Institute of Technology

This is the Institute of Technology section of the 1999-2000 Undergraduate Catalog of the University of Minnesota.

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For more than a century, the Institute of Technology (IT) has provided education, research, and technology transfer in science and engineering. With 4,500 students enrolled in its undergraduate programs, 2,000 in graduate programs, and 400 faculty, IT’s 11 departments and schools and 15 research centers are committed to excellence in all they undertake.

Computer Facilities—IT, in cooperation with the Department of Computer Science, has established a number of computer laboratories for students. These laboratories provide interactive computing using either stand-alone computers and workstations or remote access to central computing facilities, including those of the Minnesota Supercomputer Institute. Laboratories are available to IT students any time during the work day and evening and weekend hours.

Students also have access through their departments to many special-purpose machines, ranging from small tabletop units for data reduction in laboratories to larger models reserved for special projects.

The Department of Computer Science offers a series of courses in Java, FORTRAN, C, and C++. Discipline-related computing courses are offered in some departments.

Admission

Freshman Admission

The Office of Admissions reviews all applications to determine applicants' potential for academic success. This review process falls into two categories: automatic admission or admission by individual review in which freshman applicants whose records do not meet automatic admission requirements are evaluated through the Office of Admissions' individual review process. Students who do not meet criteria for automatic admission should still apply.

Automatic Admission—Students are automatically admitted to IT as freshmen if they

1. submit a complete application, including all test scores and transcripts, with a $25 application fee before the freshman class fills (ACT preferred, SAT accepted; applying early in the senior year in high school strongly recommended).
2. complete high school course preparation requirements. See “Freshman Admission” in the General Information section of this catalog.
3. meet the ACT or SAT aptitude rating standards below. The following formulas show how to calculate ACT or SAT aptitude rating using high school rank percentile and ACT or SAT test scores. If the aptitude rating falls at or above the number indicated, students are admitted automatically, provided they also meet the other admission standards listed above.

   \[ AAR = \text{High school rank percentile} + \left( \frac{2 \times \text{ACT composite score}}{10} \right) \]
   \[ SAR = \text{High school rank percentile} + \left( \frac{\text{SAT verbal score}}{10} + \frac{\text{SAT math score}}{10} \right) \]

   An AAR of 130 or better, or a SAR of 195 or better, guarantees admission. If a student’s AAR or SAR are below the automatic admission cutoffs, his or her application qualifies for the Office of Admissions' individual review process.

Admission by Individual Review—Review considerations may be based on one or more of the following.

   - A pattern of steady improvement in academic performance
   - A strong college preparatory curriculum (including advanced placement) or a particularly challenging pattern of coursework
   - The size of the applicant’s high school graduating class
   - Extenuating circumstances that have adversely affected the applicant’s academic record or preadmission test scores
   - Evidence of exceptional achievement or aptitude not reflected in the applicant’s academic record or preadmission test scores
   - Evidence of exceptional talent or ability in artistic, scholarly, leadership, or athletic performance

College Coursework Evaluation—No college coursework is required for freshman admission. However, applicants who have completed any transferable college work should have at least a 2.70 grade point average (GPA) in transferable credits (in addition to meeting criteria 1-3 above) to qualify for automatic admission. Applications of students with GPAs below 2.70 are individually reviewed.

Appeals—Any student who believes that the circumstances concerning their application need further consideration may submit a written appeal to the Office of Admissions.

Upper Division Admission—Students entering as freshmen or sophomores must apply for admission to the upper division (junior and senior years). New freshmen and sophomores are told upon admission and at orientation what GPA might be required for entry into their desired upper division major field. (For procedure, see “Upper Division” under Scholastic Policies in this college section.)

Admission Without a Designated Major—Students who want to keep their options open and learn about IT fields before selecting a specific major should indicate “IT Undecided” on the admission application. They receive advising from the Office of Lower Division Programs until they are admitted to upper division. During that period students can use the many resources available in that office to learn about IT fields. Some of the services include mentors; peer, faculty, industry, and alumni advisers; special courses; and written materials. These resources provide information about career opportunities in IT’s various fields and other colleges and help students avoid the mistake of selecting a major for the wrong reasons.

All students are urged to take advantage of the Industry Adviser and Mentor Programs, through which they can visit selected industries to talk and learn about engineering and science fields with an engineer and/or scientist of their choice. Currently, more than 200 engineers and scientists from Honeywell, 3M, and NSP serve as advisers to IT students through this program. Arrangements to participate are made in 128 Lind Hall.

IT undecided students follow the same first-year academic program as that followed by IT students with a specified major. (See page 237 for requirements common to all IT basic lower division curricula.)
Advanced Standing Admission (Transfer)

Students who have completed a year or more of college work are considered for admission with advanced standing. Students planning to transfer to IT should be pursuing a lower division engineering, science, or math program. The mathematics, chemistry, physics, and computer science courses required for the preferred major should be mostly completed at the time of application. Admission decisions are based on the overall GPA and grades in science and mathematics. Because demand for some IT programs exceeds available places, applicants are asked to indicate three majors in order of preference. Applications must include recent transcripts from all colleges attended, reflecting all college work attempted (whether satisfactorily completed or not). Applications must also include a high school transcript to show whether the preparation requirements listed have been met.

Most courses transfer routinely. Equivalency for technical courses has been established between IT and most colleges and universities (see <www.it.umn.edu/ equiv>). Technical courses in which a D has been earned do not transfer, unless the following course in the sequence was completed with at least a C.

Dual Degree (3/2) Programs—IT has cooperative agreements with a number of public and private colleges. These programs support those who want to combine a strong liberal arts background with study in engineering—and are willing to spend another year or two achieving this goal.

Under one plan a student can complete three years of study at a private college and then transfer to IT for two additional years. At the private college, core college requirements and the pre-engineering core courses in math and science are completed. A bachelor’s degree is awarded by both the private college and IT.

The second plan requires completion of a bachelor of arts degree in math or science before coming to the University to work toward a master of science degree in engineering. This typically involves completing some undergraduate engineering coursework. This plan minimizes the amount of undergraduate coursework required. The amount of such coursework will vary by department and area of study. Participating colleges include (in Minnesota) Augsburg College, Bethel College, Concordia College (Moorhead), Gustavus Adolphus College, Hamline University, Macalester College, Moorhead State University, Northwestern College, the College of St. Catherine, Saint Mary’s College, St. John’s University-College of St. Benedict, St. Scholastica, University of St. Thomas; (outside Minnesota) Augustana College, SD; Carroll College, MT; Jackson State University, MS; Luther College, IA; North Central College, IL; North Park College, IL; University of Winnipeg, Manitoba, Canada; University of Wisconsin—La Crosse, WI; University of Wisconsin—River Falls, WI; Whittier College, CA.

Degrees and Programs

Undergraduate Degrees—Each of IT’s undergraduate programs provides a rigorous and stimulating education enhanced by close interaction with distinguished research faculty and access to IT’s research facilities.

Sixteen degrees are offered:

- bachelor of aerospace engineering and mechanics
- bachelor of science in astrophysics
- bachelor of biosystems and agricultural engineering
- bachelor of chemical engineering
- bachelor of science in chemistry
- bachelor of civil engineering
- bachelor of computer engineering
- bachelor of science in computer science
- bachelor of electrical engineering
- bachelor of geological engineering
- bachelor of science in geology
- bachelor of science in geophysics
- bachelor of materials science and engineering
- bachelor of science in mathematics
- bachelor of mechanical engineering
- bachelor of science in physics
- bachelor of science in statistics

1 Program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

Graduate Degrees—The University of Minnesota is the only institution in the state that offers a full range of graduate programs in mathematics and computer science, the physical sciences, and engineering. Each IT department offers M.S. and Ph.D. degree programs in several areas within its discipline. For detailed information about the various graduate programs, consult the Graduate School Catalog.

IT and the Graduate School jointly offer a program leading to the master of engineering (M.E.) degree in any of the engineering disciplines. This program provides advanced preparation in specialized design work for recent graduates in engineering as well as for working engineers who wish to improve their technical capabilities.

The management of technology program is an executive-format graduate program that prepares working engineers and scientists for careers in technology management. It is a part-time, two-year program leading to a master of science degree in the management of technology (M.S.-M.O.T.). For more information, contact the Center for the Development of Technological Leadership, 510 West Bank Office Building, 1300 S. Second Street, Minneapolis, MN 55455 (612/624-5747).

Interdisciplinary Programs—IT students can plan interdisciplinary programs tailored to their specific interests. Although a degree is conferred by a single department, students can combine coursework from several departments.

Many interdisciplinary programs are possible. A few examples include acoustics, bioengineering, environmental engineering, nuclear engineering, and transportation. Students should contact their department office or visit 105 Lind Hall for more information.

Premedical Programs—Because there is no prescribed premedical major, some students plan their IT programs as preparation for medical school. The Minnesota medical schools, in Duluth, Minneapolis, and Rochester, give strong preference to applicants who are state residents.

The Minneapolis campus Medical School has approved the following courses to fulfill its premedical requirements.
Applications may be obtained by contacting the Office of Admissions, 240 Williamson Hall (612/625-2008).

Students with excellent grades in regular courses during the fall of their freshman year may apply to the honors program for spring semester. These students should have taken the appropriate first-semester mathematics and physics courses so they are prepared for the corresponding honors sequences.

Admission to Upper Division Programs—Students about to enter their junior year may apply to the upper division honors program administered through their major department. Admission requirements are set by the individual departments and may be obtained from the department or the IT Honors Office. Previous enrollment in the lower division honors program is not required for participation in upper division honors programs.

Graduation With Honors—Enrollment in the upper division honors program is required for graduation with the honors designations cum laude, magna cum laude, and summa cum laude. Other graduation criteria include at least two years of University of Minnesota coursework, quality of the grade record, participation in honors opportunities, fulfillment of requirements designated in the major field, and, for summa cum laude, an honors thesis. Some departments also require theses for cum laude and magna cum laude degrees.

IT Honors Office—This office provides academic advising, procedural information, and other college office services to honors students. The address is IT Honors Office, University of Minnesota, 136 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/625-2800).

Scholastic Policies

Continuation in Sequences—IT students taking the following lower division sequence courses must earn at least a C- each semester to continue in the sequence.

Chem 1021-1022, 2101-2111
Chem 2301, 2302, 2311
EE 2001, 2011
Geo 1001, 1002
Math 1155, 1271-1272
Math 1571-1572
Phys 1301, 1302
Phys 2303, 2601

1 To continue in additional mathematics courses (in particular Math 2243 or Math 2263) or sequences, IT students must earn at least a C- in Math 1272.

2 To continue in physics sequences, IT students must earn at least a C- in Phys 2003.

IT students must earn at least a C- in all 1xxx and 3xxx math, physics, and chemistry courses.

Upper Division—The upper division corresponds to the junior and senior years.

Freshmen and sophomores must apply for entry and are told at orientation what minimum GPA might be required. That GPA is calculated using the grades of all courses taken, including repeated courses. Students should file an application in 105 Lind Hall before completing their sophomore year.

Changing Majors—To change majors within IT, students must petition. Forms are available in 105 Lind Hall. A transcript must accompany the petition.

Students who graduate from IT but continue to register for courses will automatically have their major changed to adult special (nondegree) unless they had previously been admitted to a second (double) major.
To change majors from IT to another college unit or campus within the University, students must apply for transfer through the Office of the Registrar Service Center, 200 Fraser Hall, as far as possible in advance of the projected transfer. Some units have transfer application deadlines. Students must meet admission requirements of the unit they plan to enter.

**Professional Registration**

Registration as an engineer is a legal requirement for certain kinds of practice. A professional license is required before an individual may use the designation of engineer in any legal connection. Many engineers obtain a license to show their support for legal recognition of the professional standing of the engineer. Many also obtain a license because professional registration may be useful or required in future employment.

The license is awarded in most states to those graduates of an accredited engineering curriculum who have passed examinations in the fundamentals, principles, and practice of engineering and demonstrated their competence by a specified number of years of appropriate experience. The fundamentals of engineering examination covers materials studied in undergraduate curricula. This examination is given in the spring and fall each year and may be taken by students in their senior year. More information and applications may be obtained from 50 Lind Hall or by writing to the Minnesota State Board of Architecture, Engineering, Land Surveying, Landscape Architecture and Interior Design, 133 7th Street E., St. Paul, MN 55101-2333 (651/296-2388).

**Advising**

Advising for freshmen is coordinated by the Office of Lower Division Programs, 128 Lind Hall (612/624-2890). Every IT freshman is assigned to a team of approximately 100 students. During orientation, freshmen meet with their team adviser and plan their fall schedule. Students on each team take one or more courses together; this encourages the formation of study and support groups. Freshmen must meet with their team adviser at least once each term to discuss their progress and plan their schedule for the following semester.

All lower division students obtain advising through the Office of Lower Division Programs until admission to upper division.

