College of Engineering and Physical Sciences

Arthur Greenberg, Dean
Robert Henry, Associate Dean

Department of Chemical Engineering
Department of Chemistry
Department of Civil Engineering
Department of Computer Science
Department of Earth Sciences
Department of Electrical and Computer Engineering
Department of Mathematics and Statistics
Department of Mechanical Engineering
Department of Physics

Bachelor of Science
Chemical Engineering*
- Energy
- Environmental Engineering

Chemistry*
Civil Engineering*
Computer Engineering*
Computer Science*
Electrical Engineering*
Environmental Engineering*†
- Industrial Processes
- Municipal Processes

Geology*
Hydrology*
Mathematics*
Mathematics Education*
- Elementary
- Middle/Junior High
- Secondary

Mathematics, Interdisciplinary
- Computer Science
- Economics
- Electrical Science
- Physics
- Statistics

Mechanical Engineering*
Physics*
- Biophysics
- Chemical
- Materials Science

Bachelor of Arts
Chemistry
Chemistry and Physics Teaching
Earth Science Teaching
Earth Sciences
- Oceanography

Mathematics
Physics
- Biophysics

*Designated degree (the name of the specialization is on the diploma, e.g., B.S. in chemistry).

†Multidisciplinary; i.e., offered in collaboration with two departments.

The College of Engineering and Physical Sciences provides an opportunity for students to achieve educational objectives appropriate to their interests in engineering, mathematics, and the physical sciences. The college offers an education in each of its primary disciplines leading to the bachelor of science, as well as bachelor of art degrees with majors in mathematics and each of the three physical sciences. All programs include an opportunity for study in the arts, humanities, and social sciences.

The key to an undergraduate program in the college is flexibility, with a strong emphasis on personal and individualized education. In addition to specific programs, a number of options are available. Special programs can be developed to meet the specific interests of individual students.

Degree Requirement

MATH 425 and 426 (Calculus I and II) or the equivalent in transfer credits or advanced placement approved by the Department of Mathematics and Statistics are required by all departments of the college for their majors. Prerequisites for calculus are three years of college-preparatory mathematics, including a half-year of trigonometry. Before students can register for MATH 425, they are required to take the Mathematics Placement Test.

Mathematics Placement

First-year students arrive with a wide range of mathematical skills based on high school preparation. We want you to build skills, so you will enjoy an enriched first-semester experience. We will assess your mathematics development during Orientation and enroll you in the class that will allow you to continue that development. The initial entry course is Analysis and Applications of Functions (MATH 418). However, a placement test will be given to allow a student to place out of MATH 418 into MATH 425 (Calculus I). If you have received AP credit for Calculus I and/or Calculus II, you may elect to accept those credits and continue with a math course at the next level.

A semester course load usually consists of four 4-credit courses. First-year students usually take courses numbered in the 400s and 500s.

Accreditation

The baccalaureate-level programs in chemical, civil, electrical, and mechanical engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The baccalaureate-level program in computer science is accredited by the Computer Science Accreditation Commission of the Computing Sciences Accreditation Board. The Department of Chemistry's undergraduate bachelor of science program is approved by the American Chemical Society.

Degrees

Bachelor of Science

The programs leading to the bachelor of science degree, offered in each of the departments of the college, emphasize the preparation of students for a professional career and continuing or graduate education.

The degree requirements for the bachelor of science include the University general education requirements (page 17) and the specific departmental requirements for graduation. A minimum grade-point average of 2.00 must be achieved. Graduation credit requirements established by the departments range from 128 to 134. There are enrollment limitations in some programs, and it is not possible to guarantee all change-of-major requests.

Bachelor of Arts

Programs leading to a bachelor of arts degree are offered in the departments of chemistry, earth sciences, mathematics, and physics. These programs provide a broad liberal education along with a major in one of these fields. The University requirements for the bachelor of arts degree are on page 18.

Interdisciplinary Programs

Majors

Bachelor of Science in Environmental Engineering

The environmental engineering program consists of two emphases: industrial processes (IP) and municipal processes (MP) (see page 62).

Bachelor of Science in Hydrology

The hydrology major is an interdisciplinary major offered by the departments of earth sciences and civil engineering. The coordinator of the program is J. Matthew Davis of the Department of Earth Sciences (for more information, see page 58).

Minors

Interdisciplinary minors enable students to obtain experience in a specialized area and to retain identification with their major professional area. The college's interdisciplinary minors are:

Environmental engineering, see page 63.
Hydrology, see page 60.
Materials science, see page 66.
Ocean engineering, see page 104.
Oceanography, see page 104.

For University requirements as regards minors, see page 20.

Other Programs

Independent Study and Projects

All departments within the college offer courses in independent study or in projects, the content varying with the current scientific and technological needs and with student and faculty interest.

Permission of the instructor and/or the department chairperson is required. (See the course descriptions for the independent study and project courses and for specific requirements.) The initiative for independent study courses in any area rests with the student.

Special Provisions

The requirement of a given course in any prescribed curriculum may be waived by the faculty of a student's college. The student's petition must be approved by his/her major adviser and the dean of the college. This power will usually be delegated by the faculty to the dean or to a committee. (Senate Rule 05.21(s): Waiver of Requirements in a Prescribed Curriculum.)

This rule offers students the opportunity to develop a somewhat individualized plan of study with intellectual incentives and opportunities in addition to those in a regular curriculum.

In addition, upon the recommendation of the department chairperson, superior students may be allowed to count credits from up to two 800-level courses toward both a bachelor's degree and a master's degree, provided that the students have been admitted to the master's program.

Research Opportunities

The talents and expertise of the faculty in all departments are reflected in the number of ongoing research projects. Undergraduates are included in many of these research projects with the intent of discovering and fostering their creative talents. In funded research projects, students may have an opportunity to receive pay while learning.

A multiplicity of research programs is reflected in special facilities: the Analog Computer Facility, Antenna Systems Laboratory, Bioelectronics Laboratory, Computation Science Center, Electronics Laboratory, Engineering Design and Analysis Laboratory, Fluid Mechanics Laboratory, Materials Laboratories, Mechanics Research Laboratory, Sanitary Engineering Laboratory, Solid State Laboratory, Space Science Center, Wind Tunnel and Water Tunnel Facility, and X-ray Laboratory.

Students have the opportunity to acquire applied experience in business and industry by working with faculty members who undertake client-sponsored professional projects in management and technical areas for business and industry, and for state and local governments.

Study Abroad Programs

Hungary

The College of Engineering and Physical Sciences has arranged an opportunity for its students to spend the fall semester of their junior year at the Budapest University of Technology and Economics (BUTE) in Budapest, Hungary. Courses at BUTE are taught in English and receive prior approval for degree credit. Students studying in Budapest, therefore, will graduate on schedule at UNH. A general education course on the language, geography, and culture of Hungary, taken at BUTE, is required. The foreign student office at BUTE will appoint a Hungarian adviser for each student and will assist in obtaining housing either in dormitories, or in apartments. Further information is available from Carol French, administrative coordinator of the program; CEPS Dean's Office, Marina Markot, Educational Program Coordinator, Center for International Education, Hood House; or the college's foreign exchange program coordinator, Professor Andrzej Rucinski.

Puerto Rico

Students may spend one or two semesters at the University of Puerto Rico (UPR) at Mayaguez, the second largest of the three major campuses in the UPR system. While having the opportunity to learn in a Latin American environment, participants maintain their status as UNH students, pay UNH tuition, and will be able to graduate from UNH on schedule. The exchange is open to students and faculty members from all UNH majors. Since eighty percent of all courses at UPR are taught in Spanish, participants must be proficient in Spanish. Interested CEPS students should contact Carolyn Tacy, National Student Exchange Office, Hood House.

Scotland, Heriot-Watt University Exchange Program

College of Engineering and Physical Sciences students are eligible to participate in a spring semester exchange with Heriot-Watt University in Edinburgh, Scotland. The current program is designed for civil and environmental engineering majors. For more information, contact Robert Henry at (603) 862-3131 or Marina Markot, Educational Program Coordinator, Center for International Education, Hood House.

Preparing for Teaching

Students interested in mathematics education (elementary, middle/junior high, or secondary), chemistry and physics teaching, earth science teaching, or general science teaching should refer to the Department of Education section (page 33) and to the appropriate department for a description of the requirements.

Combined Programs of Study

In addition to pursuing a single major, students may combine programs of study as follows:

Minors: See page 20; see also pages 23 and 54 and Departmental Programs of Study in this section.
Second Majors: See page 20.
Interdisciplinary Majors: Many departments in the college offer programs that combine a major with another field of interest. See the descriptions that follow.
Dual-Degree Programs: See page 19.
Student-Designed Majors: See page 105.
Other combined and interdisciplinary opportunities: See page 102.

Programs of Study

In addition to the following departmental majors and options, departmental minors are offered in chemical engineering, chemistry, electrical engineering, geology, hydrology, mathematics, applied mathematics, mechanical engineering, physics, and statistics.

Chemical Engineering

(For descriptions of courses, see page 142.)

The Department of Chemical Engineering currently offers the undergraduate degree program in chemical engineering with options in energy and environmental engineering. In addition, the College of Engineering and Physical Sciences offers an interdisciplinary B.S. program in environmental engineering with the participation of the chemical engineering and civil engineering departments. See page 61.

Bachelor of Science in Chemical Engineering

Chemical engineering is concerned with the analysis and design of processes that deal with the transfer and transformation of energy and material.

The practice of chemical engineering includes the conception, development, design, and application of physicochemical processes and their products; the development, design, construction, operation, control, and management of plants for these processes; and activities relating to public service, education, and research.

Traditional employment areas in the chemical process industries include industrial chemicals, petroleum and petrochemicals, plastics, pharmaceuticals, metals, textiles, and food. Chemical engineers are also working in increasing numbers in the areas of energy engineering, pollution abatement, and biochemical and biomedical engineering; in addition, they are employed by many government laboratories and agencies as well as private industries and institutions.

The curriculum trains students to enter the diverse areas of employment or graduate study. The considerable number of electives in the curriculum provides flexibility for individuals to design programs that fulfill their needs and interests. They also provide an opportunity for students to elect departmental options or interdisciplinary minors.

A minimum of 130 credits is required for graduation with the degree of bachelor of science in chemical engineering. There are nine electives in the chemical engineering curriculum. Five of these are for the general education requirements. The remaining four electives should consist of three chemical engineering electives and one additional technical elective.

Students are required to obtain a minimum 2.00 grade-point average in CHE 501-502 and in overall standing at the end of the sophomore year in order to continue in the major.

