College of
SCIENCE AND ENGINEERING

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General Information

The University of Minnesota College of Science and Engineering (formerly the Institute of Technology) is one of the top-ranked science and engineering university programs in the country enrolling more than 4,700 undergraduate and 2,600 graduate students. The college includes 400 faculty members within 12 academic departments/schools and more than 15 research centers. The College of Science and Engineering's unique combination of engineering, physical sciences, mathematics, and computer science within one college creates many opportunities for research and education collaborations. Scientists and engineers work side by side to provide a comprehensive, high-quality education that benefits students and the entire community.

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. Admission into the College of Science and Engineering (CSE) is competitive. The college welcomes applicants who are looking for a rigorous academic environment, which encourages involvement in undergraduate research, a broad liberal education, engagement in societal issues, and a willingness to expand their leadership and communication skills. Nearly 70 percent of the Fall 2009 freshman class were from the upper 10 percent of their high school graduating class and their average composite ACT score was 29.6.

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 is customarily 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 fields within CSE before selecting a specific major should indicate "Undecided" on their 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 learning about major fields in the CSE Office of Academic Advising. Some of these resources include mentors (peer, faculty, industry, and alumni advisers), special courses, and written materials. All are designed to provide information about career opportunities in the college's various fields as well as those in other colleges, and to help students select a major that is best suited to their interests and goals.

All students are urged to take advantage of the college's Industry Adviser and Mentor Programs, which allow students to 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 CSE students through this program. Students may apply online at the **Mentor Program website** to participate.

Undecided CSE students and CSE students with a specified major follow the same first-year academic program.

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 CSE should be pursuing appropriate lower division math, science, and/or pre-engineering coursework. The first-year mathematics, chemistry, and physics courses required for the preferred major should already be completed or in progress at the time of application. Admission decisions are based on an overall "technical" GPA using grades in science, calculus, computer science, and engineering. 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. Transfer admission information, including technical course equivalencies that have been established between CSE and most colleges and universities, can be found online at **www.it.umn.edu/prospective/equiv**. Technical courses in which a D+ or less has been earned do not transfer.

Dual Degree Programs—CSE 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 who are willing to spend another year or two achieving this goal.

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

The second plan requires the student to complete 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, although 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 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.

Degrees and Programs

Undergraduate Degrees—Each of the College of Science and Engineering's undergraduate programs provides a rigorous and stimulating education enhanced by close interaction with distinguished research faculty and access to CSE's research facilities.

Eighteen undergraduate 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 earth sciences
- Bachelor of electrical engineering*
- 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

** All engineering programs are accredited by ABET.*

Students may not 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.

Interdisciplinary Emphases—CSE students can plan interdisciplinary emphases tailored to their specific interests. Although a single department approves a degree, 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—Some students plan their CSE majors as preparation for medical school. Approved specific courses are required for medical school application. Students should consult the websites of the medical schools to which they plan to apply for more information on these prerequisites. For more information, students may also contact the Health Careers Center in 2-565 Moos Tower (612-624-6767) or visit their website at 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.

Ecological Engineering (Minor Only)

Ecological engineering integrates traditional engineering concepts with ecological principles such as resiliency, adaptation, and community dynamics. The ecological engineering minor prepares students to design sustainable systems integrating human activities with the natural environment, including watershed management and enhancement; waste treatment systems; phytoremediation and bioremediation; industrial ecology; constructed and restored wetlands; mitigation of non-point source contamination; and increase of ground water recharge through "low impact" design and other methods.

Honors Program

The University Honors Program (UHP) offers 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 size, 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.

Students admitted to honors before fall 2008 will continue to follow the honors requirements outlined at the time they entered their college honors program. All students admitted to honors as of fall 2008 forward follow the requirements of the University Honors Program. Students admitted to a college honors program before fall 2008 and who change colleges, must apply to UHP if they want to participate in Honors. 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

CSE 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 1031V–1032V, 2101–2111

CHEM 2301, 2302, 2311

EE 2001, 2011

MATH 1155, 1271–1272*

MATH 1371–1372

MATH 1571H–1572H

PHYS 1301W–1302W

PHYS 2303**, 2601

** To continue in additional mathematics courses (in particular, MATH 2243 or MATH 2263) or sequences, CSE students must earn at least a C- in MATH 1272, 1372, or 1572.*

*** To continue in physics sequences CSE students must earn at least a C- in PHYS 2303.*

CSE 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 students who have junior and senior standing.

Freshmen and sophomores must apply for entry to upper division in CSE and are told at orientation what minimum GPA might be required. Students should file an application in 128 Lind Hall before completing their sophomore year.

Changing Majors

Upper division students must petition to change majors within CSE. Forms are available in 128 Lind Hall. A transcript and an APAS must accompany the petition.

Students who graduate from CSE 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.

Conduct and Discipline

CSE expects students to adhere to the University of Minnesota's Student Conduct Code, available at the Office for Student Conduct and Academic Integrity, 211 Appleby Hall, Minneapolis, MN 55455 (612-624-6073).

Professional Licensing

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), or online at www.aelslagid.state.mn.us.

Academic Advising

612-624-2890

All students obtain advising through the CSE Academic Advising Office, 128 Lind Hall (612-624-2890). Every CSE student is assigned a professional academic adviser upon beginning his/her first semester. Advisers assist students with course planning, by connecting them with college and campus organizations and resources, and encouraging them to make the most of their time as an undergraduate student in the College of Science and Engineering. Students should meet with their academic adviser once a semester, at a minimum, prior to registration. In addition, students should see their academic adviser if they have questions about University policy and procedure, concerns regarding their academic decisions, or issues with their academic performance.

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

Special Learning Opportunities and Resources

612-624-5091

Dashboard—CSE's Dashboard (it.umn.edu/dashboard) contains ITSS weekly announcements, news, and events. It serves the home page for all undergraduates in CSE.

CSE Student Services—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 email itss@umn.edu. This office is responsible for admission, diversity and outreach efforts, student events, scholastic conduct, scholarships, international programs, and related programs.

Tutors—The Smart Learning Commons, located in Walter Library, provides tutoring and academic support services for students throughout the University. See Academic Support Services section of this catalog for more information, or visit the Smart Learning Commons website at smart.umn.edu.

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 website (www.ccse.umn.edu) or contact CCSE, 50 Lind Hall (612-624-4090).

Diversity and Outreach—CSE promotes academic excellence and the increased presence of underrepresented groups (African American, Chicano/Latino, Native American) in engineering, mathematics, and the physical sciences. Through its precollege, undergraduate, and graduate/faculty programs, it promotes diversity in the classroom, laboratory, and workplace in order to prepare CSE students for careers in an ethnically diverse

workforce. The North Star STEM Alliance, Minnesota's Louis Stokes Alliance for Minority Participation (LSAMP), support multicultural students as they complete their bachelor's degree.

Working with other CSE and University offices, the Diversity and Outreach program offers a variety of academic enrichment programs such as tutoring, learning assessment, career assessment, and study groups. Through collaboration with CSE departments and corporate sponsors, the office identifies experiences outside the classroom such as internships and undergraduate research to expose students to applications in science and engineering. These collaborations also provide merit scholarships for underrepresented students in engineering, mathematics, and the physical sciences. For more information, email crame003@umn.edu or call 612-626-7566.

Computer Facilities—The College of Science and Engineering, 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.itlabs.umn.edu/itlabfees/index.php for more information about the CSE 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.

Project Lead the Way—This project, which offers a pre-engineering curriculum for middle school and high school students, seeks to create dynamic partnerships with the nation's schools in order to prepare an increasingly diverse group of students to be successful in engineering and engineering technology programs. As a PLTW national affiliate training center, the University of Minnesota hosts Core Training Institutes for teachers on campus in the summer. High school students can earn University of Minnesota college credit for the PLTW courses offered at their schools. Visit the website at: www.it.umn.edu/pltw.

UNITE Instructional Television—UNITE Distributed Learning provides continuing educational opportunities for working professionals through internet-based delivery of courses from the College of Science and Engineering. In addition to graduate courses, UNITE offerings include a selection of online undergraduate courses that can be uses in completing bachelor's degrees in computer science and electrical engineering. An array of noncredit online seminars and colloquia offerings originating from various departments and centers within the College of Science and Engineering provides a means for working professionals to keep abreast of the latest developments at the University of Minnesota, nationally and internationally. Costs for courses include the usual University of Minnesota tuition and fees, along with an additional credit-based delivery fee which helps support the UNITE system. Tuition and fees are paid either by the student or employer, depending on employer's policy. For more information, contact UNITE Distributed Learning, 514 Vincent Hall, 206 Church Street S.E., Minneapolis, MN 55455 (612-624-2332/877-668-6483).

On-Campus Living Experiences for Freshmen in CSE

The Explorations in Engineering and Sciences House (SE Explorations), the Women in Science and Engineering House (WISE), Science Technology Engineering Math (STEM) House for Underrepresented Students, and the University Honors House are CSE's 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 peer support that can enhance their success in the classroom and on campus. Faculty and staff advisers from CSE 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 1411—Exploring Careers in Science and Engineering (1 credit). This course can be used as a freshman seminar.

CSE Explorations, a co-ed community, is open to 200 freshmen 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 CSE Student Services at 612-624-8010, email kubit001@umn.edu, or visit the Housing and Residential Life website at www.housing.umn.edu. For more information on University Honors Program Housing, visit the website at www.honors.umn.edu.