**Special Learning Opportunities and Resources**

**Student Affairs Office**—Prospective and current students can discuss any questions or problems with an advising staff member in the Student Affairs Office, 105 Lind Hall (612/624-8504). This office is responsible for admission, orientation, registration, scholastic conduct, institute-wide scholarships, degree requirements and procedures, and related functions. Appointments are encouraged.

**Tutors**—IT provides peer tutors for students in chemistry, mathematics, physics, and other IT courses. These teaching assistants, selected from junior and senior IT students, are trained, qualified, and willing to assist students one-on-one with problems in IT lower division courses. Tutoring is provided in various locations—in 150 Lind Hall, by appointment in 128 Lind Hall, and in all residence halls.

Mathematics graduate teaching assistants are available in 150 Lind Hall with the undergraduate teaching assistants. In addition, graduate teaching assistants provide tutoring for computer science courses in 4-205 Electrical Engineering/Computer Science.

For more information about tutors, contact the Office of Lower Division Programs, 128 Lind Hall (612/624-2890).

**Paid Learning Opportunities**—IT Career Services (ITCS) provides information about off-campus employment related to major or career interests. Many options are available for part-time, summer internship, and cooperative education employment. Students may be eligible for part-time or summer internship opportunities as early as the end of their freshman year. Students entering upper division may be eligible to participate in cooperative education programs offered through their major department. For more information, contact ITCS, 50 Lind Hall (612/624-4090).

**Center for the Development of Technological Leadership (CDTL)**—IT, the Carlson School of Management, College of Liberal Arts, Hubert H. Humphrey Institute of Public Affairs, and College of Agricultural, Food, and Environmental Sciences participate in this interdisciplinary center. It promotes leadership in technology by supporting appropriate research and providing IT students and technical professionals with educational opportunities for increased breadth and depth in technical management, business, and liberal arts. The center administers two undergraduate programs, the management minor (see page 237) and APEXES (see below), and the master of science in the management of technology degree program.

**APEXES (Integrated Degrees in Engineering, Arts, and Sciences)**—This scholarship program is for undergraduates who integrate degrees from IT and the College of Liberal Arts. IDEAS enriches students’ education by exploring how technology and society influence each other and promotes leadership in technology by providing students with educational opportunities for increased breadth and depth in liberal arts, business, and technical management. For more information, contact the Center for the Development of Technological Leadership, 510 West Bank Office Building, 1300 S. Second Street, Minneapolis, MN 55455 (612/624-5747).

**Academic Program for Excellence in Engineering and Science (APEXES)**—APEXES promotes academic excellence and the increased presence of underrepresented groups (African American, Chicano/ Latino, Native American) in engineering and the physical sciences. Through its precollege, undergraduate, and graduate/faculty programs, it promotes diversity in the classroom, laboratory, and workplace to prepare IT students for careers in an ethnically diverse work force.

Working with other IT and University offices, the program offers a variety of academic enrichment programs such as tutoring, learning assessment, career assessment, and study groups. Through collaboration with IT departments and corporate sponsors, APEXES identifies experiences outside the classroom such as internships, cooperative programs, and work teams to expose students to applications in science and engineering. These collaborations also provide merit scholarships for underrepresented students in engineering and the physical sciences who excel academically.
For more information, contact APEXES, 107 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/626-0219; e-mail APEXES@tc.umn.edu).

Program for Women—This program supports women in their pursuit of science and engineering education and careers. Services are provided to women undergraduate and graduate students, transfer and nontraditional students, faculty, technical staff, fellows, and precollege girls.

The program recruits talented women in an attempt to increase the enrollment of women in IT degree programs to levels above national trends. It builds networks for IT women, provides skills and tools for success, and works to improve the climate for women in individual departments. Its outreach efforts focus on encouraging girls to explore and enjoy mathematics and science as well as educating parents, teachers, leaders, and the greater community on their critical roles in supporting girls and women in science and engineering. The program also provides student referral, scholarship and fellowship files, a resource library, networking information, MN-WISE electronic list server, and advocacy.

For more information, contact Program for Women, 107 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/624-1317).

UNITE Instructional Television—About 50 credit courses each semester are offered through UNITE (UNiversity-Industry Television for Education), an instructional television system for continuing education at the employee’s workplace. These include both upper division and graduate courses as well as specially developed courses and seminars. Classes are held in TV studio classrooms with on-campus students in attendance. The system is interactive, enabling students at all sites to talk with the instructor and take part in class discussions. Participating companies help support the system by paying a fee based on the number of credits for which its employees are enrolled. This fee is separate from tuition, which is paid either by the student or the company, depending on company policy.

For more information, contact the Director, UNITE Instructional Television, 114 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612/624-2332).

International Programs

IT students have a number of opportunities for study abroad. Study in English is possible at several sites. Opportunities include the International Student Exchange Program (ISEP), International Association for the Exchange of Students for Technical Experience (IAESTE), and Institute for Study Abroad (Butler University, IN).

Identifying Opportunities—Each IT department has a list of recommended locations for study abroad. Students can learn more about these options by contacting Global Campus, 102 Nicholson Hall (612/626-9000).

Opportunities in Engineering—The University’s student exchanges and consortium memberships give students access to engineering courses at universities in many countries. Courses taught in English are available in Australia, Canada, Denmark, Finland, Hong Kong, Malta, Singapore, Sweden, Tanzania, and the United Kingdom. Students with sufficient language fluency may instead choose to study in Chinese (Hong Kong), Filipino (Philippines), Finnish (Finland), French (Belgium, France), German (Germany), Italian (Italy), Korean (South Korea), Portuguese (Brazil), Spanish (Argentina, Colombia, Costa Rica, Dominican Republic, Mexico), or Thai (Thailand).

Other Information—For more information (e.g., study options, earning credit, financial aid), see “Study Abroad” in the General Information section of this catalog.

Career Information

IT Career Services (ITCS), 50 Lind Hall (612/624-4090), provides comprehensive career planning and job search assistance for IT students and alumni.

ITCS helps students explore major and career options. Each semester the office offers IoT 1312, a two-credit career exploration course that identifies how interests, skills, and abilities align with career possibilities, and provides the opportunity to meet professionals working in engineering and science fields.

ITCS provides a variety of services to students seeking part-time jobs, summer internships and cooperative program positions, or permanent jobs after graduation. ITCS hosts on-campus interviewing, posts job opportunities, and helps students learn all aspects of the job search process, including writing résumés and job search correspondence, developing interviewing skills, and learning how to access job and employer information.

The office also supplies information about and applications for the Engineer In Training (EIT) examinations.

Students are encouraged to register with ITCS as early as their sophomore year.

Student Organizations and Activities

Scientists and engineers find that membership in technical or professional societies usually helps their career development. Many of these societies have student chapters at the University. Through them students have the opportunity to participate in activities of the parent society, gain experience in conducting technical meetings, and meet senior members of the societies. In addition, regular membership in the society is facilitated upon graduation and any entrance fee is reduced or waived for former student members.

Professional Societies—Branches of the following national professional societies are maintained at the University of Minnesota by students and faculty:

American Chemical Society, American Institute of Chemical Engineers, Society of Physics Students, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society of Agricultural Engineers, American Institute of Aeronautics and Astronautics, American Institute of Industrial Engineers, and Institute of Electrical and Electronic Engineers. Additional professional societies include the Society of Women Engineers and Triangle.

Honorary Scholastic Societies—These IT societies promote the high standards of the engineering profession by conferring memberships, awards, and other honors on undergraduates distinguished for scholastic achievement and for character. The societies normally elect members from the junior and senior classes on the basis of scholarship (as measured by class rank) and character (as judged by peers and faculty). Of these honorary societies, only Tau Beta Pi selects its members from students in all IT undergraduate departments. The others confine their
membership to students from a single department: Alpha Epsilon (biosystems and agricultural engineering), Chi Epsilon (civil engineering), Eta Kappa Nu and Kappa Eta Kappa (electrical engineering), Pi Tau Sigma (mechanical engineering), and Sigma Gamma Tau (aerospace engineering and mechanics).

**Plumb Bob**—A senior honorary leadership and service society, Plumb Bob works to create and maintain a spirit of fellowship and cooperation among IT students and further the interests of IT and the University. Its members are chosen for their character, leadership, and service.

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**Directory**

(area code 612)

**Office of the Dean**
105 Walter Library
624-2006

**Office of the Associate Dean for Student Affairs**
106 Lind Hall
624-5091

**Office of Lower Division Programs**
128 Lind Hall
624-2890

**Student Affairs Office**
105 Lind Hall
624-8504

**Center for the Development of Technological Leadership**
510 West Bank Office Building
624-5747

**IT Honors Office**
136 Lind Hall
625-2800

**IT Career Services**
50 Lind Hall
624-4090

**Academic Program for Excellence in Engineering and Science (APEXES)**
107 Lind Hall
626-0219

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**Departments**

**Aerospace Engineering and Mechanics**
107 Akerman Hall
625-8000

**Astronomy**
356 Tate Laboratory of Physics
624-0211

**Biosystems and Agricultural Engineering**
213 Biosystems and Agricultural Engineering Building, St. Paul
625-7733

**Chemical Engineering and Materials Science**
151 Amundson Hall
625-1313

**Chemistry**
139 Smith Hall
624-6000

**Civil Engineering**
122 Civil Engineering Building
625-5522

**Computer Science and Engineering**
4-192 Electrical Engineering/Computer Science
625-4002

**Electrical and Computer Engineering**
4-174 Electrical Engineering/Computer Science
625-3300

**Geology and Geophysics (Earth Sciences)**
108 Pillsbury Hall
624-1333

**Mathematics**
4 Vincent Hall
625-4848

**Mechanical Engineering**
125 Mechanical Engineering
625-0705

**Physics**
148 Tate Laboratory of Physics
624-7375

**Statistics**
270 Vincent Hall
625-8046

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**IT Student Board**

This board is the executive body of IT students, representing them in matters affecting the general interests of IT and the University.

**Student Publications**

Two publications are produced by IT students: *IT Connection* (newsletter) and *IT Technology* (technical magazine). The IT Board of Publications selects editors and business managers and directs the overall policy of the publications. Students are encouraged to participate as publication staff members.
The department offers an optional engineering intern program in the upper division. The program allows students to obtain industrial work experience by alternating semesters (including the summer) of industrial employment with academic studies during their junior and senior years. Prospective participants should contact the Intern Program Director for information in the fall of their sophomore year.

**Admission Requirements**—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

**Degree Requirements**

To complete the degree, students must complete at least 126 credits, including at least 56 credits in the major. The courses required for the degree are listed below. These include two technical electives selected from IT upper division courses in an area of interest to the student. One additional technical elective must be taken from the list of five courses in the area of solid mechanics and materials. Campus liberal education requirements are to be met through the 15 credits of liberal education courses. The campus writing requirements are met by B.A.E.M. majors by taking two addition writing intensive courses. These courses may also count as liberal education electives. Two required courses, AEM 4602 and AEM 4332, are writing intensive courses, and these complete the requirements for four writing intensive courses where one course is the upper division and one course is in the major.

**Required Courses**

- **Lower Division**
  - AEM 2011—Statics
  - AEM 2012—Dynamics
  - AEM 2301—Mechanics of Flight
- **Upper Division**
  - AEM 4201—Fluid Mechanics
  - AEM 4202—Aerodynamics
  - AEM 4203—Aerospace Propulsion
  - AEM 4301—Spaceflight Dynamics
  - AEM 4303—Flight Dynamics and Control
  - AEM 3031—Deformable Body Mechanics
  - AEM 4501—Aerospace Structures
  - AEM 4502—Aeromechanics Lab
  - AEM 4331—Aerospace Vehicle Design I
  - AEM 4332—Aerospace Vehicle Design II
- Two technical electives

**Required Courses From Other Programs**

- Chem 1021—Chemical Principles I
- CSci 1107—Introduction to FORTRAN Programming for Scientists and Engineers
- EE 3005, 3006—Fundamentals of Electrical Engineering and Lab
- Math 1271, 1272—Calculus I, II
- Math 2234—Linear Algebra and Differential Equations
- Math 2263—Multivariable Calculus
- Phys 1301, 1302, 2303—Introductory Physics I, II, III
- MatS 2001—Introduction to Science of Engineering Materials
- ME 3324—Introduction to Thermal Science

Liberal education electives—15 credits
Electives

Restrictions on Upper Division Technical Electives

Three courses (9 credits) of upper division technical electives are required. Generally the elective requirement is met by selecting non-required 3xxx, 4xxx, and 5xxx courses offered by engineering departments. Some courses from mathematics or science departments are also acceptable. Exceptions and additions to this rule are the subject of this section.

