

Engineering Minors

The engineering minor, a supplement to the regular bachelor's degree Majors in the college, including the Independent Major, recognizes formal study of a particular technical subject area in engineering outside the student's Major.

Students undertaking a minor are normally expected to complete the requirements during the time of their continuous undergraduate enrollment at Cornell. By having courses for minor requirements also satisfy other degree requirements (e.g. distribution courses, approved electives), completing the minor may sometimes be done within the traditional eight semesters. However, sometimes, more than eight semesters may be needed.

To complete an engineering minor, an undergraduate engineering student must

- be enrolled in a Major that approves participation of its affiliates in the desired engineering minor.
- successfully complete all the requirements for a Bachelor of Science degree in engineering.
- satisfactorily complete six courses (18-credit minimum) as stipulated in a college-approved engineering minor offered by an engineering department/school other than that which offers the student's Major.

Students may apply for certification of an engineering minor at any time after the necessary course work has been completed in accordance with published standards. Students who receive certification in an approved engineering minor will be recognized by means of an official notation on their Cornell transcript, following graduation.

The College of Engineering currently offers minors in the following areas (offering units are indicated in parentheses):

Applied Mathematics (T&M)
Biological Engineering (BEE)
Biomedical Engineering (BME)
Civil Infrastructure (CEE)
Computer Science (CS)
Electrical and Computer Engineering (ECE)
Engineering Management (CEE)
Engineering Statistics (OR&IE)
Environmental Engineering (BEE/CEE)
Geological Sciences (EAS)
Industrial Systems and Information Science Technology (OR&IE)
Information Science (CIS)
Materials Science and Engineering (MS&E)
Mechanical Engineering (M&AE)
Operations Research and Management Science (OR&IE)

Additional information on specific minors can be found in the Major office of the department/school offering the minor, in *Courses of Study*, in Engineering Advising, and on the pages that follow.

Students interested in applying the concepts and methods of the engineering, computational, and physical sciences to living systems or health issues may pursue one of three courses of study, which are presented for ease of comparison in the following chart. For more details on these courses of study, see the appropriate sections of "Engineering Minors" and "Bioengineering Option" (p. 110).

Integrating Biology into the Engineering Curriculum

Minor in Biological Engineering

Offered by: Department of Biological and Environmental Engineering

Note: Students wishing to pursue this minor should meet with the BEE program coordinator. Students may complete only one of the Biological Engineering Minor, the Bioengineering Option, and the Biomedical Engineering Minor.

Contact: BEE Major Coordinator, 207 Riley-Robb Hall

Eligibility: Students affiliated with any Major except Biological Engineering may participate in this minor.

Educational Objectives: The application of engineering to living systems. Examples include biosensor technologies, study and control of biologically based matter transformation systems, and development of engineered devices to study and regulate fundamental biological processes. This minor is an opportunity for students to further their understanding of living systems and of the basic transport processes within these systems. Courses provide opportunities to analyze, design, and manipulate living systems at the molecular, cellular, and systems levels.

Requirements: Six (6) courses (minimum of 18 credits) including BEE 350, two analysis courses, two application courses, and one basic science course.

Academic Standards: At least C- in each course in the minor.

Notation: Official notation on transcript.

Minor in Biomedical Engineering

Offered by: Department of Biomedical Engineering

Note: Students may complete only one of this minor, the Biological Engineering Minor, and the Bioengineering Option.

Contact: BME chair, 270 Olin Hall

Eligibility: All undergraduates in the College of Engineering unless they are also pursuing the Bioengineering Option or the Biological Engineering Minor.

Educational Objectives: Biomedical engineering is the application of engineering principles and methods to a wide array of problems associated with human health. The discipline includes the design of biocompatible materials, prostheses, surgical implants, artificial organs, controlled drug-delivery systems, and wound closure devices. Diagnosing diseases and determining their biological origins depend on increasingly sophisticated instrumentation and the use of mathematical models. The purpose of this minor is to allow students in the College of Engineering to gain exposure to the breadth and depth of biomedical engineering offerings at Cornell, to prepare for advanced studies in biomedical engineering, and to obtain recognition for their interest and capability in this rapidly growing area.

Requirements: At least six (6) courses (minimum of 18 credits) from the five groups listed on page 85, with at least four of the groups represented and four (4) of which must be from categories 3, 4, and 5 (two of the courses course from category 1). At least four of the six courses must be from outside the student's Major department. Students must also complete one semester of BMEP 501.

Academic Standards: At least C- in each course in the minor and a cumulative GPA \geq 2.0.

Notation: Official notation on transcript.