International Programs

CSE 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, May Session, or summer session enhancing their cross-cultural skills, language ability, or professional experience. These opportunities can be very affordable and the Learning Abroad Center offers more than $400,000 in scholarships for study abroad per year. CSE has also been supportive to students with financial need. Each CSE department has a list of recommended locations for study abroad. Students can learn more about these options by contacting CSE Student Services, 106 Lind Hall, pagel@umn.edu, 612-624-8013.

Internship Opportunities and Field Experience 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 or call 612-624-8010 to find out about this active student chapter on campus. Engineers without Borders offers students hands-on experience on campus and abroad tackling real world engineering challenges. Visit www.tc.umn.edu/~ewb for more information on active projects and upcoming meetings.

Other Information—For information on a wide variety of credit-bearing study abroad programs, volunteer opportunities, and work-abroad options, 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 for more information. Students interested in domestic exchanges should contact the National Student Exchange Program, 240 Appleby Hall, or nseadv@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 College of Science and Engineering 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. 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 helps their career development. Many of these societies have student chapters at the University www.sua.umn.edu/groups. Through them, students have the opportunity to participate in activities of the national society, gain experience in conducting technical meetings, and meet senior members of the societies and students across the college and University. In addition, regular membership in the society is facilitated upon graduation, and any entrance fee is reduced or waived for former student members. Contact CSE Student Services, 612-624-8010, kubit001@umn.edu, for information about, and assistance with promoting and recruiting for membership in any student organization.

Science and Engineering Student Board

This board is the executive body of CSE students, representing them in matters affecting the general interests of CSE and the University. Contact SESB at SESB@umn.edu.

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 CSE 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 CSE 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, works to create and maintain a spirit of fellowship and cooperation among CSE students and further the interests of CSE and the University. Its members are chosen for their character, leadership, and service. Contact Plumb Bob at plumbbob@umn.edu.

Directory

Current student website Dashboard:
CSE.umn.edu/dashboard

Administration

Dean
105 Walter Library
612-624-2006
Email: info@it.umn.edu

Associate Dean for Undergraduate Programs
106 Lind Hall
612-624-5091
Email: itss@itdean.umn.edu

Student Services

Academic Advising
128 Lind Hall
612-624-2890
Email: itadvising@umn.edu

Career Center for Science and Engineering
50 Lind Hall
612-624-4090
Email: ccse@umn.edu

Collegiate Life
106 Lind Hall
612-624-5091
Email: itss@umn.edu

Departments

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

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

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

Bioproducts and Biosystems Engineering
203 Kaufert Laboratory
612-625-5200
Email: shri@umn.edu

Chemical Engineering and Materials Science
151 Amundson Hall
612-625-1313
Email: ericksen@cems.umn.edu

Chemistry
135 Smith Hall
612-624-8008
Email: stathopo@chem.umn.edu

Civil Engineering
122 Civil Engineering Building
612-625-5522
Email: cive@umn.edu

Computer Science and Engineering
4-192 Electrical Engineering/Computer Science
612-625-4002
Email: ugrad_info@cs.umn.edu

Electrical and Computer Engineering
3-166 Electrical Engineering/Computer Science
612-624-7777
Email: undergraduate_studies@ece.umn.edu

Earth Sciences
108 Pillsbury Hall
612-624-1333
Email: geology@umn.edu

Mathematics
115 Vincent Hall
612-625-4848
Email: ugrad@math.umn.edu

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

Physics
148 Tate Laboratory of Physics
612-624-7375
Email: ugrad@physics.spa.umn.edu

Statistics
313 Ford Hall
612-625-8046
Email: info@stat.umn.edu

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 College of Science and Engineering: 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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics Core

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

MATH 1371—IT Calculus I (4 cr)
or MATH 1271—Calculus I (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—IT 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, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)
or PHYS 2403H—Honors Physics III, H (4 cr)
or PHYS 2303—Physics III: Physics of Matter (4 cr)

Statics 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 4203—Aerospace Propulsion (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 (4 cr)
or CHEM 1031H—Honors Chemistry I, 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)
ME 3324—Introduction to Thermal Science (3 cr)
MATS 2001—Introduction to the Science of Engineering Materials (3 cr)
or MATS 3011—Introduction to Materials Science and Engineering (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

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.

Required Courses for the Sub-plan

Internship

AEM 4796—Professional Experience (3 cr)

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

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 the Office of Admissions website.

Mathematics Core

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
PHYS 2303—Physics III: Physics of Matter (4 cr)
or PHYS 2403H—Honors Physics III, H (4 cr)
or PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)
PHYS 2601—Quantum Physics (4 cr)

Program Requirements

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

Astrophysics Core

PHYS 2201—Introductory Thermodynamics and Statistical Physics (3 cr)
AST 2001—Introduction to Astrophysics (4 cr)
AST 4994W—Directed Research, WI (3–5 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

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

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

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—Revolutions in Science: The Babylonians to Newton, HIS, GP (3–4 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, WI (4 cr)
AST 5201—Methods of Experimental Astrophysics (4 cr)

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.

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Biomedical Engineering B.Bm.E.

Department of Biomedical Engineering

- Required credits to graduate with this degree: 127.
- Required credits within the major: 71.

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 10 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 the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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)

Physical Sciences

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

Preparatory Courses

BMEN 2401—Programming for Biomedical Engineers (2 cr)
BMEN 2501—Cellular and Molecular Biology for Biomedical Engineers (4 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 3001—Biomechanics (4 cr)
BMEN 3101—Biomedical Transport Processes (4 cr)
BMEN 3201—Bioelectricity 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 3061—Principles of Physiology (4 cr)
PHSL 3701—Physiology Laboratory (2 cr)
BMEN 2101—Biomedical Thermodynamics (3 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.

Multivariable Calculus

MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)
or MATH 2263—Multivariable Calculus (4 cr)

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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 (4 cr)
CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, 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 (3 cr)
BBE 4013—Transport in Biological Systems (3 cr)
BBE 4023W—Process Control and Instrumentation, WI (3 cr)
BBE 4502W—BBE Capstone Design, WI (4 cr)
CE 3502—Fluid Mechanics (4 cr)
BBE 3043—Biological and Environmental Thermodynamics (3 cr)
BBE 3002—Introduction to Engineering Design (3 cr)
STAT 3021—Introduction to Probability and Statistics (3 cr)

Program Sub-plans

Students are required to complete one of the following sub-plans. (Note for the Twin Cities and Morris campuses: The honors sub-plan does not meet this requirement. Honors students are required to complete one sub-plan plus the honors sub-plan. Please see an adviser if no honors sub-plan is listed for the program.)

Bioproducts Engineering

Required Courses for the 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 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:
Take 2 or more course(s) from the following:
BBE 4302—Organisms Impacting Bio-based Products (3 cr)
BBE 4305—Pulp and Paper Technology (3 cr)
BBE 4404—Bio-based Composites Engineering (3 cr)
BBE 4733—Renewable Energy Technologies (3 cr)
BBE 3396—Industrial Internship (Industrial Assignment) (1 cr)
BBE 4491—Senior Topics: Independent Study (1–4 cr)
BBE 4900—Intern Reports (2 cr)
BBE 4504W—Bio-based Products Development and Management, WI (3 cr)
Take 0 or more credit(s) from the following:
BIOC 3021—Biochemistry (3 cr)
CHEM 2302—Organic Chemistry II (3 cr)
CHEM 2311—Organic Lab (4 cr)
CHEM 4221—Introduction to Polymer Chemistry (3 cr)
MATS 3801—Structural Characterization Lab (3 cr)
MATS 4214—Polymers (3 cr)
ME 4431W—Energy Conversion Systems Laboratory, WI (4 cr)

IE 5551—Production Planning and Inventory Control (4 cr)
IE 5513—Engineering Safety (4 cr)
CE 4502—Water and Wastewater Treatment (3 cr)

Bioprocessing and Food Engineering Sub-plan

Required Courses for the Sub-plan

Chemistry

CHEM 2301—Organic Chemistry I (3 cr)

Emphasis Courses

EE 3005—Fundamentals of Electrical Engineering (4 cr)
BBE 4713—Biological Process Engineering (3 cr)
BBE 4723—Food Process Engineering (3 cr)
BBE 4733—Renewable Energy Technologies (3 cr)

Technical Electives

Complete at least 16 credits of technical electives.

Examples: BBE 4001, BBE 4301, BBE 4302, BBE 4404, BIOC 3021, CHEM 2302, CHEM 2311, CHEM 4221, CHEN 5754, CHEN 5759, EE 5821, FSCN 4111, FSCN 4121, IE 5513, IE 5531, IE 5541, IE 5551, MATS 3011, MATS 3801, MATS 4214, ME 4431W, ME 5381, ME 5446, VBS 2022, VBS 2032. See adviser for suggestions for selecting courses in focus areas such as food engineering or renewable energy.

Environmental and Ecological Engineering Sub-plan

Required Courses for the Sub-plan

Biochemistry

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

Emphasis Courses

EE 3005—Fundamentals of Electrical Engineering (4 cr)
BBE 3023—Ecological Engineering Principles (3 cr)

Water and Waste Management

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

BBE 4523—Ecological Engineering Design (3 cr)
BBE 4533—Agricultural Waste Management Engineering (3 cr)
BBE 5513—Watershed Engineering (3 cr)

Bioproducts and Biosystems Engineering Elective

If all three courses are taken in the Water and Waste Management sublist above, no courses are required. If only two courses are taken, select 3 credits (one course) from the following: BBE 4401, 4713, 4723, 4733.

Engineering Technical Electives

Select at least 5 credits of engineering electives.

