Institute of Technology

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General Information

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, 2,600 in graduate programs, and 400 faculty, IT’s 12 departments and schools and 15 research centers are committed to excellence in all they undertake. In addition, the programs and departments within IT offer a strong sense of community that continues even after graduation.

Computer Facilities—The Institute of Technology, in cooperation with the Department of Computer Science and Engineering and the office of Academic and Distributed Computing Services, 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. See www.itlab.umn.edu/itlabfees/index.php for more information about the IT Technology Fee Policy. 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 and C++. Discipline-related computing courses are offered in some departments.

Admission

Freshman Admission

See Freshman Admission in the General Information section of this catalog and refer to the University of Minnesota, Twin Cities Undergraduate Application Booklet for freshman admission requirements.

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 “Undecided” on the admission application. They will receive advising about their options from professional academic advisers, and be able to take advantage of the many resources that are available for students about IT fields in the IT Office of Academic Advising. Some of these resources 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, and visit selected industries to 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, NSP, and many other companies serve as advisers to IT students through this program. Arrangements to participate are made by online application.

Undecided IT students follow the same first-year academic program as that followed by IT students with a specified major.

Advanced Standing Admission (Transfer)

Students who have completed any postsecondary classes after high school 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 an overall “technical” GPA using grades in science, calculus, computer science, and engineering. 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/prospective/equiv). Technical courses in which a D has been earned do not transfer.

Dual Degree (3/2) Programs—IT has cooperative agreements with a number of public and private colleges. These programs support students 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. Core college requirements and the pre-engineering core courses in math and science are completed at the private college. 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, Bethany Lutheran College, Bethel University, Concordia College ( Moorhead), Gustavus Adolphus College, Hamline University, Macalester College, Minnesota State University—Moorhead, Northwestern College, College of St. Catherine, Saint Mary’s University of Minnesota, St. Olaf College, St. John’s University-College of St. Benedict, College of St. Scholastica, University of St. Thomas, University of Minnesota, Morris

• Outside Minnesota—Augustana College, S.D.; Carroll College, Mont.; Earlham College, Ind.; Jackson State University, Miss.; Luther College, Morningside College, and Simpson College, Iowa; North Central College, North Park College, and Wheaton College, Ill.; University of Mary, N.D.; University of Winnipeg, Manitoba, Canada; Carthage College and Lawrence University, Wisc., and University of
Institute of Technology

Wisconsin-Eau Claire (physics/geology only), La Crosse, Oshkosh, and River Falls; Westmont College and Whittier College, Calif.
For more information, visit [www.it.umn.edu/students/degrees/dual.html](http://www.it.umn.edu/students/degrees/dual.html).

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. Eighteen degrees are offered:

- Bachelor of aerospace engineering and mechanics*
- Bachelor of science in astrophysics
- Bachelor of biomedical engineering*
- Bachelor of bioproducts and biosystems 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

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

Students cannot receive two degrees in the same field (e.g. a bachelor of arts in computer science and a bachelor of science in computer science.) This limitation applies to the following majors: astronomy/astrophysics, chemistry, computer science, geology, mathematics, physics, and statistics.

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, or see [www.catalogs.umn.edu/grad](http://www.catalogs.umn.edu/grad).

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.). Similar professional master’s programs are offered in infrastructure systems and software engineering. 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 Emphases—IT students can plan interdisciplinary emphases tailored to their specific interests. Although a degree is approved by a single department, students can combine coursework from several departments. Many interdisciplinary emphases are possible. A few examples include acoustics, bioengineering, environmental engineering, nuclear engineering, and transportation. Students should contact their department office 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. Approved specific courses are required for medical school application. The following Web sites list up-to-date, required courses:

Rochester: [www.mayo.edu/mmss/md-admissions.html](http://www.mayo.edu/mmss/md-admissions.html)

For more information, contact the Health Careers Center in 2-565 Moos Tower (612-624-6767) or visit the Web site at [www.healthcareers.umn.edu](http://www.healthcareers.umn.edu).

Minors

Information Technology Minor Only

This interdisciplinary minor provides opportunities for students in nontechnical disciplines to supplement their major with courses focused on information technology. For more information, see the Degree Programs and Minors section.

Honors Program

Beginning in fall 2008, the University Honors Program (UHP) will offer rigorous and interdisciplinary curricula along with other honors experiences designed for highly qualified and motivated students. Honors courses, available only to honors students, offer small class sizes, close interaction with world-class faculty, and an engaging learning atmosphere.

The University Honors Program serves honors students in all colleges. See the “University Honors Program” section at the front of this catalog for more information, or visit the University Honors Program website at [www.honors.umn.edu](http://www.honors.umn.edu). Students admitted before fall 2008 will continue to follow honors requirements outlined at the time they entered their college honors program. All students admitted to honors as of fall 2008 will follow the requirements of the new University Honors Program. Students admitted before fall 2008 who change colleges must apply to the UHP if they want to continue to participate. If admitted, they will be held to the new UHP requirements. See the “University Honors Program” section of this catalog for further instructions on how to apply.

Scholastic Policies

Continuation in Sequences—IT students taking the following 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
MATH 1155, 1271–1272*
MATH 1371–1372
MATH 1571–1572
PHYS 1301–1302
PHYS 2303**, 2601

* 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 1271, 1372, or 1572.
** To continue in physics sequences, IT students must earn at least a C- in PHYS 2303.

IT students must earn at least a C- in all 1xxx and 3xxx math, physics, and chemistry courses, and all courses required by the major. All courses required by the major must be taken A-F.

Upper Division—This designation corresponds to junior and senior standing.

Freshmen and sophomores must apply for entry and are told at orientation what minimum GPA might be required. Students should file an application in 130 Lind Hall before completing their sophomore year.

Changing Majors—Upper division students must petition to change majors within IT. Forms are available in 130 Lind Hall. A transcript must accompany the petition.

Students who graduate from IT and continue to register for courses will automatically have their status changed to nondegree unless they had previously been admitted to a second (double) major.

To change from IT to another college unit or campus within the University, students must apply for transfer through the One Stop Student Services 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.

Conduct and Discipline

IT assumes that all students who enroll in its programs are serious about their education, and expects them to be responsible individuals who demand of themselves high standards of honesty and good personal conduct. IT expects the highest standards of honesty and integrity in the academic performance of its students. Any act of scholastic dishonesty is regarded as a serious offense, and may result in expulsion. IT defines scholastic dishonesty as submission of false records of academic achievement; cheating on assignments or examinations; plagiarizing; altering, forging, or misusing a University academic record; taking, acquiring, or using test materials without faculty permission; acting alone or in cooperation with another to falsify records or to obtain dishonestly any grades, honors, awards, or professional endorsement. Aiding and abetting a student in an act of scholastic dishonesty is also considered a serious offense.

All students at the University have the right to a calm, productive, and stimulating learning environment. Students who engage in behavior that disrupts the learning environment for others may be subject to disciplinary action under the Student Conduct Code, which prohibits disruptive conduct. In addition, students responsible for such behavior may be required to cancel their registration (or have their registration canceled).

All disciplinary cases that are academic and nonacademic in nature or that involve two or more colleges are referred to the Office for Student Conduct and Academic Integrity, 211 Appleby Hall, Minneapolis, MN 55455 (612-624-6073).

A student has the right to a hearing and to appeal any disciplinary action. Copies of the procedures for cases of scholastic dishonesty are available at the Office for Student Conduct and Academic Integrity.

Professional Registration

Registration is a legal requirement for certain kinds of practice in engineering and in geoscience. 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 or geologist. 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 of each year and may be taken by students during their senior year. More information and applications may be obtained from the Career Center for Science and Engineering in 50 Lind Hall or by writing to the Minnesota State Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience, and Interior Design, 133 7th Street E., St. Paul, MN 55101-2333 (651-296-2388).

Advising

All students obtain advising through the IT Office of Academic Advising, 130 Lind Hall (612-624-8504). Every IT student is assigned a professional academic adviser upon beginning his/her first semester. Advisers assist students in negotiating their academic pursuit and uncovering the resources and abilities needed to be successful. Students should meet with their academic adviser once a semester at a minimum, prior to registration. In addition, students should see their adviser if they have questions about University policy and procedure, concerns regarding their academic decisions, or troubles with their academic performance.

Upper division students who have applied and been accepted into a specific program will continue to work with their academic adviser and will also work with a faculty mentor. This faculty member will work with the student in areas specific to her or his success as a professional in the individual program.

Special Learning Opportunities and Resources

Student Programs Office—Prospective and current students can discuss any issues with the associate dean for undergraduate programs or the staff in 106 Lind Hall, 612-624-5091, or by e-mail liss@umn.edu. This office is responsible for admission, outreach efforts, student events, scholastic conduct, scholarships, international programs, and related functions.

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 IT Office of Academic Advising, 128 Lind Hall (612-624-2890).

**Paid Learning Opportunities**—The Career Center for Science and Engineering (CCSE) provides information about off-campus employment related to major or career interests. Many options are available for part-time employment, summer internships, international internships, 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, visit the [CCSE Web site](http://www.ccse.umn.edu) or contact CCSE, 50 Lind Hall (612-624-4090).

**Office of Diversity and Outreach**—This office 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 workforce.

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, the office 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 Office of Diversity and Outreach, 106 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455 (612-626-0219; e-mail: [bolla007@umn.edu](mailto:bolla007@umn.edu)).

**UNITE Instructional Television**—About 50 for-credit courses each semester are offered through UNITE (UnUniversity-Industry Television for Education), an instructional television system for continuing education at the employee’s workplace. In addition, 25 of these courses are offered by streaming video—live as they happen on campus—or by video-on-demand. 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, 514 Vincent Hall, 206 Church Street S.E., Minneapolis, MN 55455 (612-624-2332).

**On-Campus Living Experiences for Freshmen in IT—The Explorations in Engineering and Sciences House (IT Explorations), the Women in Science and Engineering House (WISE), and the Honors House are the IT residential learning environments. These houses create a smaller, living-learning environment in which students can benefit from others who have similar academic and career interests in science and/or engineering. Participating students find support from their peers that can enhance their success in the classroom and on campus. Faculty and staff advisers from IT provide guidance during students’ first year on campus, on-site academic advising, access to information on career options, and coordinate various social activities such as dinner with professionals, faculty members, and student organizations. All participants are strongly encouraged to register for IOFT 1312—Exploring Careers in Science and Engineering (2 credits). This course can be used as a freshman seminar.

IT Explorations is a co-ed community open to 140 students in Frontier Hall. The WISE House is a female first-year freshman community open to 30 students, also in Frontier Hall. For more information, contact the IT Student Programs Office at 612-624-8010, e-mail [kubit001@umn.edu](mailto:kubit001@umn.edu), or visit the Housing and Residential Life Web site at [www.honors.umn.edu](http://www.honors.umn.edu). For more information on Honors Housing, see the University Honors Program section of this catalog, or visit the Web site at [www.honors.umn.edu](http://www.honors.umn.edu).

**International Programs**

IT students have hundreds of study abroad programs from which to choose. Students can study in or outside their major, study a second language, or study the history and culture of a region. Study in English is possible at various sites, including Hong Kong, Sweden, Norway, England, Denmark, Australia, New Zealand, and many others. Students may spend a semester, academic year, or summer session enhancing their cross-cultural skills, language ability, or professional experience. These opportunities are very affordable and the Learning Abroad Center offers more than $400,000 in scholarships for study abroad per year. IT has also been supportive to students with financial need. Each IT department has a list of recommended locations for study abroad. Students can learn more about these options by contacting Adam Pagel, 106 Lind Hall, [pagel@umn.edu](mailto:pagel@umn.edu), or call 612-624-8013.

**Internship Opportunities in Technical Fields**—Students interested in paid international internships in a technical field should contact the International Association for the Exchanges of Students for Technical Experience (IAESTE) in 4 Lind Hall at [IAESTE@umn.edu](mailto:IAESTE@umn.edu) or call 612-624-8010 to find out about this active student chapter on campus.

**Other Information**—For information about opportunities through the International Student Exchange Program (ISEP), IAESTE, and Institute for Study Abroad (Butler University, Ind.), visit the Learning Abroad Center in 230 Heller Hall. Advisers there assist students with study and credit options, financial aid, and orientations. The Learning Abroad Center also hosts daily First Step meetings, which introduce a full listing of study abroad opportunities. Visit [www.UMabroad.umn.edu](http://www.UMabroad.umn.edu) for more information. Students interested in domestic exchanges should contact the National Student Exchange Program, 345 Fraser Hall, or [drel@class.cla.umn.edu](mailto:drel@class.cla.umn.edu)

**Career Information**

The Career Center for Science and Engineering (CCSE), 50 Lind Hall (612-624-4090), provides comprehensive career services to students and alumni from the Institute of Technology and the College of Biological Sciences.

CCSE assists students in the career exploration process as they identify and research majors and careers best suited to their skills, interests, and values. Each semester, the office offers IOFT 1312—Exploring Careers in Science and Engineering (2 credits). This course exposes students to all aspects of the career development and job search processes.

CCSE also provides resources and programs aimed at assisting students with their search for part-time, internship, and co-op positions, or permanent jobs following graduation. The
services provided by CCSE include on-campus interviewing, job postings, workshops on many job search-related topics, and individual assistance with any career issues.

In addition, the center provides information regarding the Fundamentals of Engineering (FE) exam.

**Student Organizations and Activities**

Scientists and engineers find that membership in a technical or professional society 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. Contact Susan Kubitschek, 612-624-8010, kubit001@umn.edu, for information about, and assistance with promoting and recruiting for membership in any student organization.