Freshman Year	Fall	Spring
ENGL 401, Freshman English	–	4
MATH 425-426, Calculus and II	4	4
PHYS 407, General Physics I	–	4
CHEM 405, General Chemistry	4	–
CHE 410, Survey of Current Energy and Pollution Control Technology	–	4
Electives (2)	8	–
Total	**16**	**16**
Sophomore Year		
CHEM 683-684, Physical Chemistry I and II	3	3
CHEM 685-686, Physical Chemistry Laboratory	2	2
MATH 527, Differential Equations with Linear Algebra	4	–
CS 410, Introduction to Scientific Programming	–	4
PHYS 408, General Physics II	4	–
CHE 501-502, Introduction to Chemical Engineering I and II	3	3
Elective	–	4
Total	**16**	**16**
Junior Year		
CHEM 651-652, Organic Chemistry	3	3
CHEM 653, Organic Chemistry Laboratory	2	–
CHE 601, Fluid Mechanics and Unit Operations	3	–
CHE 602, Heat Transfer and Unit Operations	–	3
CHE 603, Applied Mathematics for Chemical Engineers	4	–
CHE 604, Chemical Engineering Thermodynamics	–	4
CHE 612, Chemical Engineering Laboratory I	–	3
Electives (2)	4	4
Total	**16**	**17**
Senior Year		
CHE 605, Mass Transfer and Stagewise Operations	3	–
CHE 606, Chemical Engineering Kinetics	3	–
CHE 608, Chemical Engineering Design	–	4
CHE 613, Chemical Engineering Laboratory II	3	–
CHE 752, Process Dynamics and Control	–	4
Electives (4)	8	8
Total	**17**	**16**

Energy Option

This option covers the major areas of current interest in the energy field. The required courses provide students with a general background knowledge of fossil fuels, nuclear power, solar energy, and other alternative energy resources. The elective courses will permit the student to study topics of special interest in more depth or gain a broader perspective on energy and some closely related subjects. Three courses are required, and a minimum of two additional courses of at least three credits each should be selected from the electives list. Students interested in the energy option should declare their intention during the sophomore year to the department faculty. They may consult with Stephen S. T. Fan.

Required Courses	Credits
CHE 705, Natural and Synthetic Fossil Fuels	4
CHE 712, Introduction to Nuclear Engineering	4
ME 705, Thermal System Analysis and Design	4
Total	**12**
Elective Courses	
CHE 695, Chemical Engineering Project	3-4
CHE 696, Independent Study	3-4
ENE 772, Physicochemical Processes for Water and Air Quality Control	4
Total	**6-8**

Environmental Engineering Option

The chemical engineering program, with its substantial requirements in chemistry, fluid dynamics, heat transfer, mass transfer, unit operations, and reaction kinetics, provides students with a unique preparation to deal with many aspects of environmental pollution problems. The option gives students a special focus on the application of chemical engineering principles and processes to the solution of problems relating to air pollution, water pollution, and the disposal of solid and hazardous waste. Three required courses must be selected, plus two electives from the electives list. Each course must carry a minimum of 3 credits. Students interested in the environmental engineering option should declare their intention during the sophomore year to the department faculty. They may consult with Stephen S. T. Fan.

Required Courses	Credits
ENE 709, Fundamentals of Air Pollution and Its Control	4
ENE 772, Physicochemical Processes for Water and Air Quality Control	4
ENE 742, Solid and Hazardous Waste Engineering	3
Total	**11**

Elective Courses	
CHE 695, Chemical Engineering Project	3-4
CHE 696, Independent Study	3-4
CHE 744, Corrosion	4
ENE 746, Bioenvironmental Engineering Design	3
ENE 749, Water Chemistry	4
Total	**6-8**

Chemistry

(For descriptions of courses, see page 143.)

"Chemistry is everywhere. From agriculture to health care, chemistry extends life and improves its quality. From disposable diapers to space suits, chemistry provides new materials—for clothing, shelter, and recreation. From computer chips to fiber optics, chemistry is the foundation of today's high technology" (American Chemical Society).

Study in chemistry leads everywhere—to careers in education, law, forensics, medicine, biotechnology, environmental protection, pharmaceuticals, materials science including semiconductors, and industrial chemicals production.

Students interested in chemistry may major in one of three programs offered in the department, depending upon their plans for a career. Since the required chemistry courses in each degree program are the same in the first year, it is easy to change from one program to another.

In each of the programs, students should register for the following courses in the first year: CHEM 403 (first semester), General Chemistry; CHEM 404 (second semester), General Chemistry; MATH 425 (first semester), Calculus I; MATH 426 (second semester); Calculus II; and CHEM 400, Freshman Seminar (each semester). Students interested in a chemistry program should consult with the coordinator of undergraduate studies in the department.

Bachelor of Science in Chemistry

This curriculum prepares students for careers requiring a thorough knowledge of chemistry and provides a strong foundation for careers in industry, professional schools (e.g., medical schools) and for graduate study in chemistry or in interdisciplinary areas. The curriculum requires a greater depth in chemistry and physics than do the other degree programs.

Requirements

1. Satisfy general education requirements.
2. For specific course requirements, see the accompanying chart.

Bachelor of Arts, Chemistry Major

This curriculum offers students the opportunity to combine a chemistry major with other interests, for example, the prehealing arts, education, or business.

Requirements

1. Satisfy general education requirements.
2. Satisfy the bachelor of arts degree requirements (see page 18).
3. For specific course requirements, see the accompanying chart.

Chemistry Baccalaureate Degree Requirements	B.S.	B.A
Chemistry Courses		
400, Freshman Seminar	x	x
403, 404, General Chemistry	x	x
517, 518, Quantitative Analysis	x	x
547 & 549, Organic Chemistry I	x	x
548 & 550, Organic Chemistry II	x	x
574, Introduction to Inorganic Chemistry	x	x
683 & 685, Physical Chemistry I	x	x
684 & 686, Physical Chemistry II	x	x
762 & 763, Instrumental Methods of Chemical Analysis	x	x
698, Seminar	x	
699, Thesis	x	
755 & 756, Advanced Organic Chemistry	x	
774 & 775, Advanced Inorganic Chemistry	x	
776, Physical Chemistry III	x	
708, Spectroscopic Investigations of Organic Molecules		
778, Chemistry of Large Molecules		

Other Requirements

All majors: MATH 425 and 426, Calculus I and II.

B.S. degree: PHYS 407-408, General Physics I and II; two chemistry-related courses (only one of which may be a chemistry course).†

B.A. degree, chemistry major: PHYS 407, General Physics I, or PHYS 401-402, Introduction to Physics I and II; two other CHEM courses, except 698, or two approved chemistry-related courses.†

† Suggested courses: MATH 527, 528; PHYS 505; EE 620; BCHM 658, 751.

Bachelor of Arts, Chemistry and Physics Teaching

This major is designed for students who wish to teach chemistry and physics in secondary schools. The number of positions available for teaching only chemistry or only physics is limited, and there are more opportunities to teach both subjects on the secondary-school level. Chemistry and physics teaching majors will have good preparation for teaching these subjects and will have the necessary mathematics and education background.

Requirements

1. Satisfy general education requirements.
2. Satisfy the bachelor of arts degree requirements (see page 18).
3. Chemistry requirements: 400, Freshmen Seminar, 403-404; General Chemistry; 517, 518, Quantitative Analysis; 545, 546 or 547-548 and 549-550, Organic Chemistry; 683-684 and 685-686, Physical Chemistry I and II.
4. Physics requirements: 407, General Physics I; 408, General Physics II; 505, General Physics III; 605, Experimental Physics I. PHYS 406, Introduction to Modern Astronomy, is strongly recommended.
5. Math requirements: 425, Calculus I, and 426, Calculus II.
6. All education courses in the teacher preparation program (see page 33).

General Science Certification

See pages 33 and 78.

Civil Engineering

(For descriptions of courses, see pages 144 and 164.)

Civil engineering involves the planning, design, and construction of public works: transportation systems, water transmission systems, water treatment systems, tunnels, roads, dams, buildings, bridges, and more. These facilities must provide efficient service, be cost-effective, and be compatible with the environment. Moreover, civil engineers work under a code of ethics in which their primary, overriding responsibility is to uphold the public's trust by working to plan, design, build, and restore environmentally responsible and safe public works.

Civil engineers work as private consultants and for government agencies in a wide variety of indoor and outdoor settings around the world. There is a strong and constant market for civil engineers due to the demands placed on the profession to construct, maintain, and repair the infrastructure (e.g., transportation systems, water transmission lines, water treatment plants, power plants, bridges, and buildings).

As civil engineering is such a broad field, it is traditionally divided into several subdisciplines. At the University of New Hampshire, five are offered: civil engineering materials, environmental engineering,

geotechnical engineering, structural engineering, and water resources engineering. Additionally, the College of Engineering and Physical Sciences, through the Departments of Civil Engineering and Chemical Engineering, offers a B.S. in Environmental Engineering (ENE) which is a major for students who choose to specifically focus their attention solely in that area. (See page 61.) (Students who are interested in environmental engineering but who also want a broader or more traditional civil engineering focus should pursue the civil engineering major and elect environmental engineering courses in their senior year.) Students may readily transfer between the civil engineering (CIE) and ENE programs within the first three semesters. Civil engineering majors may choose the subdiscipline in which to focus their studies during their senior year. Both the B.S. in civil engineering and the B.S. in environmental engineering provide a firm base in mathematics, science, and engineering and all majors are expected to develop excellent communication and computer skills. Graduates are prepared to enter the profession and to pursue advanced study. Because of the broad technical background attained, some graduates also successfully pursue further education in business, law, and medicine.

Bachelor of Science in Civil Engineering

Matriculating students should have strong aptitudes in mathematics and science along with imagination, spatial and graphic abilities, communication skills, and creativity. Students then follow a four-year program which conforms to the guidelines of, and is accredited by, the Accreditation Board for Engineering and Technology (ABET). The civil engineering program has been continuously accredited by ABET at the University of New Hampshire since 1936 when accreditation first began in the U.S.

The first two years of the program provide the necessary technical knowledge in mathematics, chemistry, and physics, while introducing and developing civil engineering problem solving techniques. The junior year provides courses in each of the civil engineering subdisciplines providing students with skills in each and allowing students to determine which they wish to pursue further. The senior year is flexible, allowing students to choose where to focus attention by selecting from more than thirty elective courses in civil and environmental engineering.

The required curriculum includes seven writing intensive courses thereby not only satisfying but exceeding the University's Writing Requirement. (See page 16.)