Examples: any non-required BBE course not used as a BBE elective, CE 3202, CE 3301, CE 3402, CE 3501, CE 4301, CE 4351, CE 4501, CE 4502, CE 4511, CE 4512, IE 5513

Biology Technical Electives

Select at least 3 credits of biology electives.

Examples: BIOL 3007, 3407, EEB 3001, 4601, ES 3612, SOIL 3416, ESPM 4607

General Technical Electives

Take at least 3 credits of computer science, or choose three additional credits of Engineering Technical Electives or Biology Technical Electives.

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.

Required Courses for the Sub-plan

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)

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Chemical Engineering B.Ch.E.

Chemical Engineering and Materials Science

- Required credits to graduate with this degree: 128.
- Required credits within the major: 54.

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 14 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 the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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 (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)
and CHEM 2301—Organic Chemistry I (3 cr)
and CHEM 2302—Organic Chemistry II (3 cr)
and CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
and CHEM 2121—Process Analytical Chemistry (3 cr)
and PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)

Chemical Engineering Lower Division

CHEN 2001—Material and Energy Balances (4 cr)

Freshman Writing

WRIT 1301—University Writing (4 cr)

Program Requirements

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

Major Courses

CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
and CHEM 2311—Organic Lab (4 cr)
or CHEM 2312H—Honors Organic Lab, H (5 cr)
CHEN 3701—Introduction to Biomolecular Engineering (3 cr)
CHEN 3006—Mass Transport and Separation Processes (4 cr)
CHEN 3101—Chemical Engineering Thermodynamics (4 cr)
CHEN 3102—Reaction Kinetics and Reactor Engineering (4 cr)
CHEN 3201—Numerical methods in ChEn applications (3 cr)
CHEN 4401W—Senior Chemical Engineering Lab, WI (3 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)
CHEN 3005—Transport Phenomena: Momentum and Heat (4 cr)
CHEN 4402W—Chemical Engineering Lab II, WI (2 cr)

Technical Electives

Take 12 credits of electives. These normally include CHEN 4214 and 3 other courses selected with the aid of an adviser.

BBE 4301—Surface and Colloid Science in Bio-based Products Manufacturing (3 cr)
or BBE 4723—Food Process Engineering (3 cr)
or BBE 4733—Renewable Energy Technologies (3 cr)
or BIOC 3021—Biochemistry (3 cr)
or BIOC 4521—Introduction to Physical Biochemistry (3 cr)
or BIOC 5527—Introduction to Modern Structural Biology (4 cr)
or BIOL 4003—Genetics (3 cr)
or BIOL 4004—Cell Biology (3 cr)
or BMEN 5001—Advanced Biomaterials (3 cr)
or BMEN 5041—Tissue Engineering (3 cr)
or BMEN 5311—Advanced Biomedical Transport Processes (3–4 cr)
or BMEN 5371—Biomedical Applications of Heat Transfer in Humans (3–4 cr)
or BMEN 5501—Biology for Biomedical Engineers (3 cr)
or CE 4502—Water and Wastewater Treatment (3 cr)
or CE 4561—Solid Hazardous Wastes (3 cr)
or CE 4562—Environmental Remediation Technology (3 cr)
or CHEM 4001—Chemistry of Plant Materials (4 cr)
or CHEM 4011—Mechanisms of Chemical Reactions (3 cr)
or CHEM 4021—Computational Chemistry (3 cr)
or CHEM 4066—Chemistry of Industry (3 cr)
or CHEM 4201—Materials Chemistry (3 cr)
or CHEM 4301—Surface and Colloid Science in Bio-based Products Manufacturing (3 cr)
or CHEM 4311W—Advanced Organic Chemistry Lab, WI (2 cr)
or CHEM 4321—Organic Synthesis (3 cr)
or CHEM 4322—Advanced Organic Chemistry (3 cr)
or CHEM 4411—Introduction to Chemical Biology (3 cr)
or CHEM 4413—Nucleic Acids (3 cr)
or CHEM 4511W—Advanced Physical Chemistry Lab, WI (2 cr)
or CHEM 4701—Inorganic Chemistry (3 cr)
or CHEM 4711W—Advanced Inorganic Chemistry Lab, WI (2 cr)
or CHEM 4725—Organometallic Chemistry (3 cr)
or CHEM 4745—Advanced Inorganic Chemistry (3 cr)
or CHEM 5210—Materials Characterization (4 cr)
or CHEN 4214—Polymers (3 cr)
or CHEN 4701—Advanced Undergraduate Applied Math I: Linear Analysis (3 cr)
or CHEN 4702—Advanced Undergraduate Rheology (2 cr)
or CHEN 4703—Advanced Undergraduate Applied Math II: Nonlinear Analysis (3 cr)
or CHEN 4704—Advanced Undergraduate Physical Rate Processes I: Transport (3 cr)
or CHEN 4706—Advanced Undergraduate Physical and Chemical Thermodynamics (3 cr)
or CHEN 4707—Advanced Undergraduate Statistical Thermodynamics and Kinetics (3 cr)
or CHEN 4708—Advanced Undergraduate Chemical Rate Processes: Analysis of Chemical Reactors (3 cr)
or CHEN 5531—Electrochemical Engineering and Renewable Energy (3 cr)
or CHEN 5551—Survey of Renewable Energy Technologies (3 cr)
or CHEN 5751—Biochemical Engineering (3 cr)
or CHEN 5752—Quantitative Biology for Engineers (3 cr)
or CHEN 5753—Biological Transport Processes (3–4 cr)
or CHEN 5759—Principles of Mass Transfer in Engineering and Biological Engineering (2 cr)
or CHEN 5771—Colloids and Dispersions (3 cr)
or CSCI 5304—Computational Aspects of Matrix Theory (3 cr)
or CSCI 5451—Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3 cr)
or EE 3015—Signals and Systems (3 cr)
or EE 3161—Semiconductor Devices (3 cr)
or EE 4231—Linear Control Systems: Designed by Input/Output Methods (3 cr)
or EE 5171—Microelectronic Fabrication (4 cr)
or EE 5173—Basic Microelectronics Laboratory (1 cr)
or EE 5653—Physical Principles of Magnetic Materials (3 cr)

or EE 5655—Magnetic Recording (3 cr)
or FSCN 5441—Introduction to New Product Development (2 cr)
or IE 4521—Statistics, Quality, and Reliability (4 cr)
or IE 5441—Financial Decision Making (4 cr)
or IE 5513—Engineering Safety (4 cr)
or IE 5522—Quality Engineering and Reliability (4 cr)
or MATH 2283—Sequences, Series, and Foundations (3 cr)
or MATH 4457—Methods of Applied Mathematics I (4 cr)
or MATH 4458—Methods of Applied Mathematics II (4 cr)
or MATH 4567—Applied Fourier Analysis (4 cr)
or MATH 5445—Mathematical Analysis of Biological Networks (4 cr)
or MATH 5485—Introduction to Numerical Methods I (4 cr)
or MATH 5486—Introduction To Numerical Methods II (4 cr)
or MATS 4013—Electrical and Magnetic Properties of Materials (3 cr)
or MATS 4212—Ceramics (3 cr)
or MATS 4301W—Materials Processing, WI (4 cr)
or MATS 4511W—Corrosion and Electrochemistry of Corrosion, WI (4 cr)
or MATS 5531—Electrochemical Engineering (3 cr)
or ME 4431W—Energy Conversion Systems Laboratory, WI (4 cr)
or ME 5113—Aerosol/Particle Engineering (4 cr)
or ME 5115—Air Quality and Air Pollution Control (4 cr)
or ME 5223—Materials in Design (4 cr)
or ME 5446—Introduction to Combustion (4 cr)
or MICB 3301—Biology of Microorganisms (5 cr)
or MICB 4121—Microbial Ecology and Applied Microbiology (3 cr)
or MICB 4131—Immunology (3 cr)
or NSCI 3101—Introduction to Neuroscience I: From Molecules to Madness (3 cr)
or PHAR 6163—Pharmacokinetics (3 cr)
or PHAR 6164—Biopharmaceutics (3 cr)
or PHAR 6224—Pharmacogenomics: Genetic Basis for Variability in Drug Response (2 cr)
or PHCL 5110—Introduction to Pharmacology (3 cr)
or PHSL 5061—Principles of Physiology for Biomedical Engineering (4 cr)
or PHYS 4911—Introduction to Biopolymer Physics (3 cr)
or CHEM 4223W—Polymer Laboratory, WI (2 cr)
or CHEN 4223W—Polymer Laboratory, WI (2 cr)
or MATS 4223W—Polymer Laboratory, WI (2 cr)
or MATS 4214—Polymers (3 cr)
or CHEM 4214—Polymers (3 cr)

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty 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.

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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (4 cr)
MATH 1272—Calculus II (4 cr)
or MATH 1372—IT Calculus II (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 (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)
and CHEM 2101—Introductory Analytical Chemistry Lecture (3 cr)
and CHEM 2111—Introductory Analytical Chemistry Lab (2 cr)
and PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, 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 Physics 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 2312H—Honors Organic Lab, H (5 cr)

Electives

Take 3 or more course(s) from the following:
CHEM 4094W—Directed Research, WI (1–5 cr)
CHEM 4111W—Modern Instrumental Methods of Chemical Analysis 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

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

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.

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 the Office of Admissions website.