**Professional Societies**

Branches of the following national professional societies are maintained at the University of Minnesota by students and faculty: the American Institute of Chemical Engineers; Society of Physics Students; American Society of Civil Engineers; American Society of Mechanical Engineers; Society for Engineering in Agricultural, Food, and Biological Systems; 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, National Society of Black Engineers, Triangle, Theta Tau, and Alpha Sigma Kappa.

**Honorary Scholastic Societies**

These IT societies promote the high standards of the engineering profession by conferring memberships, awards, and other honors on undergraduates who have distinguished themselves through scholastic achievement and high standards of character. The societies normally elect members from 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 engineering departments. The others limit 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**

An 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. Contact Plumb Bob at plumbbob@umn.edu.

**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. Contact ITSB at itsb@umn.edu.

**Student Publications**

Minnesota Technolog is IT’s official student magazine. Published three times a year, this 83-year-old publication features pieces written by students on science and engineering issues. For more information contact technolog@umn.edu.

IT Student Publications selects editors and business managers and directs the overall policy of its publications. Students are encouraged to participate as publication staff members.
Directory

IT Web site: www.it.umn.edu

Office of the Dean
105 Walter Library
612-624-2006
E-mail: info@it.umn.edu

Office of the Associate Dean for Student Services
106 Lind Hall
612-624-5091
E-mail: itss@itdean.umn.edu

Office of Academic Advising
128 Lind Hall
612-624-2890
E-mail: itadvising@umn.edu

Career Center for Science and Engineering
50 Lind Hall
612-624-4090
E-mail: ccsce@umn.edu

Center for the Development of Technological Leadership
510 West Bank Office Building
612-624-5747
E-mail: general-cdtl@umn.edu

Office of Diversity and Outreach
105 Lind Hall
612-626-0219
E-mail: polla007@umn.edu

Office of Student Programs
105 Lind Hall
612-624-8504
E-mail: itss@itdean.umn.edu

Departments

Aerospace Engineering and Mechanics
107 Akerman Hall
612-625-8000
E-mail: dept@aem.umn.edu

Astronomy
356 Tate Laboratory of Physics
612-624-0211
E-mail: tjj@astro.umn.edu

Biomedical Engineering
7-105 Nils Hasselmo Hall
612-624-4507
E-mail: bmedus@umn.edu

Bioproducts and Biosystems Engineering
203 Kauffman Laboratory
612-625-5200
E-mail: shri@umn.edu

Chemical Engineering and Materials Science
151 Amundson Hall
612-625-1313
E-mail: williams@cem.umn.edu

Chemistry
135 Smith Hall
612-624-8008
E-mail: tathopo@chem.umn.edu

Civil Engineering
122 Civil Engineering Building
612-625-5522
E-mail: live@umn.edu

Computer Science and Engineering
4-192 Electrical Engineering/Computer Science
612-625-4002
E-mail: undergrad_info@cs.umn.edu

Electrical and Computer Engineering
4-174 Electrical Engineering/Computer Science
612-625-3300
E-mail: undergraduate_studies@ece.umn.edu

Geology and Geophysics (Earth Sciences)
108 Pillsbury Hall
612-624-1333
E-mail: geology@umn.edu

Mathematics
115 Vincent Hall
612-625-4848
E-mail: undergrad@math.umn.edu

Mechanical Engineering
1120 Mechanical Engineering
612-625-5842
E-mail: jeanne@me.umn.edu

Physics
148 Tate Laboratory of Physics
612-624-7375
E-mail: undergrad@physics.spa.umn.edu

Statistics
313 Ford Hall
612-625-8046
E-mail: info@stat.umn.edu
Institute of Technology

Degree Programs and Minors

Aerospace Engineering and Mechanics B.A.E.M.

Aerospace Engineering and Mechanics
• Required credits to graduate with this degree: 124.
• Required credits within the major: 54.

The mission of the bachelor of aerospace engineering and mechanics (B.A.E.M.) program is to produce graduates who are prepared to enter and sustain the practice of aerospace engineering and related fields, or to pursue advanced studies. This mission is consistent with the mission of the University of Minnesota in learning and teaching, and with the mission of the Institute of Technology: to provide a rigorous and stimulating education for its undergraduate majors and to provide programs of instruction in engineering that meet nationally accepted standards for practice of the profession of engineering.

Aerospace engineering is a multidisciplinary field that encompasses many areas of science and engineering and plays a major role in the technological advancement of society. As a constantly changing profession, aerospace engineering is concerned with a wide range of problems and the latest technologies. An aerospace engineer must have a comprehensive fundamental education in mathematics, physical sciences, and engineering sciences. The four-year program leading to the B.A.E.M. provides this broad background. The program is accredited by the Engineering Accreditation Commission of ABET.

Admission Requirements

Students must complete 9 courses before admission to the program.

Freshmen and transfer students are usually admitted to pre-major status before admission to this major.

A GPA above 2.00 is preferred for the following:
• 2.30 for students already admitted to the degree-granting college.
• 2.30 for students transferring from another University of Minnesota college.
• 2.80 for students transferring from outside the University.

For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics Core

Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses

MATH 1371—IT Calculus I, MATH (4 cr)
or MATH 1271—Calculus I, MATH (4 cr)
MATH 1372—IT Calculus II (4 cr)
or MATH 1272—Calculus II (4 cr)
MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)
or MATH 2263—Multivariable Calculus (4 cr)
MATH 2373—IIT Linear Algebra and Differential Equations (4 cr)
or MATH 2243—Linear Algebra and Differential Equations (4 cr)

Physics Core

PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)

or

PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)
PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)
or PHYS 2403H—Honors Phys III, H (4 cr)

Static and Dynamics Core

AEM 2011—Statics (3 cr)
AEM 2012—Dynamics (3 cr)

Program Requirements

AEM Core

AEM 2301—Mechanics of Flight (3 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
AEM 4201—Fluid Mechanics (4 cr)
AEM 4202—Aerodynamics (4 cr)
AEM 4303—Aeropropulsion (4 cr)
AEM 4301—Orbital Mechanics (3 cr)
AEM 4303W—Flight Dynamics and Control, WI (4 cr)
AEM 4331—Aerospace Vehicle Design (4 cr)
AEM 4501—Aerospace Structures (3 cr)
AEM 4601—Instrumentation Laboratory (3 cr)
AEM 4602W—Aeromechanics Laboratory, WI (4 cr)

Science and Engineering

CHEM 1021—Chemical Principles I, ENVT, PHYS SCI/L (4 cr)
CHEM 1031H—Honors Chemistry I, ENVT, PHYS SCI/L, H (4 cr)
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
EE 3006—Fundamentals of Electrical Engineering Laboratory (1 cr)
MATS 2001—Introduction to the Science of Engineering Materials (3 cr)
ME 3324—Introduction to Thermal Science (3 cr)

Technical Electives

At least three courses (to total at least 9 credits) are required. These are typically chosen from 4xxx and 5xxx AEM courses that extend material covered in the required courses. They may be from other engineering, math and science disciplines at the appropriate level. One may be a 2xxx or 3xxx math or science course. In particular AST 2001 may be used to complete a minor in astronomy. Details are available from [www.aem.umn.edu/teaching/undergraduate/advising_guide/index.shtml](http://www.aem.umn.edu/teaching/undergraduate/advising_guide/index.shtml).

Program Sub-Plans

A sub-plan is not required for this program.

EIP Sub-Plan

Students may obtain professional experience in an industry or government assignment through an internship. The internship program usually consists of one term experience, generally in the summer. The practical engineering experience obtained through an internship not only enhances a student’s education but also gives an edge on employment after graduation.

Students can receive 3 credits by taking AEM 4796 (report required). These credits can be counted as a technical elective toward the B.A.E.M. degree.

Internship

AEM 4796—Professional Experience (3 cr)
Astrophysics B.S. Astrop.

Astronomy
• Required credits to graduate with this degree: 120.
• Required credits within the major: 43 to 45.

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
Students must complete 8 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics Core
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physics Core
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)
PHYS 2303—Physics III: Physics of Matter (4 cr)
or PHYS 2403H—Honors Phys III, H (4 cr)
or PHYS 2503—Physics III: Foundations of Modern Physics (4 cr)
PHYS 2601—Quantum Physics (4 cr)

Program Requirements
Students interested in astrophysics are encouraged to take AST 1011H.

Astrophysics Core
AST 2001—Introduction to Astrophysics (4 cr)
AST 4994W—Directed Research, WI (3.0-5 cr)
PHYS 2605—Quantum Physics Laboratory (3 cr)
PHYS 4001—Analytical Mechanics (4 cr)
PHYS 4002—Electricity and Magnetism (4 cr)

Take 2 or more course(s) from the following:
AST 4xxx
AST 5xxx
MATH 2283—Sequences, Series, and Foundations (3 cr)
or MATH 3xxx
or MATH 4xxx

Astrophysics Focus
Students are required to complete one of the following course groups.

Data Analysis Specialist Sub-Plan
This emphasis prepares students for careers in corporate and government labs and research divisions. Examples are programming, image processing, laboratory instrumentation, and general data analysis. Suggested courses are listed below.
Take 16 or more credit(s) from the following:
AST 5201—Methods of Experimental Astrophysics (4 cr)
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
CSCI 2031—Introduction to Numerical Computing (4 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
PHYS 4051—Methods of Experimental Physics I (5 cr)
PHYS 4052W—Methods of Experimental Physics II, WI (5 cr)

Professional Astronomer Sub-Plan
This emphasis prepares students for graduate school in astronomy. The program is similar to doing a double major in astrophysics and physics. The program emphasizes observational astronomy.
16 credits of AST, MATH, CHEM, PHYS, GEO, EE, or CSCI (3xxx,4xxx,5xxx)
Suggested courses are listed below.
Take 16 or more credit(s) from the following:
PHYS 4101—Quantum Mechanics (4 cr)
PHYS 4201—Statistical and Thermal Physics (3 cr)

Take 0 or more course(s) from the following:
AST 4xxx
AST 5xxx

Take 0 or more credit(s) from the following:
CHEM 3xxx
CHEM 4xxx
CHEM 5xxx

Take 0 or more course(s) from the following:
CSCI 3xxx
CSCI 4xxx
CSCI 5xxx

Take 0 or more course(s) from the following:
EE 3xxx
EE 4xxx
EE 5xxx

Take 0 or more course(s) from the following:
GEO 3xxx
GEO 4xxx
GEO 5xxx

Take 0 or more course(s) from the following:
MATH 3xxx
MATH 4xxx
MATH 5xxx

Take 0 or more course(s) from the following:
PHYS 3xxx
PHYS 4xxx
PHYS 5xxx

Secondary Education Sub-Plan
This emphasis prepares students for entry to a masters program in secondary science education. In addition to the courses listed below, students must complete 100 hours of in-class experience across at least two semesters.
PSY 1001—Introduction to Psychology, SSCI (4 cr)
HSCI 1814—Revolution in Science: The Babylonians to Newton, HP, IP (4 cr)
or HSCI 4121—History of 20th-Century Physics (3 cr)
or HSCI 4111—History of 19th-Century Physics (3 cr)
PHIL 1005—Scientific Reasoning (4 cr)
or PHIL 3601W—Scientific Thought, OH, WI (4 cr)
AST 5201—Methods of Experimental Astrophysics (4 cr)

Note: Programs listed in this catalog are current as of March 2008.
Physics Research
This course pair replaces AST 4994 in the student’s program.
PHYS 4051—Methods of Experimental Physics I (5 cr) and PHYS 4052W—Methods of Experimental Physics II, WI (5 cr)

Technical Electives
Select 16 credits in consultation with your adviser.

Biomedical Engineering B.Bm.E.

Department of Biomedical Engineering
• Required credits to graduate with this degree: 127.
• Required credits within the major: 73.
Biomedical engineers apply the fundamentals of mathematics, physics, chemistry, and biology to solve medically-relevant problems. Examples of biomedical engineering activities include medical device design, fabrication and testing, prosthesis fabrication, ergonomics and human factors, physiological function monitoring, home health care technology development, biomedical informatics, functional imaging and tomography, biomaterial development and biocompatibility, artificial tissue and organ fabrication, cell- and biomolecule-based sensors and therapeutics, gene therapy development, and biomedical microsystems.

Admission Requirements
Students must complete 11 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
• 2.80 for students already admitted to the degree-granting college.
• 2.80 for students transferring from another University of Minnesota college.
• 3.00 for students transferring from outside the University.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Sciences
CHEM 1021—Chemical Principles I, ENVT, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENVT, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENVT, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENVT, PHYS SCI/L, H (4 cr)
CHEM 2301—Organic Chemistry I (3 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Preparatory Courses
BMEN 2101—Biomedical Thermodynamics (3 cr)
BMEN 2401—Programming for Biomedical Engineers (2 cr)

Program Requirements

Statistics
STAT 3021—Introduction to Probability and Statistics (3 cr)

Major Courses
BMEN 1601—Biomedical Engineering Undergraduate Seminar I (1 cr)
BMEN 1602—Biomedical Engineering Undergraduate Seminar II (1 cr)
BMEN 2501—Cellular and Molecular Biology for Biomedical Engineers (4 cr)
BMEN 3001—Biomechanics (4 cr)
BMEN 3101—Biomedical Transport Processes (4 cr)
BMEN 3201—Biomelectricity and Bioinstrumentation (4 cr)
BMEN 3301—Biomaterials (4 cr)
BMEN 3401—Biomedical Systems Analysis (4 cr)
BMEN 4001W—Biomedical Engineering Design I, WI (3 cr)
BMEN 4002W—Biomedical Engineering Design II, WI (3 cr)
PHSL 3063—Principles of Human Physiology, BIOL SCI/L (6 cr)

Technical Electives
Take 27 credits of technical electives approved by an adviser. A maximum of 10 credits of science courses and a maximum of 6 credits of research may be counted toward the total.

