296-3320—Calculus I and Vectors and Matrices (9)

or Math 1156-1160—

Finite Mathematics and Calc Short Course (8)

Upper Division (8)

Electives in CS courses 3xxx and above, or ECE 5305.

Applied Minor

This applied computer science minor (39-41 credits) provides a thorough introduction to the use of computers as tools and complements studies in other fields.

Lower Division (27-29)

CS 1621-1622-1623—Computer Science I-II-III

or CS 1621H-1622H-1623H—

Computer Science I-II-III (15)

CS 3610—Machine Lang, Org (4)

or ECE 3325—Microcomputer System Design (5)

Math 1296, 3320—Calculus I and Vectors and Matrices (9)

or Math 1156-1160—

Finite Mathematics and Calc Short Course (8)

Upper Division (12)

Electives in CS courses 3xxx and above and approved courses from other departments, with a significant computing component. At least 4 credits must be in Computer Science. A complete list of approved courses is available in the Computer Science Department Office.

Earth Science

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

Teaching Earth Science Minor

See College of Education and Human Service Professions section for program descriptions.

Electrical and Computer Engineering (ECE)

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

The Department of Electrical and Computer Engineering offers a program that combines topics from traditional electrical engineering with current topics that focus on computer design and analysis, leading to the bachelor of electrical and computer engineering (B.E.C.E.) degree. Electrical and computer engineering 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 topics such as VLSI design, microprocessor systems, image processing, robust control, solid state devices, neural networks, and fuzzy logic. The major (194 credits) balances theoretical and practical experience in electrical and computer engineering through analysis, synthesis, and experimentation, using facilities that include twelve major instructional laboratories and three research laboratories.

Honors Program

The honors program recognizes the accomplishments of outstanding electrical and computer engineering students. To receive departmental honors upon graduating, students must finish the program with an overall GPA of 3.50 or higher, satisfactorily complete a research project under the guidance of a faculty member, and convey the results of that project

or research in an oral and written presentation to the department. More information about the ECE honors program is available in the department office.

Freshman-Level Admission

Students who enter the electrical and computer engineering program as freshmen must follow the lower division program listed below.

Junior-Level Admission

Students should complete the lower division ECE program before applying to the upper division (junior and senior years) program. Admission is competitive and on a space-available basis. A minimum GPA of 2.50 is required for admission to the upper division program. Primary consideration is given to the overall GPA and the GPA in mathematics and science courses. Transfer students and students who have been granted joint admission with the Minnesota State Community College System should refer to the pre-engineering section of this bulletin.

Major (B.E.C.E.)

The electrical and computer engineering major (194 credits) provides a thorough study of electrical engineering fundamentals and computer design and applications. Graduates are well-prepared for careers in electrical engineering and computer hardware/software design, or for advanced study of these topics in graduate school. The major includes courses that satisfy the requirements for minors in both computer science and mathematics/statistics.

Lower Division (96)

Chem 1140—General Chemistry (5)
 Comp 1120—College Writing (5)
 CS 1621-1622-1623—Computer Science I-II-III (15)
 or CS 1621H-1622H-1623H—
 Honors Computer Science I-II-III (15)
 ECE 1001—Intro to ECE (2)
 ECE 1315—Digital Sys Design (5)
 ECE 3006—Elec Ckt Analysis (5)
 ECE 3325—Microcomp Design (5)
 ECE 3410—Solid State Semicon (3)
 Econ 1004—Prin Econ: Micro (4)
 Math 1296-1297-3298—Calculus I-II-III (15)
 or Math 1596H-1597H-3598H—
 Honors Calculus I-II-III (15)
 Math 3320—Vectors, Matrices (4)
 Math 3380—Differ Equat I (5)
 Math 3555—Discrete Math (4)
 Phys 1107-1108-1109—General Physics (15)
 Liberal education electives (4)*

Upper Division (98)