Electives

Approximately one third of the major's total credits and more than half of the senior-level courses are elected by the student. Of these, there are general education electives required by the university and other electives required by the department in order to satisfy ABET requirements.

1. The General Education Program is described on page 17. Courses required by the civil engineering major fulfill the Group 1 through Group 3 general education requirements. Therefore, students select electives to satisfy the Group 4 through Group 8 courses—one elective per group.
2. The civil engineering major also requires students to select one mathematics elective, one professional development elective, and one engineering science elective. Lists of courses that fulfill these electives are available from the department.
3. In the senior year, students take four courses specific to civil engineering subdisciplines. Students can use these electives to focus on a particular civil engineering area or can acquire a broader perspective by taking courses in a variety of areas. At least one of these four elective courses must also qualify as a civil engineering design elective. Lists of courses that fulfill these electives are available from the department.

Additional program policies and requirements

1. CIE and ENE 600- and 700-level courses are intended for CIE and ENE majors only. All others may enroll in these courses only with the permission of the instructor and may take no more than 20 credits of these courses.
2. To enter the required 600-level courses in the junior year, students:
   a. must have completed CIE 525, CIE 526, CIE 527, MATH 425, MATH 426, PHYS 407, and PHYS 408, and
   b. must have achieved an overall grade point average of 2.00 or greater for these courses.
3. To transfer into the civil engineering major, a student must:
   a. have an overall grade point average of 2.30 or greater;
   b. have completed 16 credits or more of MATH, PHYS, CHEM, CIE, and ENE courses;
   c. have an overall grade point average of 2.00 or greater for all MATH, PHYS, CHEM, CIE, and ENE courses taken to date; and
   d. have an overall grade point average of 2.50 or greater for 16 credits of the MATH, PHYS, CHEM, CIE, and ENE courses taken to date.
4. Students who are transferring into the civil engineering major may receive:
   a. a maximum of 20 credits for CIE and ENE 600- and 700-level coursework taken prior to the transfer, and
   b. credit only for CIE and ENE 600- and 700-level courses taken prior to the transfer in which the student has received a grade of C- or better.
5. To continue as a civil engineering major, a student may not:
   a. repeat more than two CIE or ENE courses,
   b. achieve a semester grade point average lower than 2.00 for each of three consecutive semesters, and
   c. achieve a cumulative grade point average of less than 2.00 for CIE and ENE courses in any three semesters.
6. To graduate with a bachelor of science in civil engineering, a student must:
   a. earn 133 or more credits,
   b. achieve credit for the civil engineering program's major and elective courses,
   c. satisfy the University's general education requirements,
   d. satisfy the University's writing intensive course requirements,
   e. earn a cumulative grade point average of 2.00 or better for all courses, and
   f. earn a cumulative grade point average of 2.00 or better for all CIE and ENE courses.

First Year	**Fall**	**Spring**
CIE 400, 401, CIE Lectures, I, II	1	2
CHEM 403, 404, General Chemistry I, II	4	4
ENGL 401, Freshman English	4	–
MATH 425, 426, Calculus I, II	4	4
Elective (1), general education requirement*	4	–
CIE 505, Surveying	–	4
PHYS 407, General Physics I	–	4
Total	**17**	**18**
Sophomore Year		
CIE 525, Statistics	3	–
MATH 527, Differential Equations with Linear Algebra	4	–
PHYS 408, General Physics II	4	–
Elective (1), Professional Development**	4	–
CIE 526, Strength of Materials	–	3
CIE 527, Dynamics	–	3
MATH 644, Statistics for Engineers and Scientists	–	4
Elective (1), MATH**	–	4
Elective (1), general education requirement*	–	4
Total	**15**	**18**
Junior Year		
CIE 622, Engineering Materials	4	–
CIE 633, Project Engineering	3	–
CIE 642, Fluid Mechanics	4	–
ENE 520, Environmental Pollution and Protection	4	–
Elective (1), general education requirement*	4	–
CIE 665, Soil Mechanics	–	4
CIE 681, Classical Structural Analysis	–	3
ENE 645, Fundamental Aspects of Environmental Engineering	–	4
Elective (1), Engineering Science**	–	3
Total	**19**	**14**

Senior Year		
CIE 760, Foundation Design I	4	–
CIE 774, Reinforced Concrete Design	4	–
Elective (1), Civil Engineering Design**	3	–
Electives (3), Civil Engineering**	3	6
Electives (2), general education requirement*	4	4
CIE or ENE 788, Project Planning and Design	–	4
Total	**18**	**14**

*See page 17 for general education requirements
**Approved list available in the CIE office

Computer Science

(For descriptions of courses, see page 149.)

Computer scientists are concerned with all aspects of the design and implementation of computer software. They are concerned with problem solving in general, with particular emphasis on the design of computer-efficient solutions. This involves detailed understanding of the nature of algorithms, the software implementation techniques necessary to utilize these algorithms on computers, and a knowledge of how algorithms can be combined in a structured manner to form highly complex software systems.

The program leads to a B.S. in computer science and is designed to prepare students for employment in the computer field or to pursue graduate study in computer science. The program emphasizes the application of computer science theory and principles but also includes a broad background in basic mathematics and an introduction to computer hardware. Most courses require heavy use of the computer, and the laboratories stress hands-on experience with computer equipment.

Computer science majors must obtain an overall grade-point average of 2.00 or better in all required computer science, mathematics, and electrical engineering courses in order to graduate. If at the end of any semester, including the first, a student's cumulative average in these courses falls below 2.00, the student may not be allowed to continue as a CS major.

All students wishing to transfer into a computer science major must have completed at least one full year of calculus (MATH 425 and MATH 426) and one full year of computer science (CS 415 and CS 416). The student must receive a grade of at least C+ in each of these four courses. In addition, the student must achieve a grade-point average of 3.00 in these two mathematics courses and a grade-point average of 3.00 in these two computer science courses. The student must also have an overall grade-point average of 2.00 or better in all courses taken at UNH.

If a student wishing to transfer into a computer science major has taken any other courses that are applicable to the computer science major, the grades in those courses must satisfy the minimum requirements for the B.S. degree in computer science. (A student is not normally expected to have taken such courses prior to requesting the transfer.)

Requirements

1. Satisfy general education requirements. PHYS 407-408, MATH 425, and PHIL 424 are required and may be used to fulfill requirements in the appropriate general education group.
2. Two additional technology or science courses, one of which may satisfy a general education requirement, chosen from the following list:

Biology
BIOL 411, Principles of Biology I
BIOL 412, Principles of Biology II
HMP 501, Epidemiology and Community Medicine
MICR 501, Public Health Microbiology
PBIO 412, Introductory Botany
PBIO 421, Concepts of Plant Growth
ZOOL 412, Principles of Zoology

Physical Science
CHEM 401-402, Introduction to Chemistry
CHEM 403-404, General Chemistry
CHEM 405, General Chemistry
ESCI 409, Environmental Geology
ESCI 450, Introduction to the Earth Sciences
ESCI 501, Introduction to Oceanography
WARM 504, Freshwater Resources
ESCI 405, Global Environmental Change

Technology
PHIL 447, Computer Power and Human Reason

Also acceptable are sections of the INCO 404, Honors Seminar that the University designates as fulfilling a category 3 general education requirement.

3. Two additional approved courses chosen from the humanities, social sciences, and arts.
4. Ten core courses in each of which the student must obtain a grade of C or better. Before taking a course having any of these ten courses as a prerequisite, the prerequisite course(s) must be passed with a grade of C or better: CS 415 and 416, Introduction to Computer Science I and II; CS 515, Data Structures; CS 611, Assembly Language Programming and Machine Organization; CS 620, Operating System Fundamentals; CS 671, Programming Language Concepts and Features; MATH 425 and MATH 426, Calculus I and II; MATH 531, Mathematical Proof; MATH 532, Discrete Mathematics.
5. One computer science theory course chosen from: CS 658, Analysis of Algorithms, CS 659, Introduction to the Theory of Computation, or CS 745, Formal Specification and Verification of Software Systems.
6. Three approved computer science courses chosen from CS courses numbered above 650.
7. One approved writing intensive course chosen from CS courses numbered above 650.
8. One course in probability and statistics: MATH 644, Probability and Statistics for Applications.
9. Two electrical engineering courses: EE 543, Introduction to Digital Systems, and EE 612, Computer Organization.

Computer and Information Technology Minor

The computer information technology minor is described under Special University Programs on page 102.

Earth Sciences

(For descriptions of courses, see page 152.)

The courses offered in the Department of Earth Sciences cover the broad spectrum of earth sciences, with emphases on geology, hydrology, geochemistry, and oceanography. The curriculum encompasses a group of related studies concerned with an understanding of the Earth and its environment. Study of the processes that shape the continents and oceans, drive the hydrologic cycle and ocean circulation, and affect climate change and the evolution of life is based on a foundation of basic mathematics, physics, and chemistry.

The need for people trained in the earth sciences has been increasing in response to society's growing concern with sound environmental and resource management, including the disposal of waste on land and in the atmosphere and oceans; the management of water resources; the development of energy and mineral resources; and the assessment of environmental hazards. In addition, the demand for well-trained secondary school teachers of earth sciences has been steadily increasing.

The Department of Earth Sciences offers five majors: B.S. geology, B.S. hydrology (interdisciplinary with the Dept. of Civil Engineering), B.A. earth sciences, B.A. earth sciences/oceanography, and B.A. earth science teaching. These programs prepare students for advanced study in the geosciences; for entry-level professional employment in public or private institutions concerned with environmental and resource management, including consulting firms, government agencies, energy- and resource-extraction firms, utilities, and nonprofit organizations; and for secondary-school teaching of earth sciences.

The Department of Earth Sciences also offers a minor in geology, as well as interdisciplinary minors in hydrology and oceanography.

Descriptions and requirements for the majors and minors are arranged alphabetically in the following pages.

Bachelor of Arts in Earth Sciences

The Bachelor of Arts in Earth Sciences is offered through the Department of Earth Sciences. This program provides students an opportunity to obtain a broad education and a general background in the earth sciences with a greater degree of freedom in choosing electives than in the bachelor of science programs. By careful choice of electives, students can prepare for graduate school, business, or industry.

This program also offers an option in oceanography for those students with broad ocean sciences interests.

Requirements

1. Satisfy the general education requirements.
2. Satisfy the bachelor of arts degree requirements (page 18).
3. Complete a minimum of eight courses in the department (with a C- or better), including ESCI 401, Principles of Geology, or ESCI 409, Environmental Geology; ESCI 402, Earth History; ESCI 512, Principles of Mineralogy; and five upper-level courses, two of which must be 700 or above.
4. Math requirements: 425, Calculus I, and 426, Calculus II.