No course equivalent to a course required in the B.A.E.M. program may be used as an elective; no 1xxx science or mathematics course may be used; and no 1xxx engineering course may be used except for one in the special category described below in (b).

a) Elective in the solid mechanics, engineering materials, and composites area: One of five courses, AEM 4502, 4511, 4581, 5501, and 5503 must be taken.

b) Restrictions on use of some courses as technical electives: One of the three technical electives other than the “solids” elective of part (a) above may be replaced by one of the following (if more than one is taken, the extra credits are not counted toward the degree requirements):
   - The second semester of chemistry, Chem 1022
   - A 2xxx mathematics, science, or engineering course
   - A 3xxx computation course (e.g., CE 3101)
   - A 3xxx statistics course (e.g., Stat 3021)

c) Other general restrictions on technical electives:
   - No 1xxx mathematics or natural science course (e.g., Ast 1001) is acceptable.
   - Only one programming course may be used; thus an AEM student will not be given credit toward the degree for more than one course of FORTRAN, Pascal, or C/C++. Students with previous programming experience are encouraged to substitute CSci 1113 for the required course CSci 1107.
   - The following 3xxx engineering courses contain material already covered in required courses and so are not acceptable as technical electives: CE 3502, ME 3322. These are essentially contained in the required course AEM 4201. CE 3202 (surveying) is not suitable.
   - No courses from the Carlson School of Management may be used as technical electives.

Sample Program

Freshman Year

Fall Semester (16 cr)
- Math 1271—Calculus I (4 cr)
- Phys 1301—Introductory Physics I (4 cr)
- Chem 1011—Chemical Principles I (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)

Spring Semester (15 cr)
- Math 1272—Calculus II (4 cr)
- Phys 1302—Introductory Physics II (4 cr)
- Biol 1001—Introductory Biology I (4 cr)
- CSci 1107—Introduction to FORTRAN (3 cr)

Sophomore Year

Fall Semester (17 cr)
- Math 2263—Multivariable Calculus (4 cr)
- Phys 2303—Introductory Physics III (4 cr)
- AEM 2011—Statics (3 cr)
- MatS 2001—Introduction to the Science of Engineering Materials (3 cr)

Spring Semester (17 cr)
- Math 2243—Linear Algebra and Differential Equations (4 cr)
- AEM 2012—Dynamics (3 cr)
- AEM 2301—Mechanics of Flight (3 cr)
- Liberal education elective (3 cr)

Junior Year

Fall Semester (15 cr)
- AEM 4201—Fluid Mechanics (4 cr)
- AEM 3031—Deformable Body Mechanics (3 cr)
- AEM 4301—Spaceflight Dynamics (3 cr)
- EE 3005—Fundamentals of Electrical Engineering (4 cr)
- EE 3006—Fundamentals of Electrical Engineering Lab (1 cr)

Spring Semester (16 cr)
- AEM 4202—Aerodynamics (4 cr)
- AEM 4501—Aerospace Structures (3 cr)
- AEM 4303—Flight Dynamics and Control (3 cr)
- AEM 4601—Instrumentation Laboratory (3 cr)
- Liberal education elective (3 cr)

Senior Year

Fall Semester (17 cr)
- ME 3324—Introduction to Thermal Science (4 cr)
- AEM 4331—Aerospace Vehicle Design I (3 cr)
- AEM 4602—Aeromechanics Laboratory (4 cr)
- Technical elective (3 cr)
- Liberal education elective (3 cr)

Spring Semester (17 cr)
- AEM 4203—Aerospace Propulsion (4 cr)
- AEM 4332—Aerospace Vehicle Design II (4 cr)
- Technical elective (3 cr)
- Solids technical elective (3 cr)
- Liberal education elective (3 cr)

Astrophysics

Department of Astronomy

B.S.Astro.P.

An undergraduate program is offered leading to a B.S. in astrophysics. The astrophysics program enables students to develop the skills necessary to tackle complex and ill-defined problems within the physical sciences. The program prepares students for careers in professional astronomy, computational astrophysics, secondary education in the physical sciences, ROTC programs in the Air Force or Navy, data analysis, or laboratory science.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

Degree Requirements

To complete the degree, students must complete at least 120 credits, including at least 19 credits in the major.

The astrophysics degree has several different tracks, depending on the area of specialization a student wishes to pursue. Each track has the same core math, physics, and astrophysics requirements. In addition to these core courses, each track requires 16 credits specific to the area of specialization.

The areas of specialization are:
- Professional astronomer
- Computational astrophysics
- Secondary education
- Data analysis specialist
- Laboratory scientist
Required Courses
Ast 1011—Exploring the Universe, Honors (recommended)
Ast 2001—Astrophysics
Two 4xxx or 5xxx astronomy courses
Ast 4994—Senior Thesis (3 cr min)
Math 1271, 1272 (or 1371, 1372 or 1571, 1572)
Math 2243, 2263, 2283
Phys 1301, 1302 (or 1401, 1402)
Phys 2303 (or 2403), 2201, 2601, 2605
Phys 4001, 4002
Electives—16 credits from the area of specialization or any 3xxx, 4xxx, or 5xxx astronomy, math, chemistry, or physics course

Final Project
A minimum of 3 credits of Ast 4994—Senior Thesis is required for the degree.

Minor Requirements
A minor in astronomy can be earned through the College of Liberal Arts by taking:
Ast 1001 or 1011
Ast 2001 and its prerequisites.

Sample Program
Freshman Year
Fall Semester (16 cr)
Phys 1301—Introductory Physics I (4 cr)
Math 1271—Calculus I (4 cr)
Ast 1011—Exploring the Universe (4 cr)
Liberal education elective (4 cr)

Spring Semester (16 cr)
Phys 1302—Introductory Physics II (4 cr)
Math 1272—Calculus II (4 cr)
EngC 1011—University Writing and Critical Reading (4 cr)
Liberal education elective (4 cr)

Sophomore Year
Fall Semester (14 cr)
Phys 2303—Introductory Physics III (4 cr)
Phys 2201—Introduction to Thermal and Statistical Physics (2 cr)
Math 2243—Linear Algebra and Differential Equations (4 cr)
Liberal education elective (4 cr)

Spring Semester (14 cr)
Phys 2601—Quantum Physics (4 cr)
Phys 2605—Quantum Physics Lab (2 cr)
Math 2203—Multivariable Calculus (4 cr)
Ast 2001—Introduction to Astrophysics (4 cr)

Junior Year
Fall Semester (16 cr)
Math 2283—Sequences, Series, and Foundations (4 cr)
Phys 4001—Analytical Mechanics (4 cr)
Ast 4xxx or 5xxx (4 cr)
Degree elective (4 cr)

Spring Semester (12 cr)
Phys 4002—Electricity and Magnetism (4 cr)
Ast 4xxx or 5xxx (4 cr)
Degree elective (4 cr)

Senior Year
Fall Semester (15-16 cr)
Ast 4994—Directed Research (3-4 cr)
Degree elective (4 cr)
Liberal education elective (4 cr)
Elective (4 cr)

Spring Semester (16 cr)
Degree elective (4 cr)
Liberal education elective (4 cr)
Elective (4 cr)
Elective (4 cr)

Biosystems and Agricultural Engineering

B.B.A.E.
Biosystems and agricultural engineers integrate engineering and biology to design efficient, economical processes to improve the quality and safety of food products for consumers; protect and enhance the environment through design of sustainable practices to maintain and improve soil, water, and air quality; design efficient, profitable food production systems that protect the environment, humans, plants, and animals; and design safe, efficient machines and processes for biological systems.

The biosystems and agricultural engineering curriculum emphasizes the physical, biological, and engineering sciences and engineering design. Students also study communications, social science, and humanities to provide a liberal education and prepare to work effectively with professionals in many disciplines. The program provides students with a background for continued professional growth and prepares them to contribute to an ever-changing society.

The curriculum includes emphases in environment, machinery systems, and bioprocessing and food. Students, with the assistance of an adviser, plan a curriculum tailored to their individual interests in one of these three emphases.
Engineering internships are available to supplement classroom instruction by providing practical education and experience with an employer. Students may begin their internships in the summer following their first year.

The biosystems and agricultural engineering program is accredited by the Accreditation Board for Engineering and Technology (ABET).

Liberal education requirements are the same for all students on the Twin Cities campus. Students must satisfy both the diversified core and designated theme requirements.

For additional information, contact Roger Ruan, Department of Biosystems and Agricultural Engineering, 213 Biosystems and Agricultural Engineering Building, 1390 Eckles Avenue, St. Paul, MN 55108. E-mail ruanx001@tc.umn.edu; fax 612/624-3005.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.20).

Degree Requirements
To complete the degree, students must complete at least 128 credits, including 29 credits in the major. Non-BAE credits include 19 credits of general education courses; 7 credits of composition; 48 credits of mathematics, chemistry, physics, biology, statistics, and computer programming; and credits needed to fulfill the University’s liberal education requirements.

Required Courses
BAE 1011—BAE Orientation (1 cr)
BAE 2113—Introduction to Design (3 cr)
BAE 3013—Engineering Principles of Molecular and Cellular Processes (3 cr)
BAE 3023—Engineering Principles of Soil-Water-Plant Processes (3 cr)
BAE 4013—Transport in Biological Systems (3 cr)
BAE 4023—Instrumentation and Control for Biological Systems (3 cr)
BAE 4122—Senior Design II (2 cr)
BAE 4112—Senior Design I (2 cr)
Math 1271—Calculus I (4 cr)
Math 1272—Calculus II (4 cr)
Math 2263—Multivariable Calculus (4 cr)
Chem 1021—Chemical Principles I (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Chem 1023—Chemical Principles II (4 cr)
Rhet 1101—Writing to Inform Convince and Persuade (4 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
ME 3324—Introduction to Thermal Science (4 cr)
Rhet 3562—Technical Writing (3 cr)
Chem 1023—Chemical Principles II (4 cr)
Rhet 3562—Technical Writing (3 cr)
Math 1271—Calculus I (4 cr)
Math 1272—Calculus II (4 cr)
Math 2263—Multivariable Calculus (4 cr)
Math 2243—Linear Algebra and Differential Equations (4 cr)

Electives—8 credits of engineering electives, 6 credits of biological science electives, plus liberal education requirements

Sample Program

Freshman Year
Fall Semester (17 cr)
Math 1271—Calculus I (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Chem 1021—Chemical Principles I (4 cr)
Rhet 1101—Writing to Inform Convince and Persuade (4 cr)

Spring Semester (15 cr)
Math 1272—Calculus II (4 cr)
Phys 1302—Introductory Physics II (4 cr)
Chem 1022—Chemical Principles II (4 cr)

Sophomore Year
Fall Semester (15 cr)
Math 2263—Multivariable Calculus (4 cr)
Biol 1009—General Biology (4 cr)
Chem 1021—Chemical Principles I (4 cr)
AEM 2021—Statics and Dynamics (4 cr)

Spring Semester (16 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
Chem 1022—Chemical Principles II (4 cr)

Junior Year
Fall Semester (16 cr)
BAE 3013—Engineering Principles of Soil-Water-Plant Processes (3 cr)
BAE 4023—Instrumentation and Control for Biological Systems (3 cr)
ME 3324—Introduction to Thermal Science (4 cr)
CE 3502—Fluid Mechanics (4 cr)

Spring Semester (16 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
BAE 4023—Instrumentation and Control for Biological Systems (3 cr)
BAE emphasis (BAE 4313*/4323*, 4533/4523, or 4713*/4723*) (3 cr)

Senior Year
Fall Semester (17 cr)
BAE 4112—Senior Design I (2 cr)
BAE 4013—Transport in Biological Systems (3 cr)
BAE emphasis or engineering elective (BAE 5513) (3 cr)

Spring Semester (15 cr)
BAE 4122—Senior Design II (2 cr)
BAE emphasis (BAE 4313*/4323*, 4533/4523, or 4713*/4723*) (3 cr)

* Offered alternating years
Chemical Engineering

**Department of Chemical Engineering and Materials Science**

B.Ch.E.

The chemical engineer is primarily a producer whose special province is to develop a process from its laboratory beginning through semiforms equipment to full-scale production. Chemical engineering is based on applications of chemistry, biology, physics, materials science, mathematics, and economics. The chemical engineering curriculum (third and fourth years) includes the study of applied mathematics: material and energy balances; properties and physics of gases, liquids, and solids; fluid mechanics; heat and mass transfer; thermodynamics; chemical and biological reaction kinetics and reactor design; and the integrating subjects of process design, control, and economic optimization. Because of this broad-based foundation, which emphasizes basic and engineering science, the chemical engineer is considered the universal engineer.

Chemical engineering deals with operations such as materials handling, mixing, fluid flow and metering, extrusion, coating, heat exchange, filtration, drying, evaporation, distillation, absorption, extraction, ion exchange, combustion, catalysis, and processing in chemical and biochemical reactors.

Because many industries are based on some chemical or physical transformation of matter, the chemical engineer is much in demand. He or she may work in the manufacture of inorganic products (fertilizers, paints, ceramics, electronic materials); in the manufacture of organic products (polymers, films, papers, petrochemicals); in the manufacture of batteries and fuel cells; in the processing of minerals and materials; in food processing and fermentation, or in the production of antibiotics and biochemical products.

**Admission Requirements**—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.70).

**Degree Requirements**

To complete the degree, students must complete at least 130 credits, including at least 30 credits in the major. The credit total includes the lower division program of chemistry, mathematics, physics, biology, and liberal education, as well as the upper division program of chemical engineering, chemistry, materials science, electives, and liberal education requirements.