Comp 3130—Adv Writ: Engineer (4)
 CS 3620—Intro Sys Software (4)
 CS 5520—Operating Systems I (4)
 ECE 3011—Lin Syst, Signal I (3)
 ECE 3012—Lin Syst, Signal II (4)
 ECE 3021—Electronics I (3)
 ECE 3035—Electronics II (4)
 ECE 3050—Control Systems (4)
 ECE 3055—Appl Lin Integr Ckts (4)
 ECE 3340—Dig Computer Ckts (5)
 ECE 3445—Electro-mag Fields (4)
 ECE 3950—Design Workshop (4)
 or ECE 3970-3971—Senior Project I-II (4)
 ECE 3980—Senior Seminar (1)
 ECE 5305—Comp Architecture (5)
 IE 3323—Automation, Robotics (4)
 Math 3350—Calculus IV (5)
 Phil 3242—Values, Technology (4)
 Stat 3562—Intro Probab, Statis (4)
 Technical electives (16)—ECE students must take 16 cr of
 ECE elective courses, including at least two courses
 from the following list: 3060, 3065, 3500, 3515.
 Liberal education electives (12)*

* *Students must take a minimum of 3 cr in Category IIIB and 8 cr in Category IVA. Remaining cr can be taken either from III or IVA (preferably at the 3xxx level).*

Minor

This electrical and computer engineering minor (66 credits) provides a complete introduction to both analog circuit design and digital computer circuit design and analysis.

Lower Division (54)

ECE 1315—Digital Sys Design (5)
 ECE 3006—Elect Ckt Analysis (5)
 ECE 3325—Microcomp Design (5)*
 Math 1296-1297-3298—Calculus I-II-III (15)
 or Math 1596H-1597H-3598H—
 Honors Calculus I-II-III (15)
 Math 3320—Vectors, Matrices (4)
 Math 3380—Differ Equat I (5)
 Phys 1107-1108-1109—General Physics (15)

Upper Division (12)

ECE 3021—Electronics I (3)
 ECE 3035—Electronics II (4)
 ECE 3340—Dig Computer Ckts (5)

* *For CS Majors: CS 3610—Machine Language and Organization, may be substituted for ECE 3325*

Engineering

(College of Science and Engineering)

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

Geology (Geol)

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

The Department of Geology offers four undergraduate programs for students interested in a variety of educational opportunities: a general geology option and a hydrogeology/environmental geology option offering training for a career as a professional geologist (which generally requires graduate study); a broad liberal arts major program; and a program for those interested in teaching earth science in secondary schools and earning the baccalaureate degree granted by the College of Education and Human Service Professions (see Earth Science).

Honors Program

The Department of Geology's honors program encourages and aids outstanding geology majors in their study of and interest in science and helps develop participants into active researchers. Students in the geology honors program must maintain a high GPA, participate in the CSE honors program, and conduct independent research under the supervision of a geology faculty member or other member of the scientific community approved by the department honors coordinator.

Major (B.A.—CLA)

This geology major (71-76 credits) is a general liberal arts major. The program provides an appropriate educational background for those curious about how the Earth works or for careers in areas related to environmental studies, land use planning, and other fields requiring sensitivity to earth systems.

Lower Division (20-25)

Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry
 or Chem 1105-1106-1107—Gen, Organ, Biol Chem (15)
 Geol 1110—Introductory Geol
 or Geol 1110H—Introductory Geol (5)
 Math 1250—Pre-Calc Analysis (5)
 or placement into Math 1296 or 1596
 on Math Placement Examination

Upper Division (51)

Comp 3150—Adv Writ: Science (4)
 Geol 3100—Geologic Field Meth (3)
 Geol 3150—Environmental Geol (4)
 Geol 3185—Geol Computer I (2)

Geol 3200—Geomorphology (4)
 Geol 3320—Intro Mineral (3)
 Geol 3324-3325-3326—Min, Pet I-II-III (12)
 Geol 3400—Strat-Sed (5)
 Geol 3520—Structural Geology (5)
 Geol 5100—Field Geology (9)

Major (B.S.)

General Geology Option

This geology major (108 credits) prepares students for professional work as geologists in industry or government and for graduate study leading to advanced degrees.