Mathematics

Honors math (MATH 1571H, 1572H, 2573H, 2574H) may be taken in place of the listed courses.
MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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 Science and Mechanics

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

Program Requirements

Major Courses

CE 3201—Transportation Engineering (3 cr)
CE 3301—Soil Mechanics I (3 cr)
CE 3401—Linear Structural Analysis (3 cr)
CE 3402—Civil Engineering Materials (3 cr)
CE 3501—Environmental Engineering, ENV (3 cr)
CE 3502—Fluid Mechanics (4 cr)
CE 4102W—Capstone Design, WI (4 cr)
CE 4301—Soil Mechanics II (3 cr)
CE 4401—Steel and Reinforced Concrete Design (4 cr)
CE 4501—Hydrologic Design (4 cr)
CE 4502—Water and Wastewater Treatment (3 cr)
AEM 2012—Dynamics (3 cr)
or CHEM 2301—Organic Chemistry I (3 cr)
or EE 2001—Introduction to Electronic and Electrical Circuits (3 cr)
or MATS 2001—Introduction to the Science of Engineering Materials (3 cr)
or CSCI 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)
or ME 3331—Thermal Sciences I (3 cr)

Computer Applications

CE 3101—Computer Applications in Civil Engineering I (3 cr)

Statistics

STAT 3021 may be substituted for CE 3102 with approval of the director of undergraduate studies.

CE 3102—Uncertainty and Decision Analysis in Civil Engineering (3 cr)
or STAT 3021—Introduction to Probability and Statistics (3 cr)

Civil Engineering Electives

Students must take 10 credits of 4xxx or higher electives offered by the civil engineering department.

Take exactly 10 credit(s) from the following:
CE 4xxx
CE 5xxx

Technical Electives

Students must take an additional 11 credits of technical electives. All courses at 4xxx or higher from an engineering department (including Civil Engineering) are acceptable as technical electives. Additional courses are acceptable as technical electives upon approval of an adviser. Consult your adviser for assistance in selecting elective courses.

Take 11 or more credit(s) from the following:
EE 4xxx
ME 4xxx
CSCI 4xxx
BBE 4xxx
GEOE 4xxx
CHEN 4xxx
BMEN 4xxx
CE 3xxx
CE 4xxx
CE 5xxx
ME 5xxx
EE 5xxx
CSCI 5xxx
CHEN 5xxx
BBE 5xxx
BMEN 5xxx
GEOE 5xxx

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Computer Engineering B.Comp.E.

Electrical and Computer 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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, 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—Introductory Circuits and Electronics Laboratory (1 cr)
EE 2011—Linear Systems and Circuits (3 cr)
EE 2301—Introduction to Digital System Design (4 cr)
EE 2361—Introduction to Microcontrollers (4 cr)

Program Requirements

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

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)
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 4363—Computer Architecture and Machine Organization (4 cr)

CompE Technical Electives

Students need to complete 28 technical elective credits with a minimum of 22 coming from EE 4xxx, EE 5xxx, CSci 4xxx, or CSci 5xxx courses. Of the technical electives one course must be chosen from four of the specialty areas and at least two courses must be chosen from one of the specialty areas. A senior design project is also required as are two additional approved lab courses. Students who complete the two-semester senior honors project only need to take one additional EE lab course.

Take 28 or more credit(s) from the following:

AEM 2021—Statics and Dynamics (4 cr)
AEM 4601—Instrumentation Laboratory (3 cr)
BBE 3013—Engineering Principles of Molecular and Cellular Processes (3 cr)
BIOC 3021—Biochemistry (3 cr)
BLAW 3058—The Law of Contracts and Agency (4 cr)
BMEN 5401—Advanced Biomedical Imaging (3 cr)
CE 3502—Fluid Mechanics (4 cr)
CE 4101W—Project Management, WI (3 cr)
CHEM 2301—Organic Chemistry I (3 cr)
CHEM 2302—Organic Chemistry II (3 cr)
CHEM 2311—Organic Lab (4 cr)
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
IE 5441—Financial Decision Making (4 cr)
IE 5511—Human Factors and Work Analysis (4 cr)
IE 5512—Applied Ergonomics (4 cr)
IE 5513—Engineering Safety (4 cr)
IE 5522—Quality Engineering and Reliability (4 cr)
IE 5531—Engineering Optimization I (4 cr)
IE 5541—Project Management (4 cr)
IE 5551—Production Planning and Inventory Control (4 cr)
IE 5552—Design and Analysis of Manufacturing Systems (4 cr)
IE 5553—Simulation (4 cr)
MATS 3011—Introduction to Materials Science and Engineering (3 cr)
MATS 3012—Metals and Alloys (3 cr)
MATS 3851W—Materials Properties Lab, WI (3 cr)
MATS 4013—Electrical and Magnetic Properties of Materials (3 cr)
MATH 3283W—Sequences, Series, and Foundations: Writing Intensive, WI (4 cr)
MATH 4xxx
MATH 5xxx
ME 3324—Introduction to Thermal Science (3 cr)
PHSL 3061—Principles of Physiology (4 cr)
PHYS 2601—Quantum Physics (4 cr)
PHYS 2605—Quantum Physics Laboratory (3 cr)
PHYS 4101—Quantum Mechanics (4 cr)
PHYS 4201—Statistical and Thermal Physics (3 cr)
STAT 5101—Theory of Statistics I (4 cr)
STAT 5041—Bayesian Decision Making (3 cr)
STAT 5102—Theory of Statistics II (4 cr)
PHYS 2303—Physics III: Physics of Matter (4 cr)
PHYS 2403H—Honors Physics III, H (4 cr)
PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)

Students must complete both courses to receive credit.

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

Students must complete both courses to receive credit.

AEM 2011—Statics (3 cr)
AEM 3031—Deformable Body Mechanics (3 cr)

Students must complete both courses to receive credit.

EE 3041—Industrial Assignment I (2 cr)
EE 4043W—Industrial Assignment II, WI (4 cr)

Management Minor

Students must complete a management minor to receive any credit. Only the following courses count.

ACCT 3001—Introduction to Management Accounting (3 cr)
or FINA 3001—Finance Fundamentals (3 cr)
or MGMT 3001—Fundamentals of Management (3 cr)
or MKTG 3001—Principles of Marketing (3 cr)
or HRIR 3021—Human Resource Management and Industrial Relations (3 cr)
or MGMT 3010—Introduction to Entrepreneurship (4 cr)
or OMS 3001—Introduction to Operations Management (3 cr)
or PA 3003—Nonprofit and Public Financial Analysis and Budgeting (3 cr)
or PA 4101—Nonprofit Management and Governance (3 cr)

Accounting Minor

Students must complete an accounting minor to receive any credit. Only the following courses count.

ACCT 5101—Intermediate Accounting I (4 cr)
or ACCT 5102W—Intermediate Accounting II, WI (4 cr)
or ACCT 3201—Intermediate Management Accounting (2 cr)
or ACCT 5135—Fundamentals of Federal Income Tax (4 cr)
or ACCT 5160—Financial Statement Analysis (2 cr)
or ACCT 5180—Consolidations and Advanced Reporting (2 cr)
or ACCT 5310—International Accounting (2 cr)

Biochemistry Minor

Students must complete a biochem minor to receive any credit. Only the following courses count.

BIOC 4331—Biochemistry I: Structure, Catalysis, and Metabolism in Biological Systems (4 cr)
or BIOC 4332—Biochemistry II: Molecular Mechanisms of Signal Transduction and Gene Expression (4 cr)
or BIOC 4025—Laboratory in Biochemistry (2 cr)

Biology Minor

Students must complete a biology minor to receive any credit. Only the following courses count.

BIOL 3xxx
or BIOL 4xxx
or BIOL 5xxx

Other Minors as Approved by Director of Undergraduate Studies

Other minors may count toward technical electives if approved by the ECE director of UG studies.

Department Electives

Take 22 or more credit(s) including 0 or more sub-requirement(s) from the following:

Senior Design Project

A senior design project is required.

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)

Lab Courses

Two additional EE lab courses are required. Senior honors project students only need to take one.

Take 2 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 4930—Special Topics in Electrical and Computer Engineering Laboratory (1–2 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 5657W—Physical Principles of Thin Film Technology, WI (4 cr)
EE 5811—Biomedical Instrumentation (3 cr)

Breadth and Depth Requirements (Specialty Areas)

One course chosen from four specialty areas and two courses chosen from one specialty area.

Computer Architecture

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

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)
EE 5393—Circuits, Computation and Biology (3 cr)
CSCI 5104—System Modeling and Performance Evaluation (3 cr)

Robotics and Embedded System Design

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

EE 4233—State Space Control System Design (3 cr)
EE 4231—Linear Control Systems: Designed by Input/Output Methods (3 cr)
EE 4341—Microprocessor and Microcontroller System Design (4 cr)
CSCI 5143—Real-Time and Embedded Systems (3 cr)
CSCI 5551—Introduction to Intelligent Robotic Systems (3 cr)
CSCI 5552—Sensing and Estimation in Robotics (3 cr)

VLSI and CAD

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

EE 4301—Digital Design With Programmable Logic (4 cr)
CSCI 5283—Computer-Aided Design I (3 cr)
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)

Networks and Communication

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

CSCI 4131—Internet Programming (3 cr)
CSCI 4211—Introduction to Computer Networks (3 cr)
CSCI 5131—Advanced Internet Programming (3 cr)
CSCI 5211—Data Communications and Computer Networks (3 cr)
CSCI 5221—Foundations of Advanced Networking (3 cr)
EE 5381—Telecommunications Networks (3 cr)
EE 5583—Error Control Coding (3 cr)

Systems and Software Design

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

CSCI 4707—Practice of Database Systems (3 cr)
CSCI 5103—Operating Systems (3 cr)
CSCI 5105—Foundations of Modern Operating Systems (3 cr)
CSCI 5106—Programming Languages (3 cr)
CSCI 5115—User Interface Design, Implementation and Evaluation (3 cr)
CSCI 5161—Introduction to Compilers (3 cr)
CSCI 5451—Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3 cr)
CSCI 5708—Architecture and Implementation of Database Management Systems (3 cr)
CSCI 5801—Software Engineering I (3 cr)
CSCI 5802—Software Engineering II (3 cr)

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Qualified students may elect to participate in the senior honors design course. This two-semester, 2-credit per semester course is taken senior year and under the direction of a faculty adviser. Advance permission is required to register for the sequence.

