Engineering

The concentration in Engineering equips students with a solid foundation for careers in engineering, to advance the knowledge base for future technologies, and to merge teaching, scholarship, and practice in the pursuit of solutions to human needs. The concentration offers one standard Bachelor of Arts (A.B.) program and nine Bachelor of Science (Sc.B.) degree program tracks. Of these, seven Sc.B. programs in biomedical, chemical and biochemical, civil through May 2016, computer, electrical, materials, and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org/. Sc.B. degree programs in environmental engineering and engineering physics are also offered, but they are not accredited by ABET. (Note: The civil track has been discontinued for all students entering after fall 2012. Students interested in structural engineering entering in the class of 2017 and beyond may pursue a Structures track within the Mechanical Engineering program.). Other programs leading to the Sc.B. or A.B. degrees in Engineering may be designed in consultation with a faculty advisor. These programs must meet the general requirement for concentrated programs in the School of Engineering. Students interested in an individualized program should consult with an Engineering faculty member willing to serve as an advisor and obtain the approval of the Engineering Concentration Committee. Engineering students with a particular interest in using their technical skills for the public benefit might also consider the Engaged Scholars Program (https://www.brown.edu/academic/engineering/undergraduate-study/engaged-scholars-program). Please note that all student concentration forms must be approved by the Engineering Concentration Committee, which reviews them for compliance with all relevant program and accreditation requirements.

Mathematics

Mathematics 0190, 0200 is the preferred sequence of courses to be taken in the freshman year. Students with weak preparation in calculus may start in MATH 0100 and take MATH 0200 in second semester. Students without college-level calculus should take MATH 0090, MATH 0100 in their first year, and should begin their sequence of engineering courses with ENGN 0030 in sophomore year. The courses APMA 0330 & APMA 0340 (Methods of Applied Math I, II) can be taken in the sophomore year as well.

Advanced Placement

Students who have taken Advanced Placement courses in high school and/or have shown proficiency through advanced placement examinations are often able to start at a higher level than suggested by the standard programs below. However, please note that Advanced Placement credit cannot be used to satisfy any concentration requirements. For example, our Sc.B. programs specify that students must take 4 semesters of math while enrolled here at Brown, beginning with MATH 0190 or MATH 0170. If a student comes in with advanced placement credit (e.g., placing out of MATH 0190 or MATH 0200), he/she is strongly recommended to take a higher level math course as a replacement. Examples of such courses are MATH 0520 (Linear Algebra), MATH 1260 (Complex Analysis), MATH 1610 (Probability), MATH 1620 (Statistics), APMA 1170 (Numerical Analysis), APMA 1210 (Operations Research), or APMA 1650 (Statistical Inference). However, the student with advanced placement calculus should take MATH 0190 or MATH 0200 also has the option of replacing the math course with an advanced-level science course, subject to the approval of the concentration advisor.

Transfer Credit

Students who have successfully completed college courses elsewhere may apply to the University for transfer credit. (See the "Study Elsewhere" section of the University Bulletin for procedures, or contact the Dean of the College.) Transfer courses that are used to meet Engineering concentration requirements must be approved by the student's concentration advisor, and must be described briefly on the student's electronic concentration form. Transfer courses that are determined by the consultation advisor to be substantially equivalent to a required Brown course automatically fulfill concentration requirements. In rare cases, students may petition the concentration committee to use courses that do not have an equivalent offered at Brown to meet a concentration requirement. Substitutions of this nature can only be approved if the student's overall program meets published educational outcomes for the concentration and has sufficient basic science, mathematics, and engineering topics courses to meet relevant accreditation requirements. Students should consult their concentration advisor for assistance with drafting a petition. The decision whether to award concentration credit is made by majority vote of the Engineering Concentration Committee.

Substitutions for Required Courses

In exceptional circumstances, a student may petition the concentration committee to substitute a course in place of a requirement. Such substitutions can only be approved if the student's modified program continues to meet the published educational outcomes for the concentration, and has sufficient basic science, mathematics, and engineering topics courses to meet accreditation requirements. Students wishing to make substitutions of this nature should consult their concentration advisor for assistance with drafting their petition. Approval of the petition is subject to majority vote of the Engineering Concentration Committee.