Bioengineering Option

Offered by: College of Engineering Faculty Bioengineering Committee

Note: Students completing this option may not pursue either the Biological Engineering or the Biomedical Engineering minor.

Contact: the Undergraduate Programs office, 167 Olin Hall

Eligibility: Students who obtain a bioengineering faculty consultant before the beginning of the sixth semester of study in engineering and who are not pursuing a minor in Biological or Biomedical Engineering.

Educational Objectives: To provide a guided course of study in addition to and in parallel with a Major of study in engineering in the area of bioengineering and to provide formal transcript recognition of the bioengineering option.

Requirements: Four (4) bioengineering courses (minimum of 12 credits), one or two science-based courses, and two or three bioengineering courses—with at least 6 credits from courses in the bioengineering list.** BMEP 501, the Bioengineering Seminar (1 credit hour minimum).

Academic Standards: At least C- in each course in the option.

Notation: Official notation on transcript.

**Consult the specific minor and option descriptions to see the lists of courses approved to fulfill these requirements.

Minor in Applied Mathematics

Offered jointly by: Department of Theoretical and Applied Mechanics and Department of Mathematics

Administered by: Department of Theoretical and Applied Mechanics

Contact Persons: Professor Richard Rand, 207 Kimball Hall, 255-7145, rhr2@cornell.edu; and Professor Tim Healey, 211 Kimball Hall, 255-3738, tjh10@cornell.edu

Eligibility: Engineering undergraduates affiliated with all Engineering Majors are eligible to participate in the Applied Mathematics minor.

Educational Objectives: This minor is aimed at providing a focus for students who are interested in applied mathematics.

Requirements

At least six (6) courses beyond MATH 294, to be chosen as follows:

- (a) At most one course may be chosen from any one of the groups 1, 2, 3, or 4.
- (b) At least three courses must be chosen from groups 5 and 6.
- (c) At most one 200-level course may be chosen.
- (d) At most one course may be chosen that is offered by the student's Major department.

I. Analysis

T&AM 310	Advanced Engineering Analysis I
MATH 323	Introduction to Differential Equations
MATH 420	Differential Equations and Dynamical Systems
A&EP 321	Mathematical Physics I

II. Computational Methods

COM S 322	Introduction to Scientific Computation
CEE 241	Engineering Computation
OR&IE 320	Optimization I

III. Probability and Statistics

OR&IE 270	Basic Engineering Probability and Statistics
OR&IE 360	Engineering Probability and Statistics II
ECE 310	Introduction to Probability and Random Signals
CEE 304	Uncertainty Analysis in Engineering
MATH 471	Basic Probability

IV. Applications

A&EP 333	Mechanics of Particles and Solid Bodies
CHEM 323	Fluid Mechanics
CEE 331	Fluid Mechanics
CEE 371	Modeling in Structural Systems
ECE 425	Digital Signal Processing
M&AE 323	Introduction to Fluid Mechanics
M&S&E 303	Thermodynamics of Condensed Systems
COM S 280	Discrete Structures

V. Advanced Courses

Only one of the following three may be chosen:

T&AM 311 Advanced Engineering Analysis II
MATH 422 Applied Complex Analysis
A&EP 322 Mathematical Physics II

Only one of the following two may be chosen:

ECE 411 Random Signals
OR&IE 361 Introductory Engineering Stochastic Processes I

Only one of the following two may be chosen:

COM S 381 Introduction to Theory of Computing
COM S 481 Introduction to Theory of Computing

Only one of the following two may be chosen:

M &AE 571 Applied Dynamics
T&AM 570 Intermediate Dynamics

Also, you may choose from:

COM S 482 Introduction to the Design of Algorithms
OR&IE 321 Optimization II
OR&IE 431 Discrete Models
OR&IE 435 Introduction to Game Theory
OR&IE 462 Introductory Engineering Stochastic Processes II
ECE 522 Nonlinear Systems
T&AM 578 Nonlinear Dynamics and Chaos
T&AM 610 Methods of Applied Math I
T&AM 611 Methods of Applied Math II

VI. Math Courses

Any 300+-level course offered by the Mathematics Department in algebra, analysis, probability/statistics, geometry, or logic, with the following exceptions:

- (i) MATH 323 or MATH 420, if any course from group 1 is chosen.
- (ii) MATH 471, if any course from group 3 is chosen.
- (iii) MATH 422, if T&AM 311 or A&EP 322 are chosen from group 5.
- (iv) Only one of the following may be chosen:
 - Math 332 Algebra and Number Theory
 - Math 335 Introduction to Cryptology
 - Math 336 Applicable Algebra

Academic Standards

At least C for each course in the minor.