EIP Sub-plan

Internship/Cooperative Learning Program

Take EE 3041 (2 cr) and then EE 4043W (4 cr), with the possibility of a third course, EE 4044 (2 cr). Since these courses include a full-time co-op experience, these courses are taken solely in a semester followed by a regular academic semester. They likely extend time to graduate to 4.5 or 5 years.

Required Courses for the Sub-plan

Internship

EE 3041—Industrial Assignment I (2 cr)
EE 4043W—Industrial Assignment II, WI (4 cr)

Computer Science B.S. Comp.Sc.

Computer Science and Engineering

- Required credits to graduate with this degree: 120.
- Required credits within the major: 42.

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

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

Admission Requirements

Students must complete 6 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:

- 2.40 for students already admitted to the degree-granting college.
- 2.40 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 the Office of Admissions website.

Mathematics Core

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

Computer Science Introductory Core

CSCI 1901—Structure of Computer Programming I (4 cr)
CSCI 1902—Structure of Computer Programming II (4 cr)
CSCI 2011—Discrete Structures of Computer Science (4 cr)

Program Requirements

Science Core

PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
Adviser approved science course.
or take 1 or more course(s) from the following:
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
CHEM 1021—Chemical Principles I (4 cr)
CHEM 1022—Chemical Principles II (4 cr)
GEO 2201—Solid Earth Dynamics (4 cr)
PSY 3011—Introduction to Learning and Behavior (3 cr)
GCD 3022—Genetics (3 cr)

Computer Science Core

CSCI 2021—Machine Architecture and Organization (4 cr)
CSCI 2033—Elementary Computational Linear Algebra (4 cr)
CSCI 3081W—Program Design and Development, WI (4 cr)
CSCI 4041—Algorithms and Data Structures (4 cr)
CSCI 4061—Introduction to Operating Systems (4 cr)
STAT 3021—Introduction to Probability and Statistics (3 cr)

Upper Division Math-oriented Requirement

CSCI 4011—Formal Languages and Automata Theory (4 cr)
or CSCI 5302—Analysis of Numerical Algorithms (3 cr)
or CSCI 5304—Computational Aspects of Matrix Theory (3 cr)
or CSCI 5403—Computational Complexity (3 cr)
or CSCI 5421—Advanced Algorithms and Data Structures (3 cr)
or CSCI 5471—Modern Cryptography (3 cr)
or CSCI 5481—Computational Techniques for Genomics (3 cr)
or CSCI 5525—Machine Learning (3 cr)
or MATH 4xxx
or MATH 5xxx

Upper Division Track

Take 24 credits of an upper division track. Sample tracks listed below represent possible options; more information may be found at www.cs.umn.edu.

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

Systems

A track is 24 credits, split into two parts. Take twelve credits from the course list below, including the two required courses: CSCI 4211 and CSCI 5103. And 12 credits from the following: CSCI 5xxx or adviser approved courses.

CSCI 4211—Introduction to Computer Networks (3 cr)
CSCI 5103—Operating Systems (3 cr)
Take 2 or more course(s) from the following:
CSCI 5104—System Modeling and Performance Evaluation (3 cr)
CSCI 5105—Foundations of Modern Operating Systems (3 cr)
CSCI 4131—Internet Programming (3 cr)
CSCI 5131—Advanced Internet Programming (3 cr)
CSCI 5143—Real-Time and Embedded Systems (3 cr)
CSCI 5161—Introduction to Compilers (3 cr)
CSCI 5221—Foundations of Advanced Networking (3 cr)
CSCI 5231—Wireless and Sensor Networks (3 cr)
CSCI 5271—Introduction to Computer Security (3 cr)
CSCI 5551—Introduction to Intelligent Robotic Systems (3 cr)

Theory

A track is 24 credits, split into two parts. Take twelve credits from the course list below, including the two required courses: CSCI 4011 and CSCI 5421. And 12 credits from the following: CSCI 5xxx or adviser approved courses.

CSCI 4011—Formal Languages and Automata Theory (4 cr)
CSCI 5421—Advanced Algorithms and Data Structures (3 cr)
Take 2 or more course(s) from the following:
CSCI 5403—Computational Complexity (3 cr)
CSCI 5451—Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3 cr)
CSCI 5471—Modern Cryptography (3 cr)
CSCI 5481—Computational Techniques for Genomics (3 cr)
CSCI 5525—Machine Learning (3 cr)
MATH 5707—Graph Theory and Non-enumerative Combinatorics (4 cr)
MATH 5711—Linear Programming and Combinatorial Optimization (4 cr)
MATH 5165—Mathematical Logic I (4 cr)
MATH 5166—Mathematical Logic II (4 cr)

Artificial Intelligence/Robotics

A track is 24 credits, split into two parts. Take 13 credits from the course list below, including the two required courses: CSCI 4511W and CSCI 5512. And 11 credits from the following: CSCI 5xxx or adviser approved courses.

CSCI 4511W—Introduction to Artificial Intelligence, WI (4 cr)
CSCI 5512—Artificial Intelligence II (3 cr)
Take 2 or more course(s) from the following:
CSCI 5521—Pattern Recognition (3 cr)
CSCI 5523—Introduction to Data Mining (3 cr)
CSCI 5525—Machine Learning (3 cr)
CSCI 5541—Natural Language Processing (3 cr)
CSCI 5551—Introduction to Intelligent Robotic Systems (3 cr)
CSCI 5552—Sensing and Estimation in Robotics (3 cr)
CSCI 5561—Computer Vision (3 cr)

Computational Science

A track is 24 credits, split into two parts. Take 12 credits from the course list below, including the two required courses: CSCI 5302 and CSCI 5304. And 12 credits from the following: CSCI 5xxx or adviser approved courses.

CSCI 5302—Analysis of Numerical Algorithms (3 cr)
CSCI 5304—Computational Aspects of Matrix Theory (3 cr)
Take 2 or more course(s) from the following:
CSCI 5109—Visualization (3 cr)
CSCI 5451—Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3 cr)
CSCI 5461—Functional Genomics, Systems Biology, and Bioinformatics (3 cr)
CSCI 5481—Computational Techniques for Genomics (3 cr)
CSCI 5523—Introduction to Data Mining (3 cr)
AST 4101—Computational Methods in the Physical Sciences (4 cr)
MATH 5075—Mathematics of Options, Futures, and Derivative Securities I (4 cr)
MATH 5467—Introduction to the Mathematics of Image and Data Analysis (4 cr)
MATH 5587—Elementary Partial Differential Equations I (4 cr)

MATH 5588—Elementary Partial Differential Equations II (4 cr)
MATH 5711—Linear Programming and Combinatorial Optimization (4 cr)

Software Engineering/Programming Languages

A track is 24 credits, split into two parts. Take 12 credits from the course list below, including the two required courses: CSCI 5106 and CSCI 5801. And 12 credits from the following: CSCI 5xxx or adviser approved courses.

CSCI 5106—Programming Languages (3 cr)
CSCI 5801—Software Engineering I (3 cr)
Take 2 or more course(s) from the following:
CSCI 4011—Formal Languages and Automata Theory (4 cr)
CSCI 5161—Introduction to Compilers (3 cr)
CSCI 5802—Software Engineering II (3 cr)
MATH 5165—Mathematical Logic I (4 cr)

Custom Track

Students may create their own track. However, such tracks must be approved before taking the elective courses constituting it. In approving such a track, special attention is paid to its coherence, to its accordance with a computer science degree, and to its match with the student's career goals. See www.cs.umn.edu for suggestions on custom tracks.

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Earth Sciences B.S.

Geology and Geophysics

- Required credits to graduate with this degree: 120.
- Required credits within the major: 58.
- This program requires summer terms.

Earth Sciences 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.

Earth scientists 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 9 courses before admission to the program.

Students interested in the earth sciences as a major may want to consider taking GEO 1001 or other GEO 1xxx course, which can be counted as an elective.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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 2263—Multivariable Calculus (4 cr)
or MATH 2373—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, PHYS (4 cr)
or CHEM 1031H—Honors Chemistry I, PHYS, H (4 cr)
CHEM 1022—Chemical Principles II, PHYS (4 cr)
or CHEM 1032H—Honors Chemistry II, PHYS, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4.0 cr)

Program Requirements

Major Courses

Major core courses required for all focus groups.

GEO 2201—Solid Earth Dynamics (4 cr)
GEO 2202—Earth History (4 cr)
GEO 2203—Earth Surface Dynamics (4 cr)
GEO 2301—Mineralogy (3 cr)
GEO 3303W—Geochemical Principles, WI (4 cr)
GEO 3202—Geodynamics II: The Fluid Earth (3 cr)
GEO 3891—Field Methods (1 cr)

Fieldwork

Take introductory field geology (GEO 3911) and choose one advanced field course from advanced field geology (GEO 4911) or field hydrogeology (GEO 4971W).