The student, together with his or her adviser, plans the degree program in stages. A course plan is submitted every semester for the first two years, and once a year after that.

**Required Courses**

- Chem 4001—Material and Energy Balances
- Chem 4002—Transport Phenomena
- Chem 4003—Heat and Mass Transfer
- Chem 4004—Separation Processes
- Chem 4101—Chemical Engineering Thermodynamics
- Chem 4102—Reaction Kinetics and Reactor Engineering
- Chem 4401—Chemical Engineering Laboratory I
- Chem 4402—Chemical Engineering Laboratory II
- Chem 4501—Chemical Engineering Process Design I
- Chem 4502—Chemical Engineering Process Design II
- Chem 4601—Process Control
- Math 1271—Calculus I
- Math 1272—Calculus II
- Math 2243—Linear Algebra and Differential Equations
- Math 2263—Multivariable Calculus
- Chem 1021—Chemical Principles I
- Chem 1022—Chemical Principles II
- Chem 2301—Organic Chemistry I
- Chem 2302—Organic Chemistry II
- Chem 2311—Organic Lab
- Chem 3501—Physical Chemistry I
- Chem 3502—Physical Chemistry II
- Chem 4121—Process Analytical Chemistry
- CSci 1107—Fortran Programming
- MatS 3011—Introduction to the Science of Materials
- Phys 1301—Introductory Physics I
- Phys 1302—Introductory Physics II
- Liberal education elective #4 (Humanities I) (3 cr)
- Math 2243—Multivariable Calculus (4 cr)
- ChEn 4001—Material and Energy Balances (4 cr)
- Math 2271—Calculus III (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)
- Phys 1302—Introductory Physics II (4 cr)
- Liberal education elective #4 (Humanities I) (3 cr)

**Sample Program**

### Freshman Year

**Fall Semester (16 cr)**
- Chem 1021—General Principles of Chemistry I with Lab (4 cr)
- Math 1271—Calculus I (4 cr)
- Phys 1301—Introductory Physics I (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)
- Liberal education elective #1 (Biol with lab) (4 cr)

**Spring Semester (16 cr)**
- Chem 2301—Organic Chemistry I (3 cr)
- Math 2263—Multivariable Calculus (4 cr)
- CSci 1107—Introduction to FORTRAN (3 cr)
- Liberal education elective #2 (Social Sciences I) (3 cr)
- Liberal education elective #3 (Social Sciences II) (3 cr)

### Sophomore Year

**Fall Semester (16 cr)**
- Chem 2302—Organic Chemistry II (3 cr)
- Math 1272—Calculus II (4 cr)
- Phys 1302—Introductory Physics II (4 cr)
- Liberal education elective #1 (Biol with lab) (4 cr)

**Spring Semester (17 cr)**
- Chem 2302—Organic Chemistry II (3 cr)
- Math 2271—Calculus III (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)
- Liberal education elective #2 (Social Sciences II) (3 cr)
- Liberal education elective #3 (Social Sciences III) (3 cr)
- Liberal education elective #4 (Humanities I) (3 cr)
Junior Year (17 cr)
Fall Semester
Chem 2311—Organic Chemistry Lab I (3 cr)
Chem 3502—Physical Chemistry II (3 cr)
ChEn 4101—Chemical Engineering Thermodynamics (4 cr)
ChEn 4002—Transport Phenomena (4 cr)
Liberal education elective #5 (Literature I) (3 cr)
Spring Semester (17 cr)
Chem 4121—Process Analytical Chemistry (3 cr)
ChEn 4102—Reaction Kinetics and Reactor Engineering (4 cr)
ChEn 4003—Heat and Mass Transfer (4 cr)
Liberal education elective #6 (History I) (3 cr)
Technical elective (Emphasis I) (3 cr)
Senior Year
Fall Semester (16 cr)
ChEn 4401—Chemical Engineering Lab I (3 cr)
ChEn 4501—Chemical Engineering Process Design I (3 cr)
MatS 3011—Introduction to the Science of Materials (3 cr)
Technical elective (Emphasis II) (3 cr)
Spring Semester (15 cr)
ChEn 4502—Chemical Engineering Process Design II (3 cr)
ChEn 4601—Process Control (3 cr)
ChEn 4402—Chemical Engineering Lab II (3 cr)
Technical elective (Emphasis III) (3 cr)
Technical elective (Emphasis IV) (3 cr)

Chemistry
Department of Chemistry
B.S. Chem.
Chemistry probes the fundamental concepts of nature and helps us understand the world around us. It deals with all substances at the molecular level: their composition, their properties, and how they are transformed into new substances.

Chemistry is a central science of great importance to society. It provides a broad range of opportunities in many specialized fields, including biotechnology, polymer chemistry, environmental chemistry, materials chemistry, and medicine.

After graduating with a bachelor’s degree, many chemistry majors go on to graduate or professional schools to pursue advanced degrees. Other graduates find employment in industry, education, or government.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00)

Degree Requirements
To complete the degree, students must complete at least 120 credits, including 40 credits in the major. The chemistry curriculum includes courses in chemistry, physics, mathematics, and the liberal arts. Specific degree are:

Chemistry Lect/Lab (31 cr)
Mathematics (12 cr)
Calculus-based Physics (8 cr)
Advanced Chemistry Lect Elective (3 cr)
Advanced Chemistry Lab Electives (6 cr)
Advanced technical electives (6 cr)
Math or Physics Elective (4 cr)
Liberal education electives (15 cr)
Free electives (27 cr)

All required courses must be taken A-F. A grade of C- or better is required in all technical courses.

By selecting appropriate electives, a student can construct a program with emphasis in special interest areas such as bioscience, chemical physics, education, environmental chemistry, and materials chemistry. Other special interest areas are also possible, and chemistry advisers can be helpful in designing such programs. A student can do dual degrees, but this option requires careful course planning and should be discussed as early as possible with an adviser.

All chemistry majors are advised by faculty and staff in the chemistry advising office. Each student plans his or her degree program by submitting one-year plans in consultation with an adviser. The final one-year degree plan must be certified for graduation by the department.

Required Courses
Chem 1021—Chemical Principles I (4 cr)
Chem 1022—Chemical Principles II (4 cr)
Chem 2301—Organic Chemistry I (3 cr)
Chem 2302—Organic Chemistry II (3 cr)
Chem 2311—Organic Chemistry Lab (3 cr)
Chem 2101—Analytical Chemistry (3 cr)
Chem 2111—Analytical Chemistry Lab (2 cr)
Chem 3501—Physical Chemistry I (3 cr)
Chem 3502—Physical Chemistry II (3 cr)
Chem 4701—Inorganic Chemistry Lect (3 cr)
Advanced chemistry lecture elective (3 cr)
Advanced chemistry lab elective (6 cr)

(Three courses selected from Chem 4111, 4311, 4511, 4711, Chem 4094—Directed Studies)
Civil Engineering

Department of Civil Engineering

B.C.E.
Civil engineering deals with the science and art of engineering applied to solving problems related to the human environment and natural resource needs. Principal fields within civil engineering are structural engineering, environmental engineering, water resources engineering, transportation engineering, and geotechnical engineering. The upper division civil engineering program requires students to take introductory courses in all of the above areas. In addition, students may emphasize a special interest in one of the areas by selecting appropriate technical electives in consultation with their adviser.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.30).

Degree Requirements
To complete the degree, students must complete at least 128 credits, including 58 credits in the major. In addition to the liberal education requirements for all Twin Cities campus students, the lower division program requires coursework in basic and engineering science, math, physics, chemistry, geology, statistics, computer science, statics, and deformable body mechanics.

The upper division program requires courses in surveying, transportation, soil mechanics, fluid mechanics, water resources, environmental sciences, structures, project management, engineering economics, and engineering design. Students are also required to select appropriate technical elective courses.

Required Courses
CE 3101—Computer Applications (3 cr)
CE 3201—Transportation Engineering (3 cr)
CE 3202—Surveying and Mapping (2 cr)
CE 3301—Soil Mechanics I (3 cr)
CE 3401—Linear Structural Analysis (3 cr)
CE 3402—Construction Materials (3 cr)
CE 3501—Environmental Engineering (3 cr)
CE 3502—Fluid Mechanics (4 cr)
CE 4101—Project Management (3 cr)
CE 4102—Capstone Design (3 cr)
CE 4301—Soil Mechanics II (3 cr)
CE 4401—Steel and Concrete Design I (4 cr)
CE 4501—Hydrologic Design (4 cr)
CE 4502—Water and Wastewater Treatment (3 cr)
Technical electives (14 cr)

A total of 62 credits are required from other departments, distributed as follows:
Math 1271, 1272, 2243, 2263 (16 cr)
Phys 1301, 1302 (8 cr)
Chem 1021, 1022 (8 cr)
Geo 1001 (3 cr)
AEM 2011—Statics (3 cr)
AEM 2012—Dynamics (3 cr)
AEM 3031—Deformable Body Mech (3 cr)
Stat 3021—Applied Statistics (3 cr)
Liberal education electives (15 cr)

1 Substitutions—Upon recommendation of an adviser, students may make the following substitutions:
A CSci programming course for CE 3101
A CE environmental course for AEM 2011

2 Electives—Students may obtain guidelines for meeting the technical elective requirement in 122 Civil Engineering. The following substitutions may be used:
Up to two IT Freshman Seminar courses
One course from another IT department
The solar car built by IT students finished second in the nation in Sunrayce '95 and second in its class in the World Solar Car Rally in Akita, Japan.

The computer engineering resulted from the tremendous development of computers and, in particular, the evolution of microprocessors. The design process for almost every electronic system includes the specification and development of the control program for the system’s microprocessor. A particular computer engineering job can be more closely related to hardware or software, to functional design or detailed design. The undergraduate CompE degree provides the background necessary for persons, with continuing study, to work in any of the many computer engineering subfields. The degree itself does not, however, provide highly specialized knowledge in any particular subfield.

The computer engineering curriculum, offered jointly by the Department of Electrical and Computer Engineering (ECE) and the Department of Computer Science and Engineering (CSE), gives graduates a strong theoretical and practical background. It requires students to learn to work in teams and to develop good oral and written communication skills. It offers students an opportunity to concentrate in one of several areas, such as computer design, computer architecture and networks, and very-large integrated circuit design and computer-aided circuit design. Elective courses may be selected from ECE, CSE, or other departments to tailor a program to fit particular interests.

An honors program and an engineering co-op program are available to qualified upper division students. The honors program offers students an opportunity to do a year-long individual project under the guidance of a faculty member. The co-op program offers industrial experience and some financial support through alternate on-campus study and off-campus industrial assignment.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.50).

Degree Requirements
To complete the degree, students must complete at least 126 credits, including 78 credits in the major. The curriculum includes 16 credits of calculus from mathematics; 8 credits of calculus-based physics; 4 credits of an engineering science elective outside of electrical engineering; 34 credits of required electrical engineering courses; 20 credits of required computer science courses, 22 credits of senior-level technical
electives from computer science, electrical engineering, or other IT departments; and liberal education requirements. Honors students may substitute their senior design project credits for senior technical electives and the general senior project design course. Co-op students may use their second and third industrial assignment credits as non-major senior technical electives.

Transfer students must satisfy IT’s residency requirements, and all senior technical electives must be taken from the University. All technical courses must be taken A-F. The average of all grades must be C- or better, and the average grade in all electrical engineering courses must be C- or better.

**Required Courses**

EE 2301—Introduction to Digital System Design  
EE 2361—Introduction to Computer Architecture and Assembly Language  
EE 2001—Introduction to Electronic and Electrical Circuits  
EE 2002—Introductory Circuits and Electronics Laboratory  
EE 2011—Linear Systems and Circuits  
EE 3115—Analog and Digital Electronics  
EE 3015—Signals and Systems  
EE 3025—Statistical Methods in Electrical and Computer Engineering  
EE 3101—Circuits and Electronics Laboratory I  
EE 3102—Circuits and Electronics Laboratory II  
EE 3601—Electromagnetic Fields and Waves  
EE 4951—Senior Design Project  
CSci 1901—Structure of Computer Programming I  
CSci 1902—Structure of Computer Programming II  
CSci 2011—Discrete Structures of Computer Science  
CSci 4041—Algorithms and Data Structures  
CSci 4061—Introduction to Operating Systems  
Math 1271—Calculus I  
Math 1272—Calculus II  
Math 2243—Linear Algebra and Differential Equations  
Math 2263—Multivariable Calculus  
Phys 1301—Introductory Physics I  
Phys 1302—Introductory Physics II  
Engineering science elective (3 cr)

**Final Project**

All students must take EE 5951—Senior Design Project (2 cr). Students are organized into teams of approximately five members and design and construct a project under the direction of a faculty member.