Bioproducts and Biosystems Engineering B.B.E.

Bioproducts and Biosystems Engineering
• Required credits to graduate with this degree: 128.
• Required credits within the major: 40 to 48.
The bioproducts and biosystems engineering curriculum provides a broad fundamental scientific and engineering background to harness the molecular building blocks of renewable resources for sustainable utilization, to design and develop biological systems, and to help improve the environment by developing solutions for environmental and natural resource issues affecting soil, water, and air. The curriculum offers three areas of specialization: bioproducts engineering, bioprocessing and food engineering, and environmental and ecological engineering. The program produces graduates who
• have a broad fundamental engineering background including mathematics, physical science, biological science and engineering science and design;
• serve the engineering needs of clientele in the areas of bioproducts, bioprocessing and food, and environment and ecology;
• are successfully employed in engineering jobs in industry, consulting, government, or academia;
• are engaged in professional development and lifelong learning.

Admission Requirements
Students must complete 10 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
• 2.50 for students transferring from outside the University.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).
Institute of Technology

Mathematics
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Biological and Physical Sciences
Biol 1009—General Biology, BIOL SCI/L (4 cr)
CHEM 1021—Chemical Principles I, ENVIT, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENVIT, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENVIT, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENVIT, PHYS SCI/L, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401W—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402W—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Mechanics and Structural Design
Take exactly 1 course(s) from the following:
BBE 3001—Mechanics and Structural Design (4 cr)

Program Requirements
Common Core
BBE 1001—Bioproducts and Biosystems Engineering Orientation (1 cr)
BBE 3013—Engineering Principles of Molecular and Cellular Processes (3 cr)
BBE 3033—Material and Energy Balances in Biological Systems (3 cr)
BBE 4303—Introduction to Bio-based Materials Science (4 cr)
BBE 4013—Transport in Biological Systems (4 cr)
BBE 4023W—Process Control and Instrumentation, WI (3 cr)
BBE 4502W—BBE Capstone Design, WI (4 cr)
CE 3502—Fluid Mechanics (4 cr)
ME 3331—Thermal Sciences I (3 cr)
BBE 4504W—Bio-based Products Development and Management, WI (3 cr)
or BBE 5212—Safety and Environmental Health Issues in Plant and Animal Production and Processing, CPE, ENVT, H (3 cr)

Program Sub-Plans
Students are required to complete one of the following sub-plans.

Bioproducts and Food Engineering Sub-Plan
Chemistry
CHEM 2301—Organic Chemistry I (3 cr)

Emphasis Courses
EE 3005—Fundamentals of Electrical Engineering (4 cr)
STAT 3021—Introduction to Probability and Statistics (3 cr)
BBE 4713—Biological Process Engineering (3 cr)
BBE 2113—Introduction to Design (3 cr)
BBE 4723—Food Process Engineering (3 cr)
BBE 4733—Renewable Energy Technologies (3 cr)

Technical Electives
Take 12 or more credit(s) from the following:
BBE 4302—Organisms Impacting Bio-based Products (3 cr)
BBE 4305—Pulp and Paper Technology (3 cr)
BBE 4312—Pulp and Paper Unit Operations (4 cr)
BBE 4314—Pulp and Paper Unit Operations (4 cr)
BBE 5212—Safety and Environmental Health Issues in Plant and Animal Production and Processing, CPE, ENVT, H (3 cr)

Bioproducts Engineering Sub-Plan
Chemistry
CHEM 2301—Organic Chemistry I (3 cr)
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)

Emphasis Courses
BBE 4713—Biological Process Engineering (3 cr)
BBE 4501—Process and Product Design I (2 cr)
BBE 1002—Wood and Fiber Science (3 cr)
BBE 4001—Chemistry of Plant Materials (4 cr)
BBE 4301—Surface and Colloid Science in Bio-based Products Manufacturing (3 cr)
BBE 4401—Bioproducts Engineering (3 cr)
BBE 4402—Bio-based Products Engineering Lab I (1 cr)
BBE 4403—Bio-based Products Engineering Lab II (1 cr)

Technical Electives
Must include at least 2 BBE courses from this list. See adviser for suggestions in creating a materials focus or an energy and manufacturing focus.

Take 12 or more credit(s) from the following:
BBE 4302—Organisms Impacting Bio-based Products (3 cr)
BBE 4305—Pulp and Paper Technology (3 cr)
BBE 4312—Pulp and Paper Unit Operations (4 cr)
BBE 4314—Pulp and Paper Unit Operations (4 cr)
BBE 4362—Pulping and Bleaching (4 cr)
BBE 4404—Bio-based Composites Engineering (3 cr)
BBE 4733—Renewable Energy Technologies (3 cr)

Technical Electives
Take 12 or more credit(s) from the following:
BBE 4302—Organisms Impacting Bio-based Products (3 cr)
BBE 4305—Pulp and Paper Technology (3 cr)
BBE 4312—Pulp and Paper Unit Operations (4 cr)
BBE 4314—Pulp and Paper Unit Operations (4 cr)
BBE 4362—Pulping and Bleaching (4 cr)
BBE 4404—Bio-based Composites Engineering (3 cr)
BBE 4733—Renewable Energy Technologies (3 cr)

Take 0 or more credit(s) from the following:
BBE 4713—Biological Process Engineering (3 cr)
BBE 4501—Process and Product Design I (2 cr)
BBE 4503—Process and Product Design II (2 cr)
BBE 4504W—BBE Capstone Design, WI (4 cr)
BBE 4505—Pulp and Paper Technology (3 cr)
BBE 4506—Pulp and Paper Unit Operations (4 cr)
BBE 4514—Pulp and Paper Unit Operations (4 cr)
BBE 5212—Safety and Environmental Health Issues in Plant and Animal Production and Processing, CPE, ENVT, H (3 cr)

EIP Sub-Plan
This sub-plan is optional and does not fulfill the sub-plan requirement for this program.

This option provides students with a hands-on work experience after the freshman year of the degree program. Students can take up to two semesters of intern work with one or more employers. An example may be two summers and one semester. This may be adjusted to suit individual needs. Students have an opportunity to assist in design work and apply their knowledge to practical problem solving. The experience helps students choose a career and select electives for the degree.

During the academic portion of the intern program students are expected to take a normal load of 11-13 credits. Graduation may be delayed because of the intern experience. It is important to plan ahead, since biosystems and agricultural engineering classes are usually offered only once per year, and in some cases in alternating years. Students registering for BBE 4900 must first submit a proposed plan of study with the intern coordinator.

Internship
A total of 4 BBE 4900 intern experience credits may be taken and applied toward the degree program as general engineering electives, but not as BBE electives.
BBE 4900—Intern Reports (2 cr)

Note: Programs listed in this catalog are current as of March 2008.
Environmental and Ecological Engineering Sub-Plan

Biochemistry
BIOC 2011—Biochemistry for the Agricultural and Health Sciences (3 cr)

Emphasis Courses
EE 3005—Fundamentals of Electrical Engineering (4 cr)
STAT 3021—Introduction to Probability and Statistics (3 cr)
BBE 2113—Introduction to Design (3 cr)
BBE 3023—Engineering Principles of Soil-Water-Plant Processes (3 cr)
Take 2 or more course(s) from the following:
BBE 4523—Water Management Engineering (3 cr)
BBE 4533—Agricultural Waste Management Engineering (3 cr)
BBE 5513—Watershed Engineering (3 cr)

Engineering Technical Electives
Select at least 8 credits of engineering electives. Examples: any non-required BBE course not used as a BBE elective, CE 3202, 3301, 3402, 3501, 4301, 4351, 4501, 4502, 4511, 4512

Biology Technical Electives
Select at least 8 credits of biology electives. Examples: BIOL 3007, 3407, EEB 3001, 4601, ES 3612, SOIL 3416, ESPM 4607

Chemical Engineering B.Ch.E.

Chemical Engineering and Materials Science
• Required credits to graduate with this degree: 128.
• Required credits within the major: 30.
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, chemical engineers are much in demand. They 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
Students must complete 11 courses before admission to the program. Freshmen and transfer students are usually admitted to pre-major status before admission to major. A GPA above 2.00 is preferred for the following:
• 2.60 for students already admitted to the degree-granting college.
• 2.60 for students transferring from another University of Minnesota college.
• 3.00 for students transferring from outside the University. For information about University of Minnesota admission requirements, visit http://admissions.tc.umn.edu.

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)

MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Sciences
CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
CHEM 2301—Organic Chemistry I (3 cr)
CHEM 2302—Organic Chemistry II (3 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Program Requirements
Students interested in chemical engineering are encouraged to take CHEN 1001.

Major Courses
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
CHEM 4121—Process Analytical Chemistry (3 cr)
CHEM 2311—Organic Lab (4 cr)
or CHEM 2312—Honors Organic Lab, H (5 cr)
CHEN 3701—Introduction to Biomolecular Engineering (3 cr)
CHEN 4001—Material and Energy Balances (4 cr)
CHEN 4005—Transport Phenomena: Momentum and Heat (4 cr)
CHEN 4006—Mass Transport and Separation Processes (4 cr)
CHEN 4101—Chemical Engineering Thermodynamics (4 cr)
CHEN 4102—Reaction Kinetics and Reactor Engineering (4 cr)
CHEN 4201—Numerical methods in ChEn applications (3 cr)
CHEN 4401W—Chemical Engineering Lab I, WI (3 cr)
CHEN 4402W—Chemical Engineering Lab II, WI (2 cr)
CHEN 4501W—Chemical Engineering Process Design, WI (3 cr)
CHEN 4502W—Chemical Engineering Process Design II, WI (2 cr)
CHEN 4601—Process Control (3 cr)
MATS 3011—Introduction to Materials Science and Engineering (3 cr)

Technical Electives
Take 17 credits of electives. These normally include CHEN 4214 and 3 other courses selected with the aid of an adviser.

Chemistry B.S.Chem.

Chemistry
• Required credits to graduate with this degree: 120.
• Required credits within the major: 40.
The mission of the Department of Chemistry is to enrich the science of chemistry through the education of students from all disciplines, the training of future professional chemists, and the pursuit of knowledge.
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.

For the most up-to-date listing of program requirements, visit the Online Catalog at www.catalogs.umn.edu/programs.html
Admission Requirements
Students must complete 10 courses before admission to the program. Freshmen and transfer students are usually admitted to pre-major status before admission to this major. A GPA above 2.00 is preferred for the following:
• 2.80 for students transferring from outside the University.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2273—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Sciences
CHEM 1021—Chemical Principles I, ENVT, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
CHEM 2101—Introductory Analytical Chemistry Lecture (3 cr)
CHEM 2111—Introductory Analytical Chemistry Lab (2 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
or PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Additional Math, Science, or Statistics
An additional course in Math or Physics. If a student completes the Honors Math sequence this requirement is automatically fulfilled.
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
or PHYS 2303—Physics III: Physics of Matter (4 cr)
or PHYS 2403H—Honors Phys III, H (4 cr)
or STAT 3021—Introduction to Probability and Statistics (3 cr)

Program Requirements
Major Courses
CHEM 2301—Organic Chemistry I (3 cr)
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
CHEM 4701—Inorganic Chemistry (3 cr)
CHEM 2302—Organic Chemistry II (3 cr)
Lab can be taken concurrent with or after taking CHEM 2302
CHEM 2311—Organic Lab (4 cr)
or CHEM 3212—Honors Organic Lab, H (5 cr)

Electives
Take 3 or more course(s) from the following:
CHEM 4094W—Directed Research, WI (1.0-3 cr)
CHEM 4111W—Intermediate Analytical Chemistry Lab, WI (2 cr)
CHEM 4311W—Advanced Organic Chemistry Lab, WI (2 cr)
CHEM 4511W—Advanced Physical Chemistry Lab, WI (2 cr)
CHEM 4711W—Advanced Inorganic Chemistry Lab, WI (2 cr)
CHEM 4223W—Polymer Laboratory, WI (2 cr)
Select one course (3 credits) from any non-required upper division course in chemistry.
CHEM 4xxx
or CHEM 5xxx

Technical Electives
Take two 3xxx or higher courses of 3 credits or more in any field of science (at least 6 credits).
Technical Elective 1
Technical Elective 2

Civil Engineering B.C.E.

Civil Engineering
• Required credits to graduate with this degree: 128.
• Required credits within the major: 64.
Civil engineering deals with the science and art of engineering applied to solving problems and designing systems related to infrastructure and the environment. 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
Students must complete 10 courses before admission to the program. Freshmen and transfer students are usually admitted to pre-major status before admission to this major. A GPA above 2.00 is preferred for the following:
• 2.80 for students transferring from outside the University.
It is recommended that students take GEO 1001 and CE 1101, but these courses are not required to be admitted to the program.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2273—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2274—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Science and Mechanics
AEM 2011—Statics (3 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
or PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Program Requirements
Major Courses
CE 3201—Transportation Engineering (3 cr)
CE 3202—Surveying and Mapping (2 cr)
CE 3301—Soil Mechanics I (3 cr)
Take 1 or more course(s) from the following:

Consult your adviser about selecting courses to meet this requirement.

Geomechanics Engineering

Consult your adviser about selecting courses to meet this requirement.