GEO 3911—Introductory Field Geology (4 cr)
GEO 4911—Advanced Field Geology (4 cr)
or GEO 4971W—Field Hydrogeology, WI (4 cr)

Technical Electives

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

Upper Division Requirements

The general requirement for completion of upper division is 26 credits in consultation with the Director of Undergraduate Studies. Students may chose one of six focus groups (Geology, Geophysics, Biogeoscience, Hydrogeology, Geochemistry, or Environmental Geology) for a recommended list of upper division courses.

Earth Science Focus Groups

Six focus groups exist: Geology, Geophysics, Biogeoscience, Hydrogeology, Geochemistry, and Environmental Geology.

Geology

GEO 2302—Petrology (3 cr)
GEO 4501—Structural Geology (3 cr)
GEO 4602—Sedimentology and Stratigraphy (3 cr)
GEO 4702—General Hydrogeology (3 cr)

GEO 4701—Geomorphology (3.0-4 cr)
or GEO 4703—Glacial Geology (4 cr)
10–11 additional GEO credits with at least 7 credits at 4xxx or 5xxx levels

or

Geophysics

GEO 2302—Petrology (3 cr)
GEO 4211—Solid Earth Geophysics I (3 cr)
GEO 4501—Structural Geology (3 cr)
MATH 2374—IT Multivariable Calculus and Vector Analysis (4 cr)
PHYS 2303—Physics III: Physics of Matter (4 cr)
or PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)
Take 2 or more course(s) from the following:
GEO 4212—Solid Earth Geophysics II (3 cr)
GEO 4203—Principles of Geophysical Exploration (3 cr)
GEO 4204—Geomagnetism and Paleomagnetism (3 cr)
GEO 5203—Mineral and Rock Physics (3 cr)
GEO 5205—Fluid Mechanics in Earth and Environmental Sciences (3 cr)
Take 3 or more credit(s) from the following:
GEO 4xxx
GEO 5xxx

or

Biogeoscience

GEO 4801—Geobiology and Astrobiology (3 cr)
GEO 5302—Isotope Geology (3 cr)
GEO 4401—Aqueous Environmental Geochemistry (3 cr)
or GEO 4402—Biogeochemical Cycles in the Ocean (3 cr)
17 additional GEO credits at least 9 at 4xxx or 5xxx

or

Hydrogeology

GEO 4403—Atmosphere, Oceans, and the Climate System (3 cr)
GEO 4602—Sedimentology and Stratigraphy (3 cr)
GEO 4702—General Hydrogeology (3 cr)
GEO 4401—Aqueous Environmental Geochemistry (3 cr)
or GEO 4701—Geomorphology (3.0-4 cr)
or GEO 4703—Glacial Geology (4 cr)
13–14 additional GEO credits with at least 9 credits at 4xxx or 5xxx

or

Geochemistry

GEO 2302—Petrology (3 cr)
GEO 4501—Structural Geology (3 cr)
GEO 4801—Geobiology and Astrobiology (3 cr)
GEO 5302—Isotope Geology (3 cr)
GEO 4401—Aqueous Environmental Geochemistry (3 cr)
or GEO 4402—Biogeochemical Cycles in the Ocean (3 cr)
11 additional GEO credits with at least 9 credits at 4xxx or 5xxx

or

Environmental Geology

GEO 4401—Aqueous Environmental Geochemistry (3 cr)
GEO 4402—Biogeochemical Cycles in the Ocean (3 cr)
GEO 4403—Atmosphere, Oceans, and the Climate System (3 cr)
GEO 4702—General Hydrogeology (3 cr)
GEO 4703—Glacial Geology (4 cr)
or GEO 4801—Geobiology and Astrobiology (3 cr)
10–11 additional GEO credits with at least 9 credits at 4xxx or 5xxx

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Ecological Engineering Minor

Bioproducts and Biosystems Engineering

Minor Related to a Major

- Requirements for this program are current for Fall 2010.
- Required credits in this minor: 18 to 20.

Ecological engineering integrates traditional engineering concepts with ecological principles such as resiliency, adaptation, and community dynamics. The ecological engineering minor prepares students to design sustainable systems integrating human activities with the natural environment, including watershed management and enhancement; waste treatment systems; phytoremediation and bioremediation; industrial ecology; constructed and restored wetlands; mitigation of non-point source contamination; and increase of ground water recharge through "low impact" design and other methods.

The minor, offered by faculty in the Department of Bioproducts and Biosystems Engineering and administered through the College of Science and Engineering, involves courses in bioproducts and biosystems engineering; civil engineering; ecology, evolution, and behavior; environmental sciences, policy and management; forest resources; and geology.

Minor Requirements

Core Group Courses

Students must take 9 or more credits from the list of courses selecting at least one course in each of the three core areas of ecological sciences, hydrologic sciences, and ecological engineering design. Acceptable courses in each of the core areas are shown below.

Ecological Sciences

Take at least one course from this subgroup
BIOL 3407—Ecology, ENVT (3 cr)
or BIOL 3408W—Ecology, ENVT, WI (3 cr)
or BIOL 3807—Ecology, ENVT (4 cr)

Hydrologic Sciences

Take at least one course from this subgroup
CE 4501—Hydrologic Design (4 cr)
or BBE 5513—Watershed Engineering (3 cr)
or FR 3114—Hydrology and Watershed Management (3 cr)

Ecological Engineering Design

Take at least one course from this subgroup
BBE 4523—Ecological Engineering Design (3 cr)
or BBE 5523—Ecological Engineering Design (3 cr)

Additional Courses

In addition to the core courses, the students must take 9 or more credits from the following list of courses.

BBE 3023—Ecological Engineering Principles (3 cr)
or BBE 4013—Transport in Biological Systems (3 cr)
or BBE 4533—Agricultural Waste Management Engineering (3 cr)
or BBE 5533—Assessment and Diagnosis of Impaired Waters (3 cr)
or CE 3301—Soil Mechanics I (3 cr)
or CE 3501—Environmental Engineering, C/PE, ENVT (3 cr)
or CE 4351—Groundwater Mechanics (3 cr)
or CE 4352—Groundwater Modeling (3 cr)
or CE 4502—Water and Wastewater Treatment (3 cr)
or CE 4512—Open Channel Hydraulics (4 cr)
or CE 4561—Solid Hazardous Wastes (3 cr)
or CE 4562—Environmental Remediation Technology (3 cr)
or CE 5541—Environmental Water Chemistry (3 cr)
or CE 5581—Water Resources: Individuals and Institutions (3 cr)
or EEB 3001—Ecology and Society, ENVT (3 cr)
or EEB 3603—Science, Protection, and Management of Aquatic Environments (3 cr)
or EEB 4014—Ecology of Vegetation (3 cr)
or EEB 4609W—Ecosystem Ecology, WI (3 cr)
or EEB 4611—Biogeochemical Processes (3 cr)
or EEB 5601—Limnology (3 cr)
or ESPM 3101—Conservation of Plant Biodiversity, ENVT (3 cr)
or ESPM 3111—Hydrology and Water Quality Field Methods (3 cr)
or ESPM 3245—Sustainable Land Use Planning and Policy, ENVT (3 cr)
or ESPM 3251—Natural Resources in Sustainable International Development, ENVT, IP (3 cr)
or ESPM 3603—Environmental Life Cycle Analysis (3 cr)
or ESPM 3604—Environmental Management Systems and Strategy (3 cr)
or ESPM 4216—Contaminant Hydrology (2 cr)
or ESPM 4608—Bioremediation (2 cr)
or ESPM 5111—Hydrology and Water Quality Field Methods (3 cr)
or FR 3104—Forest Ecology (4 cr)
or FR 3204—Landscape Ecology and Management (3 cr)
or FR 5153—Forest and Wetland Hydrology (3 cr)
or GEO 3005—Earth Resources, C/PE, IP (3 cr)
or GEO 4631W—Earth Systems: Geosphere/Biosphere Interactions, WI (3 cr)
or GEO 5108—Principles of Environmental Geology (3 cr)
or GEO 5205—Fluid Mechanics in Earth and Environmental Sciences (3 cr)
or GEO 5701—General Hydrogeology (3 cr)
or SUST 3003—Sustainable People, Sustainable Planet, ENVT, C/PE (3 cr)

Electrical Engineering B.E.E.

Electrical and Computer Engineering

- Required credits to graduate with this degree: 128.
- Required credits within the major: 105.

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.

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 the Office of Admissions website.

Mathematics

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

or

Honors Curriculum

For those students pursuing Latin Honors
MATH 1571H—Honors Calculus I, H (4 cr)
and MATH 1572H—Honors Calculus II, H (4 cr)
and MATH 2573H—Honors Calculus III, H (4 cr)
and MATH 2574H—Honors Calculus IV, H (4 cr)
or MATH 2582H—Honors Calculus II: Advanced Placement, H (5 cr)
and MATH 2583H—Honors Calc 3—Advanced Placement, H (5 cr)
and MATH 3584H—Honors Calculus IV: Advanced Placement, H (5 cr)

Chemistry and Physics

CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
Take 1 or more course(s) from the following:
CHEM 1022—Chemical Principles II (4 cr)
CHEM 1032H—Honors Chemistry II, H (4 cr)
PHYS 2303—Physics III: Physics of Matter (4 cr)
PHYS 2311—Modern Physics (4 cr)
PHYS 2403H—Honors Physics III, H (4 cr)
PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)

Computer Science

EE 1301—Introduction to Computing Systems (4 cr)

Lower Division Core Courses

EE 2001—Introduction to Electronic and Electrical Circuits (3 cr)
EE 2002—Introductory Circuits and Electronics Laboratory (1 cr)
EE 2011—Linear Systems and Circuits (3 cr)
EE 2301—Introduction to Digital System Design (4 cr)
EE 2361—Introduction to Microcontrollers (4 cr)

Program Requirements

Upper Division Required 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)

EE Technical Electives

Students need to complete 34 technical elective credits with a minimum of 22 coming from EE 4xxx or 5xxx courses. Of the technical electives one course must be chosen from four of the specialty areas and at least two courses must be chosen from one of the specialty areas. A senior design project is also required as are two additional EE lab courses. Students who complete the two-semester senior honors project instead of the senior design project only need to take one additional EE lab course.