It is strongly advised that students complete, as early as possible, a year each of college chemistry and physics.

Bachelor of Arts in Earth Sciences, Oceanography Option

The Bachelor of Arts in Earth Sciences, Oceanography Option, is offered by the Department of Earth Sciences. This program provides students an opportunity to obtain a broad education and a general background in the earth sciences, as well as the flexibility to choose electives in the area of oceanography. A clear, comprehensive understanding of the ocean environment will prepare students for graduate school or for employment opportunities available on our coasts in ocean-related fields such as aquaculture, fishing, tourism, environmental protection, shipping, construction, government regulation, and education.

Requirements

1. Satisfy the general education requirements.
2. Satisfy the bachelor of arts degree requirements (page 18).
3. Complete a minimum of eight courses in the department (with a C- or better) including ESCI 401; ESCI 402, Earth History or ZOOL 503, Introduction to Marine Biology; ESCI 501, Introduction to Oceanography; ESCI 512, Principles of Mineralogy; and four upper-level ocean related courses, two of which must be 700 or above. Typically these would be chosen from ESCI 653, Estuaries and Coasts; ESCI 658, Earth, Ocean, and Atmosphere Dynamics; ESCI 750, Biological Oceanography; ESCI 752, Chemical Oceanography; ESCI 758, Physical Oceanography; and ESCI 759, Geological Oceanography.
4. Math requirements: 425, Calculus I, and 426, Calculus II.

It is strongly advised that students complete, as early as possible, a year each of college chemistry and physics.

Oceanography Minor

See Special University Programs, Interdisciplinary Programs, Marine Sciences section of the catalog, page 104.

Bachelor of Arts in Earth Science Teaching

The Bachelor of Arts in Earth Science Teaching program is offered by the Department of Earth Sciences in coordination with the Department of Education. The program is specifically designed to prepare students to teach earth sciences in secondary school. Upon graduation from this typically five-year program, students receive full teacher certification which is recognized in most states.

Requirements

1. Satisfy the general education requirements.
2. Satisfy the bachelor of arts degree requirements (page 18).
3. Complete the following: ESCI 401, Principles of Geology, or ESCI 409, Environmental Geology; ESCI 402, Earth History; ESCI 501, Introduction to Oceanography; GEOG 473, The Weather; CHEM 403-404, General Chemistry; PHYS 401-402, Introduction to Physics I and II, PHYS 406, Introduction to Modern Astronomy; plus 12 approved elective credits from intermediate and/or advanced earth sciences courses.
4. Math requirements: 425, Calculus I, and 426, Calculus II.
5. Satisfy the secondary-school teacher education program (see page 33).

General Science Certification

See pages 33 and 78.

Bachelor of Science in Geology

The Bachelor of Science in Geology is offered through the Department of Earth Sciences. The program represents a strong concentration in the earth sciences and is especially well suited for students who plan to continue their studies in graduate school. Beyond a central core of courses, there is sufficient flexibility in course selection so that students may, in consultation with their academic advisers, orient the program toward a particular facet of the earth sciences (e.g., mineralogy-petrology, oceanography, hydrogeology, geophysics-structural geology, geomorphology-glacial geology, geochemistry, paleontology-stratigraphy). Students are encouraged to attend an off-campus field camp, for which scholarship funds may be available.

Requirements

1. Satisfy the general education requirements.
2. Satisfactorily complete MATH 425 and 426, CHEM 403-404 (or CHEM 405), and PHYS 407-408 and 505 or ESCI 658. Some of these courses may also satisfy Group 2 and part of Group 3 of the general education requirements.
3. Complete a minimum of twelve courses in earth sciences, which should include ESCI 401, Principles of Geology, or ESCI 409, Environmental Geology; ESCI 402, Earth History; ESCI 501, Introduction to Oceanography; ESCI 512, Principles of Mineralogy; ESCI 614, Optical Mineralogy and Petrography; ESCI 530, Field Methods; ESCI 631, Structural Geology; ESCI 561, Surficial Processes; ESCI 652, Paleontology; and three approved earth sciences 700-level electives.
4. Complete four approved electives. The following should be considered: one additional 700-level course in the earth sciences; additional courses in mathematics, chemistry, and physics; as well as courses in computer science, engineering, and the biological sciences; and an off-campus field camp.

Geology Minor

Any University student who is interested in earth sciences may minor in geology. The minor consists of at least 18 semester hours, typically from five ESCI courses, each with a grade of C- or better, while maintaining a cumulative grade-point average of 2.0. A maximum of 8 credits may be used for both major and minor credit. Courses include both introductory and more advanced courses (as described on pages 152). Specific course requirements are flexible to accommodate the student's interest in different facets of the geosciences. Interested students

should see the earth sciences' undergraduate coordinator to complete an Intent to Minor form no later than their junior year.

Bachelor of Science in Hydrology

The Bachelor of Science in Hydrology is an interdisciplinary major coordinated in the Department of Earth Sciences, in association with the Department of Civil Engineering. The hydrology major provides a sound foundation for understanding and managing fresh-water resources. It prepares students for entry-level professional employment in firms and agencies and for graduate study.

Requirements

1. University General Education. Students are required to complete the University general education requirements. Completion of the hydrology core curriculum automatically satisfies the requirement for one course in quantitative reasoning (Group 2) and two physical science courses in Group 3. To complete the requirements in Group 3, hydrology majors must take one of the following biological science courses: PBIO 412, PBIO 421, NR 412, WILD 433, or ZOOL 412.
2. Core Courses: MATH 425, 426, 527; STAT 644 or BIOL 528; PHYS 407-408; CHEM 403-404 (or CHEM 405); CS 410; ESCI 401 or 409, 512, 530, 561; CIE 642; ESCI 703 or CIE 741; ESCI 705, 710; two of the following: CIE 745, ENE 643, or ESCI 747.
3. Major Electives. Three approved electives are to be selected with the guidance of the adviser. Qualifying courses may be selected from a list of hydrogeology, biohydrology, water quality, fluid flow, water resources management, and weather and climate courses offered in various departments in the University.

For a list of the elective courses and for further information about the hydrology major, contact the coordinator, J. Matthew Davis, Department of Earth Sciences.

Hydrology Minor

The minor in hydrology is an interdisciplinary minor of the Departments of Earth Sciences and Civil Engineering. The minor is open to all students in the University. It consists of a minimum of six courses totaling at least 18 credits. Students must earn grades of C (2.00) or better and take no pass/fail courses. No more than 8 major requirement credits may be used. All courses in the program shall be selected by students in consultation with the hydrology minor adviser in the Department of Earth Sciences.

Requirements

Required courses are: ESCI 401, Principles of Geology; or ESCI 409, Environmental Geology; ESCI 705, Principles of Hydrology; ESCI 710, Groundwater Hydrology; at least three of the following courses: ESCI 561, 703, 708, 747; CIE 642, 741, 745; ENE 643, 742, 749; NR 757, 759, 760; WARM 504, 603, 700, 711, 713, 716, 718, 721; PBIO 717, 719.

Students are encouraged to declare their intention to enter the program before the end of the junior year. During the final semester, students must apply to the dean to have the minor appear on the transcript.

Electrical and Computer Engineering

(For descriptions of courses, see page 158.)

The Department of Electrical and Computer Engineering offers a B.S. in Electrical Engineering degree program that is accredited by the Accreditation Board for Engineering and Technology (ABET). The Department's B.S. in Computer Engineering degree program, which commenced in September 2002, has been designed in accordance with the rules and guidelines of ABET. Accreditation of the Computer Engineering degree program will be sought at the earliest opportunity afforded by ABET's rules, i.e., upon graduation of the first entering class in 2006.

Electrical Engineering Program

Electrical engineers are concerned with the design, development, and production of products and systems that involve electrical signals. Thus, broad areas of application are covered, such as monitoring the environment, outer space and the ocean floor, developing robots for factories and biomedical instruments for hospitals, and building microcomputers and power systems. They use such principles and techniques as computer-aided design, optics, acoustics, electronics, automatic control theory, and electromagnetics. Further, it is essential for electrical and computer engineers to include in their work a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, social implications, and environmental impact.

Electrical engineering graduates readily move into design, product development, manufacturing, sales and marketing, customer application support, and business management roles within prominent computer and electronic system companies. They routinely secure professional positions with the nation's leading computer and network hardware and software firms, wireless communication and telecommunication providers, medical electronic industries, and custom integrated circuit developers. The strength of the electrical engineering program is such that many graduates successfully complete advanced degrees in engineering and business at top-ranked graduate schools, while others have gone on to obtain law or medical degrees.

At UNH, the cornerstone of the electrical engineering program is the involvement of students in the solution of real-world problems. During the freshman and sophomore years, students take basic courses in mathematics and science, learn how to use computers, and receive introductory experience in electric circuits, logic design, electronics, computer organization, and random processes. Building upon this foundation, students in the junior year develop core competencies in electronics, signal processing and control systems, computer engineering, and electromagnetics. In the senior year, students select professional elective courses to acquire both breadth and depth in specific areas of electrical engineering.

In addition to general University requirements, the department has a number of grade-point average and credit requirements.

1. For an electrical engineering major to enter the junior year and take any of the first-term junior courses (ECE 603, ECE 617, ECE 633, or ECE 651), he or she must have taken, and achieved a cumulative grade point average of 2.10 in all of the following freshman and sophomore courses: MATH 425, 426, 527; PHYS 407, 408; and ECE 541, 543, 544, 548, and 612.
2. Any electrical engineering major whose cumulative grade-point average in ECE courses is less than 2.00 during any three semesters will not be allowed to continue as an electrical engineering major.
3. Electrical engineering majors must achieve a 2.00 grade-point average in ECE courses as a requirement for graduation.

To make an exception to any of these departmental requirements based on extenuating circumstances, students must petition the department's undergraduate committee. Mindful of these rules, students, with their advisers' assistance, should plan their programs, based on the distribution of courses in the chart below for a total of at least 131 credits.