Take 1 or more course(s) from the following:

Environmental Engineering

Consult your adviser about selecting courses to meet this requirement.

Take 1 or more course(s) from the following:

Public Works Engineering

Consult your adviser about selecting courses to meet this requirement.

Take 1 or more course(s) from the following:

Structural Engineering

Consult your adviser about selecting courses to meet this requirement.

Take 1 or more course(s) from the following:
Institute of Technology

MATH 5487—Computational Methods for Differential and Integral Equations in Engineering and Science I (4 cr)
ME 5247—Stress Analysis, Sensing, and Transducers (4 cr)
CE 3111—CADD for Civil Engineers (2 cr)
CE 4190—Engineering Co-op Assignment (2.0-6 cr)

Transportation Engineering
Consult your adviser about selecting courses to meet this requirement.
Take 1 or more course(s) from the following:
CE 1101—Civil Engineering Orientation (1 cr)
CE 3111—CADD for Civil Engineers (2 cr)
CE 4121—Computer Applications in Civil Engineering II (3 cr)
CE 4190—Engineering Co-op Assignment (2.0-6 cr)
CE 4201—Highway Design (3 cr)
CE 4231—Principles of Pavement Design (3 cr)
CE 5211—Traffic Engineering (3 cr)
CE 5212—Transportation Policy, Planning, and Deployment (4 cr)
CE 5231—Pavement Management and Rehabilitation (3 cr)
CE 5232—Advanced Portland Cement Concrete (3 cr)
CE 5233—Advanced Bituminous Materials (3 cr)
CSCI 2021—Introduction to Numerical Computing (4 cr)
MATH 4242—Applied Linear Algebra (4 cr)
MATH 4512—Differential Equations with Applications (3 cr)
STAT 5021—Statistical Analysis (4 cr)
STAT 5302—Applied Regression Analysis (4 cr)

Water Resources Engineering
Consult your adviser about selecting courses to meet this requirement.
Take 1 or more course(s) from the following:
BBE 5513—Watershed Engineering (3 cr)
CE 1101—Civil Engineering Orientation (1 cr)
CE 3111—CADD for Civil Engineers (2 cr)
CE 4121—Computer Applications in Civil Engineering II (3 cr)
CE 4190—Engineering Co-op Assignment (2.0-6 cr)
CE 4341—Engineering Geostatistics (3 cr)
CE 4351—Groundwater Mechanics (3 cr)
CE 4352—Groundwater Modeling (3 cr)
CE 4511—Hydraulic Structures (4 cr)
CE 4512—Open Channel Hydraulics (4 cr)
CSCI 2031—Introduction to Numerical Computing (4 cr)
GEO 4701—Geomorphology (3.0-4 cr)

Program Sub-Plans
A sub-plan is not required for this program.

EIP Sub-Plan
CE 4190—Engineering Co-op Assignment (2.0-6 cr)

Computer Engineering B.Comp.E.

Computer Science and Engineering
• Required credits to graduate with this degree: 128.
• Required credits within the major: 103.

The mission of the computer engineering program is to educate students in the core topics as well as in a broad set of specialties of computer engineering, to impart students with professional attributes that characterize a well-schooled engineer and citizen, and to provide students with opportunities for research experience in one of the leading computer engineering centers of scholarship.

The field of 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 B.Comp.Eng. degree provides the background necessary for persons, with continuing study, to work in any of the many computer engineering subfields. The bachelor’s degree itself does not, however, provide highly specialized knowledge in any particular subfield.

Admission Requirements
Students must complete 10 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
• 2.30 for students already admitted to the degree-granting college.
• 2.30 for students transferring from another University of Minnesota college.
• 2.80 for students transferring from outside the University.

For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physics
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI, H (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Preparatory Courses
CSCI 1901—Structure of Computer Programming I (4 cr)
CSCI 1902—Structure of Computer Programming II (4 cr)
EE 2001—Introduction to Electronic and Electrical Circuits (3 cr)
EE 2002—Introduction Circuits and Electronics Laboratory (1 cr)
EE 2111—Linear Systems and Circuits (3 cr)

Take all of the following in the same term:
EE 2301—Introduction to Digital System Design (4 cr)
EE 301—Introduction to Digital System Design: Discussion (0 cr)
Take all of the following in the same term:
EE 2361—Introduction to Microcontrollers (4 cr)
EE 361—Introduction to Microcontrollers: Discussion (0 cr)

Program Requirements
Students interested in pursuing computer engineering or electrical engineering as a major are encouraged to take EE 1001 during their first year.

Program Requirements

Major Courses
CSCI 2011—Discrete Structures of Computer Science (4 cr)
CSCI 4041—Algorithms and Data Structures (4 cr)
CSCI 4061—Introduction to Operating Systems (4 cr)
EE 3015—Signals and Systems (3 cr)
EE 3025—Statistical Methods in Electrical and Computer Engineering (3 cr)
Electives
With adviser approval, courses from areas outside of EE/CSCI may be substituted to meet up to 6 credits of this requirement (i.e., the technical electives). Courses taken as part of the EIP program may be used to meet the technical elective requirement. Courses may not be used to meet both the core and the elective requirements.

Take 28 or more credit(s) from the following:
Courses used to fulfill other requirements will not count as lab experiences.
Take 3 or more course(s) from the following:
If students take EE 4951W they need at least two other laboratory courses
EE 4951W—Senior Design Project, WI (4 cr)
or Honors Project
If students complete the Honors courses, they need at least one other laboratory course
EE 4981H—Senior Honors Project I, H (2 cr)
EE 4982V—Senior Honors Project II, WI, H (2 cr)
Take 1 or more course(s) from the following:
EE 4111—Advanced Analog Electronics Design (4 cr)
EE 4235—Linear Control Systems Laboratory (1 cr)
EE 4237—State Space Control Laboratory (1 cr)
EE 4301—Digital Design With Programmable Logic (4 cr)
EE 4341—Microprocessor and Microcontroller System Design (4 cr)
EE 4505—Communications Systems Laboratory (1 cr)
EE 4703—Electric Drives Laboratory (1 cr)
EE 4722—Power System Analysis Laboratory (1 cr)
EE 4743—Switch-Mode Power Electronics Laboratory (1 cr)
EE 5141—Introduction to Microsystem Technology (4 cr)
EE 5173—Basic Microelectronics Laboratory (1 cr)
EE 5327—VLSI Design Laboratory (3 cr)
EE 5545—Digital Signal Processing Design (3 cr)
EE 5613—RF/Microwave Circuit Design Laboratory (2 cr)
EE 5622—Physical Optics Laboratory (1 cr)
EE 5628—Fiber Optics Laboratory (1 cr)
EE 5811—Biomedical Instrumentation (3 cr)
Take 0 or more course(s) from the following:
CSCI 4xxx
CSCI 5xxx
EE 4xxx
EE 5xxx

Program Sub-Plans
A sub-plan is not required for this program.

EIP Sub-Plan
Internship/Cooperative Learning
Take EE 3961 (1 credit) and then EE 4961 (2 credits), with the possibility of a third course, EE 4962 (2 credits).
EE 3961 and EE 4961 are also listed in Senior Electives and may not be used to satisfy both requirements.

Internship
EE 3961—Industrial Assignment I (1 cr)
EE 4961—Industrial Assignment II (2 cr)
Computer Science Emphases (Technical Electives)

17 credits of approved 4xxx and 5xxx electives that form a coherent academic program in an area of computer science or its applications; it must include at least 9 credits of computer science electives and no more than 3 credits from CSCI 59xx or CSCI 4970 or outside independent study. The emphases listed below represent possible options; students should consult with their adviser before choosing their technical electives.

Students are required to complete one of the following course groups.

**Computer Architecture**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 4203—Computer Architecture (4 cr)
CSCI 5204—Advanced Computer Architecture (3 cr)
CSCI 5283—Computer-Aided Design I (3 cr)

**Artificial Intelligence**
*Take 17 or more credit(s) from the following:*

CSCI 5511—Artificial Intelligence I (3 cr)
CSCI 5512W—Artificial Intelligence II, WI (3 cr)
CSCI 5521—Pattern Recognition (3 cr)
CSCI 5551—Introduction to Intelligent Robotic Systems (3 cr)
CSCI 5561—Computer Vision (3 cr)
PSY 5031W—Perception, WI (3 cr)
PSY 5038W—Introduction to Neural Networks, WI (3 cr)

**Hardware**
*Take 17 or more credit(s) from the following:*
CSCI 4203—Computer Architecture (4 cr)
CSCI 4211—Introduction to Computer Networks (3 cr)
CSCI 5204—Advanced Computer Architecture (3 cr)
CSCI 5283—Computer-Aided Design I (3 cr)
EE 4341—Microprocessor and Microcontroller System Design (4 cr)

**Computational Biology**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 5481—Computational Techniques for Genomics (3 cr)

**Databases**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 4707—Practice of Database Systems (3 cr)
CSCI 5708—Architecture and Implementation of Database Management Systems (3 cr)
CSCI 5421—Advanced Algorithms and Data Structures (3 cr)

**Graphics**
*Take 17 or more credit(s) from the following:*
CSCI 4707—Practice of Database Systems (3 cr)
CSCI 5707—Principles of Database Systems (3 cr)
CSCI 5108—Fundamentals of Computer Graphics II (3 cr)
CSCI 5109—Visualization (3 cr)
CSCI 5115—User Interface Design, Implementation and Evaluation (3 cr)
CSCI 5116—GUI Toolkits and Their Implementation (3 cr)
PSY 5031W—Perception, WI (3 cr)

**Management of Information Systems**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 4707—Practice of Database Systems (3 cr)
CSCI 5708—Architecture and Implementation of Database Management Systems (3 cr)
IDSC 4441—Electronic Commerce (2 cr)

**Network Security**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 4211—Introduction to Computer Networks (3 cr)
CSCI 5103—Operating Systems (3 cr)
CSCI 5471—Modern Cryptography (3 cr)
MATH 5248—Cryptology and Number Theory (4 cr)

**Networking**
*Take 17 or more credit(s) from the following:*
CSCI 4211—Introduction to Computer Networks (3 cr)
EE 5505—Wireless Communication (3 cr)
INET 4011—Network Administration (4 cr)
INET 4021—Network Programming (4 cr)
INET 4041—Emerging Network Technologies and Applications (3 cr)

**Programming**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 4131—Internet Programming (3 cr)
CSCI 5106—Programming Languages (3 cr)
CSCI 5801—Software Engineering I (3 cr)

**Software Engineering**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 5801—Software Engineering I (3 cr)
CSCI 5802—Software Engineering II (3 cr)
CSCI 5106—Programming Languages (3 cr)

**Theoretical Chemistry**
Consult your adviser for additional courses to meet the 17-credit requirement.
Take 4 or more course(s) from the following:
CSCI 5421—Advanced Algorithms and Data Structures (3 cr)
CSCI 5403—Computational Complexity (3 cr)
CSCI 5451—Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3 cr)
CSCI 5481—Computational Techniques for Genomics (3 cr)
MATH 4707—Introduction to Combinatorics and Graph Theory (4 cr)

**User Interfaces**
Consult your adviser for additional courses to meet the 17-credit requirement.
CSCI 5115—User Interface Design, Implementation and Evaluation (3 cr)
CSCI 5116—GUI Toolkits and Their Implementation (3 cr)
PSY 5031W—Psychology of Human-Machine Interaction, WI (3 cr)
KIN 5001—Foundations of Human Factors/Ergonomics (3 cr)

**Electrical Engineering B.E.E.**

**Electrical and Computer Engineering**
• Required credits to graduate with this degree: 128.
• Required credits within the major: 103.

The mission of the electrical engineering program is to educate students in the core topics as well as in a broad set of specialties of electrical engineering, to impart students with professional attributes that characterize a well-schooled engineer and citizen, and to provide students with opportunities for research experience in one of the leading electrical engineering centers of scholarship.

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.

**Admission Requirements**

Students must complete 9 courses before admission to the program.

Freshmen and transfer students are usually admitted to pre-major status before admission to this major.

A GPA above 2.00 is preferred for the following:

- 2.30 for students already admitted to the degree-granting college.
- 2.30 for students transferring from another University of Minnesota college.
- 2.80 for students transferring from outside the University.

Students interested in pursuing a degree in computer engineering or electrical engineering are encouraged to take EE 1001 in their first year.

For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

**Mathematics**

Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.

MATH 1271—Calculus I, MATH (4 cr)
- or MATH 1371—IT Calculus I, MATH (4 cr)
- or MATH 1272—Calculus II (4 cr)
- or MATH 1372—IT Calculus II (4 cr)
- MATH 2243—Linear Algebra and Differential Equations (4 cr)
- or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
- MATH 2263—Multivariable Calculus (4 cr)
- or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

**Physical Sciences**

CHEM 1021—Chemical Principles I, ENVT, PHYS SCI/L (4 cr)
- or CHEM 1031H—Honors Chemistry I, ENVT, PHYS SCI/L, H (4 cr)
- CHEM 1022—Chemical Principles II, ENVT, PHYS SCI/L (4 cr)
- or CHEM 1032H—Honors Chemistry II, ENVT, PHYS SCI/L, H (4 cr)
- or PHYS 2303—Physics III: Physics of Matter (4 cr)
- or PHYS 2311—Modern Physics (4 cr)
- or PHYS 2403H—Honors Phys III, H (4 cr)
- PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
- or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
- PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
- or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

**Preparatory Courses**

EE 2011—Introduction to Electronic and Electrical Circuits (3 cr)
EE 2012—Introductory Circuits and Electronics Laboratory (1 cr)
EE 2011—Linear Systems and Circuits (3 cr)
EE 1301—Introduction to Computing Systems (4 cr)

Take all of the following in the same term:

EE 301—Introduction to Digital System Design: Discussion (0 cr)
EE 2301—Introduction to Digital System Design (4 cr)

Take all of the following in the same term:

EE 361—Introduction to Microcontrollers: Discussion (0 cr)
EE 2361—Introduction to Microcontrollers (4 cr)

**Program Requirements**

**Major Courses**

EE 3015—Signals and Systems (3 cr)
EE 3025—Statistical Methods in Electrical and Computer Engineering (3 cr)
EE 3101—Circuits and Electronics Laboratory I (2 cr)
EE 3102—Circuits and Electronics Laboratory II (2 cr)

EE 3115—Analog and Digital Electronics (4 cr)
EE 3161—Semiconductor Devices (3 cr)
EE 3601—Transmission Lines, Fields, and Waves (3 cr)

**Technical Program Breadth and Depth Requirement**

At least 22 credits must be taken from EE 4xxx or 5xxx courses; remaining 12 credits may be taken from an approved list of technical electives from other departments.