Minor in Biomedical Engineering

Offered by: Department of Biomedical Engineering

Administered by: Michael Shuler, Chair, 270 Olin Hall, mls50@cornell.edu, 255-7577

Eligibility: All undergraduates in the College of Engineering are eligible to participate in the Biomedical Engineering minor. (Students may participate in only one of the Bioengineering Option, the Biological Engineering Minor, and the Biomedical Engineering minor.)

Educational Objectives: Biomedical engineering is the application of engineering principles and methods to a wide array of problems associated with human health. The discipline includes the design of biocompatible materials, prostheses, surgical implants, artificial organs, controlled drug-delivery systems, and wound closure devices. Diagnosing diseases and determining their biological origins depend upon increasingly sophisticated instrumentation and the use of mathematical models. The purpose of this minor is to allow students in the College of Engineering to gain exposure to the breadth and depth of biomedical engineering offerings at Cornell, to prepare for advanced studies in biomedical engineering, and to obtain recognition for their interest and capability in this rapidly growing area.

Menu of Courses: See below.

Requirements

At least six (6) courses (minimum of 18 credits) from the five groups listed below, with at least four of the groups represented and four of which must be from categories 3, 4, and 5 (two of the courses should be in categories 1 and/or 2 with no more than one course from category 1). At least four of the six courses must be from outside the student's Major department.

Students who are considering the BME minor are asked to register with the Department of Biomedical Engineering Office, 270 Olin Hall. A BME faculty advisor will be assigned and will approve their BME minor plan.

Required Course

BMEP 501 (1) Bioengineering Seminar

I. Introductory Biology (maximum of 4 credits and one course toward BME minor)

BIOG 110 and ENGR1 101 Biological Principles and Introduction to Biomedical Engineering Analysis

BIOG 101, 102, 103, and 104 Biological Sciences

BIOG 105 and 106 Introductory Biology

BIOG 107 and 108 General Biology

A "5" on AP Biology Test

II. Advanced Biology

BIOGM 330 Principles of Biochemistry, Individualized Instruction

BIOGM 333 Principles of Biochemistry, Proteins, Metabolism, and Molecular Biology

BIOGM 331 and 332 Principles of Biochemistry, Proteins and Metabolism and Principles of Biochemistry, Molecular Biology

BIOAP 311 Introductory Animal Physiology Lectures

BIOGD 281 Genetics

- BIONB 222 Introduction to Neurobiology
- BIOMI 290 General Microbiology Lectures
- BIOGD 389 Embryology

III. Molecular and Cellular Biomedical Engineering

- BMEP 301 (CHEME 401)* Molecular Principles of Biomedical Engineering
- BMEP 302 (CHEME 402)* Cellular Principles of Biomedical Engineering
- A&EP 252 The Physics of Life
- BEE 360 Molecular and Cellular Bioengineering

IV. BME Analysis of Physiological Systems

- BMEP 401* Biomedical Engineering of Metabolic and Structural Systems
- BMEP 402* Information Exchange in BME Systems (Planned for spring 2004)
- M&AE 464 Orthopaedic Tissue Mechanics
- M&AE 463 Neuromuscular Biomechanics
- BEE 454 Physiological Engineering
- CHEME 481 Biomedical Engineering
- BIONB 330 Introduction to Computational Neuroscience

V. Biomedical Engineering Applications

- A&EP 470 Biophysical Methods
- BEE 450 Bioinstrumentation
- BEE 453 Computer-Aided Engineering:
Applications to Biomedical Processes
- BEE 459 Biosensors and Bioanalytical Techniques
- COM S 321 Numerical Methods in Computational Molecular Biology
- ECE 402 CDE in Biomedical System Design
- ECE 336 Nanofabrication
- ECE 578 Computer Analysis of Biomedical Images
- BIONB 440 Electronics in Neurobiology
- BIONB 441 Computer in Neurobiology
- BEE 365 Properties of Biological Materials
- M S&E 461 Biological Materials and Their Applications
- TXA 439 Biomedical Materials and Devices for Human Body Repair
- M&AE 565 Biomechanical Systems—Analysis and Design

Academic Standards

At least C- in each course in the minor and a GPA \geq 2.0 for all courses in the minor.

*Students interested in professional practice as biomedical engineers should consider the new MEng degree in BME. The recommended sequence for admission to the M.Eng. BME will be two courses from category 1 and 2 as well as BME 301, 302, 401, and 402. The M.Eng. BME program will require a knowledge of molecular and cellular BME, and of BME analysis of physiological systems.