**Sample Program**

**Freshman Year**

Fall Semester (15 cr)  
EngC 1011—University Writing and Critical Reading (4 cr)  
Math 1271—Calculus I (4 cr)  
Phys 1301—Introductory Physics I (4 cr)  
Liberal education elective (3 cr)  
Spring Semester (16 cr)  
Math 1272—Calculus II (4 cr)  
Phys 1302—Introductory Physics II (4 cr)  
CSci 1901—Structure of Computer Programming I (4 cr)  
Biology with lab (4 cr)

**Sophomore Year**

Fall Semester (16 cr)  
Math 2243—Linear Algebra and Differential Equations (4 cr)  
CSci 1902—Structure of Computer Programming II (4 cr)  
EE 2001—Introduction to Electronic and Electrical Circuits (3 cr)  
EE 2002—Introductory Circuits and Electronics Lab (1 cr)  
EE 2301—Introduction to Digital System Design (4 cr)  
Spring Semester (17 cr)  
Math 2263—Multivariable Calculus (4 cr)  
CSci 2011—Discrete Structures of Computer Science (4 cr)  
EE 2011—Linear Systems and Circuits (3 cr)

**Jrior Year**

Fall Semester (15 cr)  
EE 3115—Analog and Digital Electronics (4 cr)  
EE 3015—Signals and Systems (3 cr)  
EE 3101—Circuits and Electronics Lab I (2 cr)  
Engineering science elective (3 cr)  
Liberal education elective (3 cr)

Spring Semester (16 cr)  
CSci 4041—Algorithms and Data Structures (4 cr)  
EE 3025—Statistical Methods II (3 cr)  
EE 3102—Circuits and Electronics Lab II (2 cr)  
EE 3601—Electromagnetic Fields and Waves (4 cr)  
Liberal education elective (3 cr)

**Senior Year**

Fall Semester (16 cr)  
CSci 4061—Introduction to Operating Systems (4 cr)  
Senior technical electives (12 cr)  
Spring Semester (15 cr)  
EE 4951—Senior Design Project (2 cr)  
Senior technical electives (10 cr)  
Liberal education elective (3 cr)

**Computer Science**

Department of Computer Science

B.S.Comp.Sc.

Computer science is concerned with the study of the hardware, software, and theoretical aspects of high-speed computing devices and with the application of these devices to scientific, technological, and business problems.

A bachelor’s degree gives students a basic understanding of computer science. After completing a required set of fundamental courses, students arrange their subsequent work around one of several upper division emphases within either computer science or an interdisciplinary area involving computer applications. The degree prepares students for graduate work or for various industrial, governmental, and business positions involving the use of computers.

Admission Requirements—Complete Math 2243, CSci 1901, 1902, 2011, and meet GPA requirement set by IT (currently 2.70).

Degree Requirements

To complete the degree, students must complete at least 124 credits, including 45 credits in the major. The bachelor of science degree requires, in addition to University requirements, four mathematics courses, two physics courses, and one statistics course. The degree also requires 36 credits of required CSci classes, plus an upper division emphasis. The upper division emphasis is any program that

- forms a coherent academic program in an area of computer science or its applications;
- consists of at least 17 credits of 4xxx (or higher) courses with at least nine of these being CSci courses (3xxx courses from outside CSci will be allowed if they have a 1xxx or 2xxx prerequisite in the same, or a related, field);
Electrical Engineering

Department of Electrical and Computer Engineering

B.E.E.

Electrical engineers work in highly diverse areas such as computers, telecommunications, semiconductors, electric energy, consumer and entertainment electronics, biomedical technology, defense and aerospace systems, and automotive electronics. They design and develop components, software, and systems; carry out analysis; and work in research, management, and sales. The bachelor of electrical engineering prepares students for immediate entry into professional work, for graduate study and further specialization in engineering, for advanced work in business and management, or for study in a different direction such as medicine.

The curriculum administered by the Department of Electrical and Computer Engineering gives graduates a strong theoretical and practical background based on design experiences. It requires students to work in teams and develop good oral and written communication skills. It offers an opportunity to concentrate in one of several specialized areas, including biomedical engineering, communications, computers, control systems, electric energy systems and power electronics, microelectronic devices and circuit design, optics and magnetic recording, and signal processing.

An honors program and an engineering co-op program are available to qualified upper division students. The honors program offers an opportunity to do a year-long individual project under the guidance of a faculty member. The co-op program offers industrial experience and some financial support through alternate on-campus employment and off-campus industrial assignment.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.30).

Degree Requirements
To complete the degree, students must complete at least 126 credits, including 63 credits in the major. The requirement includes 16 credits of calculus from mathematics, 8 credits of calculus-based physics, 4 credits of chemistry, 4 additional credits from chemistry or physics, 4 credits of computer science, 4 credits of an engineering science elective outside of electrical engineering, 37 credits of required electrical engineering courses, 26 credits of senior-level technical electives from electrical engineering and other IT departments, and liberal education courses. Honors students may substitute their senior design project credits for senior technical electives and the general senior project design course. Co-op students may use their second and third industrial assignment credits as non-major senior technical electives.
Transfer students must satisfy IT’s residency requirements, and all senior technical electives must be taken from the University. All technical courses must be taken A-F. The average grade in all electrical engineering courses must be C- or better.

**Required Courses**

EE 2301—Introduction to Digital System Design  
EE 2361—Introduction to Computer Architecture and Assembly Language  
EE 2001—Introduction to Electronic and Electrical Circuits  
EE 2002—Introduction to Circuits and Electronics Laboratory  
EE 2011—Linear Systems and Circuits  
EE 3115—Analog and Digital Electronics  
EE 3161—Semiconductor Devices  
EE 3015—Signals and Systems  
EE 3025—Statistical Methods in Electrical and Computer Engineering  
EE 3101—Circuits and Electronics Laboratory I  
EE 3102—Circuits and Electronics Laboratory II  
EE 3601—Electromagnetic Fields and Waves  
EE 4951—Senior Design Project  
Math 2271—Calculus I  
Math 2272—Calculus II  
Math 2243—Linear Algebra and Differential Equations  
Math 2263—Multivariable Calculus  
Phys 1301—Introductory Physics I  
Phys 1302—Introductory Physics II  
Chem 1021—Chemical Principles I  
Chem 1022—Chemical Principles II  
or  
Phys 2303—Introductory Physics III  
CSci 1113—Introduction to C/C++ Programming for Scientists and Engineers  

Engineering science elective (4 cr)  
Electives—8 credits of senior technical electives from an approved list of IT courses.

**Final Project**

All students must take EE 4951—Senior Design Project (2 cr). Students are organized into teams of approximately five members and design and construct a project under the direction of a faculty member.

**Sample Program (with second semester of chemistry)**

**Freshman Year**

**Fall Semester (16-17 cr)**  
Math 1271—Calculus I (4 cr)  
Phys 1301—Introductory Physics I (4 cr)  
CSci 1113—Introduction to C/C++ Programming (4 cr)  
EngC 1011—University Writing and Critical Reading (4 cr)  
EE 1001—Introduction to Electrical Engineering (1 cr) (optional)

**Spring Semester (16 cr)**  
Math 1272—Calculus II (4 cr)  
Phys 1302—Introductory Physics II (4 cr)  
Chem 1021—Chemical Principles I (4 cr)  
Biology with lab (4 cr)

**Sophomore Year**

**Fall Semester (16 cr)**  
Math 2243—Linear Algebra and Differential Equations (4 cr)  
Chem 1022—Chemical Principles II (4 cr)  
EE 2301—Introduction to Digital System Design (4 cr)  
EE 2361—Introduction to Computer Architecture and Assembly Language Program (3 cr)  

**Spring Semester (16 cr)**  
Math 2263—Multivariable Calculus (4 cr)  
EE 2361—Introduction to Computer Arch and Assembly Language Program (3 cr)  
EE 2011—Linear Systems and Circuits (3 cr)  
Liberal education elective (6 cr)

**Junior Year**

**Fall Semester (16 cr)**  
EE 3115—Analog and Digital Electronics (4 cr)  
EE 3015—Signals and Systems (3 cr)  
EE 3101—Circuits and Electronics Lab I (2 cr)  
Engineering science elective (4 cr)  
Liberal education elective (3 cr)

**Spring Semester (15 cr)**  
EE 3025—Statistical Methods (3 cr)  
EE 3102—Circuits and Electronics Lab II (2 cr)  
EE 3161—Semiconductor Devices (3 cr)  
EE 3601—Electromagnetic Fields and Waves (4 cr)  
Liberal education elective (3 cr)

**Senior Year**

**Fall Semester (16 cr)**  
Senior technical elective (16 cr)

**Spring Semester (15 cr)**  
EE 4951—Senior Design Project (2 cr)  
Senior technical elective (10 cr)  
Liberal education elective (3 cr)

**Sample Program (with modern physics)**

**Freshman Year**

**Fall Semester (16-17 cr)**  
Math 1271—Calculus I (4 cr)  
Phys 1301—Introductory Physics I (4 cr)  
CSci 1113—Introduction to C/C++ for Science and Engineering (4 cr)  
EngC 1011—University Writing and Critical Reading (4 cr)  
EE 1001—Introduction to Electrical Engineering (1 cr) (optional)

**Spring Semester (16 cr)**  
Math 1272—Calculus II (4 cr)  
Phys 1302—Introductory Physics II (4 cr)  
Chem 1021—Chemical Principles I (4 cr)  
Biology with lab (4 cr)

**Sophomore Year**

**Fall Semester (16 cr)**  
Math 2243—Linear Algebra and Differential Equations (4 cr)  
Phys 2303—Introductory Physics III (4 cr)  
EE 2301—Introduction to Digital System Design (4 cr)  
EE 2361—Introduction to Computer Architecture and Assembly Language Program (3 cr)  
EE 2011—Linear Systems and Circuits (3 cr)  
Liberal education elective (6 cr)

**Junior Year**

**Fall Semester (16 cr)**  
EE 3115—Analog and Digital Electronics (4 cr)  
EE 3015—Signals and Systems (3 cr)  
EE 3101—Circuits and Electronics Lab I (2 cr)  
Engineering science elective (4 cr)  
Liberal education elective (3 cr)

**Spring Semester (15 cr)**  
EE 3025—Statistical Methods (3 cr)  
EE 3102—Circuits and Electronics Lab II (2 cr)  
EE 3161—Semiconductor Devices (3 cr)  
EE 3601—Electromagnetic Fields and Waves (4 cr)  
Liberal education elective (3 cr)
Geological Engineering

Department of Civil Engineering

B.Geo.E.

A geological engineer applies the principles of engineering and science to the problems of planning, analysis, design, construction, and operation of facilities on and under the surface of the Earth. Geological engineering is based on applications of geology, physics, chemistry, mathematics, and engineering mechanics. A geological engineer requires many of the skills required of a civil engineer, an environmental engineer, and a geologist. The geological engineer, however, is uniquely qualified to work at the interfaces of these disciplines.

Within the geological engineering program are two degree paths:

The geoenvironmental option focuses on (1) soil and groundwater contamination, modeling, and remediation; (2) solid and hazardous waste characterization, management, and disposal; (3) groundwater resources management and exploitation.

The geomechanics option focuses on (1) foundations for buildings, bridges, roads, and dams; (2) analysis and design of surface and subsurface excavations; (3) evaluation of natural geologic hazards.

The most common professional employment for graduates is within the private sector as consulting engineers. Graduates also work at international, national, state, and local agencies involved with environmental protection, energy conservation and generation, and natural-resources conservation and exploitation.

After completing approximately four semesters, students may enter an engineering educational cooperative. Participants alternate study semesters with a six-month work period, for which they earn three credits.

With less than one year of additional study beyond the requirements for the geological engineering degree, students can now obtain a double degree: a B. Geological Engineering and B.S. Geology.

The geological engineering program is accredited by the Engineering Accreditation Commission of ABET.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.30).

Degree Requirements

To complete the degree, students must complete at least 128 credits, including 40 credits in the major. The first two years of the curriculum are almost identical with the first years of the civil engineering program and are similar to those in other IT engineering programs.

Students may transfer to geological engineering from another IT engineering program, another University college or campus, or another academic institution.

By choosing one of the two curricular paths within geological engineering, and by selecting appropriate technical electives (in consultation with their academic adviser), students can emphasize various special interest areas in their upper division curriculum.

With few exceptions, all upper division courses in geological engineering, civil engineering, and geology may be used to fulfill the technical elective requirements. Many courses from other IT departments may be used as technical electives in the geological engineering program. However, each student’s final program must satisfy the detailed curricular requirements specified by ABET for a geological engineering degree.