Standard Program for the A.B. degree:

Candidates for the Bachelor of Arts (A.B.) degree with a concentration in Engineering must complete at least eight approved Engineering courses. The eight courses must include at least two 1000-level Engineering courses. Of these 1000-level courses, one must be a design or independent study course and the other an in-classroom experience. The set of Engineering courses must be chosen with careful attention to the prerequisites of the 1000-level courses. Please note that this A.B. degree program is not accredited by ABET.

Not all engineering courses may be used to satisfy the engineering course requirement for the A.B. degree. For example, the following courses cannot be used to satisfy the engineering course requirement for the A.B. degree: ENGN 0020, ENGN 0090, ENGN 0900, ENGN 0930A, ENGN 0930C, ENGN 1010. Therefore, the program of study must be developed through consultation with the concentration advisor.

The A.B. program also requires preparation in Mathematics equivalent to MATH 0200 and APMA 0330, as well as at least one college-level science course from the general areas of chemistry, life sciences, physics, or geological sciences. Remedial courses, such as CHEM 0100, cannot be used to satisfy this requirement. A programming course is also recommended, but not required. The entire program is subject to approval by an Engineering Concentration Advisor and the Chair of the Engineering Concentration Committee.

Standard programs for the Sc.B. degree

All Bachelor of Science (Sc.B.) program tracks build upon a common core of engineering knowledge and skills applicable across all engineering disciplines. The goal of this engineering core curriculum is to prepare engineering students to rapidly changing technology. Two-thirds of this four-year program consists of a core of basic mathematics, physical sciences and engineering sciences common to all branches of engineering, including a thorough grounding in programming and technical problem solving. This core provides our graduates with the basis of theory, design, and analysis that will enable them to adapt to whatever may come along during their careers. At the same time, the core courses assist students in making informed choices in determining their areas of specialization, at the end of their sophomore year. To this end, first-year students are given an introduction to engineering - featuring case studies from different disciplines in engineering as well as guest speakers from industry. This aspect of the program is different from that at many other schools where students are expected to select a specific branch of engineering much earlier in their academic program.

In addition, all Sc.B. programs in Engineering must be complemented by at least four courses in humanities and social sciences.
four-course humanities and social sciences requirement for the Sc.B. in Engineering cannot be met by advanced placement credit.

Chemical and Biochemical Engineering Track:
The Chemical and Biochemical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Chemical and Biochemical Engineering program are to prepare graduates: (1) to pursue productive scientific and technical careers, beginning with entry-level engineering positions in industry, or graduate study in chemical or biochemical engineering or related fields; or to successfully pursue other careers that benefit from the analytical or quantitative skills acquired through the Brown CBE Program; (2) to effectively apply the principles of chemical and biochemical engineering, problem-solving skills, and critical and independent thinking, to a broad range of complex, multidisciplinary technological and societal problems; (3) to communicate effectively, both orally and in writing, to professionals and audiences of diverse backgrounds, and to pursue technical approaches and innovations that address the needs of society in an ethical, safe, sustainable, and environmentally responsible manner.

The student outcomes of this program are the ABET (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