Curriculum for B.S. in Electrical Engineering

Freshman Year	Fall	Spring
MATH 425, Calculus I	4	—
CS 410, Introduction to Scientific Programming#	4	—
ECE 401, Perspectives in Electrical and Computer Engineering	4	—
TECH 696, Chemistry for Engineers	4	—
MATH 426, Calculus II	—	4
General Education Elective#	—	4
PHYS 407, Physics I	—	4
ENGL 401, General Education Writing	—	4
Total	**16**	**16**

Sophomore Year	Fall	Spring
PHYS 408, Physics II	4	—
MATH 527, Differential Equations with Linear Algebra	4	—
ECE 541, Electrical Circuits	4	—
ECE 543, Introduction to Digital Systems	4	—
ME 523, Introduction to Statics and Dynamics		3
ECE 544, Engineering Analysis	—	4
ECE 548, Electronic Design I	—	4
ECE 612, Computer Organization	—	4
Total	**16**	**15**

Junior Year	Fall	Spring
EE 617, Junior Lab I	4	—
EE 651, Electronic Design II	4	—
EE 633, Signals and Systems I	3	—
ECE 603, Electromagnetic Fields and Waves	3	—
General Education Elective	4	—
ECE 618, Junior Laboratory II	—	4
ECE 634, Signals and Systems II	—	3
ECE 647, Random Processes and Signals in Engineering	—	3
EE 668, Fundamentals of Computer Engineering	—	4
General Education Elective	—	4
Total	**18**	**18**

Senior Year	Fall	Spring
Professional Elective*	4	—
Professional Elective*	4	—
General Education Elective	4	—
General Education Elective	4	—
ECE 791, Senior Project I	2	—
Professional Elective*	—	4
Professional Elective*	—	4
General Education Elective	—	4
ECE 792, Senior Project II	—	2
Total	**18**	**14**

*Professional electives normally consist of 700-level ECE courses. Each course must carry at least three credits, and no more than one can be an independent study, special topics, or project course. An alternative is a student-designed plan approved by the ECE Undergraduate Committee.

#Students who wish to preserve the option of transferring to the Computer Engineering major without incurring a delay in graduation should consult with their academic advisor before electing these courses. It is recommended that such students take CS 415, Introduction to Computer Science I in the Fall semester and CS 416, Introduction to Computer Science II in the Spring semester in place of the listed courses.

Computer Engineering Program

Computers have become embedded in virtually every electrical engineering system. Computer engineering, traditionally a subset of electrical engineering, is a rapidly growing field that emphasizes the design, interfacing, hardware/software tradeoffs, and real-time applications of computers. Students who elect this major will gain a knowledge of both hardware and software concepts, and will learn to design, build and test systems containing digital computers.

In addition to general University requirements, the department has a number of grade-point average and credit requirements.

1. For a Computer Engineering major to enter the junior year and take any of the first-term junior courses, he or she must have taken, and achieved a cumulative grade point average of 2.10 in all of the following freshman and sophomore courses: MATH 425, 426, 527; PHYS 407, 408; CS 415, 416, 515; and ECE 543, ECE 544, ECE 612, and ECE 523.
2. Any computer engineering major whose cumulative grade-point average in ECE and CS courses is less than 2.0 during any three semesters will not be allowed to continue as a computer engineering major.
3. Computer engineering majors must achieve a 2.00 grade-point average in ECE courses as a requirement for graduation.

To make an exception to any of these departmental requirements based on extenuating circumstances, students must petition the department's undergraduate committee. Mindful of these rules, students, with their advisers' assistance, should plan their programs, based on the distribution of courses in the chart below for a total of at least 130 credits.

Curriculum for B.S. in Computer Engineering

Freshman Year	Fall	Spring
MATH 425, Calculus I	4	—
CS 415, Intro to Computer Science I	4	—
ECE 401, Perspectives in Electrical and Computer Engineering	4	—
General Education Elective	4	—
Math 426, Calculus II	—	4
CS 416, Intro to Computer Science II	—	4
ECE 543, Intro to Digital Systems	—	4
Engl 401, General Education Writing	—	4
Total	**16**	**16**

Sophomore Year	Fall	Spring
PHYS 407, Physics I	4	—
Math 527, Differential Equations with Linear Algebra	4	—
CS 515, Data Structures	4	—
ECE 612, Computer Organization	4	—
PHYS 408, Physics II	—	4
ECE 544, Engineering Analysis	—	4
CS 620, Operating Systems Fundamentals	—	4
ECE 523, Design with Programmable Logic	—	4
Total	**16**	**16**

Junior Year	Fall	Spring
ECE 541, Electrical Circuits	4	—
ECE 633, Signals and Systems I	3	—
ECE 649, Embedded Microcomputer Based Design	4	—
General Education Elective	4	—
ECE 548, Electronic Design I	—	4
ECE 667, Introduction to Computer Engineering	—	4
ECE 647, Random Processes and Signals in Engineering	—	3
General Education Elective	—	4
Total	**15**	**15**

Senior Year	Fall	Spring
Professional Elective**	4	—
ECE 734, Network Data Communications	4	—
ECE 714, Intro to Digital Signal Processing	4	—
General Education Elective	4	—
ECE 791, Senior Project I	2	—
Professional Elective**	—	4
Professional Elective**	—	4
General Education Elective	—	4
General Education Elective	—	4
ECE 792, Senior Project II	—	2
Total	**18**	**18**

**Three professional electives must be selected from the following categories of courses:

At least one from: ECE 711, ECE 715, ECE 717
No more than one from: DS 630, DS 650, DS 765
ECE 603, ECE 634, ECE 651, ECE 7XX
CS 658, CS 659, CS 671, CS 7XX

Environmental Engineering

(For descriptions of courses, see page 164.)

The College of Engineering and Physical Sciences offers a Bachelor of Science Degree in Environmental Engineering (ENE) and an interdisciplinary minor in environmental engineering.

The ENE degree program consists of two emphases (curricula): Industrial Processes (IP) and Municipal Processes (MP).

The objective of the program's strong analytical core and multidisciplinary focus combining engineering and the sciences is to prepare graduates for many career opportunities in public, private, or academic

career paths. Graduates from the program will possess strong analytical aptitude as well as exhibit creativity, imagination, and excellent written and oral communication skills. They will understand environmental problems and approaches to their solutions and how to organize the technical resources needed to implement remedies. Graduates will be able to apply knowledge of mathematics, science, and engineering to environmental engineering problems, analyze and interpret data and solve environmental engineering problems, design environmental engineering systems, function on multidisciplinary teams, communicate effectively, understand the impact of engineering solutions on society, and understand professional and ethical responsibility.

At the end of the sophomore year, students are required to have a minimum overall grade-point average of 2.00 and a grade-point average of 2.00 in all mathematics, physics, chemistry, and engineering courses to be permitted to enroll in junior-level courses.

To qualify for graduation, an ENE major must: have satisfied the previously specified course requirements, have satisfied the University's general education requirements, have a minimum cumulative grade-point average of 2.00, and have a minimum grade-point average of 2.00 in engineering courses.

Bachelor of Science in Environmental Engineering-Industrial Processes (IP) Emphasis

The industrial processes (IP) emphasis of environmental engineering is a process-based program that draws on the principles of chemistry, physics, mathematics, and engineering sciences. Due to the complex nature of many aspects of environmental pollution, a broad understanding of the fundamentals of engineering and sciences forms the most desirable preparation for a career in the environmental field. The program is designed to provide training not only for end-of-pipe pollution control technologies, but also for expertise in process engineering and process design, essential for achieving the objectives of pollution curtailment and prevention. Such training is especially valuable in resolving industrial pollution problems. Career opportunities for environmental engineers with this background are found in industry, research institutes, government agencies, teaching, and consulting practice. Students may also enter graduate study at the M.S. or Ph.D. levels.

Engineering design is a critical aspect of the IP curriculum. In order to meet the objective of producing creative, problem-solving engineers, design concepts are introduced early in the curriculum and design experience is integrated into every engineering course. Students learn to seek optimal solutions to open-ended problems and function in design-based team projects. Design ability is finally demonstrated at the end of the capstone course (ENE 608), when self-directed teams develop a comprehensive design report for a full-scale engineering process based on a national process design competition problem.

Since 1993, the program faculty has administered a Pollution Prevention Internship Program with industries in New Hampshire, Maine, and Massachusetts, initially funded by US EPA and NHDES. In the past nine years, the program has served more than forty facilities. Each year about 12 students have enrolled in the Pollution Prevention Internship Program which provides hands-on industrial employment for ten weeks during the summer assisting industry with projects in process modification, material substitution, chemical re-use, risk assessment, safety and economic analysis. The program faculty also assisted NHDES in setting up instrumentation in the Seacoast region of New Hampshire to monitor the precursor of ozone formation.

The B.S. program requires a minimum of 134 credits for graduation and can be completed in four years. There are eight electives in the curriculum: five for the fulfillment of the University's general education requirements and the remaining three for technical electives to be chosen from the specified elective course list. Due to the substantial overlap in course requirements for the environmental engineering IP and chemical engineering majors, students will be able to transfer between these two programs during the first three semesters without losing any course credits towards graduation.

First Year	**Fall**	**Spring**
CHEM 405, General Chemistry	4	–
MATH 425-426, Calculus I & II	4	4
PHYS 407, General Physics I	–	4
ENGL 401, Freshman English	4	–
ME 441, Engineering Design and Graphics	4	–
General Education Electives	–	8
Total	**16**	**16**
Second Year		
CHE 501-502 Introduction to Chemical Engineering I & II	3	3
CHEM 683-684, Physical Chemistry I & II	3	3
CHEM 685, Physical Chemistry Lab I	2	–
MATH 527, Differential Equations	4	–
PHYS 408, General Physics II	4	–
CS 410, Introduction to Scientific Programming	–	4
General Education Electives	–	8
Total	**16**	**18**
Third Year		
CHE 601, Fluid Mechanics and Unit Operations	3	–
CHE 604, Chemical Engineering Thermodynamics	–	4
ENE 612, Unit Operations Lab II	–	3
CHEM 651-652, Organic Chemistry I & II	3	3
CHEM 653, Organic Chemistry Lab I	2	–
ENE 742, Solid and Hazardous Waste Engineering	–	3
MATH 644, Statistics for Engineers & Scientists	4	–
General Education and Technical Electives	4	3–4
Total	**16**	**16–17**
Fourth Year		
CHE 605, Mass Transfer and Stagewise Operations	3	–
ENE 608, Industrial Process Design	–	4
ENE 613, Unit Operations Lab II	3	–
ENE 709, Fundamentals of Air Pollution and Control	4	–
ENE 752, Process Dynamics and Control	–	4
ENE 772, Physicochemical Processes for Water and Air Quality Control	–	4
ESCI 710, Groundwater Hydrology	–	4
MICR 501, Microbes in Human Disease	4	–
Technical Electives	3–4	3–4
Total	**17-18**	**19-20**

Suggested Technical Electives	**Credits**
CHE 602, Heat Transfer and Unit Operations	3
CHE 606, Chemical Engineering Kinetics	3
CHE 744, Corrosion	4
ENE 739, Industrial Wastewater Treatment	3
ENE 746, Bioenvironmental Engineering Design	4
ENE 747, Introduction to Marine Pollution	3
CIE 766, Introduction to Geo-Environmental Engineering	3
ESCI 409, Environmental Geology	4
ESCI 561, Surficial Processes	4
ESCI 705, Principles of Hydrology	4
ESCI 708, Hydrology	3
ESCI 715, Global Atmospheric Chemistry	3
EE 772, Control Systems	4
MICRO 503, General Microbiology	5

Bachelor of Science in Environmental Engineering-Municipal Processes (MP) Emphasis

Environmental engineers graduating from the municipal processes (MP) emphasis plan, design, and construct public and private facilities to minimize the impact of human activity on the environment and to protect human health. For example, environmental engineers with a municipal processes perspective design and build drinking water treatment systems, municipal and industrial wastewater treatment plants, solid waste management facilities, contaminated ground water remediation systems, and hazardous waste remediation facilities. These facilities must meet regulatory requirements, be cost-effective to build and maintain, be safe to operate, and have minimal environmental impact. The environmental engineer is trained to lead the multidisciplinary teams needed to solve complex environmental problems.