Take 34 or more credit(s) from the following:

AEM 2021—Statics and Dynamics (4 cr)
AEM 4601—Instrumentation Laboratory (3 cr)
BBE 3013—Engineering Principles of Molecular and Cellular Processes (3 cr)
BIOC 3021—Biochemistry (3 cr)
BLAW 3058—The Law of Contracts and Agency (4 cr)
BMEN 5401—Advanced Biomedical Imaging (3 cr)
CE 3502—Fluid Mechanics (4 cr)
CE 4101W—Project Management, WI (3 cr)
CHEM 2301—Organic Chemistry I (3 cr)
CHEM 2302—Organic Chemistry II (3 cr)
CHEM 2311—Organic Lab (4 cr)
CHEM 3501—Introduction to Thermodynamics, Kinetics, and Statistical Mechanics (3 cr)
CHEM 3502—Introduction to Quantum Mechanics and Spectroscopy (3 cr)
CSCI 4xxx
CSCI 5xxx
IE 5441—Financial Decision Making (4 cr)
IE 5511—Human Factors and Work Analysis (4 cr)
IE 5512—Applied Ergonomics (4 cr)
IE 5513—Engineering Safety (4 cr)
IE 5522—Quality Engineering and Reliability (4 cr)
IE 5531—Engineering Optimization I (4 cr)
IE 5541—Project Management (4 cr)
IE 5551—Production Planning and Inventory Control (4 cr)
IE 5552—Design and Analysis of Manufacturing Systems (4 cr)
IE 5553—Simulation (4 cr)
MATS 3011—Introduction to Materials Science and Engineering (3 cr)
MATS 3012—Metals and Alloys (3 cr)
MATS 3851W—Materials Properties Lab, WI (3 cr)
MATS 4013—Electrical and Magnetic Properties of Materials (3 cr)
MATH 3283W—Sequences, Series, and Foundations: Writing Intensive, WI (4 cr)
MATH 4xxx
MATH 5xxx
ME 3324—Introduction to Thermal Science (3 cr)
PHSL 3061—Principles of Physiology (4 cr)
PHYS 2601—Quantum Physics (4 cr)
PHYS 2605—Quantum Physics Laboratory (3 cr)
PHYS 4101—Quantum Mechanics (4 cr)
PHYS 4201—Statistical and Thermal Physics (3 cr)
STAT 5101—Theory of Statistics I (4 cr)
STAT 5041—Bayesian Decision Making (3 cr)
STAT 5102—Theory of Statistics II (4 cr)
Students must complete both courses to receive credit.
AEM 2011—Statics (3 cr)
AEM 2012—Dynamics (3 cr)
Students must complete both courses to receive credit.
AEM 2011—Statics (3 cr)
AEM 3031—Deformable Body Mechanics (3 cr)
Students must complete both courses to receive credit.
EE 3041—Industrial Assignment I (2 cr)
EE 4043W—Industrial Assignment II, WI (4 cr)

Management Minor

Students must complete a management minor to receive any credit. Only the following courses count.

ACCT 3001—Introduction to Management Accounting (3 cr)
or FINA 3001—Finance Fundamentals (3 cr)
or MGMT 3001—Fundamentals of Management (3 cr)
or MKTG 3001—Principles of Marketing (3 cr)
or HRIR 3021—Human Resource Management and Industrial Relations (3 cr)
or MGMT 3010—Introduction to Entrepreneurship (4 cr)
or OMS 3001—Introduction to Operations Management (3 cr)
or PA 3003—Nonprofit and Public Financial Analysis and Budgeting (3 cr)
or PA 4101—Nonprofit Management and Governance (3 cr)

Accounting Minor

Students must complete an Accounting minor to receive any credit. Only the following courses count.

ACCT 5101—Intermediate Accounting I (4 cr)
or ACCT 5102W—Intermediate Accounting II, WI (4 cr)
or ACCT 3201—Intermediate Management Accounting (2 cr)
or ACCT 5135—Fundamentals of Federal Income Tax (4 cr)
or ACCT 5160—Financial Statement Analysis (2 cr)
or ACCT 5180—Consolidations and Advanced Reporting (2 cr)
or ACCT 5310—International Accounting (2 cr)

Biochemistry Minor

Students must complete a Biochem minor to receive any credit. Only the following courses count.

BIOC 4331—Biochemistry I: Structure, Catalysis, and Metabolism in Biological Systems (4 cr)
or BIOC 4332—Biochemistry II: Molecular Mechanisms of Signal Transduction and Gene Expression (4 cr)
or BIOC 4025—Laboratory in Biochemistry (2 cr)

Biology Minor

Students must complete a Biology minor to receive any credit. Only the following courses count.

BIOL 3xxx
or BIOL 4xxx
or BIOL 5xxx

Other Minors as approved by Director of Undergraduate Studies

Other minors may count toward Technical Electives if approved by the ECE Director of UG Studies.

Department Electives

Take 22 or more credit(s) including 0 or more sub-requirement(s) from the following:

Senior Design Project

A senior design project is required.

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)

Lab Courses

Two additional EE lab courses are required. Senior honors project students only need to take one.

Take 2 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 4930—Special Topics in Electrical and Computer Engineering Laboratory (1–2 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 5657W—Physical Principles of Thin Film Technology, WI (4 cr)
EE 5811—Biomedical Instrumentation (3 cr)

Breadth and Depth Requirements (Specialty Areas)

One course chosen from four specialty areas and two courses chosen from one specialty area.

Communications, Signal Processing, and Biomedical

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

EE 4501—Communications Systems (3 cr)
EE 4541—Digital Signal Processing (3 cr)
EE 5381—Telecommunications Networks (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 5545—Digital Signal Processing Design (3 cr)
EE 5549—Digital Signal Processing Structures for VLSI (3 cr)
EE 5551—Multiscale and Multirate 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 5811—Biomedical Instrumentation (3 cr)
EE 5821—Biological System Modeling and Analysis (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 Optimization (3 cr)

Digital Systems and Computer Architecture

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

EE 4301—Digital Design With Programmable Logic (4 cr)
EE 4341—Microprocessor and Microcontroller System Design (4 cr)
EE 4363—Computer Architecture and Machine Organization (4 cr)
EE 4389W—Introduction to Empirical Inference and Soft Computing, WI (3 cr)
EE 4609—Digital Signal Integrity (3 cr)
EE 5364—Advanced Computer Architecture (3 cr)
EE 5371—Computer Systems Performance Measurement and Evaluation (3 cr)
EE 5393—Circuits, Computation and Biology (3 cr)
EE 5863—Computer Systems Performance Analysis (2 cr)

VSLI 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 5327—VLSI Design Laboratory (3 cr)
EE 5329—VLSI Digital Signal Processing Systems (3 cr)
EE 5333—Analog Integrated Circuit Design (3 cr)

Electronics,Microelectronics, and Semiconductor Devices

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

EE 4111—Advanced Analog Electronics Design (4 cr)
EE 5121—Transistor Device Modeling for Circuit Simulation (3 cr)
EE 5141—Introduction to Microsystem Technology (4 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)
EE 5181—Introduction to Nanotechnology (4 cr)
EE 4161—Energy Conversion and Storage (3 cr)
EE 5657W—Physical Principles of Thin Film Technology, WI (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—Electric Drives in Sustainable Energy Systems (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)

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 5611—Plasma-Aided Manufacturing (4 cr)
EE 5613—RF/Microwave Circuit Design Laboratory (2 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 5628—Fiber Optics Laboratory (1 cr)
EE 5629—Optical System Design (2 cr)
EE 5653—Physical Principles of Magnetic Materials (3 cr)
EE 5655—Magnetic Recording (3 cr)

Program Sub-plans

A sub-plan is not required for this program.

EIP Sub-plan

Internship/Cooperative learning program.

Take EE 3041 (2 cr) and then EE 4043W (4 cr), with the possibility of a third course, EE 4044 (2 cr).

Required Courses for the Sub-plan

Internship

EE 3041—Industrial Assignment I (2 cr)
EE 4043W—Industrial Assignment II, WI (4 cr)

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Geological Engineering B.Geo.E.

Civil Engineering

- Required credits to graduate with this degree: 128.
- Required credits within the major: 61.
- This program requires summer terms.

The mission of the geological engineering program comprises three overlapping and mutually supportive components:

- Prepare students to become productive engineers and contributing members of their professional community
- Prepare students for continual learning and professional development
- Prepare students for formal advanced education.

The program has four core objectives:

1. To produce graduates with a strong fundamental scientific and technical knowledge base and critical thinking skills required for engineering problem formulation and problem solving.
2. To produce graduates with the ability to work as a professional team member. This includes the ability to communicate effectively through both oral and written language.
3. To produce graduates with an understanding of their obligations as professional geological engineers to protect human health, welfare, and the environment.
4. To ensure that graduates have had opportunities to complement their academic studies with scholarly (research) investigations, co-ops, and internships.