Minor in Civil Infrastructure

Offered by: School of Civil and Environmental Engineering

Administrative Contact: CEE undergraduate Major coordinator, 221 Hollister Hall, 607 255-3412. www.cee.cornell.edu

Eligibility: Students in all Majors except Civil Engineering may participate in this minor.

Educational Objectives: The Civil Infrastructure minor is intended to introduce engineering undergraduates to the engineering methodologies of mechanics, materials, analysis, design, and construction and to show how these are brought to bear in solving problems in the development maintenance and operation of the built environment that is vital for any modern economy.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. Required Course

ENGRD 202 Mechanics of Solids

II. Additional Courses: Choose any five (groupings are for information only)*

Geotechnical Engineering

CEE 341 Introduction to Geotechnical Engineering and Analysis
CEE 440 Foundation Engineering
CEE 441 Retaining Structures and Slopes
CEE 444 Environmental Applications of Geotechnical Engineering

Structural Engineering

CEE 371 Structural Behavior and Mechanics
CEE 372 Structural Analysis and Mechanics
CEE 471 Fundamentals of Structural Mechanics
CEE 472 Finite Element Analysis of Solids and Structures
CEE 473 Design of Concrete Structures
CEE 474 Design of Metal Structures
CEE/BEE 481 LRFD-Based Engineering of Wood Structures

Other Related Courses

CEE 332 Hydraulic Engineering
CEE 361 Introduction to Transportation Engineering
CEE 585 Construction Planning and Operations

Academic Standards

At least a C in each course in the minor.

*Other CEE courses approved by petition in advance.

Minor in Computer Science

Offered by: Department of Computer Science

Administered by: Department of Computer Science, 303 Upson Hall

Contact Person: Dan Jenkins, 303 Upson Hall, 255-9220, jenkins@cs.cornell.edu

Eligibility: Students in all Majors except Computer Science may participate in this minor.

Educational Objectives: This minor is for students who anticipate that computer science will have a prominent role to play in their academic and professional career.

Requirements

At least six (6) courses (minimum of 18 credits) chosen as follows:

I. Required Courses

COM S/ENGRD 211	Computers and Programming
COM S 321	Numerical Methods in Computational Biology
or COM S/ENGRD 322	Introduction to Scientific Computing
or COM S 421	Numerical Analysis
or COM S 428	Introduction to Computational Biophysics
COM S/ECE 314	Computer Organization

II. Additional Courses

Three (3) COM S courses numbered 280 or higher (excluding seminars and CS 490)

Academic Standards

At least C in each course in the minor.

Note: Computing courses offered by other departments cannot be applied toward the Computer Science minor, with the exception of ECE 314. All qualifying courses must be taken at Cornell for a letter grade. No substitutions allowed.

Minor in Electrical and Computer Engineering

Offered by: School of Electrical and Computer Engineering

Administrative Contact: ECE undergraduate field coordinator, 222 Phillips Hall

Eligibility: Students in all Majors except Electrical and Computer Engineering may participate in this minor.

Educational Objectives: The School of Electrical and Computer Engineering offers a minor to students who wish to complement their Major by obtaining a background in electrical and computer engineering. The minor offers the opportunity to study analog and digital circuits, signals and systems, electromagnetic majors, and additionally specialize at higher levels in one of several different areas such as circuit design and electronic devices, communications and signal processing, computer engineering and networks, or electromagnetic and space engineering.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. Required Courses

ENGRD/ECE 210	Introduction to Circuits for Electrical and Computer Engineers—(must take lab) - 4 credits
ECE 220	Signals and Information - 4 credits
ENGRD 230	Introduction to Digital Logic Design - 4 credits

II. Two (2) of the following

ECE 303	Electromagnetic Majors and Waves
ECE/COM S 314	Computer Organization
ECE 315	Electronic Circuit Design
ECE 320	Networks and Systems

III. One (1) other nonproject ECE course at the 300 level or above (3-credit minimum)

IV. One (1) other nonproject ECE course at the 400 level or above (3-credit minimum)

Academic Standards

The grades and grade point averages for courses used to satisfy the Electrical and Computer Engineering minor must meet the same requirements as the Electrical and Computer Engineering major; a grade of at least C- or better for every course in the minor and a GPA \geq 2.3 for all courses in the minor.

Minor in Engineering Management

Offered by: School of Civil and Environmental Engineering

Administrative Contact: CE undergraduate Major coordinator, 221 Hollister Hall, 607 255-3412. www.cee.cornell.edu

Eligibility: Students in all Majors except Civil Engineering may participate in this minor.