Lower Division (45)

Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry (15)
 Geol 1110—Introductory Geol
 or Geol 1110H—Introductory Geol (5)
 Math 1296-1297—Calculus I-II
 or Math 1596H-1597H—Honors Calculus I-II (10)
 Phys 1107—General Physics
 or Phys 1137H—Honors Physics (5)
 Phys 1108—General Physics (5)
 Phys 1109—General Physics
 or Phys 1129H—Honors Gen Physics (5)

Upper Division (63)

Comp 3150—Adv Writ: Science (4)
 Geol 3100—Geologic Field Meth (3)
 Geol 3185—Geol Computer I (2)
 Geol 3200—Geomorphology (4)
 Geol 3320—Intro Mineral (3)
 Geol 3324-3325-3326—Min, Pet I-II-III (12)
 Geol 3400—Strat-Sed (5)
 Geol 3520—Structural Geology (5)
 Geol 5100—Field Geology (9)
 Geol 5600—Economic Geology (4)
 Stat 3062—Statistical Methods (4)
 Geol electives numbered 5xxx (8)
 Geol 5305—Optical Mineralogy strongly recommended

Hydrogeology/Environmental Geology Option

This option (120 credits) prepares students for careers or graduate work in geology and provides a broad knowledge of surface and subsurface water and the geologic factors that govern its occurrence and movement. Careers are in the field of investigating and monitoring such natural fluid systems as they may affect environmental quality and water resources.

Lower Division (55)

Biol 1111—General Biology (5)
 Biol 1113—Plant Biology (5)
 Chem 1110-1111-1112—General Chemistry
 or Chem 1130H-1131H-1132H—General Chemistry
 or Chem 1105-1106-1107—Gen, Organ, Biol Chem (15)
 Geol 1110—Introductory Geol
 or Geol 1110H—Introductory Geol (5)
 Math 1296-1297—Calculus I-II
 or Math 1596H-1597H—Honors Calculus I-II (10)

Phys 1107—General Physics
 or Phys 1137H—Honors Physics (5)
 Phys 1108—General Physics (5)
 Phys 1109—General Physics
 or Phys 1129H—Honors Gen Physics (5)

Upper Division (65)

Comp 3150—Adv Writ: Science (4)
 Geol 3100—Geologic Field Meth (3)
 Geol 3150—Environmental Geol (4)
 Geol 3185—Geol Computer I (2)
 Geol 3200—Geomorphology (4)
 Geol 3320—Intro Mineral (3)
 Geol 3324-3325-3326—Min, Pet I-II-III (12)
 Geol 3520—Structural Geology (5)
 Geol 5100—Field Geology (9)
 Geol 5201—Hydrogeology (4)
 Geol 5210—Appl Hydrogeology (4)
 Stat 3062—Statistical Methods (4)

Upper division electives in geology (7) from:

Geol 3400—Strat-Sed (5)
 Geol 5143—Clastic Sed Analysis (2)
 Geol 5211—Glacial, Quaternary (4)
 Geol 5215—Contam Hydrogeology (4)
 Geol 5226—Geo/Waste Mgt (3)
 Geol 5411—Aqueous Geochem (3)

The following courses outside the major are strongly recommended:

Biol 5403—General Microbiol (5)
 Biol 5773—Limnology (4)
 Biol 5777—Plankton Ecology (4)
 Biol 5871—Water Pollut Biol (3)
 Chem 3512-3513—Organic Chemistry (10)
 Geog 5440—Water Resource Mgt (4)

Minor (30)

Core (13 or 23)

Geol 1110—Introductory Geol
 or Geol 1110H—Introductory Geol (5)
 Geol 3120—Geology of North Am (3)
 Geol 3300—Basic Mineral, Petro (5)
 or Geol 3320—Intro Mineral (3)
 and Geol 3324-3325-3326—Min, Pet I-II-III (12)

Upper Division (7 or 17)

Geol electives numbered 3xxx or above for a minimum of 30 total credits

Industrial Engineering (IE)

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

Industrial engineering is a professional discipline based on a four-year baccalaureate degree program. Industrial engineers are proficient in design and improvement of integrated 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 must consider technical,

economic, and human factors. In addition to engineering topics, the B.I.E. curriculum provides skills in the mathematical, physical, and social sciences as well as in English and the humanities.