Note: 5xxx courses may be taken by undergraduates with a 3.20 GPA or with permission.

A total of three courses having a lab component are required.

Students must take at least 1 course from four different core areas (12-16 credits), and must take a minimum of 2 courses from one area (6-8 credits).

**Take 34 or more credit(s) including 4 or more subrequirement(s) from the following:**

**Senior Design**

Each of these courses counts as one lab course.
EE 4951W—Senior Design Project, WI (4 cr)
or EE 4981H—Senior Honors Project I, H (2 cr)
EE 4982V—Senior Honors Project II, WI, H (2 cr)

**Communications, Signal Processing, and Biomedical**

**Take 0 or more course(s) from the following:**

EE 4541—Digital Signal Processing (3 cr)
EE 4501—Communications Systems (3 cr)
EE 5501—Digital Communication (3 cr)
EE 5505—Wireless Communication (3 cr)
EE 5531—Probability and Stochastic Processes (3 cr)
EE 5542—Adaptive Digital Signal Processing (3 cr)
EE 5551—Multiscale and Multivariate Signal Processing (3 cr)
EE 5561—Image Processing and Applications (3 cr)
EE 5581—Information Theory and Coding (3 cr)
EE 5583—Error Control Coding (3 cr)
EE 5585—Data Compression (3 cr)
EE 5821—Biological System Modeling and Analysis (3 cr)

**Laboratory courses**

**Take 0 or more course(s) from the following:**

EE 4505—Communications Systems Laboratory (1 cr)
EE 5545—Digital Signal Processing Design (3 cr)
EE 5811—Biomedical Instrumentation (3 cr)

**Controls**

**Take 0 or more course(s) from the following:**

EE 4231—Linear Control Systems: Designed by Input/Output Methods (3 cr)
EE 4233—State Space Control System Design (3 cr)
EE 5231—Linear Systems and Optimal Control (3 cr)
EE 5235—Robust Control System Design (3 cr)
EE 5239—Introduction to Nonlinear and Optimization (3 cr)

**Laboratory Courses**

**Take 0 or more course(s) from the following:**

EE 4235—Linear Control Systems Laboratory (1 cr)
EE 4237—State Space Control Laboratory (1 cr)

**Digital Systems and Computer Architecture**

**Take 0 or more course(s) from the following:**

EE 4609—Digital Signal Integrity (3 cr)
EE 4363—Computer Architecture and Machine Organization (4 cr)
EE 4389W—Introduction to Empirical Inference and Soft Computing, WI (3 cr)
EE 5364—Advanced Computer Architecture (3 cr)
EE 5371—Computer Systems Performance Measurement and Evaluation (3 cr)

**Laboratory Courses**

**Take 0 or more course(s) from the following:**

EE 4341—Microprocessor and Microcontroller System Design (4 cr)
EE 4301—Digital Design With Programmable Logic (4 cr)

For the most up-to-date listing of program requirements, visit the [Online Catalog](http://www.catalogs.umn.edu/programs.html) at www.catalogs.umn.edu.
VLSI and CAD
Take 0 or more course(s) from the following:
- EE 5301—VLSI Design Automation I (3 cr)
- EE 5302—VLSI Design Automation II (3 cr)
- EE 5323—VLSI Design I (3 cr)
- EE 5324—VLSI Design II (3 cr)
- EE 5329—VLSI Digital Signal Processing Systems (3 cr)
- EE 5333—Analog Integrated Circuit Design (3 cr)

Laboratory Courses
Take 0 or more course(s) from the following:
- EE 5121—Transistor Device Modeling for Circuit Simulation (3 cr)
- EE 5163—Semiconductor Properties and Devices I (3 cr)
- EE 5164—Semiconductor Properties and Devices II (3 cr)
- EE 5171—Microelectronic Fabrication (4 cr)

Power and Energy
Take 0 or more course(s) from the following:
- EE 4701—Electric Drives (3 cr)
- EE 4721—Introduction to Power System Analysis (3 cr)
- EE 4724—Power System Planning and Operation (3 cr)
- EE 4741—Power Electronics (3 cr)
- EE 5705—Advanced Electric Drives (3 cr)
- EE 5721—Power Generation Operation and Control (3 cr)
- EE 5725—Power Systems Engineering (3 cr)
- EE 5741—Advanced Power Electronics (3 cr)

Laboratory Courses
Take 0 or more course(s) from the following:
- EE 4703—Electric Drives Laboratory (1 cr)
- EE 4722—Power System Analysis Laboratory (1 cr)
- EE 4743—Switch-Mode Power Electronics Laboratory (1 cr)

Magnetics, Optics, and RF
Take 0 or more course(s) from the following:
- EE 4607—Wireless Hardware System Design (3 cr)
- EE 5601—Introduction to RF/Microwave Engineering (3 cr)
- EE 5602—RF/Microwave Circuit Design (3 cr)
- EE 5616—Antenna Theory and Design (3 cr)
- EE 5621—Physical Optics (3 cr)
- EE 5624—Optical Electronics (4 cr)
- EE 5627—Optical Fiber Communication (3 cr)
- EE 5629—Optical System Design (2 cr)
- EE 5653—Physical Principles of Magnetic Materials (3 cr)
- EE 5655—Magnetic Recording (3 cr)

Laboratory Courses
Take 0 or more course(s) from the following:
- EE 5613—RF/Microwave Circuit Design Laboratory (2 cr)
- EE 5622—Physical Optics Laboratory (1 cr)
- EE 5628—Fiber Optics Laboratory (1 cr)

Program Sub-Plans
A sub-plan is not required for this program.

EIP Sub-Plan
Internship/Cooperative learning program.
Take EE 3961 (1 cr) and then EE 4961 (2 cr), with the possibility of a third course, EE 4962 (2 cr).
EE 3961 and EE 4961 are also listed in Senior Electives and may not be used to fulfill both requirements simultaneously.

Note: Programs listed in this catalog are current as of March 2008.
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

**Program Requirements**

**Geology**
GEO 2301—Mineralogy (3 cr)
GEO 2302—Petrology (3 cr)
GEO 3890—Field Workshop (1 cr)
GEO 4501—Structural Geology (3 cr)
GEO 1001—Earth and Its Environments, ENV, PHYS SCI/L (4 cr)
or GEO 2201—Geodynamics I: The Solid Earth (3 cr)
GEO 3911—Introductory Field Geology (4 cr)
or GEO 4917W—Field Hydrogeology, WI (4 cr)
GEO 4203—Principles of Geophysical Exploration (3 cr)
or GEO 4211—Solid Earth Geophysics I (3 cr)
GEO 4602—Sedimentology and Stratigraphy (3 cr)
or GEO 4701—Geomorphology (3.0-4 cr)
or GEO 4703—Glacial Geology (4 cr)

**Engineering**
CE 3101—Computer Applications in Civil Engineering I (3 cr)
CE 3502—Fluid Mechanics (4 cr)
GEOE 4102W—Capstone Design, WI (4 cr)
GEOE 4351—Groundwater Mechanics (3 cr)
CE 4101W—Project Management, WI (3 cr)
CE 3102—Uncertainty and Decision Analysis in Civil Engineering (3 cr)
CE 3501—Environmental Engineering, CPE, ENV (3 cr)
CE 3301—Soil Mechanics I (3 cr)
or GEOE 3301—Soil Mechanics I (3 cr)
or GEOE 3302—Soil Mechanics II (3 cr)
CE 4311—Rock Mechanics (4 cr)
or GEOE 4311—Rock Mechanics (4 cr)

**Dynamics or Organic Chemistry**
AEM 2012—Dynamics (3 cr)
or CHEM 2301—Organic Chemistry I (3 cr)

**Geological Engineering Options**
Take 10 or more credits of technical electives, which typically will have a geoenvironmental emphasis or a geomechanics emphasis.

**Geoenvironmental**
Focuses on soil and groundwater contamination, modeling, and remediation; solid and hazardous waste characterization, management, and disposal; and groundwater resources management and exploitation.
Typical courses would be chosen from:
*Take 0 or more course(s) from the following:*
CE 4352—Groundwater Modeling (3 cr)
CE 4501—Hydrologic Design (4 cr)
CE 4502—Water and Wastewater Treatment (3 cr)
CE 4531—Environmental Process Engineering (3 cr)
CE 4561—Solid Hazardous Wastes (3 cr)
CE 4562—Environmental Remediation Technology (3 cr)
CE 4591—Environmental Law for Engineers (3 cr)
CE 5541—Environmental Water Chemistry (3 cr)
GE 4401—Aquifer Environmental Geochemistry (3 cr)
GEO 4402—Biogeochemical Cycles in the Ocean (3 cr)
GEO 5108—Principles of Environmental Geology (3 cr)
GEO 5701—General Hydrogeology (3 cr)

**Geomechanics**
Focuses on foundations for buildings, bridges, roads, and dams; analysis and design of surface and subsurface excavations; and evaluation of natural geologic hazards.
Typical courses would be chosen from:
*Take 0 or more course(s) from the following:*
CE 2201—Geomechanics (3 cr)
CE 3401—Linear Structural Analysis (3 cr)
CE 3402—Construction Materials (3 cr)
CE 4111—Engineering Systems Analysis (3 cr)
CE 4121—Computer Applications in Civil Engineering II (3 cr)
CE 4231—Principles of Pavement Design (3 cr)
CE 4252—Cemented Materials (3 cr)
CE 4401—Steel and Reinforced Concrete Design (4 cr)
CE 4412—Reinforced Concrete Design II (3 cr)
CE 4415—Steel Design II (3 cr)
CE 5311—Experimental Geomechanics (3 cr)
CE 5321—Geomechanics (3 cr)

**Geology B.S.Geol.**

Geology and Geophysics
- Required credits to graduate with this degree: 120.
- Required credits within the major: 52.
This program requires summer terms.

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 state governments; and research institutions.

For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

**Mathematics**
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)

Multivariable Calculus may be substituted.
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2235—IT Linear Algebra and Differential Equations (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

**Physical Sciences**
CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)

One course of Physics I and one course of Physics II must be complete before admission to upper division.

PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
Institute of Technology

PHYS 1302W—Introduction to Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

**Program Requirements**

**Major Courses**
- GEO 2201—Geodynamics I: The Solid Earth (3 cr)
- GEO 2301—Mineralogy (3 cr)
- GEO 2302—Petroleum (3 cr)
- GEO 2303W—Geochronological Principles, WI (3 cr)
- GEO 3202—Geodynamics II: The Fluid Earth (3 cr)
- GEO 3401—Geochronology and Earth History (3 cr)
- GEO 3911—Introductory Field Geology (4 cr)
- GEO 4501—Structural Geology (3 cr)
- GEO 4602—Sedimentology and Stratigraphy (3 cr)
- GEO 4631W—Earth Systems: Geosphere/Biosphere Interactions, WI (3 cr)

**Workshops and Advanced Fieldwork**
Take one course in advanced field geology during the summer after the junior year.
*Take 2 or more course(s) from the following:*
- GEO 3870—Modeling Workshop (1 cr)
- GEO 3880—Laboratory Workshop (1 cr)
- GEO 3890—Field Workshop (1 cr)
- GEO 3911—Advanced Field Geology (4 cr)
or GEO 4971W—Field Hydrogeology, WI (4 cr)

**Electives**
Take at least 12 additional credits of geology during the junior and senior years, with no more than 4 credits from 1xxx and 3 credits from 2xxx.
*Take 12 or more credit(s) from the following:*
- GEO 1xxx
- GEO 2xxx
- GEO 3xxx
- GEO 4xxx
- GEO 5xxx

**Technical Electives**
Take 8 credits of additional elective courses in physical and natural sciences or mathematics, chosen in consultation with an adviser.

**Geophysics B.S.**

**Geology and Geophysics**
- Required credits to graduate with this degree: 120.
- Required credits within the major: 52.

This program requires summer terms.

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**
Students must complete 11 courses before admission to the program.

A GPA above 2.00 is preferred for the following:
- 2.50 for students transferring from outside the University.

Students interested in a geophysics major may want to consider taking Geology 1001, which can be counted as a geology elective.