Educational Objectives: This minor focuses on giving engineering students a basic understanding of engineering economics, accounting, statistics, project management methods, and analysis tools necessary to manage technical operations and projects effectively. The minor provides an important set of collateral skills for students in any engineering discipline.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. Required Courses (3)

CEE 323	Engineering Economics and Management
OR&IE 350	Financial and Managerial Accounting
and	
CEE 304†	Uncertainty Analysis in Engineering
or ENGRD 270	Basic Engineering Probability and Statistics
or ECE 310	Introduction to Probability and Random Signals

II. Additional Courses—Choose any three*

CEE 490	Management Practice in Project Engineering
CEE 492	Engineers for a Sustainable World
CEE 593	Engineering Management Methods: Data, Information, and Modeling
CEE 594	Engineering Management Methods II: Managing Uncertain Systems
CEE 595	Construction Planning and Operations
CEE 597	Risk Analysis and Management
CEE 598	Introduction to Decision Analysis
NBA 507 (formerly NBA 401)	Entrepreneurship for Scientists and Engineers
or M&AE/ENGRG 461/OR&IE 452	Entrepreneurship for Engineers
or BEE 489	Engineering Entrepreneurship, Management, and Ethics

Academic Standards

At least C in each course in the minor.

*Other courses approved by petition in advance.

†T&AM 310 cannot be substituted for CEE 304.

Minor in Engineering Statistics

Offered by: Department of Statistical Science and School of Operations Research and Industrial Engineering

Administered by: ORE undergraduate Major consultant, 202 Rhodes Hall

Eligibility: Students in all Majors except Operations Research and Engineering may participate in this minor.

Educational Objectives: This minor requires the student to develop expertise in engineering statistics. The goal of the program is to provide the student with a firm understanding of statistical principles and engineering applications and the ability to apply this knowledge in real-world situations.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. Required Courses

ENGRD 270 Basic Engineering Probability and Statistics
OR&IE 360 Basic Engineering Probability and Statistics II
or ECE 310 or Introduction to Probability and Random Signals

II. Four courses (11 credits minimum) taken from the following list*

OR&IE 361 Introductory Engineering Stochastic Processes I
or ECE 411 or Random Signals in Communications/Signal Processing
OR&IE 476 Applied Linear Statistical Models
OR&IE 576 Regression
OR&IE 563 Applied Time Series Analysis
OR&IE 575 Experimental Design
OR&IE 577 Quality Control
OR&IE 580 Simulation Modeling and Analysis
MATH 472 Basic Probability
or BTRY 409 or Theory of Statistics
BTRY 602 Statistical Methods II
BTRY 603 Statistical Methods III
or ILRST 411 or Statistical Analysis of Qualitative Data
ILRST 310 Statistical Sampling
ILRST 314 Graphical Methods for Data Analysis
ILRST 410 Techniques of Multivariate Analysis

Academic Standards

At least C- in each course in the minor and a GPA \geq 2.0 in all courses in the minor.

Note: A student may not receive credit for more than one minor offered by the School of Operations Research and Industrial Engineering.

*Other course options approved by petition in advance. The student should be aware that some of these courses require others as prerequisites. All these courses are cross-listed under the Department of Statistical Science.

Minor in Environmental Engineering

Offered by: Department of Biological and Environmental Engineering and School of Civil and Environmental Engineering

Administrative Contact: BE undergraduate Major coordinator, 207 Riley-Robb Hall, or CE undergraduate Major coordinator, 221 Hollister Hall

Eligibility: Students in all Majors except Biological Engineering and Civil Engineering may participate in this minor.

Educational Objectives: A fundamental challenge for the engineering profession is development of a sustainable society and environmentally responsible industry and agriculture reflecting an integration of economic and environmental objectives. We are called upon to be trustees and managers of our nation's resources, the air in our cities, and use and quality of water in our aquifers, streams, estuaries, and coastal areas. This minor encourages engineering students to learn about the scientific, engineering, and economic foundations of environmental engineering so that they are better able to address environmental management issues.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

Students must select courses from the following group listings, with at least one (1) course from each group.