The industrial engineering degree program (196 credits) is accredited by the Accreditation Board for Engineering and Technology (ABET). It strongly emphasizes manufacturing and management to prepare graduates for positions in automated manufacturing and service industries or for further study in graduate school.

Freshman-Level Admission

All students who are interested in industrial engineering should pursue the lower division B.I.E. program listed below.

The industrial engineering program is firmly based in modern industrial practices. All students will be required to develop effective computer skills for analysis and management of advanced practices in industry. Therefore, each student is strongly encouraged to maintain UMD computer access privileges throughout their enrollment.

B.I.E. Program Admission

All students seeking acceptance into the upper division B.I.E. program should apply for admission after having completed Engr 3015, IE 1010, Math 3298, Math 3320, and Phys 1109. The B.I.E. application can be obtained from the industrial engineering department office. This application process must occur before the Engineering Degree Requirement Form is completed. Applicants are considered on the basis of their completed coursework and academic performance. Space availability is also a factor.

Major (B.I.E.)

Lower Division (103-105)

Chem 1140—General Chemistry (5)
 Comp 1120—College Writing (5)
 CS 1501—FORTRAN Programming (3)
 Econ 1004—Prin Econ: Micro (4)
 Engr 3015—Statics (4)
 Engr 3016—Deform Body Mech (4)
 Engr 3036—Dynamics (4)
 Engr 3200—Electrical Power (3)
 or ECE 3006 Electrical Circuit Analysis (5)
 IE 1010—Intro to Manufacturing Engr (4)
 IE 1025—Engr Graphic (4)
 IE 3005—Intro Mat Sci Engr (4)
 IE 3111—Intro Engr Mgt (4)
 Math 1296-1297-3298—Calculus I-II-III (15)
 Math 3320—Vectors, Matrices (4)
 Math 3380—Differ Equat I (5)

Phys 1107-1108-1109—General Physics (15)
 Stat 3562—Intro Probab, Statist I (4)
 Liberal education electives (12)

Upper Division (91-93)

ChE 3651—Engineering Economy (4)
 Comp 3130—Adv Writ: Engineer
 or Comp 3150—Adv Writ: Science (4)
 IE 3014—Machining (3)
 IE 3015—Mach Tls, Mchtronic(3)
 IE 3016—Tool Design (4)
 IE 3021—Prod Processes I (4)
 IE 3040—Ind Health, Safety (3)
 IE 3061—Production Systems (4)
 IE 3070—Operations Res I (3)
 IE 3120—Indus Labor, Law (4)
 IE 3301—Ergonomic Design (4)
 IE 3316—Engr Quality Contr (4)
 IE 3323—Automation, Robotics (4)
 IE 3331—Prod Processes II (4)
 IE 3355-3356—IE Team Design I-II
 or IE 3350—Project
 or IE 3360—Industrial Intern (6)
 IE 3372—CAD/CAM (5)
 IE 5070—Operations Res II (3)
 IE 5150—IE Simulation (4)
 IE 5160—Production Mgt (4)
 Liberal education elective (4)
 Restricted technical elective (2-4*)
 Technical electives (7)
 Advanced humanities/social sciences elective (4)

* Four credits required if Engr 3200 is taken in lower division

Life Science

Teaching Life Science Major (B.A.S.),
 Teaching Life Science Minor

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

Mathematics and Statistics (Math/Stat)

Professors: Sabra S. Anderson, Joseph A. Gallian, Richard F. Green, Ronald R. Regal, Harlan W. Stech (department head); *Associate Professors:* Duane E. Anderson, John R. Greene, Barry R. James, 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

Programs in the Department of Mathematics and Statistics develop competence in mathematical techniques, sharpen mathematical insight, and prepare students for graduate study and for careers in business, industry, government, and teaching.

Honors Program

The department honors program gives outstanding mathematics and statistics majors recognition for achievement above that required for graduation.