For information about the University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

**Mathematics**
- MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
- MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
- MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
- MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

**Physical Sciences**
- CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
- CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
- PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
- PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)
- PHYS 2303—Physics III: Physics of Matter (4 cr)

**Program Requirements**

**Major Courses**
- GEO 2201—Geodynamics I: The Solid Earth (3 cr)
- GEO 2301—Mineralogy (3 cr)
- GEO 2302—Petroleum (3 cr)
- GEO 2303W—Geochronological Principles, WI (3 cr)
- GEO 3202—Geodynamics II: The Fluid Earth (3 cr)
- GEO 3401—Geochronology and Earth History (3 cr)
- GEO 3911—Introductory Field Geology (4 cr)
- GEO 4501—Structural Geology (3 cr)
- GEO 4911—Advanced Field Geology (4 cr)
or GEO 4971W—Field Hydrogeology, WI (4 cr)

*Take 2 or more course(s) from the following:*
- GEO 3870—Modeling Workshop (1 cr)
- GEO 3880—Laboratory Workshop (1 cr)
- GEO 3890—Field Workshop (1 cr)
- GEO 3911—Advanced Field Geology (4 cr)
or GEO 4971W—Field Hydrogeology, WI (4 cr)

*Take 9 or more credit(s) from the following:*
- GEO 4203—Principles of Geophysical Exploration (3 cr)
- GEO 4204—Geomagnetism and Paleomagnetism (3 cr)
- GEO 4205—Solid Earth Geophysics I (3 cr)
- GEO 4206—Solid Earth Geophysics II (3 cr)
- GEO 4211—Solid Earth Geophysics I (3 cr)
- GEO 4212—Solid Earth Geophysics II (3 cr)
- GEO 4220—Geodynamics I: The Solid Earth (3 cr)
- GEO 4221—Geodynamics II: The Fluid Earth (3 cr)
- GEO 4251—Geophysical Fluid Dynamics (3 cr)
- GEO 4301—Geodynamics I: The Solid Earth (3 cr)
- GEO 4302—Geodynamics II: The Fluid Earth (3 cr)
- GEO 4401—Structural Geology (3 cr)
- GEO 4402—Structural Geology (3 cr)
- GEO 4411—Advanced Field Geology (4 cr)
or GEO 4971W—Field Hydrogeology, WI (4 cr)

*Take 9 additional credits of GEO courses, with no more than 4 credits of 1xxx and 3 credits of 2xxx.*

*Take 9 or more credit(s) from the following:*
- GEO 1xxx
- GEO 2xxx
- GEO 3xxx
- GEO 4xxx
- GEO 5xxx

**Note:** Programs listed in this catalog are current as of March 2008.
Technical Electives
Take 9 additional credits of math or science approved by adviser.

Information Technology Minor
Computer Science and Engineering
• Required credits in this minor: 16.

This interdisciplinary minor requires at least 14 credits, including two core courses from the Institute of Technology and three breadth courses from the Colleges of Human Ecology, Liberal Arts, or Architecture and Landscape Architecture. The minor enables students in nontechnical disciplines to supplement their major with a practical set of courses focused on information technology.

Required Courses for the Minor
Take 2 or more course(s) from the following:
CSCI 1103—Introduction to Computer Programming in Java (4 cr)
CSCI 1121—Introduction to the Internet 1 (4 cr)

Breadth Courses
Note: DHA 2334 is a prerequisite for more advanced graphic design courses; although these courses are limited to graphic design majors, admission can be obtained through permission of the instructor.
Take 3 or more course(s) from the following:
COMM 3201—Introduction to Electronic Media Production (4 cr)
COMM 3211—Introduction to U.S. Electronic Media (3 cr)
COMM 4231—Comparing Electronic Media Systems, IP (3 cr)
COMM 4235—Electronic Media and Ethnic Minorities—A World View, IP (3 cr)
COMM 4291—New Telecommunication Media (3 cr)
DHA 2334—Computer Applications I: Digital Composition for Design (3 cr)
DHA 4334—Computer Applications II: Design for the Digital Environment (3 cr)
DHA 5382—Digital Sound and Video (3 cr)
DHA 5383—Digital Illustration and Animation (4 cr)
GEOG 3561—Principles of Geographic Information Science (4 cr)
GEOG 5563—Advanced Geographic Information Science (3 cr)
GEOG 5564—Urban Geographic Information Science and Analysis (3 cr)
JOUR 3764—History of Media Communication, HP (3 cr)
JOUR 3776—Mass Communication Law (3 cr)

Materials Science and Engineering B.Mat.S.E.
Chemical Engineering and Materials Science
• Required credits to graduate with this degree: 128.
• Required credits within the major: 38.

The 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.

The Materials Science and Engineering (MSE) program is designed to prepare students to achieve the following career and professional accomplishments after graduation:
• Be employed as a materials engineer or a related engineering or science position, using and developing his or her skills based on the demands of the job.
• Enter into a graduate or professional program, applying his or her knowledge and experience toward an advanced or professional degree.
• Be an effective team member, using and developing communication and teamwork skills.
• Be a responsible engineer/scientist or professional, demonstrating ethical and professional responsibility and continuing to learn through formal and informal educational experiences.

Admission Requirements
Students must complete 11 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
• 2.80 for students transferring from outside the University.
Students interested in materials science and engineering are recommended to take MATS 1001/CHEN 1001 to learn more about the field.

For information about University of Minnesota admission requirements, visit http://admissions.tc.umn.edu

Mathematics
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Sciences
AEM 2011—Statics (3 cr)
CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
CHEM 2301—Organic Chemistry I (3 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1301V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1302V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)
PHYS 2305—Physics III: Physics of Matter (4 cr)
or PHYS 2403H—Honors Physics III, H (4 cr)

Program Requirements
Major Courses
AEM 3031—Deformable Body Mechanics (3 cr)
AEM 4511—Mechanics of Composite Materials (3 cr)
CE 3101—Computer Applications in Civil Engineering I (3 cr)
MATS 3011—Introduction to Materials Science and Engineering (3 cr)
MATS 3012—Metals and Alloys, WI (3 cr)
MATS 3801—Structural Characterization Lab (3 cr)
MATS 3851W—Materials Properties Lab, WI (3 cr)
MATS 4001—Thermodynamics of Materials (4 cr)
MATS 4002—Mass Transport and Kinetics (4 cr)
MATS 4013—Electrical and Magnetic Properties of Materials (3 cr)
MATS 4212—Ceramics (3 cr)
MATS 4214—Polymers (3 cr)
MATS 4221—Materials Design and Performance (4 cr)
MATS 4301W—Materials Processing, WI (4 cr)
MATS 4400—Senior Design Project (3 cr)

For the most up-to-date listing of program requirements, visit the Online Catalog at www.catalogs.umn.edu/programs.html.
Technical Electives
Students must take 13 credits of technical electives. See an adviser for a list of possible courses.

Mathematics B.S. Math.
School of Mathematics
• Required credits to graduate with this degree: 120.
• Required credits within the major: 56.

The mission of the program is to provide high-quality mathematics instruction in a stimulating intellectual atmosphere. The goal is to educate students at all levels to provide cultural enrichment, to give them the analytic tools they need to become responsible citizens, and to prepare them for careers involving mathematics.

The School of Mathematics offers a program leading to the bachelor of science degree. The course of study is flexible and may be adapted to satisfy a wide variety of interests and needs. Students may prepare for graduate study in mathematics or emphasize various fields of interest, such as preparation for secondary school teaching, actuarial science, or programs in applied mathematics, including industrial mathematics, biology, mathematics applicable to computer science, and numerical analysis. Programs for specializations in actuarial science, preparation for teaching in the secondary school, and mathematics applicable to computer science earn a designation that appears on the diploma.

Admission Requirements
Students must complete 4 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2237—IT Linear Algebra and Differential Equations (4 cr)
MATH 2265—Multivariable Calculus (4 cr)
or MATH 2234—IT Multivariable Calculus and Vector Analysis (4 cr)
MATH 2283—Sequences, Series, and Foundations (3 cr)
or MATH 3283W—Sequences, Series, and Foundations: Writing Intensive, WI (4 cr)

Physics
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401W—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or PHYS 1402W—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Program Requirements
Students must complete eight upper division math courses at 4xxx or above and two technical elective courses, which can be mathematics courses.
The School of Mathematics will accept STAT 5101 and 5102 as part of the eight-course upper division mathematics requirement. The content of STAT 5101 is the same as MATH 5651. 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.
MATH 4512 may not be used to satisfy part of the eight course upper division math requirement, though it may be used as technical elective. MATH 3113, 3116, 3118, 4113, 4116, 4118, 3283W, and 4005 may not be used to satisfy part of the eight-course upper division math requirement or as technical electives.

In addition to the specializations described below, students who wish to pursue a pure mathematics track or are planning to go to graduate school in mathematics should consult their adviser about appropriate course choices.

Specializations in Mathematics
Students are required to complete one of the following course groups.

Mathematics (No Specialization)
Students who do not choose one of the specializations complete the basic requirements listed here. For the technical electives requirement, students must take at least 6 credits from courses that meet the following criteria: prerequisite of calculus; 3xxx or higher; courses form a coherent part of the student’s program.

Algebra Sequence
Take 2 or more course(s) from the following:
Take 1 or more course(s) from the following:
MATH 4281—Introduction to Modern Algebra (4 cr)
MATH 5248—Cryptology and Number Theory (4 cr)
MATH 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves (4 cr)
MATH 5285H—Honors: Fundamental Structures of Algebra I, H (4 cr)
MATH 5286H—Honors: Fundamental Structures of Algebra II, H (4 cr)
MATH 5385—Introduction to Computational Algebraic Geometry (4 cr)

Take 0 or more course(s) from the following:
MATH 4242—Applied Linear Algebra (4 cr)
MATH 5705—Enumerative Combinatorics (4 cr)
MATH 5707—Graph Theory and Non-Enumerative Combinatorics (4 cr)
MATH 5711—Linear Programming and Combinatorial Optimization (4 cr)
MATH 5485—Introduction to Numerical Methods I (4 cr)

Analysis Sequence
Depending on specialization chosen, choice of analysis courses may be restricted.
Take 2 or more course(s) from the following:
Take 1 or more course(s) from the following:
MATH 4606—Advanced Calculus (4 cr)
MATH 5486—Introduction To Numerical Methods II (4 cr)
MATH 5525—Introduction to Ordinary Differential Equations (4 cr)
MATH 5535—Dynamical Systems and Chaos (4 cr)
MATH 5583—Complex Analysis (4 cr)
MATH 5587—Elementary Partial Differential Equations I (4 cr)
MATH 5588—Elementary Partial Differential Equations II (4 cr)
MATH 5652—Introduction to Stochastic Processes (4 cr)
MATH 5654—Prediction and Filtering (4 cr)
MATH 5615H—Honors: Introduction to Analysis I, H (4 cr)
MATH 5616H—Honors: Introduction to Analysis II, H (4 cr)
MATH 5651—Basic Theory of Probability and Statistics (4 cr)
or STAT 5101—Theory of Statistics I (4 cr)

Computer Science Requirement
CSCI 1103—Introduction to Computer Programming in Java (4 cr)
or CSCI 1107—Introduction to FORTRAN Programming for Scientists and Engineers (3 cr)
or CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
or CSCI 1901—Structure of Computer Programming I (4 cr)
or CSCI 1901—Structure of Computer Programming II (4 cr)
and CSCI 1902—Structure of Computer Programming II (4 cr)

Note: Programs listed in this catalog are current as of March 2008.
Third-Semester Physics  
PHYS 2303—Physics III: Physics of Matter (4 cr)  
or  
PHYS 2311—Modern Physics (4 cr)  
or  
PHYS 2503—Physics III: Foundations of Modern Physics (4 cr)  
Complete 6 credits of technical electives selected in consultation with your adviser.  

-OR-  
Mathematical Biology Specialization  
Students select one of three options: environmental science, genomics, or physiology. Consult an adviser for more information.  
MATH 4428—Mathematical Modeling (4 cr)  

Algebra Requirement  
MATH 4242—Applied Linear Algebra (4 cr)  
Take 1 or more course(s) from the following:  
MATH 4281—Introduction to Modern Algebra (4 cr)  
MATH 5248—Cryptography and Number Theory (4 cr)  
MATH 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves (4 cr)  
MATH 5285H—Honors: Fundamental Structures of Algebra I, H (4 cr)  
MATH 5286H—Honors: Fundamental Structures of Algebra II, H (4 cr)  
MATH 5385—Introduction to Computational Algebraic Geometry (4 cr)  

Introductory Biology Requirements  
BIOL 1099—General Biology, BIOL SCI/L (4 cr)  
or  
BIOL 1001—Introductory Biology I: Evolutionary and Ecological Perspectives, BIOL SCI/L, ENVY (4 cr)  

Computer Science Requirement  
CSCI 1103—Introduction to Computer Programming in Java (4 cr)  
or  
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)  
or  
CSCI 1107—Introduction to FORTRAN Programming for Scientists and Engineers (3 cr)  
or  
CSCI 1901—Structure of Computer Programming I (4 cr)  
or  
CSCI 1902—Structure of Computer Programming II (4 cr)  
or  
CSCI 2011—Discrete Structures of Computer Science (4 cr)  

Analysis Requirement  
MATH 5525—Introduction to Ordinary Differential Equations (4 cr)  
MATH 5535—Dynamical Systems and Chaos (4 cr)  
MATH 5651—Basic Theory of Probability and Statistics (4 cr)  
Senior seminar (1 credit)  
Complete an approved research internship for at least four credits.  
Complete the requirements for the environmental science or genomics or physiology option. See your adviser for specifics.  

-OR-  
Actuarial Specialization  
Complete the requirements for the actuarial sub-plan.  

-OR-  
Mathematics Education Specialization  
Complete the requirements for the mathematics education sub-plan.  

-OR-  
Computer Applications Specialization  
Complete the requirements for the computer applications sub-plan.  