Group A. Environmental Engineering Processes

BEE 251	Engineering for a Sustainable Society
CEE 351	Environmental Quality Engineering
CEE 451	Microbiology for Environmental Engineering
CEE 452	Water Supply Engineering
CEE 453	Laboratory Research in Environmental Engineering
CEE 454	Sustainable Small-Scale Water Supplies
BEE 476	Solid Waste Engineering
BEE 478	Ecological Engineering
CEE 444	Environmental Site and Remediation Engineering
BEE 651	Bioremediation
CEE 653	Water Chemistry for Environmental Engineering
CEE 656	Physical/Chemical Processes
CEE 657	Biological Processes
CEE 658	Microbial Biodegradation and Biocatalysis Laboratory

Group B. Environmental Systems

ENGRI 113	Solving Environmental Problems for Urban Regions (May count only if taken before the junior year)
BEE 475	Environmental Systems Analysis
CEE 597	Risk Analysis and Management
CEE 623	Environmental Quality Systems Engineering
BEE 678	Nonpoint Source Models

Group C. Hydraulics, Hydrology, and Environmental Fluid Mechanics

CEE 331	Fluid Mechanics (CHEME 323 or M&AE 323 may be substituted for CEE 331)
CEE 332	Hydraulic Engineering
BEE 371	Hydrology and the Environment
CEE 431/BEE 471	Introduction to Groundwater Hydrology
CEE 432	Hydrology
CEE 436	Case Studies in Environmental Fluid Mechanics
CEE 437/637	Experimental Methods in Fluid Dynamics
BEE 473	Watershed Engineering
BEE 474	Drainage and Irrigation Systems
CEE 631	Computational Simulation of Transport in the Environment
CEE 633	Flow in Porous Media and Groundwater
CEE 655	Transport Mixing and Transformation in the Environment
BEE 671	Analysis of the Flow of Water and Chemicals in Soils
BEE 672	Drainage

Academic Standards

At least C- in each course in the minor and a GPA \geq 2.0 in all courses in the minor.

Minor in Geological Sciences

Offered by: Department of Earth and Atmospheric Sciences

Administrative Contact: GEO S undergraduate Major consultant, 2124 Snee Hall

Eligibility: Students in all Majors except Geological Sciences may participate in this minor.

Educational Objectives: Whereas many engineering students will encounter and have to understand the naturally operating systems of the Earth in their professions, the tools and techniques used by earth scientists to understand these solid and fluid systems over the widest scales of space and time are of use to a wide cross-section of engineering students. This minor is designed to give a flexible set of options for students looking to complement training in their Major with a core education in geological sciences.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. Choose one or both of these courses:

ENGRD 201 Introduction to the Physics and Chemistry of the Earth
EAS 210 Introduction to Field Methods in Geological Sciences

II. Choose at least two courses from the following list of core courses:

EAS 302 Evolution of the Earth System
EAS 321 Introduction to Biogeochemistry
EAS 326 Structural Geology
EAS 355 Mineralogy
EAS 356 Petrology and Geochemistry
EAS 375 Sedimentology and Stratigraphy
EAS 388 Geophysics and Geotectonics

III. To complete the minor, these three to four courses are to be supplemented with two to three additional EAS courses \geq 300. These may include, for example, additional courses from the above list of core courses, undergraduate research courses, and outdoor field courses.

Academic Standards

At least C- in each course in the minor and a GPA \geq 2.0 in all courses in the minor.

Minor in Industrial Systems and Information Technology

Offered by: School of Operations Research and Industrial Engineering

Administered by: OR&E undergraduate major consultant, 202 Rhodes Hall

Eligibility: Students in all Majors except Operations Research and Engineering may participate in this minor.

Educational Objective: The aim of this minor is to provide an in-depth education in the issues involved in the design and analysis of industrial systems and the tools from information technology that have become an integral part of the manufacturing process. Students will become familiar with the problems, perspectives, and methods of modern industrial engineering and be prepared to work with industrial engineers in designing and managing manufacturing and service operations. That is, rather than providing a comprehensive view of the range of methodological foundations of operations research, this minor is designed to give the student a focused education in the application area most closely associated with these techniques.

Requirements

At least six (6) courses (minimum of 18 credits), chosen as follows:

I. At least three of the following

- ENGRD 270 Basic Engineering Probability and Statistics
- OR&IE 310 Industrial Systems Analysis
- OR&IE 320 Optimization I
- OR&IE 480 Information Technology

II. The remaining courses/credit hours from the following

- OR&IE 350 Financial and Managerial Accounting
- OR&IE 416 Design of Manufacturing Systems
- OR&IE 451 Economic Analysis of Engineering Systems
- OR&IE 525 Production Planning and Scheduling Theory and Practice
- OR&IE 577 Quality Control
- OR&IE 580 Simulation Modeling and Analysis

Academic Standards

At least C- in each course in the minor and a GPA \geq 2.0 in all courses in the minor.

Note: A student may not receive credit for more than one minor offered by the School of Operations Research and Industrial Engineering.