Required Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEM 2011</td>
<td>Statics</td>
</tr>
<tr>
<td>AEM 2012</td>
<td>Dynamics (geomechanics option only)</td>
</tr>
<tr>
<td>AEM 3031</td>
<td>Deformable Body Mechanics</td>
</tr>
<tr>
<td>Chem 1001</td>
<td>Chemical Principles I</td>
</tr>
<tr>
<td>Chem 1022</td>
<td>Chemical Principles II</td>
</tr>
<tr>
<td>Geo 1001</td>
<td>The Dynamic Earth</td>
</tr>
<tr>
<td>Geo 2301</td>
<td>Mineralogy</td>
</tr>
<tr>
<td>Geo 2302</td>
<td>Petrology</td>
</tr>
<tr>
<td>Geo 4201</td>
<td>Principles of Geophysical Exploration</td>
</tr>
<tr>
<td>or</td>
<td>Solid Earth Geophysics I</td>
</tr>
<tr>
<td>Geo 3911</td>
<td>Introduction to Field Geology</td>
</tr>
<tr>
<td>Geo 4501</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>Geo 4602</td>
<td>or 4701 or 4703</td>
</tr>
<tr>
<td>Math 1271</td>
<td>Calculus I</td>
</tr>
<tr>
<td>Math 1272</td>
<td>Calculus II</td>
</tr>
<tr>
<td>Math 2243</td>
<td>Linear Algebra and Differential Equations</td>
</tr>
<tr>
<td>Math 2263</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>Phys 1301</td>
<td>Introductory Physics I</td>
</tr>
<tr>
<td>Phys 1302</td>
<td>Introductory Physics II</td>
</tr>
<tr>
<td>Stat 3021</td>
<td>Probability and Statistics</td>
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</table>

Geoenvironmental Option

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CE 3101</td>
<td>Computer Applications</td>
</tr>
<tr>
<td>GeoE 3301</td>
<td>Soil Mechanics I</td>
</tr>
<tr>
<td>CE 3501</td>
<td>Environmental Engineering</td>
</tr>
<tr>
<td>CE 3502</td>
<td>Fluid Mechanics</td>
</tr>
<tr>
<td>GeoE 4101</td>
<td>Capstone Design</td>
</tr>
<tr>
<td>GeoE 4341</td>
<td>Engineering Geostatistics</td>
</tr>
<tr>
<td>GeoE 4351</td>
<td>Groundwater Mechanics</td>
</tr>
<tr>
<td>GeoE 4352</td>
<td>Groundwater Modeling</td>
</tr>
<tr>
<td>CE 4501</td>
<td>Hydrologic Design</td>
</tr>
<tr>
<td>CE 4531</td>
<td>Environmental Process Engineering</td>
</tr>
<tr>
<td>CE 4561</td>
<td>Solid and Hazardous Waste</td>
</tr>
<tr>
<td>GeoE technical electives (6 cr)</td>
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</table>

Geomechanics Option

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CE 3101</td>
<td>Computer Applications</td>
</tr>
<tr>
<td>GeoE 3301</td>
<td>Soil Mechanics I</td>
</tr>
<tr>
<td>GeoE 3311</td>
<td>Rock Mechanics I</td>
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<tr>
<td>CE 3502</td>
<td>Fluid Mechanics</td>
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<td>GeoE 4101</td>
<td>Capstone Design</td>
</tr>
<tr>
<td>CE 4121</td>
<td>Computer Applications II</td>
</tr>
<tr>
<td>GeoE 4301</td>
<td>Soil Mechanics II</td>
</tr>
<tr>
<td>GeoE 4311</td>
<td>Rock Mechanics II</td>
</tr>
<tr>
<td>GeoE 4341</td>
<td>Engineering Geostatistics</td>
</tr>
<tr>
<td>CE 4355</td>
<td>Groundwater Mechanics</td>
</tr>
<tr>
<td>GeoE technical electives (7 cr)</td>
<td></td>
</tr>
</tbody>
</table>

Final Project

All students must take GeoE 4102—Capstone Design. This course is an extensive capstone design project and requires written and oral presentations of project results.

Geoenvironmental Option

Sample Program

Freshman Year

Full Semester (16 cr)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>Math 1271</td>
<td>Calculus I</td>
<td>4 cr</td>
</tr>
<tr>
<td>Phys 1301</td>
<td>Introductory Physics I</td>
<td>4 cr</td>
</tr>
<tr>
<td>Biol 1009</td>
<td>General Biology</td>
<td>4 cr</td>
</tr>
<tr>
<td>EngC 1011</td>
<td>University Writing and Critical Reading</td>
<td>4 cr</td>
</tr>
</tbody>
</table>

Spring Semester (15 cr)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 1272</td>
<td>Calculus II</td>
<td>4 cr</td>
</tr>
<tr>
<td>Phys 1302</td>
<td>Introductory Physics II</td>
<td>4 cr</td>
</tr>
<tr>
<td>Geo 1001</td>
<td>Introduction to Geology</td>
<td>4 cr</td>
</tr>
</tbody>
</table>

Liberal education elective (3 cr)
Sophomore Year

Fall Semester (17 cr)
- Math 2263—Multivariable Calculus (4 cr)
- Chem 1021—Chemical Principles I (4 cr)
- AEM 2011—Statics (3 cr)
- Stat 3021—Probability and Statistics (3 cr)
- Liberal education elective (3 cr)

Spring Semester (17 cr)
- Math 2243—Linear Algebra and Differential Equations (4 cr)
- Chem 1022—Chemical Principles II (4 cr)
- AEM 3031—Deformable Body Mechanics (3 cr)
- Liberal education elective (3 cr)
- Liberal education elective (3 cr)

Junior Year

Fall Semester (16 cr)
- CE 3101—Computer Applications I (3 cr)
- CE 3501—Environmental Engineering (3 cr)
- CE 3502—Fluid Mechanics (4 cr)
- Geo 2301—Mineralogy (3 cr)
- Liberal education elective (3 cr)

Spring Semester (13 cr)
- GeoE 3301—Soil Mechanics I (3 cr)
- CE 4501—Hydrologic Design (4 cr)
- GeoE 4341—Engineering Geostatistics (3 cr)
- Geo 2302—Petroleum (3 cr)

Summer Session (3 cr)
- Geo 3911—Field Geology (3 cr)

Senior Year

Fall Semester (16 cr)
- GeoE 4301—Soil Mechanics II (3 cr)
- GeoE 4351—Groundwater Mechanics (3 cr)
- Geo 4203—Principles of Geophysical Exploration (3 cr)
- Geo 4703—Glacial Geology (3 cr)
- Technical elective (GeoE) (4 cr)

Spring Semester (13 cr)
- GeoE 4311—Rock Mechanics II (3 cr)
- GeoE 4102—Senior Design (3 cr)
- Geo 4501—Structural Geology (3 cr)
- GeoE technical elective (4 cr)

Geology

Department of Geology and Geophysics

B.S. Geol.
Geology is the study of the composition, structure, and history of the Earth and of the processes that operate on and within it, with emphasis on the crust, oceans, and atmosphere. The department’s programs emphasize applications of physics, chemistry, and biology to understanding the Earth.

Geologists and geophysicists are employed in a wide range of fields, including exploration for and development of natural resources (hydrocarbons, minerals, groundwater); environmental science; urban planning; education; and oceanography. Potential employers include the oil, gas, and minerals industries; environmental consultants; federal and private research institutions; universities; schools; and government agencies. An advanced degree is usually required for a career in research or teaching.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

Degree Requirements
To complete the degree, students must complete at least 120 credits, including 52 credits in the major. Geology and geophysics are closely related fields, and this is reflected in the similarities between the two degree programs. Both are built around a core of basic Earth-science courses taken mainly in the sophomore and junior years. Both programs provide a strong foundation in mathematics, physics, and chemistry.

Selection of a degree program should be made during the second year, though a later decision is possible. Both degree programs offer a good foundation for students preparing either for graduate work or for professional work with the baccalaureate degree.
The department offers two tracks within the B.S. Geology degree program: (1) environmental geology and (2) geochemistry. These tracks are completed by selecting appropriate geology and related science courses in consultation with a faculty adviser. Students must pass all core courses with a grade of C- or better.

**Required Courses**
Geo 2201—Geodynamics I: The Solid Earth
Geo 2301—Mineralogy
Geo 2302—Petrology
Geo 2303—Geochemical Principles
Geo 3202—Geodynamics II: The Fluid Earth
Geo 3401—Geochronology and Earth History
Geo 3911—Introduction to Field Geology
Geo 4501—Structural Geology
Geo 4602—Sedimentology and Stratigraphy
Geo 4631—Earth Systems: Geosphere/Biosphere Interactions

**Any two of:**
Geo 3870—Modeling Workshop
Geo 3880—Laboratory Workshop
Geo 3890—Field Workshop

**Any one of:**
Geo 4911—Advanced Field Geology
Geo 4921—Field Geophysics
Geo 4971—Field Hydrogeology

15 credits of elective geology, with no more than 4 credits of 1xxx courses and 3 credits of 2xxx courses

**Required Courses From Other Programs**
Math 1271, 1272—Calculus I and II (or 1371, 1372 or 1571, 1572)
Math 2243—Linear Algebra and Differential Equations
Phys 1301, 1302—Introductory Physics I and II
Chem 1021, 1022—Chemical Principles I and II

**Electives—** 12 credits total of appropriate elective courses in physical and natural sciences, engineering, and mathematics, chosen in consultation with a faculty adviser

**Minor Requirements**
Geo 1001 or equivalent and 14 credits of 2xxx (or higher) geology or geophysics courses. Available through the College of Liberal Arts.

**Sample Program**

### Freshman Year

**Fall Semester (15 cr)**
- Math 1271—Calculus I (4 cr)
- Phys 1301—Introductory Physics I (4 cr)
- Chem 1021—Principles of Chemistry I (4 cr)
- Liberal education elective (3 cr)

**Spring Semester (16 cr)**
- Math 1272—Calculus II (4 cr)
- Phys 1302—Introductory Physics II (4 cr)
- Chem 1022—Principles of Chemistry II (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)

### Sophomore Year

**Fall Semester (14 cr)**
- Math 2243—Linear Algebra and Differential Equations (4 cr)
- Geo 2201—Geodynamics I: The Solid Earth (3 cr)
- Geo 2301—Mineralogy (3 cr)
- Biology with lab (4 cr)

**Spring Semester (12 cr)**
- Geo 2303—Geochemical Principles (3 cr)
- Geo 2302—Petrology (3 cr)
- Liberal education elective (3 cr)
- Technical elective (3 cr)

### Junior Year

**Fall Semester (15 cr)**
- Geo 3202—Geodynamics II: The Fluid Earth (3 cr)
- Geo 3401—Geochronology and Earth History (3 cr)
- Liberal education elective (3 cr)
- Liberal education elective (3 cr)
- Technical elective (3 cr)

**Spring Semester (13 cr)**
- Geo 4501—Structural Geology (3 cr)
- Geo 4602—Sedimentology and Stratigraphy (3 cr)
- Geo 3890—Field Workshop (1 cr)
- Liberal education elective (3 cr)
- Geology elective (3 cr)

### Senior Year

**Fall Semester (15 cr)**
- Geo 4631—Earth Systems: Geosphere/Biosphere Interactions (3 cr)
- Geo elective (3 cr)
- Geo elective (3 cr)
- Technical elective (3 cr)
- Free elective (3 cr)

**Spring Semester (14 cr)**
- Geo 3890—Field Workshop (1 cr)
- Geo elective (3 cr)
- Geo elective (3 cr)
- Technical elective (3 cr)
- Free elective (4 cr)

**Geophysics**

**Department of Geology and Geophysics**

**B.S.Geophys.**

Geophysics is the study of the physical structure and properties of the Earth through application of the principles and techniques of classical physics. Major topics include the physical properties of rocks and minerals, the origin and dynamics of the Earth’s gravity and magnetic fields, earthquakes and the propagation of waves in the Earth (seismology), and the dynamics of the Earth’s crust, mantle, and deep interior.

Geologists and geophysicists are employed in a wide range of fields, including exploration for and development of natural resources (hydrocarbons, minerals, groundwater); environmental science; urban planning; education; and oceanography. Potential employers include the oil, gas, and minerals industries; environmental consultants; federal and private research institutions; universities; schools; and government agencies. An advanced degree is usually required for a career in research or teaching.

**Admission Requirements**—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

**Degree Requirements**

To complete the degree, students must complete at least 120 credits, including 52 credits in the major. Geology and geophysics are closely related fields, and this is reflected in the similarities between the two degree programs. Both programs are built around a core of basic Earth-science courses taken mainly in the sophomore and junior years. Both programs provide a strong foundation in mathematics, physics, and chemistry.
Selection of a degree program should be made during the second year, though a later decision is possible. Both degree programs offer a good foundation for students preparing either for graduate work or for professional work with the baccalaureate degree.

Students must pass all core courses with a grade of C- or better.