Program Sub-Plans  
A sub-plan is not required for this program.  

Actuarial Science Sub-Plan  
Students should take 8 courses of mathematics or statistics and math electives in economics, accounting, insurance, and finance. For the computer science requirement, only 1103 or 1113 should be chosen.  

Math and Computer Science  
These courses fulfill the analysis course requirement and one of the algebra course requirements.  
MATH 4065—Theory of Interest (3 cr)  
MATH 5067—Actuarial Mathematics I (4 cr)  
MATH 5068—Actuarial Mathematics II (4 cr)  

Algebra Requirement  
MATH 4242—Applied Linear Algebra (4 cr)  

Group A Algebra  
Take 1 or more course(s) from the following:  
MATH 4281—Introduction to Modern Algebra (4 cr)  
MATH 5248—Cryptography and Number Theory (4 cr)  
MATH 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves (4 cr)  
MATH 5285H—Honors: Fundamental Structures of Algebra I, H (4 cr)  
MATH 5286H—Honors: Fundamental Structures of Algebra II, H (4 cr)  
MATH 5385—Introduction to Computational Algebraic Geometry (4 cr)  

Group B Algebra  
Take 0 or more course(s) from the following:  
MATH 5707—Graph Theory and Non-Enumerative Combinatorics (4 cr)  
MATH 5711—Linear Programming and Combinatorial Optimization (4 cr)  
MATH 5485—Introduction to Numerical Methods I (4 cr)  

Computer Science Requirement  
CSCI 1103—Introduction to Computer Programming in Java (4 cr)  
or  
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)  

Analysis Requirement (Statistics)  
MATH 5651—Basic Theory of Probability and Statistics (4 cr)  
or  
STAT 5101—Theory of Statistics I (4 cr)  
MATH 5652—Introduction to Stochastic Processes (4 cr)  
or  
STAT 5102—Theory of Statistics II (4 cr)  

Economics and Business  
ECON 1101—Principles of Microeconomics, IP, SSCI (4 cr)  
and  
ECON 1102—Principles of Macroeconomics, IP, SSCI (4 cr)  

-OR-  
ECON 1104—Principles of Microeconomics, IP, SSCI (4 cr)  
and  
ECON 1105—Principles of Macroeconomics, IP, SSCI (4 cr)  
ACCT 2050—Introduction to Financial Reporting (4 cr)  
ECON 3101—Intermediate Microeconomics (4 cr)  
FINA 3401—Finance Fundamentals (3 cr)  
ECON 4751—Financial Economics (3 cr)  
or  
FINA 4241—Corporate Financing Decisions (4 cr)  
Take 2 or more course(s) from the following:  
INS 4200—Insurance Theory and Practice (2 cr)  
INS 4201—Employee Benefits (2 cr)  
INS 4200—Insurance Theory and Practice (2 cr)  

Computer Applications Sub-Plan  
Take at least 24 credits of math/computer science courses relating to computer applications. Students who complete the computer application emphasis also satisfy the requirements for a minor in computer science.  
MATH 5486 may be used toward the analysis distribution requirement and MATH 5485 toward the algebra requirement.  

Computer Applications  
MATH 5486 may be used toward the analysis distribution requirement and MATH 5485 toward the algebra requirement.  
CSCI 2011—Discrete Structures of Computer Science (4 cr)  
MATH 5165—Mathematical Logic I (4 cr)  
MATH 5485—Introduction to Numerical Methods I (4 cr)  
MATH 5486—Introduction To Numerical Methods II (4 cr)  
CSCI 1103—Introduction to Computer Programming in Java (4 cr)  
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)  
or  
CSCI 1901—Structure of Computer Programming I (4 cr)  
CSCI 1902—Structure of Computer Programming II (4 cr)  

For the most up-to-date listing of program requirements, visit the ONLINE CATALOG at www.catalogs.umn.edu/programs.html.
**Additional Algebra**

*Take 1 or more course(s) from the following:*

- MATH 4281—Introduction to Modern Algebra (4 cr)
- MATH 5248—Cryptology and Number Theory (4 cr)
- MATH 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves (4 cr)
- MATH 5285—Honors: Fundamental Structures of Algebra I, H (4 cr)
- MATH 5286—Honors: Fundamental Structures of Algebra II, H (4 cr)
- MATH 5385—Introduction to Computational Algebraic Geometry (4 cr)

**Additional Analysis**

*Take 1 or more course(s) from the following:*

- MATH 4600—Advanced Calculus (4 cr)
- MATH 5525—Introduction to Ordinary Differential Equations (4 cr)
- MATH 5535—Dynamical Systems and Chaos (4 cr)
- MATH 5583—Complex Analysis (4 cr)
- MATH 5587—Elementary Partial Differential Equations I (4 cr)
- MATH 5588—Elementary Partial Differential Equations II (4 cr)
- MATH 5652—Introduction to Stochastic Processes (4 cr)
- MATH 5654—Prediction and Filtering (4 cr)
- MATH 5657—Honors: Introduction to Analysis I, H (4 cr)
- MATH 5616—Honors: Introduction to Analysis II, H (4 cr)
- MATH 5651—Basic Theory of Probability and Statistics (4 cr)
- or STAT 5101—Theory of Statistics I (4 cr)

**Additional Computing-Related Mathematics**

A course chosen from this group that also meets the algebra distribution requirement must be taken in addition to the two courses required for all majors.

- MATH 4242—Applied Linear Algebra (4 cr)
- or MATH 5166—Mathematical Logic II (4 cr)
- or MATH 5248—Cryptology and Number Theory (4 cr)
- or MATH 5251—Error-Correcting Codes, Finite Fields, Algebraic Curves (4 cr)
- or MATH 5285—Honors: Fundamental Structures of Algebra I, H (4 cr)
- or MATH 5286—Honors: Fundamental Structures of Algebra II, H (4 cr)
- or MATH 5385—Introduction to Computational Algebraic Geometry (4 cr)
- or MATH 5487—Computational Methods for Differential and Integral Equations in Engineering and Science I (4 cr)
- or MATH 5705—Enumerative Combinatorics (4 cr)
- or MATH 5707—Graph Theory and Non-Enumerative Combinatorics (4 cr)
- or MATH 5711—Linear Programming and Combinatorial Optimization (4 cr)

**Computer Science**

Upper level computer science courses may be counted as technical electives.

*Take 3 or more course(s) from the following:*

- CSCI 4041—Algorithms and Data Structures (4 cr)
- CSCI 5107—Fundamentals of Computer Graphics I (3 cr)
- CSCI 5108—Fundamentals of Computer Graphics II (3 cr)
- CSCI 5403—Computational Complexity (3 cr)
- CSCI 5421—Advanced Algorithms and Data Structures (3 cr)
- CSCI 5511—Artificial Intelligence I (3 cr)
- CSCI 5521—Pattern Recognition (3 cr)
- CSCI 8442—Computational Geometry and Applications (3 cr)
- CSCI 5520—Artificial Intelligence II, Wi (3 cr)
- or CSCI 5519—Artificial Intelligence II (non-WI) (3 cr)

**Physics**

A physics course from the following list should be taken in the third semester (fall semester of the second year).

- PHYS 2303—Physics III: Physics of Matter (4 cr)
- or PHYS 2311—Modern Physics (4 cr)
- or PHYS 2503—Physics III: Foundations of Modern Physics (4 cr)

**Mathematics Education Sub-Plan**

Preparation for teaching in secondary education.

Courses that are recommended but not required for this specialization include MATH 5652 Stochastic Processes or STAT 5102 Theory of Statistics II; and MATH 5336 Geometry II. IT majors can satisfy the technical elective requirement with courses in mathematics education. These may include two of MTHE 5011, MTHE 5021, and MTHE 5031, but the mathematics adviser should be consulted to approve the technical elective.

**Mathematics Education**

These courses fulfill both the algebra and analysis requirements.

- MATH 5335—Geometry I (4 cr)
- MATH 4242—Applied Linear Algebra (4 cr)
- or MATH 4281—Introduction to Modern Algebra (4 cr)
- or MATH 5285—Honors: Fundamental Structures of Algebra I, H (4 cr)
- or MATH 4707—Introduction to Combinatorics and Graph Theory (4 cr)
- or MATH 5705—Enumerative Combinatorics (4 cr)
- or MATH 5707—Graph Theory and Non-enumerative Combinatorics (4 cr)
- or MATH 5651—Basic Theory of Probability and Statistics (4 cr)
- or STAT 5101—Theory of Statistics I (4 cr)

**Computer Science**

- CSCL 1103—Introduction to Computer Programming in Java (4 cr)
- or CSCL 1107—Introduction to FORTRAN Programming for Scientists and Engineers (3 cr)
- or CSCL 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
- or CSCL 1901—Structure of Computer Programming I (4 cr)
- or CSCL 1901—Structure of Computer Programming II (4 cr)

**Physics**

Take one of the following physics courses in the third semester (fall semester of the second year).

- PHYS 2303—Physics III: Physics of Matter (4 cr)
- or PHYS 2311—Modern Physics (4 cr)
- or PHYS 2503—Physics III: Foundations of Modern Physics (4 cr)

**School Mathematics**

Consult an adviser before completing this requirement.

*Take 2 or more course(s) from the following:*

- MTHE 5011—Arithmetic Structures in School Mathematics (3 cr)
- MTHE 5021—Algebraic Structures in School Mathematics (3 cr)
- MTHE 5031—Geometric Structures in School Mathematics (3 cr)

**Mechanical Engineering**

**B.M.E.**

**Mechanical Engineering**

- Required credits to graduate with this degree: 128.
- Required credits within the major: 49.

This program requires summer terms.

The Department of Mechanical Engineering is committed to offering undergraduate and graduate education of the highest quality in mechanical and industrial engineering, to conducting significant basic and applied research in selected areas, and to providing professional service to the appropriate constituencies of a major land grant university.

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 machine/consumer products production. A mechanical engineer may be engaged in design, development, research, testing, manufacturing, administration, marketing, consulting, or education.
Degree Programs • Mechanical Engineering B.M.E.

Admission Requirements
Students must complete 9 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
• 2.50 for students already admitted to the degree-granting college.
• 2.50 for students transferring from another University of Minnesota college.
• 3.00 for students transferring from outside the University.
For information about University of Minnesota admission requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Mathematics
Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses,
MATH 1271—Calculus I, MATH (4 cr)
or MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Physical Sciences
CSCI 1111—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
CHEM 1021—Chemical Principles I, ENVT, PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENVT, PHYS SCI/L, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, W (4 cr)
or PHYS 1402V—Honors Physics II, PHYS SCI/L, W, H (4 cr)

Statics and Dynamics
AEM 2021—Statics and Dynamics (4 cr)
or take the following course pair
AEM 2011—Statics (3 cr)
AEM 2012—Dynamics (3 cr)

Program Requirements
Major Courses
AEM 3031—Deformable Body Mechanics (3 cr)
EE 3005—Fundamentals of Electrical Engineering (4 cr)
EE 3006—Fundamentals of Electrical Engineering Laboratory (1 cr)
IE 4521—Statistics, Quality, and Reliability (4 cr)
MATS 2001—Introduction to the Science of Engineering Materials (3 cr)
MATS 2002—Introduction to the Science of Engineering Materials Laboratory (1 cr)
ME 2011—Introduction to Engineering (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—System Dynamics and Control (4 cr)
ME 3331—Thermal Sciences I (3 cr)
ME 3332—Thermal Sciences II (3 cr)
ME 3333—Thermal Sciences III (3 cr)
ME 4031W—Basic Mechanical Measurements Laboratory, WI (4 cr)
ME 4054W—Design Projects, WI (4 cr)

Electives
ME 4131W—Thermal Environmental Engineering Laboratory, WI (4 cr)
or ME 4231—Motion Control Laboratory (4 cr)
or ME 4232—Fluid Power Control Lab (4 cr)
or ME 4331—Thermal Engineering Laboratory (4 cr)
or ME 4431W—Energy Conversion Systems Laboratory, WI (4 cr)
or ME 5133—Aerosol Measurement Laboratory (4 cr)

Technical Electives
Complete 16 credits of upper division technical electives, with at least 8 credits in ME/IE. Students may choose options in power and propulsion, design and manufacturing, thermodynamics and heat transfer, or environment or select electives in consultation with their adviser.

Program Sub-Plans
A sub-plan is not required for this program.

EIP Sub-Plan
ME EIP program (engineering intern program or 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. Students in the ME EIP program (engineering intern program or Co-op program) register for three industrial assignment courses. ME 3041 (2 credits), ME 4042 (2 credits), and ME 4043W (4 credits) for a total of 8 credits. These courses are used in place of two technical electives.

Students register for industrial assignments as they would for regular classes. Requirements for the course include writing a summary of an article in a technical journal, attending a workshop (ME 3041, ME 4043), submitting a report draft, and writing a final report. The course grade is based on writing; work performance cannot be considered in assigning a grade. The last industrial assignment, ME 4043, is oriented toward solving a design problem and fulfills a 4-credit intensive writing course requirement. Cooperation from company personnel is required in accomplishing most reports, particularly the ME 4043 reports.

Internship
ME 3041—Industrial Assignment I (2 cr)
ME 4042—Industrial Assignment II (2 cr)
ME 4043W—Industrial Assignment II, WI (4 cr)

Industrial Engineering Sub-Plan
The IE option gives students an understanding of managerial and human factor issues involved in designing products and running manufacturing, logistics, and service operations. Students also learn additional skills for analysis, optimization, and simulation of large-scale systems such as factories, logistical systems, and organizational networks. Students who select the IE option complete the same set of required courses as other mechanical engineering students, but their technical electives are selected from the industrial engineering course options and in consultation with a faculty adviser.