Minor in Information Science

Offered by: Department of Computer Science

Administered by: Department of Computer Science, 303 Upson Hall

Contact Person: Dan Jenkins, 303A Upson Hall, 255-9220, rdj2@cornell.edu

Eligibility: Students in all Majors except Information Science, Systems and Technology may participate in this minor. Students interested in pursuing the Information Science minor must initiate the process by sending an e-mail message with their name, college, year of study (e.g., second-semester sophomore), expected graduation date, and (intended) Major to infosci-minor@cornell.edu.

Educational Objective: The program has three main areas: information systems, human-centered systems, and social systems. The minor has been designed to ensure that students have substantial grounding in all three of these areas in addition to having a working knowledge of basic probability and statistics necessary for analyzing data occurring in the real world.

Requirements

At least six (6) courses (minimum of 18 credits) chosen as follows:

I. Statistics: one course

II. Information systems (primarily computer science): two courses

III. Human-centered systems (human computer interaction and cognitive science): one course

IV. Social systems (social, economic, political, cultural, and legal issues): one course

V. Elective: one additional course from either human-centered systems or social systems

Statistics

An introductory course that provides a working knowledge of basic probability and statistics and their application to analyzing data occurring in the real world.

ENGRD 270	Basic Engineering Probability and Statistics
CEE 304	Uncertainty Analysis in Engineering
ECE 310	Introduction to Probability and Random Signals

Information Systems

COM S 211	Computers and Programming*
INFO 230	Intermediate Web Design and Programming for the Web*
INFO 330	Applied Databases
LING 424	Computational Linguistics
INFO 430	Information Retrieval
INFO 431	Web Information Systems
COM S 432	Introduction to Database Systems
COM S 465	Computer Graphics I
COM S 472	Foundations of Artificial Intelligence
LING 474	Introduction to Natural Language Processing
OR&IE 474	Statistical Data Mining
COM S 478	Machine Learning

OR&IE 480	Information Technology
COM S 501	Software Engineering
ECE 562	Fundamental Information Theory
COM S 578	Empirical Methods in Machine Learning and Data Mining

Human-Centered Systems

COGST 101	Introduction to Cognitive Science
PSYCH 205	Perception
INFO 214	Cognitive Psychology
INFO 245	Psychology of Social Computing
PSYCH 280	Introduction to Social Psychology
PSYCH 342	Human Perception: Applications to Computer Graphics, Art, and Visual Display
INFO 345	Human-Computer Interaction Design
PSYCH 347	Psychology of Visual Communications
PSYCH 380	Social Cognition
PSYCH 413	Information Processing: Conscious and Unconscious
PSYCH 416	Modeling Perception and Cognition
INFO 440	Advanced Human-Centered Systems
INFO 450	Language and Technology
DEA 470	Applied Ergonomic Methods

Social Systems

STS 250	Technology in Society
INFO 292	Inventing an Information Society
ECON 301	Microeconomics*
SOC 304	Social Networks and Social Processes
ECON 313	Intermediate Microeconomic Theory*
AEM 322	Technology, Information, and Business Strategy
INFO 349	Media Technologies
INFO 355	Computers: From Babbage to Gates
ECON 368	Game Theory
INFO 387	The Automatic Lifestyle: Consumer Culture and Technology
LAW 410	Limitation and Protection of Creative Expression—Copyright Law and Its Close Neighbors
STS 411	Knowledge, Technology, and Property
ECON 419	Economic Decisions Under Uncertainty
COMM 428	Communication Law
OR&IE 435	Introduction to Game Theory*
STS 438	Minds, Machines, and Intelligence
INFO 440	Social and Economic Data (also ILRLE 447 and ILRLE 740)
ECON 476/576	Decision Theory I and II
INFO 515	Culture, Law, and Politics of the Internet

Academic Standards

At least C in each course in the minor.

*Computer Science majors cannot use INFO 230. COM S 211 cannot be used by majors for which it is a required course, e.g., computer science and operations research.
 Only one of ECON 301 and ECON 313 can be taken for IS credit.
 Only one of OR&IE 435 and ECON 368 can be taken for IS credit.

Minor in Materials Science and Engineering

Offered by: Department of Materials Science and Engineering

Administrative Contact: MS&E undergraduate program director, 214 Bard Hall, 255-9159

Eligibility: Students in all Majors except Materials Science and Engineering may participate in this minor.

Educational Objectives: Materials form the core basis of many engineering disciplines including mechanical, civil, chemical, and electrical engineering. This minor provides engineers in related majors with the fundamental understanding of mechanisms that determine the performance, properties, and processing of modern materials.