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 the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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)

Mechanics

AEM 2011—Statics (3 cr)
AEM 3031—Deformable Body Mechanics (3 cr)

Physical Sciences

CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)
and PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, 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, PHYS, ENV (4 cr)
or GEO 2201—Solid Earth Dynamics (4 cr)
GEO 3911—Introductory Field Geology (4 cr)
or GEO 4971W—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 (3–4 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, ENV (3 cr)
CE 3301—Soil Mechanics I (3 cr)
or GEOE 3301—Soil Mechanics I (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

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

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 5591—Environmental Law for Engineers (3 cr)
CE 5541—Environmental Water Chemistry (3 cr)
GEO 4401—Aqueous 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 3201—Transportation Engineering (3 cr)
CE 3401—Linear Structural Analysis (3 cr)
CE 3402—Civil Engineering Materials (3 cr)
CE 4111—Engineering Systems Analysis (3 cr)
CE 4121—Computer Applications in Civil Engineering II (3 cr)
CE 4401—Steel and Reinforced Concrete Design (4 cr)
CE 4412—Reinforced Concrete Design II (3 cr)
CE 4413—Steel Design II (3 cr)
CE 5311—Experimental Geomechanics (3 cr)
CE 5321—Geomechanics (3 cr)

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Information Technology

Computer Science and Engineering

This is a Free-Standing Minor

- Required credits in this minor: 16.

This interdisciplinary minor requires at least 14 credits, including two core courses from the College of Science and Engineering 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.

Minor Requirements

Minor Courses

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 (3–4 cr)
COMM 3211—Introduction to U.S. Electronic Media (3 cr)
COMM 4231—Comparing Electronic Media Systems (3 cr)
COMM 4235—Electronic Media and Ethnic Minorities—A World View, IP (3 cr)
COMM 4291—New Telecommunication Media (3 cr)
GDES 2334—Computer Applications I: Digital Composition for Design (3 cr)
GDES 4334—Computer Applications II: Design for the Digital Environment (3 cr)
GDES 5383—Digital Illustration and Animation (3 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 3614—History of Media Communication, HIS (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 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.

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 the Office of Admissions website.

Mathematics

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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

AEM 2011—Statics (3 cr)
CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)
and CHEM 2301—Organic Chemistry I (3 cr)
and PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
and PHYS 2303—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 (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)

Technical Electives

Students must take 13 credits of technical electives. See an adviser for a list of possible courses.

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

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 the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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)
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, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, 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:

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 I (4 cr)
and CSCI 1902—Structure of Computer Programming II (4 cr)

Third-Semester Physics

PHYS 2303—Physics III: Physics of Matter (4 cr)
or PHYS 2311—Modern Physics (4 cr)
or PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (4 cr)

Complete 6 credits of technical electives selected in consultation with your adviser.

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—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)

Introductory Biology Requirements

BIOL 1009—General Biology, BIOL SCI/L (4 cr)

or take the following course pair

BIOL 1001—Introductory Biology I: Evolutionary and Ecological Perspectives, BIOL SCI/L, ENVT (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 I (4 cr)
and CSCI 1902—Structure of Computer Programming II (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.

Actuarial Specialization

Complete the requirements for the actuarial sub-plan.

Mathematics Education Specialization

Complete the requirements for the mathematics education sub-plan.

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.

Required Courses for the Sub-plan

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—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)

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

1101–1102

ECON 1101—Principles of Microeconomics, SOCS (4 cr)
ECON 1102—Principles of Macroeconomics, IP, SSCI (4 cr)

or

1104–05

ECON 1104—Principles of Microeconomics (4 cr)
or ECON 1105—Principles of Macroeconomics (4 cr)
ACCT 2050—Introduction to Financial Reporting (4 cr)
ECON 3101—Intermediate Microeconomics (4 cr)
FINA 3001—Finance Fundamentals (3 cr)
and ECON 4751—Financial Economics (3 cr)

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

INS 4100—Corporate Risk Management (2 cr)
INS 4101—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.

Required Courses for the Sub-plan

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

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 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)

Additional Analysis

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

MATH 4606—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 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)

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 5285H—Honors: Fundamental Structures of Algebra I, H (4 cr)
or MATH 5286H—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 1 (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)
or CSCI 5512—Artificial Intelligence II (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: Intro to Waves, Optics, and Special Relativity (4 cr)

Mathematics Education

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.

Required Courses for the Sub-plan

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 5285H—Honors: Fundamental Structures of Algebra I, H (4 cr)
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)
MATH 5651—Basic Theory of Probability and Statistics (4 cr)
or STAT 5101—Theory of Statistics I (4 cr)

Computer Science

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 I (4 cr)
CSCI 1902—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: Intro to Waves, Optics, and Special Relativity (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)

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

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 machinery/consumer products production. A mechanical engineer may be engaged in design, development, research, testing, manufacturing, administration, marketing, consulting, or education.

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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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 1113—Introduction to C/C++ Programming for Scientists and Engineers (4 cr)

CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)

Statics and Dynamics

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

Required Courses for the Sub-plan

Internship

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

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at **www.honors.umn.edu/academics/curriculum/dept_courses_current.html**.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

The honors thesis extends over two semesters. Students register for ME 4081 the first semester (2 credits) and ME 4082 during the second semester (2 credits). Credits earned during the second semester may be applied to the technical electives requirement. Formal written theses must be submitted and presented orally by students during their final semester. Students are encouraged to form contacts late in the junior year with potential faculty advisers for the honors thesis.

Industrial Engineering EIP Sub-plan

The Engineering Intern Program (EIP or co-op program) for industrial engineering students is offered through an industrial engineering option. Students complete the same set of required courses as other mechanical engineering students, but their technical electives must be selected from an approved list and in consultation with a faculty adviser. Students selecting the option may also apply to the co-op program.

Technical electives should be taken in the IE department. Students should also take the necessary course in conjunction with their internship/co-op program.

Required Courses for the Sub-plan

Technical Electives

Choose four courses (16 cr) 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—Financial Decision Making (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)

Tech Elective—Operations Research
or IE 5531—Engineering Optimization I (4 cr)
or IE 5553—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)

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.

Required Courses for the Sub-plan

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—Financial Decision Making (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)
Tech Elective—Operations Research
or IE 5531—Engineering Optimization I (4 cr)
or IE 5553—Simulation (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 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 the Office of Admissions website.

Preparatory Mathematics

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

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)
PHYS 2403H—Honors Physics III, H (4 cr)
or PHYS 2503—Physics III: Intro to Waves, Optics, and Special Relativity (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.

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.

Complete the requirements for professional physics or those for any of the following physics sub-plans: 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 3xxx
MATH 4xxx
MATH 5xxx

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

PHYS 3xxx
PHYS 4xxx
PHYS 5xxx

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.

Required Courses for the Sub-plan

Physics for Biology

BIOC 3021—Biochemistry (3 cr)
BIOL 1009—General Biology, BIOL (4 cr)
CHEM 1021—Chemical Principles I (4 cr)
CHEM 1022—Chemical Principles II (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.

Students should take Phys 4001 and 4002 and 4101 and 4201 and technical electives.

Required Courses for the Sub-plan

Computational Physics—Core Courses

Students should take 4001 and 4002 and 4101 and 4201 and 14 credits from the specified technical electives plus 11 additional chosen in consultation with the adviser.

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 14 or more credit(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)
or 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
and 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.

Required Courses for the Sub-plan

Physics for Engineering

CHEM 1021—Chemical Principles I (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.

Required Courses for the Sub-plan

Chemistry and Upper-Division Physics

CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, 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 2201—Solid Earth Dynamics (4 cr)
GEO 3303W—Geochemical Principles, WI (4 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 (3 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.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.

Required Courses for the Sub-plan

PHYS 4960H—Honors Seminar, H (1 cr)

Statistics B.S. Stat.

College of Science and Engineering

- 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.

For information about University of Minnesota admission requirements, visit the Office of Admissions website.

Mathematics

MATH 1271—Calculus I (4 cr)
or MATH 1371—IT Calculus I (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)
and STAT 4102—Theory of Statistics II (4 cr)
or STAT 5101—Theory of Statistics I (4 cr)
and 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 (4 cr)
BIOL 1009H—Honors: General Biology, BIOL, H (4 cr)

Take 0–2 course(s) from the following:
CHEM 1021—Chemical Principles I (4 cr)
or CHEM 1031H—Honors Chemistry I, H (4 cr)
and CHEM 1022—Chemical Principles II (4 cr)
or CHEM 1032H—Honors Chemistry II, H (4 cr)

Take 0–2 course(s) from the following:
PHYS 1301W—Introductory Physics for Science and Engineering I, PHYS, WI (4 cr)
or PHYS 1401V—Honors Physics I, PHYS, WI, H (4 cr)
and PHYS 1302W—Introductory Physics for Science and Engineering II, PHYS, WI (4 cr)
or PHYS 1402V—Honors Physics II, PHYS, WI, H (4 cr)

Technical Electives

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

Program Sub-plans

A sub-plan is not required for this program.

Honors (UHP) Sub-plan

Students admitted to the University Honors Program (UHP) must fulfill UHP requirements in addition to degree program requirements. Honors courses used to fulfill degree program requirements will also fulfill UHP requirements. Current departmental honors course offerings are listed at www.honors.umn.edu/academics/curriculum/dept_courses_current.html.

Honors students complete an honors thesis project in the final year, most often in conjunction with an honors thesis course, or with an honors directed studies or honors directed research course. Students select honors courses and plan for a thesis project in consultation with their UHP adviser and their departmental faculty adviser.