Candidates for the honors degree designation complete honors projects (Math 5980) and participate in optional scholarly activities, including honors calculus courses (Math 1596H-1597H-3598H), department colloquia, professional meetings, discussions with guest lecturers, and Putnam mathematics examinations. Program participants are eligible for summer stipends to support their research projects. Application for admission to the honors program may be made after completion of the mathematics core. Applications are available in the department office.

Mathematics Core (24)

CS 1621—Computer Science I
or CS 1621H—Computer Science I (5)

Math 1296-1297-3298—Calculus I-II-III
or Math 1596H-1597H-3598H—
Honors Calculus I-II-III (15)

Math 3320—Vectors, Matrices (4)

With advance department approval, an alternative core program may be arranged, competency in computer programming in a language other than Pascal may be substituted for CS 1621 or CS 1621H, and competency in vectors and matrices may be substituted for Math 3320.

Major (B.A.—CLA)

This mathematics major (72 credits) is for students seeking a liberal arts degree in mathematics or planning to attend graduate school.

Lower Division (29)

Mathematics core (24)
Math 3350—Calculus IV (5)

Upper Division (43)

Comp 3xxx—Advanced Writing (4)
Math 3380—Differ Equat I (5)
Math 3555—Discrete Math (4)
Math 3699—Interm Analysis (4)
Math 3941—Seminar for Majors (1)
Math 5326—Linear Algebra I (3)
Math 5670—Abstract Algebra I (4)
Math 5701-5702—Real Variables I-II and Math 5671-5672—
Abstract Algebra II-III
or one of these pairs and a pair of 5xxx courses
approved by the department (12)

Stat 3562—Prob, Stat I (4)

Electives from Math or Stat courses above 3320 open to majors (2)

Major (B.S.)

This mathematics major is for students planning mathematics and statistics careers in business, industry, and government or planning to attend graduate school. A working knowledge of FORTRAN is assumed for some of the upper division numerical courses.

Applied Mathematics Option (75)

Lower Division (47)

Mathematics core (24)
CS 1622—Computer Science II
or CS 1622H—Computer Science II (5)
Math 3350—Calculus IV (5)
Math 3380—Differ Equat I (5)
Math 3555—Discrete Math (4)
Stat 3562—Prob, Stat I (4)

Upper Division (28)

Comp 3130—Adv Writ: Engineer
or Comp 3150—Adv Writ: Science (4)
Math 3699—Interm Analysis (4)
Math 3941—Seminar for Majors (1)
Math 5326—Linear Algebra I (3)
Math 5370—Operational Math
or Math 5380—Part Differ Equat
or Math 5385—Differ Equat II (3)
Electives from Math 5381, 5382, 5386, 5534, 5535, 5536 (7)
Electives from Math or Stat courses at the 5xxx level (6)

Mathematics as a Double Major Option (77)

This option allows for an individualized program only for those students who have already received a major from outside of the Department of Mathematics and Statistics or who will receive such a major concurrently with this option. Students may select up to 12 elective credits of courses with substantial mathematical and/or statistical content from other programs. These electives must be approved by the Department of Mathematics and Statistics.

Lower Division (47)

Mathematics core (24)
Electives from CS 1622 and/or math or statistics courses
above 3320 level (23)

Upper Division (30)

Electives (30) from math or statistics courses above 3320 level with at least 15 math or statistics credits at the 5xxx level. Up to 12 credits of 3xxx and/or 5xxx courses of substantial mathematical content may, with the approval of the Department of Mathematics and Statistics, be selected from other programs. This provision cannot be used to reduce the 15 math or statistics credits above the 5xxx level. Selected courses cannot be used toward any major or minor outside math or statistics.