Requirements

At least six (6) courses (+ of 18 credits), chosen as follows:

I. Required

M S&E 261 Mechanical Properties of Materials: From Nanodevices to Superstructures
or MS&E 262 Electronic Materials for the Information Age

II. Two of the following

M S&E 204 Materials Chemistry
M S&E 206 Atomic and Molecular Structure of Matter
M S&E 302 Mechanical Properties of Materials, Processing, and Design
M S&E 303 Thermodynamics of Condensed Systems
M S&E 304 Kinetics, Diffusion, and Phase Transformations
M S&E 305 Electronic, Magnetic, and Dielectric Properties of Materials

III. Three electives chosen from the following:

- Any MS&E course at the 300 level or above
- Selected courses in materials properties and processing (at the 300 level or above) from A&EP, CHEME, CEE, ECE, M&AE, PHYS, and CHEM, as approved by the MS&E undergraduate coordinator.

Academic Standards

At least C in each course in the minor.

Minor in Mechanical Engineering

Offered by: Sibley School of Mechanical and Aerospace Engineering

Administered by: M&AE associate director, 108 Upson Hall, 255-3573, np18@cornell.edu

Eligibility: Students in all Majors except Mechanical Engineering may participate in this minor.

Educational Objectives: The primary educational objective of this minor is to provide students from outside M&AE the necessary skills and tools to interact technically with mechanical engineers on various multidisciplinary fronts. This minor has the appearance of being very broad since it encompasses nearly all of the M&AE upper division courses. However, the prerequisites of the upper-division courses will dictate, to a large extent, that a student concentrate in a sub-area of mechanical engineering. Many upper-level M&AE courses have multiple prerequisites. A recommended strategy for designing a minor is to select a few upper-level courses of interest and work backward from them to determine what courses will be needed as prerequisites or prerequisites of prerequisites. (Note: Instructors may waive certain prerequisites in some circumstances.) The prerequisite structure dictates that most curricula will focus either on fluids/thermal systems or mechanical systems/design courses.

Requirements

At least six (6) courses (+ 18 credits) from among the following: M&AE courses at the 200+ level; ENGRD 202, Mechanics of Solids; ENGRD 203, Dynamics.

Rules for Selecting Courses

- (1) The selection of courses must satisfy the following three requirements.
 - (a) At least two courses must be numbered above 300.
 - (b) At least one course must be either (i) numbered above 500 or (ii) numbered above 326 and have as its prerequisite ENGRD 202, ENGRD 203, or an M&AE course.
 - (c) Each course must be worth at least 3 credits.

- (2) All courses used to satisfy the M&AE minor must be M&AE courses, ENGRD 202 or ENGRD 203. No substitutions will be accepted from other departments at Cornell or elsewhere. Transfer credit can not be used to satisfy the M&AE minor. Students intending to earn a Minor in Mechanical Engineering should seek advice and pre-approval of their Minor academic program from the Associate Director of Undergraduate Affairs in Mechanical Engineering before taking courses toward the Minor. Minor applications may be obtained in 108 Upson Hall.

Academic Standards

At least C- in each course in the minor

Minor in Operations Research and Management Science

Offered by: School of Operations Research and Industrial Engineering

Administrative Contact: OR&E undergraduate Major consultant, 202 Rhodes Hall, 255-5088

Eligibility: Students in all Majors except Operations Research and Engineering may participate in this minor.

Educational Objectives: Operations Research and Management Science(OR/MS) aims to provide rational bases for decision making by seeking to understand and model complex situations and to use this understanding to predict system behavior and improve system performance. This minor gives the student the opportunity to obtain a wide exposure to the core methodological tools for OR/MS, including mathematical programming, stochastic and statistical models, and simulation. The intent of this minor is that the student should obtain a broad knowledge of these fundamentals, rather than training the student in a particular application domain. In this way, the student can adjust the selection of the advanced courses in the minor, so as to pursue those areas, either methodological or application oriented, of greatest interest and relevance to the overall educational goals.

Requirements

At least six (6) courses (+ 18 credits), chosen as follows:

I. Choose three courses from the following list

- ENGRD 270 Basic Engineering Probability and Statistics
- OR&E 320 Optimization I
- OR&E 321 Optimization II
- OR&E 360 Engineering Probability and Statistics II
- OR&E 361 Introduction Engineering Stochastic Processes I
- OR&E 580 Simulation Modeling and Analysis

II. Any OR&E courses at the 300 level or higher (including those in I)

Academic Standards

At least C- in each course in the minor and a GPA + 2.0 in all courses in the minor.

Note: A student may receive credit for at most one minor offered by the School of Operations Research and Industrial Engineering.