**Required Courses**
Geo 2201—Geodynamics I: The Solid Earth
Geo 2301—Mineralogy
Geo 2302—Petrology
Geo 2303—Chemical Principles
Geo 2302—Geodynamics II: The Fluid Earth
Geo 3401—Geochronology and Earth History
Geo 4501—Structural Geology
Geo 3911—Introduction to Field Geology

*Any two of:*
Geo 3870—Modeling Workshop
Geo 3880—Laboratory Workshop
Geo 3890—Field Workshop

*Any one of:*
Geo 4911—Advanced Field Geology
Geo 4921—Field Geophysics
Geo 4971—Field Hydrogeology
9 cr of 4xxx elective geophysics courses
9 cr of elective geology courses (no more than 4 cr being 1xxx courses and no more than 3 cr being 2xxx courses)

**Required Courses From Other Programs**
Chem 1021, 1022—Chemical Principles I and II
Math 1271, 1272—Calculus I and II (or 1371, 1372 or 1571, 1572)
Math 2243—Linear Algebra and Differential Equations
Math 2263—Multivariable Calculus
Phys 1301, 1302, 2303—Introductory Physics I, II, and III

Electives—9 credits total of appropriate elective courses in physical and natural sciences, engineering, and mathematics, chosen in consultation with a faculty adviser

**Minor Requirements**
Geo 1001 or equivalent and 14 credits of 2xxx (or higher) geology or geophysics courses

**Sample Program**

**Freshman Year**

**Fall Semester (15 cr)**
Math 1271—Calculus I (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Liberal education elective (3 cr)

**Spring Semester (16 cr)**
Math 1272—Calculus II (4 cr)
Phys 1302—Introductory Physics II (4 cr)
Chem 1021—Principles of Chemistry I (4 cr)
EngC 1011—University Writing and Critical Reading (4 cr)

**Sophomore Year**

**Fall Semester (14 cr)**
Math 2243—Linear Algebra and Differential Equations (4 cr)
Geo 2201—Geodynamics I: The Solid Earth (3 cr)

**Spring Semester (13 cr)**
Math 2263—Multivariable Calculus (4 cr)
Geo 2303—Geological Principles (3 cr)
Liberal education elective (3 cr)

**Summer Session (4 cr)**
Geo 3911—Introduction to Field Geology (4 cr)

**Junior Year**

**Fall Semester (15 cr)**
Geo 3202—Geodynamics II: The Fluid Earth (3 cr)
Geo 3401—Geochronology and Earth History (3 cr)
Geophysics elective (3 cr)
Liberal education elective (3 cr)
Technical elective (3 cr)

**Spring Semester (14 cr)**
Geo 4501—Structural Geology (3 cr)
Geo 3890—Field Workshop (1 cr)
Geophysics elective (3 cr)
Biology with lab (4 cr)
Liberal education elective (3 cr)

**Summer Session (4 cr)**
Geo 4921—Field Geophysics (4 cr)

**Senior Year**

**Fall Semester (14 cr)**
Geo elective (3 cr)
Technical elective (3 cr)
Technical elective (3 cr)
Free elective (2 cr)

**Spring Semester (13 cr)**
Geo 3890—Field Workshop (1 cr)
Geo elective (3 cr)
Geo elective (3 cr)
Free elective (3 cr)
Liberal education elective (3 cr)

**Materials Science and Engineering**

**Department of Chemical Engineering and Materials Science**

**B.Mat.S.E.**

The four-year program in materials science and engineering leads to a bachelor’s degree that enables students to immediately enter the profession. The program develops an understanding of the properties and the origin of these properties in a broad range of materials, including metals, ceramics, semiconductors, polymers, and composites. Because the program is broadly based, graduates find employment across a broad range of industries, including the automotive, chemical, electronics, energy, and medical technology industries. Graduates also find positions in consulting, research, technical management, and teaching.

**Admission Requirements**—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.30).

**Degree Requirements**
To complete the degree, students must complete at least 128 credits, including 33 credits in the major. Credits include the specific required courses listed below and at least 60 credits of upper division courses. In addition, the University’s liberal education requirements must be met.

**Required Courses**
MatS 3011—Introduction to the Science of Materials (3 cr)
MatS 3012—Introduction to Mechanical Behavior of Materials (4 cr) (includes lab)
MatS 4001—Introduction to the Thermodynamics of Materials (3 cr)
MatS 4002—Mass Transport and Kinetics (3 cr)
MatS 4013—Introduction to Electric and Magnetics Properties of Materials (3 cr)
MatS 4212—Introduction to Ceramic Materials (3 cr)
MatS 4214—Polymer Physical Properties (3 cr)
MatS 4221—Materials Design and Performance (4 cr) (includes lab)
MatS 4301—Materials Processing (4 cr) (includes lab)
Materials Science and Engineering
Mathematics
Mechanical Engineering

MatS 4400—Senior Design Project (3 cr)
AEM 2011—Statics (4 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
AEM 4511—Mechanics of Composite Materials (3 cr)
CE 3101—Computer Applications I (3 cr)
Chem 1021—Chemical Principles I (4 cr)
Chem 1022—Chemical Principles II (4 cr)
Chem 2301—Organic Chemistry I (3 cr)
Math 1271—Calculus I (4 cr)
Math 1272—Calculus II (4 cr)
Math 2243—Linear Algebra and Differential Equations (4 cr)
Math 2263—Multivariable Calculus (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Phys 1302—Introductory Physics II (4 cr)
Phys 2303—Introductory Physics III (4 cr)

Electives—Most 2xxx, 3xxx, 4xxx, or 5xxx courses in mathematics, chemistry, or engineering programs in IT. Other courses may qualify; see the director of undergraduate studies.

Final Project
The senior design project, MatS 4400, requires a written final report and an oral presentation.

Sample Program

Freshman Year
Fall Semester (16 cr)
Chem 1021—General Principles I with Lab (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Math 1271—Calculus I (4 cr)
EngC 1011—University Writing and Critical Reading (4 cr)

Spring Semester (16 cr)
Chem 1022—General Principles II with Lab (4 cr)
Phys 1302—Introductory Physics II (4 cr)
Math 1272—Calculus II (4 cr)
Liberal education elective #1 (Biol and lab) (4 cr)

Sophomore Year
Fall Semester (17 cr)
Chem 2301—Organic Chemistry I (3 cr)
Math 2263—Multivariable Calculus (4 cr)
AEM 2011—Statics (4 cr)
Liberal education elective #2 (social sciences I) (3 cr)
Liberal education elective #3 (social sciences II) (3 cr)

Spring Semester (17 cr)
Math 2243—Linear Algebra and Differential Equations (4 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
CE 3101—Computer Applications I (3 cr)
Phys 2303—Introductory Physics III (4 cr)
Liberal education elective #4 (humanities I) (3 cr)

Junior Year
Fall Semester (15 cr)
MatS 3011—Introduction to Materials Science (no lab) (3 cr)
MatS 4001—Thermodynamics (3 cr)
Technical elective I (3 cr)
Technical elective II (3 cr)
Liberal education elective #5 (literature I) (3 cr)

Spring Semester (17 cr)
MatS 3012—Physical Materials and Mechanical Behavior of Materials (4 cr)
MatS 4013—Electronic Materials (3 cr)
Mat 4002—Kinetics and Mass Transport (3 cr)
Elective (4 cr)
Technical elective III (3 cr)

Senior Year
Fall Semester (17 cr)
MatS 4212—Ceramics (3 cr)
MatS 4214—Polymers (3 cr)
MatS 4221—Materials Design and Performance and Lab (4 cr)
Technical elective IV (4 cr)
Liberal education elective #6 (history I) (3 cr)

Spring Semester (13 cr)
MatS 4400—Senior Design (3 cr)
MatS 4301—Senior Design #2 (3 cr)
AEM 4511—Composite Materials (3 cr)
Technical elective V (3 cr)

Mathematics

School of Mathematics
B.S.Math.
The School of Mathematics offers a program leading to the bachelor of science degree. The course of study is flexible and can be adapted to satisfy a wide variety of interests and needs. Students can prepare for graduate study in mathematics or for secondary school teaching, or can emphasize various fields of interest, such as applied mathematics, computer science, or actuarial science.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

Degree Requirements
To complete the degree, students must complete at least 120 credits, including 48 credits in the major, not counting the elective. Students take a lower division mathematics sequence of five semesters (four semesters if honors sequence is chosen) and then take eight approved upper division mathematics courses, including two courses in algebra and two in analysis. Also required are three semesters of physics, one semester of computer science, and two semesters of technical electives (which can be more mathematics). Students must take all required mathematics, physics, computer science, and composition courses A-F and must earn a grade of C- or better in all of those courses.

Required Courses

Lower Division Requirement
One of the following sequences:
Math 1271-1272-2243-2263-2283
Math 1371-1372-2373-2374-2283
Math 1571-1572-2573-3574

Upper Division Requirements
Eight upper division math courses and two technical elective courses (which can be mathematics courses)

To satisfy the algebra requirement, students must take two courses from the following:
Math 5285—Honors: Fundamental Structures of Algebra I
Math 5286—Honors: Fundamental Structures of Algebra II
Math 4242—Applied Linear Algebra
Math 5248—Cryptography and Number Theory
Math 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves
Math 5711—Linear Programming and Combinatorial Optimization
Math 5385—Introduction to Computational Algebraic Geometry
Math 5705—Combinatorics A
or
Math 5707 Combinatorics B (but not both)

To satisfy the analysis requirement, students must take two courses from the following:
Math 5615—Honors: Introduction to Analysis I
Math 5616—Honors: Introduction to Analysis II
Math 4606—Advanced Calculus
Math 5525—Introduction to Ordinary Differential Equations
Math 5535—Dynamical Systems and Chaos
Math 5587—Elementary Partial Differential Equations
Math 5583—Complex Variables
Math 5651—Basic Theory of Probability and Statistics
Math 5652—Introduction to Stochastic Processes
Math 5654—Prediction and Filtering
Math 5486—Introduction to Numerical Methods II

The School of Mathematics will accept the following courses from other departments as part of the eight-course upper division mathematics requirement:

- CSci 5301—Numerical Analysis
- CSci 5302—Analysis of Numerical Algorithms
- Stat 5101—Theory of Statistics I
- Stat 5102—Theory of Statistics II

Note that the content of Stat 5101 is the same as Math 5651—Basic Theory of Probability and Statistics.

No other courses from other departments may be used as part of the eight-course math requirement, though other courses may be used as technical electives.

Note: The following three upper division mathematics courses cannot be used to satisfy part of the eight course upper division math requirement, though they may be used as technical elective:
- Math 4457—Methods of Applied Mathematics I
- Math 4458—Methods of Applied Mathematics II
- Math 4512—Differential Equations With Applications

Math 3113 and Math 3118, Topics in Elementary Mathematics I and II, may not be used as upper division math courses or as technical electives.

Required Courses From Other Programs

Phys 1301—Introductory Physics I
and Phys 1302—Introductory Physics II
and Phys 2303—Introductory Physics III
or Phys 1401—Honors Physics I
and Phys 1402—Honors Physics II
and Phys 2403—Honors Physics III

One course in computer programming, usually one of the following:
- CSci 1107—Introduction to FORTRAN Programming for Scientists and Engineers
- CSci 1113—Introduction to C/C++ Programming for Scientists and Engineers

Liberal education electives (15 cr)

Electives—Technical elective (two courses, not necessarily in mathematics, of at least 3 credits each that satisfy three requirements):
1. Calculus (1271 or equivalent) is a prerequisite (or a prerequisite for a prerequisite);
2. The courses are 3xxx or higher;
3. The courses form a coherent part of the student’s program, as determined in consultation with the student’s advisor.

Minor Requirements

A minor is available through the College of Liberal Arts. Complete all lower division requirements for the major plus two approved upper division math courses.

Sample Program

Freshman Year

Fall Semester (15 cr)
- Math 1271—Calculus I (4 cr)
- Phys 1301—Introductory Physics I (4 cr)
- EngC 1011—University Writing and Critical Reading (4 cr)
- Liberal education elective (3 cr)

Spring Semester (15 cr)
- Math 1272—Calculus II (4 cr)
- Phys 1302—Introductory Physics II (4 cr)
- CSci 1107—Introduction to FORTRAN
- CSci 1113—Introduction to C/C++ (4 cr)
- Liberal education elective (3 cr)

Sophomore Year

Fall Semester (15 cr)
- Math 2243—Linear Algebra and Differential Equations (4 cr)
- Phys 2303—Introduction to Physics III (4 cr)
- Liberal education elective (3 cr)
- Biology with lab (4 cr)

Spring Semester (15 cr)
- Math 2263—Multivariable Calculus (4 cr)
- Math 2283—Sequences, Series and Foundations (3 cr)
- Liberal education elective (4 cr)
- Free elective (4 cr)

Junior Year

Fall Semester (15-16 cr)
- Upper division math 1 (3-4 cr)
- Upper division math 2 (4 cr)
- Technical elective 1 (4 cr)
- Upper division composition (4 cr)

Spring Semester (16 cr)
- Upper division math 3 (4 cr)
- Upper division math 4 (4 cr)
- Technical elective 2 (4 cr)
- Liberal education elective (4 cr)

Senior Year

Fall Semester (15 cr)
- Upper division math 5 (4 cr)
- Upper division math 6 (4 cr)
- Free elective (7 cr)

Spring Semester (15 cr)
- Upper division math 7 (4 cr)
- Upper division math 8 (4 cr)
- Free elective (7 cr)

Mechanical Engineering

Department of Mechanical Engineering

B.M.E.

Mechanical engineering is involved in most technological activities of society and dominates many, including automotive, transportation and materials handling, environmental and pollution control systems, refrigeration and cryogenics, power systems design, automation, system dynamics and control, computer-aided design and manufacturing, and machinery/consumer products production. The mechanical engineer may be engaged in design, development, research, testing, manufacturing, administration, marketing, consulting, or education.