In ENE 400, students are introduced to the full spectrum of environmental engineering projects that they will subsequently explore in design teams during their degree program. As part of these experiences, students visit and tour field sites, and interact with engineers who have been involved in the design and/or construction of the projects. Design is integrated throughout the curriculum, and particularly emphasized in junior- and senior-level courses. As part of these projects, students analyze treatment alternatives, recommend a system that meets regulatory operational needs, and prepare an implementation schedule and project budget. Detailed design projects are performed in ENE 744 and 746. ENE 788 serves as a capstone design experience where students work on an environmental engineering project provided by a local engineering firm or municipality and apply skills learned in other courses while working with real world clients.

The following schedule is a sample of a planned program for environmental engineering students completing the major within the municipal processes emphasis.

First Year	**Fall**	**Spring**
ENE 400, 401, Environmental Engineering Lectures I, II	1	1
ENGL 401, Freshman English	4	–
MATH 425, 426, Calculus I, II	4	4
General Education Electives*	4	4
CHEM 403, 404, General Chemistry I, II	4	4
PHYS 407, General Physics I	–	4
Total	**17**	**17**
Second Year		
ENE 520, Environmental Pollution and Protection	4	–
ENE 521, Environmental Engineering Seminar	–	1
CIE 525, 526, 527, Statics, Strength, Dynamics	3	6
MATH 527, Differential Equations with Linear Algebra	4	–
CHEM 545, Organic Chemistry Lecture	3	–
CHEM 546, Organic Chemistry Laboratory	2	–
TECH 564, Fundamentals of CAD	–	3
General Education Elective*	–	4
Total	**16**	**14**
Third Year		
CIE 633, Project Engineering	3	–
CIE 642, Fluid Mechanics	4	–
CIE 665, Soil Mechanics	–	4
ENE 643, Environmental Sampling and Analysis	4	–
MATH 644, Statistics for Engineers and Scientists	4	–
ENE 645, Fundamental Aspects of Environmental Engineering	–	4
ENE 656, Environmental Engineering Microbiology	–	4
ENE 742, Solid and Hazardous Waste Engineering	–	3
General Education Elective*	4	–
Total	**19**	**15**
Summer		
Environmental Engineering Experience† (ENE 696 or 697)		1–2 cr.
Fourth Year		
ENE 746, Bioenvironmental Engineering Design	4	–
ENE 749, Water Chemistry	4	–
General Education Elective*	4	–
Environmental Engineering Elective**	6	4
ENE 744, Physicochemical Treatment Design	–	4
ENE 788, Project Planning and Design	–	4
ESCI 710, Groundwater Hydrology	–	4
Total	**18**	**16**

*See page 17 for general education requirements.

**Approved list is available in the Department of Civil Engineering office. Must take a minimum of three ENE electives totaling at least 10 credits. One ENE elective course must be from the design category.

†During one summer, it is strongly recommended that majors have a job at an approved level in the environmental engineering field, perform an approved internship in environmental engineering or conduct a research project under the supervision of a faculty member. A student may receive a one credit field experience or up to two credits for an environmental engineering internship. The internship could be used as an environmental engineering elective, but this would require approval of the faculty.

The municipal processes emphasis of the ENE program requires a minimum of 132 total credits for graduation.

Environmental Engineering Minor

The environmental engineering minor is intended primarily for students in engineering and physical sciences, who are not in the chemical, civil, or environmental engineering degree programs. Students contemplating such a minor should plan on a strong background in the sciences and mathematics (including differential equations).

The minor provides a comprehensive introduction to major areas of interest in environmental protection, namely air pollution and water pollution, through the three required courses. Further breadth in environmental engineering or depth in specific areas can be attained through the choice of appropriate elective courses.

The minor requires a minimum of five courses as follows: (1) three required courses: ENE 645, Fundamental Aspects of Environmental Engineering; ENE 709, Fundamentals of Air Pollution and Its Control; ENE 772, Physicochemical Processes for Water and Air Quality Control, or ENE 643, Environmental Sampling and Analysis; (2) a minimum of two elective ENE courses.

Choice of elective courses should be made in consultation with the minor area adviser, James P. Malley Jr., civil engineering, or Dale P. Barkey, chemical engineering. Students normally start this program in the junior year and should declare their intention to enter the program as early as possible during the sophomore year. During the final semester, students must apply to the dean to have the minor appear on the transcript.

Mathematics and Statistics

(For descriptions of mathematics courses, see page 194.)

A variety of programs is offered by the Department of Mathematics and Statistics. These programs provide flexibility through elective choices and are designed to maximize educational and employment opportunities.

Each student must enroll in one specific program; however, changes between programs can usually be accomodated.

The first two years of all programs are similar. In the first year, students are expected to take MATH 425 and 426 as well as an introductory computer science course (either CS 410, Introduction to Scientific Programming, or CS 415, Introduction to Computer Science I). In the sophomore year

MATH 527, 528, 531, and/or 545, or the linearity sequence MATH 525-526 (that combines the material of MATH 527, 528, and 645), keep a student on schedule in most programs.

In addition to its degree programs, the department has an active interest in the actuarial profession and is an examination center for the Society of Actuaries. Those interested in actuarial science should seek the advice of the coordinator of the actuarial program in the department

For more information about the department's undergraduate programs, visit the Web site, www.math.unh.edu/pub/undergrad.

Standards for Graduation

To be certified for graduation with a degree from the Department of Mathematics and Statistics, a student must complete all courses used to satisfy the requirements for the major program with a grade of C- or better and have an overall grade-point average of 2.00 in these courses. The student must remain in good standing within the defined requirements of the University.

Please note that neither CS 401 nor CS 403 may be taken for credit in any program in mathematics.

In extenuating circumstances a student may petition for a variance in academic policy, including changes in program requirements by submitting the appropriate form for this purpose with his/her adviser, who will then forward the petition to the appropriate committee or to the CEPS Dean's Office for further action.

Bachelor of Arts, Mathematics Major

This program offers a broader liberal arts education than the bachelor of science programs. By a careful selection of electives, students can shape this major into a preparation for graduate school, business, or industry.

Requirements

General education requirements
(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)
Foreign language requirement as defined by the University for the B.A. degree.

Required MATH/CS courses
CS 410, Introduction to Scientific Programming (or CS 415, Introduction to Computer Science I)
MATH 425-426, Calculus I and II
MATH 527*, Differential Equations with Linear Algebra
MATH 528*, Multidimensional Calculus
MATH 531, Mathematical Proof (or 545*, Introduction to Linear Algebra and Mathematical Proof)
MATH 639, Introduction to Statistical Analysis
MATH 761, Abstract Algebra
MATH 762, Linear Algebra
MATH 767, One-Dimensional Real Analysis
Two approved MATH or CS electives chosen in consultation with adviser

*These requirements can be satisfied by MATH 525-526, Linearity

Bachelor of Science in Mathematics

This program offers the strongest concentration in mathematics, requiring courses that are intended to prepare the student for graduate work in mathematics. Through a judicious choice of electives, students may design stronger pre-graduate programs, a program in applied mathematics, or slant the program toward a career in business or industry.

Requirements

General education requirements
(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)

Other required courses
PHYS 407-408, General Physics I and II (satisfies two of the three courses for general education in Group 3, biological science, physical science, and technology)

Required MATH/CS courses
CS 410, Introduction to Scientific Programming (or CS 415, Introduction to Computer Science I)
MATH 425-426, Calculus I and II
MATH 527*, Differential Equations with Linear Algebra
MATH 528*, Multidimensional Calculus
MATH 531, Mathematical Proof
(or 545*, Introduction to Linear Algebra and Mathematical Proof)
MATH 639, Introduction to Statistical Analysis
MATH 761, Abstract Algebra
MATH 762, Linear Algebra
MATH 767, One-Dimensional Real Analysis
MATH 784, Topology
MATH 788, Complex Analysis
One approved MATH elective chosen in consultation with an adviser
One approved MATH or CS elective chosen in consultation with an adviser

*These requirements can be satisfied by MATH 525-526, Linearity

Bachelor of Science: Interdisciplinary Programs in Mathematics and Its Applications

The interdisciplinary programs in mathematics prepare students for employment in areas of applied mathematics and statistics. Some of them can lead to graduate work in appropriate fields (e.g., physics, computer science, economics). The major may consist of mathematics combined with computer science, economics, statistics, electrical science, or physics.

Each interdisciplinary major consists of ten mathematics courses plus at least six courses in the discipline of the option. Specific requirements follow.

Requirements

General education requirements
(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)
Required courses in all options
MATH 425-426, Calculus I and II
MATH 527*, Differential Equations with Linear Algebra
MATH 528*, Multidimensional Calculus
MATH 531, Mathematical Proof (or 545*, Introduction to Linear Algebra and Mathematical Proof)
MATH 639, Introduction to Statistical Analysis
MATH 645*, Linear Algebra for Applications
CS 410, Introduction to Scientific Programming (or CS 415, Introduction to Computer Science I)
If MATH 545 is taken, credit may not be received for MATH 645. Instead, students should take another mathematics course chosen in consultation with their adviser.

*These requirements can be satisfied by MATH 525-526, Linearity.