Numerical and Computational Mathematics Option (83-84)

Lower Division (50)

Mathematics core (24)
CS 1622-1623—Computer Science II-III
or CS 1622H-1623H—Computer Science II-III (10)
CS 3610—Machine Lang, Org (4)
CS 3620—Intro Sys Software (4)
Math 3555—Discrete Math (4)
Stat 3562—Prob, Stat I (4)

Upper Division (33-34)

Comp 3130—Adv Writ: Engineer
or Comp 3150—Adv Writ: Science (4)
CS 3000—Internship in Comp Sci

or Math 3940—Internship
 or Math 3941—Seminar for Majors (1)
 CS 5510—Computer Arch I (4)
 CS 5518—Adv Data Struct, Algor (4)
 Math 3350—Calculus IV
 or Math 3699—Interm Analysis (4-5)
 Math 3380—Differ Equat I (5)
 Math 5326—Linear Algebra I (3)
 Electives from Math 5382, 5534, 5535, 5536 (8)

Statistics and Actuarial Science Option (75)

Actuarial science students should discuss the national actuarial examinations with their advisers.

Lower Division (45)

Mathematics core (24)
 CS 1622—Computer Science II
 or CS 1622H—Computer Science II (5)
 Math 3350—Calculus IV (5)
 Math 3555—Discrete Math (4)
 Stat 3562—Prob, Stat I (4)
 Stat 3563—Prob, Stat II (3)

Upper Division (30)

Comp 3130—Adv Writ: Engineer
 or Comp 3150—Adv Writ: Science (4)
 Math 3699—Interm Analysis (4)
 Math 3941—Seminar for Majors (1)
 Math 5326—Linear Algebra I (3)
 Stat 5562—Regression Analysis (4)
 Stat 5595—Probability (4)
 Stat 5596—Stat Inference (4)
 Stat 5598—Stochastic Process (3)
 Electives from 5xxx Math or Stat courses (3)

Traditional Mathematics Option (73)

Lower Division (29)

Mathematics core (24)
 Math 3350—Calculus IV (5)

Upper Division (44)

Comp 3xxx—Advanced Writing (4)
 Math 3380—Differ Equat I (5)
 Math 3555—Discrete Math (4)
 Math 3699—Interm Analysis (4)
 Math 3941—Seminar for Majors (1)
 Math 5326—Linear Algebra I (3)
 Math 5670—Abstract Algebra I (4)
 Math 5671-5672—Abstract Algebra II-III
 or Math 5701-5702—Real Variables I-II (6)
 Students who plan to enter graduate school in mathematics should take both sequences.
 Stat 3562—Prob, Stat I (4)
 Electives from Math or Stat courses above 3320 open to majors, with at least 6 credits at the 5xxx level (9)

Minor (34)

Lower Division (24)

Mathematics core (24)

Upper Division (10)

Electives in Math or Stat courses above 3030 (10)

Teaching Mathematics Major (B.A.S.), Teaching Mathematics Minor

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

Physical Science

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

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

Physics (Phys)

Professor Emeritus: Howard G. Hanson; *Assistant Professor Emeritus:* J. Gordon Likely; *Professors:* Thomas F. Jordan, John N. Ringsred, Michael Sydor; *Associate Professors:* Bo R. Casserberg, John R. Hiller (department head), John L. Kroening; *Assistant Professors:* Jonathan Maps, Lewis Oakland

The Department of Physics offers a number of undergraduate programs. The two bachelor of science majors provide professional preparation in pure and applied physics. A liberal arts major and various minors are also offered. Both undergraduate and graduate students participate in research, which is primarily focused on theoretical physics, instrumentation, and experimental solid state physics. Courses required for several professional and pre-professional programs, such as engineering and medicine, are provided. The graduate program leads to an M.S. degree (see Graduate School).

Honors Program

The honors program provides outstanding physics majors an opportunity to develop their abilities in research and encourage them in their study of physics. This is accomplished by physics honors courses, student participation in research under the supervision of a faculty member, discussions with seminar speakers, and participation in the college honors program. It requires maintenance of a high GPA. Interested students should contact the Physics Honors Program coordinator, Thomas F. Jordan.

The following courses constitute the required core for most majors and minors in physics:

Required Core (26)

Phys 1107—General Physics
 or Phys 1137H—Honors Physics (5)
 Phys 1108—General Physics (5)
 Phys 1109—General Physics
 or Phys 1109H—General Physics (5)
 Phys 3007—Interm Gen Physics (4)
 Phys 3010—Oscillations (3)
 Phys 3500—Modern Physics
 or Phys 5101—Modern Physics (4)

Major (B.S.)