Technical Electives
Take 4 Courses (16 credits) from the following list. Choose one course from each area.
Tech Elective—Human Factors
or IE 5511—Human Factors and Work Analysis (4 cr)
or IE 5512—Applied Ergonomics (4 cr)
or IE 5513—Engineering Safety (4 cr)
Tech Elective—Engineering Management
or IE 5441—Engineering Cost Accounting and Cost Control (4 cr)
or IE 5522—Quality Engineering and Reliability (4 cr)
or IE 5541—Project Management (4 cr)
Tech Elective—Production Systems
or IE 5551—Production Planning and Inventory Control (4 cr)
or IE 5552—Design and Analysis of Manufacturing Systems (4 cr)

For the most up-to-date listing of program requirements, visit the Online Catalog at [www.catalogs.umn.edu/programs.html](http://www.catalogs.umn.edu/programs.html).
Institute of Technology

Requirements, visit http://admissions.tc.umn.edu.

For information about University of Minnesota admission

A GPA above 2.00 is preferred for the following:

major status before admission to this major.

Freshmen and transfer students are usually admitted to pre-

Students must complete 7 courses before admission to the

Technical Electives

Choose four courses (16 cr) from the following. Choose one course

Tech Elective—Human Factors

Tech Elective—Applied Ergonomics (4 cr)

Tech Elective—Engineering Safety (4 cr)

Tech Elective—Engineering Management

Tech Elective—Engineering Cost Accounting and Cost Control (4 cr)

Tech Elective—Quality Engineering and Reliability (4 cr)

Tech Elective—Project Management (4 cr)

Tech Elective—Production Systems

Tech Elective—Production Planning and Inventory Control (4 cr)

Tech Elective—Design and Analysis of Manufacturing Systems (4 cr)

Tech Elective—Operations Research

Tech Elective—Engineering Optimization I, H (4 cr)

Tech Elective—Simulation (4 cr)

Internship

ME 3041—Industrial Assignment I (2 cr)

ME 4042—Industrial Assignment II (2 cr)

ME 4043W—Industrial Assignment II, WI (4 cr)

Physics B.S. Phys.

School of Physics and Astronomy

• Required credits to graduate with this degree: 120.

• Required credits within the major: 38 to 41.

The 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. Students should

consult a physics adviser to help formulate objectives for study.

Admission Requirements

Students must complete 7 courses before admission to the

Freshmen and transfer students are usually admitted to pre-

major status before admission to this major.

A GPA above 2.00 is preferred for the following:

• 2.50 for students transferring from another University of

Minnesota college.

• 2.80 for students transferring from outside the University.

For information about University of Minnesota admission

requirements, visit [http://admissions.tc.umn.edu](http://admissions.tc.umn.edu).

Preparatory Mathematics

Math 1571-1572-2573 (Honors math sequence) may be taken in place of

the listed courses.

MATH 1271—Calculus I, MATH (4 cr)

or MATH 1371—IT Calculus I, MATH (4 cr)

MATH 1272—Calculus II (4 cr)

or MATH 1372—IT Calculus II (4 cr)

MATH 2243—Linear Algebra and Differential Equations (4 cr)

or MATH 2373—IT Linear Algebra and Differential Equations (4 cr)

MATH 2263—Multivariable Calculus (4 cr)

or MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Preparatory Physics

PHYS 2201—Introductory Thermodynamics and Statistical Physics (3 cr)

PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)

or PHYS 1401W—Honors Physics I, PHYS SCI/L, WI, H (4 cr)

PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)

or PHYS 1402W—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

PHYS 2403H—Honors Phys III, H (4 cr)

or PHYS 2503—Physics III: Foundations of Modern Physics (4 cr)

Program Requirements

In addition to the official concentrations in physics (biological

physics, computational physics, engineering physics, physics

for teaching), students may also complete a focus in

professional physics.

Students intending to pursue graduate study in physics are

strongly encouraged to take PHYS 4303.

Program Requirements

Major Courses

PHYS 2601—Quantum Physics (4 cr)

PHYS 2605—Quantum Physics Laboratory (3 cr)

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

PHYS 4052W—Methods of Experimental Physics II, WI (5 cr)

Options or Specializations

Students are required to complete one of the following course

groups.

Specialization

Complete the requirements for professional physics or those for any

of the following physics subplans: computational physics, biological,

engineering, or teaching, plus technical electives.

Professional Physics

For students who want the strongest possible grounding in physics, are

interested in fundamental physics or astrophysics or applying physics to

the workplace, or plan to continue physics education in graduate school.

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)

Take an additional 19 credits of approved technical electives from the sciences,

math, or engineering.

Take 3 or more credit(s) from the following:

MATH 3xx

MATH 4xx

MATH 5xx

Take 1 or more course(s) totaling 3 or more credit(s) from the following:

PHYS 3xx

PHYS 4xx

PHYS 5xx

Note: Programs listed in this catalog are current as of March 2008.
Program Sub-Plans
A sub-plan is not required for this program.

Biological Sub-Plan
For students with an interest in the biological applications of physics.

Physics for Biology
BIOC 3021—Biochemistry (3 cr)
BIOL 1009—General Biology, BIOL SCI/L (4 cr)
CHEM 1021—Chemical Principles I, ENV. PHYS SCI/L (4 cr)
CHEM 1022—Chemical Principles II, ENV. PHYS SCI/L (4 cr)
CHEM 2301—Organic Chemistry I (3 cr)
PHYS 4001—Analytical Mechanics (4 cr)
PHYS 4002—Electricity and Magnetism (4 cr)
Complete 14 credits of technical electives with a biology emphasis, chosen in consultation with your adviser.
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
or PHYS 4201—Statistical and Thermal Physics (3 cr)
CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
or PHYS 4101—Quantum Mechanics (4 cr)

Computational Physics Sub-Plan
For students who are interested in the practical application of physics and computational methods, but who want a less specialized education than they would find in a computer science department.

Computational Physics-Core Courses
Students should take PHYS 4001 and 4002 and 4101 and 4201 and technical electives.

Take 14 or more credits(s) from the following:
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
CSCI 2031—Introduction to Numerical Computing (4 cr)
CSCI 1901—Structure of Computer Programming I (4 cr)
CSCI 1107—Introduction to Fortran Programming for Scientists and Engineers (3 cr)
CHEM 4021—Computational Chemistry (3 cr)
or AEM 5251—Computational Fluid Mechanics (3 cr)
or comparable math or physics class
AST 4101—Computational Methods in the Physical Sciences (4 cr)

Engineering Sub-Plan
For students interested in physics as applied in engineering professions.

Take the two remaining courses you did not use to satisfy the major core requirements from the list of PHYS 4001, 4002, 4101, and 4201.

Physics for Engineering
CHEM 1021—Chemical Principles I, ENV. PHYS SCI/L (4 cr)
PHYS 4101—Quantum Mechanics (4 cr)
Complete 25 credits of technical electives in various engineering fields, physical sciences, or math, in consultation with your adviser.
PHYS 4001—Analytical Mechanics (4 cr)
EE 3601—Transmission Lines, Fields, and Waves (3 cr)
or PHYS 4002—Electricity and Magnetism (4 cr)
ME 3324—Introduction to Thermal Science (3 cr)
or PHYS 4201—Statistical and Thermal Physics (3 cr)

Teaching Sub-Plan
For students with an interest in teaching the physical sciences at the primary or secondary levels.

Chemistry and Upper Division Physics
CHEM 1021—Chemical Principles I, ENV. PHYS SCI/L (4 cr)
or CHEM 1031H—Honors Chemistry I, ENV. PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV. PHYS SCI/L (4 cr)
or CHEM 1032H—Honors Chemistry II, ENV. PHYS SCI/L, H (4 cr)
Students are encouraged to complete all four courses.
Take 2 or more course(s) from the following:
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)

Technical Electives
Complete 22 credits, including 8 or 9 credits chosen in consultation with an adviser. To meet licensure requirements, technical electives should include two courses in engineering, one of which has a substantial design component. Students must also demonstrate knowledge of computer programming in at least one language through coursework or completion of a project. Students will receive credit for either 4201 or ME 3321, not both.

Take 13 or more credit(s) from the following:
History and philosophy of science
Other courses may be substituted in consultation with your adviser.
Take exactly 1 course(s) from the following:
HSCI 4111—History of 19th-Century Physics (3 cr)
HSCI 4121—History of 20th-Century Physics (3 cr)

Relativity, astrophysics, and cosmology
Other courses may be substituted in consultation with your adviser.
Take exactly 1 course(s) from the following:
AST 4001—Astrophysics I (4 cr)
AST 4002—Astrophysics II (4 cr)
PHYS 3022—Introduction to Cosmology (3 cr)
PHYS 5022—Relativity, Cosmology, and the Universe (4 cr)

Earth sciences
Other courses may be substituted in consultation with your adviser.
Take exactly 1 course(s) from the following:
GEO 2303W—Geochemical Principles, WI (3 cr)
GEO 3202—Geodynamics II: The Fluid Earth (3 cr)
GEO 3401—Geochronology and Earth History (3 cr)

Technology
Other courses may be substituted in consultation with your adviser.
Take exactly 1 course(s) from the following:
AEM 4201—Fluid Mechanics (4 cr)
EE 5621—Physical Optics (3 cr)
PHYS 4711—Introduction to Optics (5 cr)
PHYS 5701—Solid-State Physics for Engineers and Scientists (4 cr)
Complete an additional 8 or 9 credits (three courses), preferably in engineering and computer science. Consult your adviser for appropriate choices.

For the most up-to-date listing of program requirements, visit the Online Catalog at www.catalogs.umn.edu/programs.html.
Institute of Technology

- Required credits to graduate with this degree: 120.
- Required credits within the major: 38.

The program gives students an understanding of the theory of statistics, trains them in basic use of the most important types of statistical methods, and prepares them for graduate work or for jobs in such diverse areas as marketing analysis, quality management, and support for scientific research.

The program provides a broad foundation in statistics that can be combined with coursework in other technical disciplines or as a basis for further specialization in statistics.

Admission Requirements
Students must complete 4 courses before admission to the program.
Freshmen and transfer students are usually admitted to pre-major status before admission to this major.
A GPA above 2.00 is preferred for the following:
- 2.50 for students transferring from outside the University.

For information about University of Minnesota admission requirements, visit http://admissions.tc.umn.edu.

Mathematics
MATH 1271—Calculus I, MATH (4 cr)
or
MATH 1371—IT Calculus I, MATH (4 cr)
MATH 1272—Calculus II (4 cr)
or
MATH 1372—IT Calculus II (4 cr)
MATH 2243—Linear Algebra and Differential Equations (4 cr)
or
MATH 2373—IT Linear Algebra and Differential Equations (4 cr)
MATH 2263—Multivariable Calculus (4 cr)
or
MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)

Program Requirements
Major Courses
STAT 3011—Introduction to Statistical Analysis, MATH (4 cr)
or
STAT 3021—Introduction to Probability and Statistics (3 cr)
MATH 4242—Applied Linear Algebra (4 cr)
STAT 3022—Data Analysis (4 cr)
STAT 4893W—Senior Paper, WI (1 cr)
Take one of the following pairs of courses.
STAT 4101—Theory of Statistics I (4 cr)
STAT 4102—Theory of Statistics II (4 cr)
or
STAT 5101—Theory of Statistics I (4 cr)
STAT 5102—Theory of Statistics II (4 cr)

Electives
Take 10 or more credit(s) from the following:
STAT 5031—Statistical Methods for Quality Improvement (4 cr)
STAT 5041—Bayesian Decision Making (3 cr)
STAT 5201—Sampling Methodology in Finite Populations (3 cr)
STAT 5302—Applied Regression Analysis (4 cr)
STAT 5303—Designing Experiments (4 cr)
STAT 5401—Applied Multivariate Methods (3 cr)
STAT 5421—Analysis of Categorical Data (3 cr)
STAT 5601—Nonparametric Methods (3 cr)

Computer and Physical Sciences
CSCI 1103—Introduction to Computer Programming in Java (4 cr)
or
CSCI 1107—Introduction to FORTRAN Programming for Scientists and Engineers (3 cr)
or
CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)

Students must complete 3 science courses with a lab component, chosen from at least 2 of the fields of physics, chemistry, biology.

Take 3 or more course(s) including 2 or more sub-requirement(s) from the following:
Take 0–1 course(s) from the following:
BIOL 1009—General Biology, BIOL, SCI/L (4 cr)
BIOL 1009H—Honors: General Biology, BIOL, SCI/L, H (4 cr)
Take 0–2 course(s) from the following:
CHEM 1021—Chemical Principles I, ENV, PHYS SCI/L (4 cr)
or
CHEM 1031H—Honors Chemistry I, ENV, PHYS SCI/L, H (4 cr)
CHEM 1022—Chemical Principles II, ENV, PHYS SCI/L (4 cr)
or
CHEM 1032H—Honors Chemistry II, ENV, PHYS SCI/L, H (4 cr)
Take 0–2 course(s) from the following:
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS SCI/L, WI (4 cr)
or
PHYS 1401V—Honors Physics I, PHYS SCI/L, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS SCI/L, WI (4 cr)
or
PHYS 1402V—Honors Physics II, PHYS SCI/L, WI, H (4 cr)

Technical Electives
Students complete 10 credits of adviser-approved courses in computer science, biostatistics, industrial engineering, mathematics, or other areas. Technical Elective

Note: Programs listed in this catalog are current as of March 2008.