Other required courses by option:

Computer Science Option
MATH 532, Discrete Mathematics
MATH 753, Introduction to Numerical Methods I
One additional MATH course chosen from approved electives.

CS 415-416, Introduction to Computer Science I and II
CS 515, Data Structures
EE 543, Introduction to Digital Systems
CS 610, Operating System Fundamentals
CS 611, Assembly Language Programming and Machine Organization
CS 658, Analysis of Algorithms (*or* CS 659, Introduction to the Theory of Computation)
One additional CS course chosen in consultation with adviser.

Economics Option
MATH 739, Applied Regression Analysis
One MATH course chosen from: MATH 740, 741, 742, 755
One additional MATH course chosen from approved electives.

ECON 401, Principles of Economics (Macro)
ECON 402, Principles of Economics (Micro)
ECON 605, Intermediate Microeconomic Analysis
ECON 611, Intermediate Macroeconomic Analysis
EREC 715, Linear Programming and Quantitative Models
One additional ECON or DS course.

Electrical Science Option
MATH 646, Introduction to Partial Differential Equations
MATH 647, Complex Analysis for Applications
MATH 753, Introduction to Numerical Methods I
EE 541, Electrical Circuits
EE 548, Electronics Design I
EE 603, Electromagnetic Fields and Waves I
EE 633, Signals and Systems I
EE 634, Signals and Systems II
EE 757, Fundamentals of Communication Systems

Physics Option
MATH 646, Introduction to Partial Differential Equations
MATH 647, Complex Analysis for Applications
MATH 753, Introduction to Numerical Methods I

PHYS 407, 408, 505, Physics I-III

Three additional PHYS courses, chosen from the following seven courses

PHYS 508, Thermodynamics and Statistical Mechanics
PHYS 616, Physical Mechanics
PHYS 701, 702, Introduction to Quantum Mechanics I, II
PHYS 703, 704, Electricity and Magnetism I, II
PHYS 708, Optics

Statistics Option
MATH 739, Applied Regression Analysis
MATH 755, Probability and Stochastic Processes with Applications
MATH 756, Principles of Statistical Inference

Two additional courses chosen from

MATH 740, Design of Experiments I
MATH 741, Biostatistics and Life Testing
MATH 742, Multivariate Statistics Methods

Three additional MATH courses chosen in consultation with adviser.

Bachelor of Science in Mathematics Education

This professional degree program prepares students for mathematics teaching at the elementary, middle/junior high, or secondary level. The program is coordinated with the education department's teacher certification programs. For the elementary option, full certification requires the five-year program. Students may complete the degree requirements for middle/junior high or secondary option with full teacher certification in either four or five years. Students electing the four-year option must plan for one semester of student teaching (EDUC 694) in their senior year and should consult with the mathematics department program adviser concerning the schedule of mathematics courses. The five-year program involves a required year-long teaching internship in the fifth year. (The internship can be coupled with other graduate work leading to a master's degree.) See education, College of Liberal Arts, page 33.

Elementary School Option Requirements
General education requirements

(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)
Required mathematics courses
MATH 425-426, Calculus I and II
MATH 531, Mathematical Proof
MATH 545, Introduction to Linear Algebra and Mathematical Proof
MATH 619, Historical Foundations of Mathematics
MATH 621, Number Systems for Teachers
MATH 622, Geometry for Teachers
MATH 623, Topics in Mathematics for Teachers
MATH 639, Introduction to Statistical Analysis
MATH 657, Geometry
MATH 703, The Teaching of Mathematics, K-6
MATH 791, The Teaching of Mathematics, 7-12
One approved MATH or CS elective chosen in consultation with adviser

Other required courses
CS 410, Introduction to Scientific Programming
(or CS 415, Introduction to Computer Science I)
PHYS 406, Introduction to Modern Astronomy (satisfies one of three courses for general education in Group 3, biological science, physical science, and technology)
EDUC 500, Exploring Teaching
EDUC 700, Educational Structure and Change
EDUC 701, Human Development and Learning: Educational Psychology
EDUC 705, Alternative Perspectives on the Nature of Education
EDUC 706, Introduction to Reading Instruction in the Elementary Schools

*Note: EDUC 751 and EDUC 703F and EDUC 703M are requirements for certification and can be completed at either the undergraduate or graduate level.

Middle/Junior High School Option Requirements
General education requirements

(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)

Required mathematics courses
MATH 425-426, Calculus I and II
MATH 531, Mathematical Proof
MATH 545, Introduction to Linear Algebra and Mathematical Proof
MATH 619, Historical Foundations of Mathematics
MATH 621, Number Systems for Teachers
MATH 622, Geometry for Teachers
MATH 639, Introduction to Statistical Analysis
MATH 657, Geometry
MATH 698, Senior Seminar
MATH 761, Abstract Algebra
MATH 791, The Teaching of Mathematics, 7-12

One approved MATH or CS elective chosen in consultation with adviser.

Other required courses
CS 410, Introduction to Scientific Programming *or* CS 415, Introduction to Computer Science I
EDUC 500, Exploring Teaching
EDUC 700, Educational Structure and Change
EDUC 701, Human Development and Learning: Educational Psychology
EDUC 705, Alternative Perspectives on the Nature of Education

Note: EDUC 751 is a requirement for certification and can be completed at either the undergraduate or graduate level.

Secondary School Option Requirements
General education requirements

(MATH 425 satisfies the Group 2 requirement, quantitative reasoning.)

Required mathematics courses
MATH 425-426, Calculus I and II
MATH 527*, Differential Equations with Linear Algebra
MATH 528*, Multidimensional Calculus
MATH 531, Mathematical Proof
MATH 545*, Introduction to Linear Algebra and Mathematical Proof
MATH 619, Historical Foundations of Mathematics
MATH 639, Introduction to Statistical Analysis
MATH 657, Geometry
MATH 698, Senior Seminar
MATH 761, Abstract Algebra
MATH 791, The Teaching of Mathematics, 7-12

*These requirements can be satisfied by MATH 525-526, Linearity

One approved MATH or CS elective chosen in consultation with adviser.

Other required courses
CS 410, Introduction to Scientific Programming *or* CS 415, Introduction to Computer Science I
EDUC 500, Exploring Teaching
EDUC 700, Educational Structure and Change
EDUC 701, Human Development and Learning: Educational Psychology
EDUC 705, Alternative Perspectives on the Nature of Education

*Note: EDUC 751 is a requirement for certification and can be completed at either the undergraduate or graduate level.

Minoring in Mathematics

The Department of Mathematics and Statistics offers three options for minor programs: mathematics, applied mathematics, and statistics. These are open to all students enrolled at the University. Each option requires a minimum of five courses as detailed below. (These requirements assume that the student has credit for MATH 425 and MATH 426, or their equivalents.) Students whose major program requires by specific course number more than 8 credit hours in courses required by the departmental minor may substitute additional courses from the

list of optional courses in the minor to meet the five-course minimum.

Mathematics Minor

Required (3): MATH 528*, MATH 531 (or 545*), and MATH 761 (or 767)

Options (2): Two courses chosen from among MATH 527*, 656, 657, 658, 761, 762, 764, 767, 776, 783, 784, 788

*These requirements can be satisfied by MATH 525-526, Linearity

Applied Mathematics Minor

Required (4): MATH 527*, 528*, 545* (or 645*), and 753

Options (1): One course chosen from among MATH 639 (or 644), MATH 646, 647, 745, 746, 747, or 754

*These requirements can be satisfied by MATH 525-526, Linearity

Statistics Minor

Required (2): MATH 639 (or 644) and MATH 545 (or 645)

Options (3): Three courses chosen from among MATH 737, 739, 740, 741, 742, 744, 755, 756

Mechanical Engineering

(For descriptions of courses, see page 197.)

Mechanical engineering is a challenging profession encompassing research, design, development, and production of aerospace vehicles, underwater vessels, instrumentation and control systems, nuclear and conventional power plants, and consumer and industrial products in general. The profession also makes contributions through more fundamental studies of material behavior, the mechanics of solids and fluids, and energy transformation. Additional information can be found at the mechanical engineering Web site: www.unh.edu/mechanical-engineering/index.html.

The mechanical engineering program develops the student's creative potential to meet the increasingly complex needs of industry, government, and education while giving an appreciation of the role of technology in a modern society.

The curriculum prepares prospective graduates either for more advanced studies or for beginning professional engineering careers. It provides a foundation of knowledge in the basic physical sciences, mechanics of solids and fluids, dynamic systems, thermal sciences, materials science, and design. Students develop abilities in analysis, experimentation, and design. Elective courses allow students to gain additional competence in any of these specific areas. Other elective courses in the arts, humanities, and the social sciences are included to provide a liberal education.

Students, with their advisers' assistance, should plan a program based on the following distribution of courses that totals not less than 128 credits. The outline that follows is to be considered as being typical only in format. Within the constraints of satisfying all of the requirements and having all the necessary prerequisites, schedules may vary because of scheduling needs or student preference. Some mechanical engineering elective courses may not be offered every year.

The curriculum has thirteen elective courses. These should be selected in consultation with a departmental adviser to lead to a balanced program that addresses chosen areas of interest. Five of the elective courses are selected from groups four through eight of the University's general education requirements, with the Group 7 general education course being either ECON 402 or EREC 411. One of the elective courses must be selected from the biological science listing of Group 3 of the general education requirements. Seven technical elective courses of at least 3 credits each are required. They may be selected from 600-700 level courses in College of Engineering and Physical Sciences, excluding BET, and from the following 500 level courses, ENE 520, ESCI 501 and ECE 543. Three of the seven technical electives must come from the prescribed lists: A. engineering practice; B. mathematics; C. advanced engineering topics. These lists are available in the mechanical engineering office. All students must take one course from each list. Two of the remaining four technical electives can be used for studying a focused area such as a foreign language, or a preprofessional program, or a minor, with mechanical engineering department approval. Some programs may require additional elective courses to reach the minimum of 128 credits required for graduation. Other programs may exceed 128 credits to include all the required courses.

To enter the junior-year courses in the mechanical engineering major, students must have at least a 2.00 combined grade-point average for the following group of courses: PHYS 407-408, ME 503, ME 525, and ME 526.

In order to graduate in the mechanical engineering major, students must have at least a 2.00 grade-point average in all engineering and science courses, including required technical electives normally taken as department requirements after the start of the junior year. The option of repeating required engineering, science, and technical elective courses normally taken after the start of the junior year may be exercised in only one of the following: (1) one course may be repeated twice; and (2) a maximum of two courses may be repeated once.