This physics major (102-104 credits) is primarily for students planning to work toward an advanced degree in physics. It includes a minor in mathematics.

Lower Division (63-65)

Required core (26)

Chem 1140—General Chemistry (5)

CS 1621—Computer Science I (5)

or CS 1501—FORTRAN Programming (3)

Math 1296-1297-3298—Calculus I-II-III (15)

Math 3320—Vectors, Matrices (4)

Math 3350—Calculus IV (5)

Math 3380—Differ Equat I (5)

Upper Division (39)

Comp 3150—Advanced Writ: Science

or Comp 3130—Adv Writ: Engineer (4)

Phys 3041—Lab Electronics (4)

Phys 3071—Physics Laboratory (2)

Phys 3981—Physics Seminar (1)

Phys 5102-5103—Modern Physics (8)

Phys 5107—Thermal Physics (4)

Phys 5109—Statistical Physics (4)

Phys 5123—Theoretical Mech (4)

Phys 5124—Mathematical Meth (4)

Phys 5125—Electromag Theory (4)

Major (B.A.—CLA)

This physics major (79 credits) is for students who wish to complete a liberal arts degree.

Lower Division (50)

Required core (26)

Math 1296—Calculus I (5)

Math 1297—Calculus II (5)

Math 3298—Calculus III (5)

Math 3320—Vectors, Matrices (4)

Math 3380—Differ Equat I (5)

Upper Division (29)

Comp 3150—Adv Writ: Science

or Comp 3130—Adv Writ: Engineer (4)

Phys 3071—Physics Laboratory (2)

Phys 5102-5103—Modern Physics (8)

Phys electives numbered 3xxx or above;

Engr 3036 may be used (15)

Applied Physics Major (B.S.)

This physics major (115-118 credits) prepares students to work in industry. It includes a research project option and a minor in mathematics.

Lower Division (67-70)

Required core (26)

Chem 1140—General Chemistry (5)

CS 1621-1622—Computer Science I-II

or CS 1501—FORTRAN Programming

and CS 1511—Intermed FORTRAN (7-10)

Math 1296-1297-3298—Calculus I-II-III (15)

Math 3320—Vectors, Matrices (4)

Math 3350—Calculus IV (5)

Math 3380—Differ Equat I (5)

Upper Division (48)

Comp 3150—Adv Writ: Science

or Comp 3130—Adv Writ: Engineer (4)

Phys 3041—Lab Electronics (4)

Phys 3071—Physics Laboratory (2)

Phys 3991—Appl Phys Seminar (1)

Phys 5045—Adv Lab Electronics (4)

Phys 5107—Thermal Physics (4)

Phys 5123—Theoretical Mech (4)

Phys 5124—Mathematical Meth (4)

Phys 5125—Electromag Theory (4)

Phys 5141-5142—Comp Phys, Modeling (8)

Electives chosen from the following list (9):

ChE 3211—Transport Phenomena (5)

ChE 3212—Fl Flow, Heat Transf (4)

Chem 3010—Prop Materials (4)

ECE 3060—Digital Signal Proc (3)

ECE 3540—Optical Electronics (3)

ECE 3545—Electronic Devices (3)

IE 3021—Production Processes I (4)

Phys 3990—Appl Phys Project (4-5)

Phys 5109—Statistical Phys (4)

Phys 5119—Optics (4)

or other courses approved by the department

Minor

This program (46 credits) is for students who wish to complete a minor in physics for liberal arts or professional purposes.

Lower Division (41)

Required core (26)

Math 1296—Calculus I (5)

Math 1297—Calculus II (5)

Math 3298—Calculus III (5)

Upper Division (5)

Phys 3071—Physics Laboratory (2)

Phys electives numbered 3xxx or above (3);

Engr 3036 may be used

Teaching Physics Minor

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

Statistics (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 statistics program offers students training in theoretical, applied, and computational statistics used in a wide variety of disciplines. Undergraduate training for a statistics career is based on a mathematics major. See Mathematics and Statistics for a description of the mathematics major (B.S.) with a statistics and actuarial science option.