The program prepares students for an industrial career in mechanical engineering or for graduate work. A strong background in the basic sciences of mathematics, physics, and chemistry is balanced with courses in engineering science and engineering design. Through electives, each student has an opportunity to develop a program of study that reflects his or her particular area of interest.

A co-op program is available during the last two years of study. Upper division status and a satisfactory GPA are required for admission. The co-op program provides applied engineering training in selected established industries during semesters of supervised assignments that alternate with semesters of University studies.

Professional training in industrial engineering is offered through an industrial engineering option. Students selecting this option complete the same set of required courses as other mechanical engineering students, but their technical electives must be selected from an approved list and in consultation with a faculty advisor. Students selecting the option may also apply to the co-op program.
The program is accredited by the Engineering Accreditation Commission of ABET.

Further details and information about alternative course selections, elective programs, area of specialization, and changes in course or credit requirements are available in 125 Mechanical Engineering, (612/625-5842, e-mail u-gradinfo@me.umn.edu).

**Admission Requirements**—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.50).

**Degree Requirements**
To complete the degree, students must complete at least 127 credits, including 48 credits in the major. The courses required for the degree are listed below. These include four technical electives totaling 16 credits.

**Required Courses**

**Lower Division**
ME 2011—Introduction to Mechanical Engineering (4 cr)

**Upper Division**
ME 3031—Basic Mechanical Measurements Laboratory (4 cr)
ME 3221—Design and Manufacturing I: Engineering Materials and Manufacturing Processes (4 cr)
ME 3222—Design and Manufacturing II (4 cr)
ME 3281—Systems, Dynamics, and Controls (4 cr)
ME 3321—Thermodynamics (4 cr)
ME 3322—Heat Transfer and Fluid Flow (4 cr)
ME 4054—Senior Design (4 cr)
ME 4x3x—Senior Laboratory (4 credits to be selected from those offered; senior lab courses are numbered ME 4x3x) (4 cr)
IE 4521—Statistics, Quality, and Reliability (4 cr)

Technical electives: four 4-credit, upper division IT courses, a minimum two of which must be ME or IE courses. The other two should be upper division IT courses, though one course may be selected from Phys 2303, Chem 1022, or Math 2283. (Note: the credits required for electives will be 15 if Math 2283 is one of the electives selected.)

**Required Courses From Other Programs**
Math 1271-1272—Calculus I, II (4 cr each)
Math 2243—Linear Algebra and Differential Equations (4 cr)
Math 2263—Multivariable Calculus (4 cr)
Phys 1301, 1302—Introductory Physics I, II (4 cr each)
Chem 1021—Chemical Principles I (4 cr)
AEM 2021—Statics and Dynamics (4 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
and 3006—Lab (1 cr)
CSci 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
MatS 2001 (4 cr)—Introduction to the Science of Engineering Materials (The lab associated with this class is required.)
Liberal education electives (15 cr)

**Electives**—One of the following may be used as a technical elective: Phys 2303, Chem 1022, or Math 2283.

**Sample Program**

**Freshman Year**
Fall Semester (16 cr)
Math 1271—Calculus I (4 cr)
Phys 1301—Introductory Physics I (4 cr)
Chem 1021—General Principles of Chemistry I (4 cr)
EngC 1011—University Writing and Critical Reading (4 cr)

Spring Semester (15 cr)
Math 1272—Calculus II (4 cr)
Phys 1302—Introductory Physics II (4 cr)
Liberal education elective** (3 cr)
Biology with lab (4 cr)

**Sophomore Year**
Fall Semester (16 cr)
Math 2263—Multivariable Calculus (4 cr)
AEM 2021—Statics and Dynamics (4 cr)
CSci 1113—Introduction to C/C++ Programming (4 cr)
MatS 2001—Introduction to Mechanical Properties* (4 cr)

Spring Semester (17 cr)
Math 2243—Linear Algebra and Differential Equations (4 cr)
ME 2011—Introduction to Mechanical Engineering (4 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
Liberal education elective** (3 cr)
Liberal education elective** (3 cr)

**Junior Year**
Fall Semester (16 cr)
ME 3221—Design and Manufacturing I (4 cr)
ME 3321—Thermodynamics (4 cr)
EE 3005—Fundamentals of Electrical Engineering Lecture (4 cr)
EE 3006—Fundamentals of Electrical Engineering Lab (1 cr)
Liberal education elective** (3 cr)

Spring Semester (16 cr)
ME 3222—Design and Manufacturing II (4 cr)
ME 3322—Heat Transfer and Fluid Flow (4 cr)
Technical elective #1 (4 cr)

**Senior Year**
Fall Semester (16 cr)
ME 3281—System Dynamics and Controls (4 cr)
ME 4054—Senior Design (4 cr)
IE 4521—Statistics, Quality, and Reliability (4 cr)
Technical elective #2 (4 cr)

Spring Semester (15 cr)
ME 4x3x—Senior Lab (4 cr)
Technical elective #3 (4 cr)
Technical elective #4 (4 cr)
Liberal education elective** (3 cr)

* The 4-credit course has a 3-credit lecture and 1-credit lab.
** The assumption is that liberal education courses will each be 3 credits.
Physics

School of Physics and Astronomy

B.S.Phys.

Physics is concerned with the fundamental properties and interactions of all forms of matter. Experimental and theoretical investigations are combined to formulate mathematical relationships that describe and predict the behavior of nature.

The undergraduate physics program prepares students for employment, often in industrial or governmental laboratories, or for further study at graduate or professional schools in physics, engineering, biophysics, medicine, education, law, or business.

The program integrates a broad foundation in physics that can be flexibly combined with coursework in other technical disciplines or used to specialize in physics. By choosing appropriate technical electives, a student can prepare for graduate or professional school in physics, medicine, biophysics, engineering, chemistry, environmental physics, geophysics, or atmospheric physics. Students should consult a physics adviser to help formulate objectives for undergraduate study.

Admission Requirements—Complete specific lower division courses and meet GPA requirement set by IT (currently 2.00).

Degree Requirements

To complete the degree, students must complete at least 120-128 credits, including 30-38 credits in the major.

Physics majors must take all required physics and mathematics courses A-F and must earn a grade of C- or better in all physics, mathematics, and technical elective courses (except those offered S-N only). Only students with grades of B or better in the introductory physics courses can generally expect to succeed in the major.

Students must also complete the University’s liberal education requirements.

Required Courses

Core Program for all Physics Majors

Phys 1301, 1302, 2303 or Phys 1401, 1402, 2403 (12 cr)

Phys 2021—Introduction to Thermal and Statistical Physics (2 cr)

Phys 2601—Quantum Physics (4 cr)

Phys 2605—Quantum Physics Laboratory (3 cr)

Phys 4051—Methods of Experimental Physics I (5 cr)

Phys 4052—Methods of Experimental Physics II (5 cr)

At least two of the following four courses:

- Phys 4001—Analytical Mechanics (4 cr)
- Phys 4002—Electricity and Magnetism (4 cr)
- Phys 4101—Quantum Mechanics (4 cr)
- Phys 4201—Statistical and Thermal Physics (3 cr)

One of the following four sequences:

- Math 1271, 1272, 2243, 2263 or Math 1371, 1372, 2373, 2374 or Math 1571, 1572, 2573 (15-16 cr)

Liberal education requirements

Additional Requirements (depending on emphasis)

Physics Emphasis (30-33 cr)

The remaining two courses not already chosen from the list of Phys 4001, 4002, 4101, 4201 (7-8 cr)

Upper division or graduate physics elective (3-4 cr)

Technical electives (17 cr; adviser approval required)

Engineering Emphasis (35-38 cr)

Chem 1021—Chemical Principles I (4 cr)

Two courses (or indicated substitutes) not already chosen from the list (7 cr):

- Phys 4001 or AEM 2021 or AEM 2011-2012
- Phys 4002 or EE 3601

Technical electives in biology or related areas (14 cr; 3xxx or higher; adviser approval required)

Teaching Emphasis (30-34 cr)

Chem 1021—Chemical Principles I (4 cr)

Chem 1022—Chemical Principles II (4 cr)

One course from each of the following four groups (adviser approval required; the following are suggested courses):

- History and Philosophy of Science

Geo 2201—Geodynamics I: The Solid Earth (4 cr)

Geo 3201—Geodynamics II: The Fluid Earth (4 cr)

Geo 2303—Geochemical Principles (3 cr)

Geo 3401—Geochronology and Earth History (3 cr)

Technology

Phys 4711—Introduction to Optics (3 cr)

EE 5621—Physical Optics (4 cr, together with EE 5622—Physical Optics Lab)

Phys 5701—Solid State Physics (4 cr)

AEM 4201—Fluid Mechanics

Technical electives in physics and related areas (10 cr; 3xxx or higher; adviser approval required)

Technical electives in biology or related areas (14 cr; 3xxx or higher; adviser approval required)

Two courses in engineering, one of which has a substantial design component

Students must demonstrate knowledge of computer programming in at least one language through coursework or completion of project.

Students are strongly advised to participate in a program of voluntary secondary school teaching. Such experience is required for students wishing to enter the University’s College of Education and Human Development Secondary School Graduate Program leading to certification to teach. (For information, contact Student and Professional Services, 110 Wulling Hall.) Early admission into the program is possible in the junior year.

Electives—19 credits of technical courses from any appropriate department.

Technical electives must be approved by a physics adviser.

Minor Requirements

A physics minor is available through the College of Liberal Arts.

Sample Program

Freshman Year

Fall Semester (15 cr)

Math 1271 or 1371 or 1571—Calculus I (4 cr)

Phys 1301 or 1401—Introductory Physics I (4 cr)

EngC 1011—University Writing and Critical Reading (4 cr)

Liberal education elective (3 cr)

259
Spring Semester (15 cr)
Math 1272 or 1372 or 1572—Calculus II (4 cr)
Phys 1302 or 1402—Introductory Physics II (4 cr)
Technical elective (chemistry)* (4 cr)
Liberal education elective (3 cr)

Sophomore Year
Fall Semester (14 cr)
Math 2243 or 2373 or 2573—Linear Algebra/Differential Equations (4 cr)
Phys 2303 or 2403—Introductory Physics III (4 cr)
Phys 2201—Thermal and Statistical Physics (2 cr)
Liberal education elective (biology) (4 cr)

Spring Semester (15 cr)
Math 2263 or 2374 or 3574 (4 cr)
Phys 2601—Quantum Physics (4 cr)
Phys 2605—Quantum Physics Lab (3 cr)
Technical elective (CSci C/C++ programming)* (4 cr)

Junior Year
Fall Semester (16 cr)
Phys 4001—Analytical Mechanics (4 cr)
Phys 4051—Methods of Experimental Physics I (5 cr)
Math elective (4 cr)
Open elective (3 cr)

Spring Semester (16 cr)
Phys 4002—Electricity and Magnetism (4 cr)
Phys 4052—Methods of Experimental Physics II (5 cr)
Technical elective (math)* (4 cr)
Liberal education elective (3 cr)

Senior Year
Fall Semester (14 cr)
Phys 4101—Quantum Physics (4 cr)
Phys 4201—Statistical and Thermal Physics (3 cr)
Technical elective (waves, optics)* (3 cr)
Liberal education elective (4 cr)

Spring Semester (15 cr)
Physics or astrophysics elective (4 cr)
Technical elective (lab project)* (4 cr)
Liberal education elective (4 cr)
Open elective (3 cr)

* Recommended for physics students going on to graduate school

Required Courses
Stat 3011—Introduction to Statistical Analysis
or Stat 3021—Introduction to Probability and Statistics
Stat 3022—Data Analysis
Stat 4101-4102—Theory of Statistics I-II
or Stat 5101-2—Mathematical Statistics I-II
At least 10 credits of adviser-approved statistics electives chosen from
Math 1271-1272—Calculus I-II
Math 2263—Multivariable Calculus
Math 4242—Applied Linear Algebra
One course among the following three:
CSci 1103—Introduction to Computer Programming in Java
CSci 1107—Introduction to FORTRAN Programming for Scientists and Engineers
CSci 1113—Introduction to C/C++ Programming for Scientists and Engineers
Three courses with lab, chosen from at least two of the fields of physics, chemistry, biology
Three adviser-approved courses in statistics or related fields such as
computer science, biostatistics, industrial engineering/operations research, mathematics

Minor Requirements
At least 14 credits from 3xxx-5xxx School of Statistics courses, including at least two 5xxx courses.

Statistics

School of Statistics
B.S.Stat.
The School of Statistics offers a four-year curriculum leading to a bachelor of science degree. Statistics deals with methods and theories of data collection, tabulation, analysis, and interpretation, and with the use of data for inference and decision making in industrial, scientific, and government enterprises.

Degree Requirements
To complete the degree, students must complete at least 120 credits, including at least 38 credits in the major.
Required are two years of math, a year of statistical theory, five courses in statistical methods, three courses with lab in the sciences, and three electives courses in statistics or related fields.