Freshman Year	**Fall**	**Spring**
MATH 425, Calculus I	4	–
MATH 426, Calculus II	–	4
ME 441, Engineering Graphics	4	–
General Education Elective	–	4
General Education Elective	4	–
ENGL 401, Freshman English	–	4
CHEM 403, General Chemistry	4	–
PHYS 407, General Physics I	–	4
Total	**16**	**16**
Sophomore Year		
†MATH 527, Differential Equations with Linear Algebra	–	4
†MATH 528, Multidimensional Calculus	4	–
ME 525, 526, Mechanics I and II	3	3
ME 503, Thermodynamics	–	3
ME 561, Introduction to Materials Science	–	4
PHYS 408, General Physics II	4	–
Technical elective	3-4	–
General education elective	4	4
Total	**18-19**	**18**
Junior Year		
CS 410, Introduction to Scientific Programming	4	–
ME 608, Fluid Dynamics	3	–
ME 603, Heat Transfer	–	3
ME 627, Mechanics III	3	–
ME 643, Elements of Design	–	3
ME 646, Experimental Measurement and Data Analysis	–	4
ECE 537, Introduction to Electrical Engineering	4	–
ME 670, Systems Modeling, Simulation, and Control	–	4
Technical electives (2)	3–4	3-4
Total	**17-18**	**17-18**
Senior Year		
ME 705, Thermal System Analysis and Design	4	–
‡ME 755, Senior Design Project I	2	–
ME 756, Senior Design Project II	–	2
ME 747, Experimental Measurement and Modeling of Complex Systems	4	–
Technical electives (4)	3–4	9–12
General education electives (2)	4	4
Total	**17–18**	**15–18**

†MATH 525 and MATH 526 (Linearity I and II) may be substituted for MATH 527 and MATH 528 and a MATH technical elective

‡TECH 797 Undergraduate Ocean Research Project may be substituted for ME 755 and ME 756

Materials Science Minor

The minor, administered by the Department of Mechanical Engineering, is open to all students of the University and offers a broad introduction to materials science.

Students must complete at least 18 credits and a minimum of five courses as follows: ME 561 (required); ME 760 (required); and ME 730 (required); additional courses from the following: 731, 744, 761, 762, 763, and 795 (materials).

By midsemester of their junior year, interested students should consult the minor supervisor, James E. Krzanowski, Department of Mechanical Engineering.

Physics

(For descriptions of courses, see page 215.)

Physics is concerned with the properties of matter and the laws that describe its behavior. It is an exact science based on precise measurement, and its objective is the kind of understanding that leads to the formulation of mathematical relationships between measured quantities. As a fundamental science, its discoveries and laws are basic to understanding in nearly all areas of science and technology. Advances in such diverse fields as medical instrumentation, solid state electronics, and space research have relied heavily on the application of basic physical laws and principles.

Students interested in the study of physics at the University of New Hampshire will find a strong interaction between research and academic programs. Undergraduates have participated in research studies ranging from nuclear scattering experiments at major particle accelerators to astrophysical studies of the solar system using space probes. These experiences have proven beneficial to engineering and physics students alike. The department has its own library, which provides a comfortable, inviting atmosphere for study and relaxed reading.

The suggested programs that follow are indicative of the flexibility available to students, whether they are preparing for graduate work in physics, industrial opportunities, governmental research, secondary-level teaching, or a general education that might utilize the fundamental knowledge of physics.

Several undergraduate degree programs are offered through the Department of Physics. The B.S. degree is designed for students who wish to work as professional physicists or engineers; the interdisciplinary option allows for students to combine physics with other disciplines. The B.A. degree is designed for students who want a strong background in physics but also want a broad liberal education. A minor in physics allows a student to combine an interest in physics with another major.

Physics related degrees are also offered in other departments. For those students with strong interests in both math and physics, the Department of Mathematics offers a B.S. interdisciplinary option in physics (see page 65). For those interested in a career as a middle or high school educator in both physics and chemistry, the Department of Chemistry offers a B.A. in chemistry and physics teaching.

Interested students are encouraged to contact the department for further information. More detailed information is also on the Physics Department Web page at www.physics.unh.edu.

Minor in Physics

The minor in physics consists of five courses in physics. All students must take PHYS 407, 408, and 505, including labs. Two other physics courses at the 500 level or above must be chosen in consultation with the student's physics minor adviser.

Bachelor of Arts, Chemistry and Physics Teaching

For information, see page 56.

Physics Major, Bachelor of Arts

This degree provides an opportunity for a broad and liberal education, which in some cases may be sufficient for graduate work. A judicious choice of electives may also prepare students for interdisciplinary programs that require proficiency in a restricted area of physics.

Requirements

1. Satisfy general education and writing requirements
2. Satisfy bachelor of arts degree requirements (page 18)
3. PHYS 407-408, 505, 506, 508, 615, 616, 701, 703, 705. Note that MATH 425, 426, and MATH 527, 528 or MATH 525, 526 are prerequisites for some of the courses. A total of 40 credits is required.

In the following table, "Electives" include general education courses, writing intensive courses, language courses required for the B.A. (see page 18), and free choice electives.

Suggested Curriculum for B.A. in Physics

Freshman Year	Fall	Spring
PHYS 407-408, General Physics I and II	4	4
MATH 425, 426, Calculus I and II (Group 2)	4	4
ENGL 401, Freshman English	–	4
Elective	8	4
Physics 400, Freshman Seminar	1	–
Total	**17**	**16**
Sophomore Year		
PHYS 505-506, General Physics III and Lab	4	–
PHYS 615, Introduction to Mathematical Physics	–	4
MATH 527, Differential Equations or MATH 525, Linearity I	4 or 6	–
MATH 528, Multidimensional Calculus or MATH 526, Linearity II	–	4 or 6
Elective	8	8
Total	**16 or 18**	**16 or 18**
Junior Year		
PHYS 605, Experimental Physics I	5	–
PHYS 508, Thermodynamics and Statistical Mechanics	–	4
PHYS 616, Physical Mechanics	4	–
PHYS 701, Introduction to Quantum Mechanics I	–	4
Electives	8	8
Total	**17**	**16**
Senior Year		
PHYS 705, Experimental Physics II	–	4
PHYS 703, Electricity and Magnetism I	–	4
Elective	16	8
Total	**16**	**16**

Bachelor of Science in Physics

The bachelor of science degree in physics prepares students for professional work as physicists. The required courses in the standard options are those typically necessary for admission to graduate study in physics. The new interdisciplinary options require fewer physics courses combined with a concentration in another area (chemistry, biology, or materials science).

Requirements

1. Satisfy general education and writing requirements.
2. Satisfy bachelor of science requirements (page 53).
3. Minimum physics requirements: 407-408, 505, 506, 508, 605, 615-616, 701, 702, 703, 704, 705; two physics electives selected from the 700-level physics courses.
4. Chemistry: 403-404 or 405
5. Math: 425-426, and 527-528 or 525-526
6. Computer Science: CS 410
7. By the end of the spring semester of the sophomore year, a student must have a minimum grade of C in each 400- or 500-level course specifically required for the B.S. degree and an overall grade-point average of 2.33 in these courses in order to continue in the B.S. program.

Physics electives
In the following table, "Electives" include general education courses, writing intensive courses, physics electives, and free choice electives. Note that physics electives can only be taken in the junior or senior year because of prerequisites.

Suggested Curriculum for B.S. in Physics

Freshman Year	**Fall**	**Spring**
PHYS 407-408, General Physics I and II	4	4
MATH 425, 426, Calculus I and II (Group 2)	4	4
CHEM 403-404, General Chemistry (Group 3)	4	4
ENGL 401, Freshman English	–	4
Elective	4	–
Physics 400, Freshman Seminar	1	–
Total	**17**	**16**
Sophomore Year		
PHYS 505-506, General Physics III and Lab	4	–
PHYS 508, Thermodynamics and Statistical Mechanics	–	4
PHYS 615, Introduction to Mathematical Physics	–	4
MATH 527, Differential Equations or MATH 525, Linearity I	4 or 6	–
MATH 528, Multidimensional Calculus or MATH 526, Linearity II	–	4 or 6
CS 410, Introduction to Scientific Programming	4	–
Elective	4	4
Total	**16 or 18**	**16 or 18**
Junior Year		
PHYS 605, Experimental Physics I	5	–
PHYS 616, Physical Mechanics	4	–
PHYS 701, Introduction to Quantum Mechanics I	–	4
PHYS 703, Electricity and Magnetism I	–	4
Electives	8	8
Total	**17**	**16**
Senior Year		
PHYS 702, Quantum Mechanics II	4	–
PHYS 704, Electricity and Magnetism II	4	–
PHYS 705, Experimental Physics II	–	4
Elective	8	12
Total	**16**	**16**

Biophysics Option, Bachelor of Science in Physics
1. Satisfy general education and writing requirements.
2. Satisfy bachelor of science degree requirements.
3. One course in English is required in addition to the University requirement.
4. Physics requirements: PHYS 407-408; 505-506, 508, and 605
5. Chemistry: CHEM 403-404 or 405, 651-654 (organic)
6. Biology: BIOL 411, 412
7. Biochemistry: BCHM 658-659
8. Mathematics: MATH 425, 426, 527, 528
9. Computer Science: CS 410
10. 18 additional credits in approved physics, chemistry, biology or biochemistry courses; at least two of these courses must be in physics.

Chemical Physics Option, Bachelor of Science in Physics
1. Satisfy general education and writing requirements.
2. Satisfy bachelor of science requirements.
3. One course in English is required in addition to the University requirement.
4. Physics requirements: PHYS 407-408, 505-506, 605, 615, 616, 701, 703, 705, 718 (optional), 795 (senior thesis)
5. Chemistry: CHEM 405-407, 547, 548, 549, 574, 550, 683, 684, 685, 686, 762, 763, 776
6. Mathematics: MATH 425-426, 527, 528, 646
7. Computer Science: CS 410

Materials Science Option, Bachelor of Science in Physics
1. Satisfy general education and writing requirements.
2. Satisfy bachelor of science requirements.
3. One course in English is required in addition to the University requirement.
4. Physics requirements: PHYS 407-408, 505-506, 508, 605, 615-616, 701, 703, 705, 795 (8 credit hours).
5. Mechanical Engineering: 561, 730, 760
6. Math: 425-426, 527-528, or 525-526
7. Computer Science: CS 410
8. Electives in Option: Three courses selected from MATH 646, ME 731, 761, 763, 795, MS 760, PHYS 718
9. Chemistry: 403-404 or 405