1. Core Courses:
ENGN 0030 Introduction to Engineering 1
ENGN 0040 Dynamics and Vibrations 1
ENGN 0410 Materials Science 1
ENGN 0510 Electricity and Magnetism 1
ENGN 0520 Electrical Circuits and Signals 1
ENGN 0720 Thermodynamics 1
ENGN 0810 Fluid Mechanics 1
Biol 0200 The Foundation of Living Systems 1
Chem 0330 Equilibrium, Rate, and Structure 1
MATH 0190 Advanced Placement Calculus (Physics/Engineering) 1
or MATH 0170 Advanced Placement Calculus
MATH 0200 Intermediate Calculus (Physics/Engineering) 1
or MATH 0180 Intermediate Calculus
or MATH 0350 Honors Calculus
Apma 0330 Methods of Applied Mathematics I, II 1
or Apma 0350 Applied Ordinary Differential Equations
Apma 0340 Methods of Applied Mathematics I, II 1
or Apma 0360 Methods of Applied Mathematics I, II
2. Upper-Level Chemical & Biochemical Engineering Curriculum
ENGN 1110 Transport and Biotransport Processes 1
ENGN 1120 Chemical and Biochemical Reactor Design 1
ENGN 1130 Phase and Chemical Equilibria 1
ENGN 1710 Heat and Mass Transfer 1
Chem 0350 Organic Chemistry 1
Advanced Chemistry elective course 2
Chem 0360 Organic Chemistry 1
or Chem 0400 Biophysical and Bioinorganic Chemistry
or Chem 0500 Inorganic Chemistry
or Chem 1140 Physical Chemistry: Quantum Chemistry
Advanced Natural Sciences elective course 3
ENGN 1140 Chemical Process Design 1
*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21

2 An advanced chemistry course approved by concentration advisor; the following courses are pre-approved for this requirement.
3 An advanced course in the natural sciences approved by the concentration advisor. For suggestions of acceptable courses that fulfill this requirement, please see the concentration advisor.

Civil Engineering Track (Available to students entering Brown on or before the Fall of 2012):
Important Announcement: Civil Engineering program will continue through May 2016, and will be available to all students currently enrolled at Brown, including those who arrived as Freshmen in the Fall of 2012 (the class of 2016). Students entering in the class of 2017 and later, with interest in Structural Engineering will be able to concentrate in this discipline through a Structures track within the Mechanical Engineering program. Students interested in Environmental Problems and Planning are directed to the programs in Chemical and Biochemical Engineering or Environmental Engineering.

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Civil Engineering program are to prepare graduates: (1) to have distinctive careers, beginning with either entry level positions in structural and environmental areas of civil engineering or graduate study in these fields; (2) to adapt to changing opportunities, both in engineering and in other professional and business pursuits; (3) to be ethically responsible, to engage in lifelong learning, and to be of service to the engineering community and to society at large. The student outcomes of this program are the ABET (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

1. Core courses:
ENGN 0030 Introduction to Engineering 1
ENGN 0040 Dynamics and Vibrations 1
ENGN 0310 Mechanics of Solids and Structures 1
ENGN 0410 Materials Science 1
ENGN 0510 Electricity and Magnetism 1
ENGN 0520 Electrical Circuits and Signals 1
ENGN 0720 Thermodynamics 1
ENGN 0810 Fluid Mechanics 1
Chem 0330 Equilibrium, Rate, and Structure 1
MATH 0190 Advanced Placement Calculus (Physics/Engineering) 1
or MATH 0170 Advanced Placement Calculus
MATH 0200 Intermediate Calculus (Physics/Engineering) 1
or MATH 0180 Intermediate Calculus
or MATH 0350 Honors Calculus
Apma 0330 Methods of Applied Mathematics I, II 1
or Apma 0350 Applied Ordinary Differential Equations
Apma 0340 Methods of Applied Mathematics I, II 1
or Apma 0360 Methods of Applied Mathematics I, II
2. Upper-Level Civil Engineering Curriculum
ENGN 1110 Transport and Biotransport Processes 1
ENGN 1120 Chemical and Biochemical Reactor Design 1
ENGN 1130 Phase and Chemical Equilibria 1
ENGN 1710 Heat and Mass Transfer 1
Chem 0350 Organic Chemistry 1
Advanced Chemistry elective course 2
Chem 0360 Organic Chemistry 1
or Chem 0400 Biophysical and Bioinorganic Chemistry
or Chem 0500 Inorganic Chemistry
or Chem 1140 Physical Chemistry: Quantum Chemistry
Advanced Natural Sciences elective course 3
ENGN 1140 Chemical Process Design 1
*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21

1 Note: ENGN 1120 and 1130 are only offered in alternate years.
Computer Engineering Program:

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Computer Engineering program are to prepare graduates: (1) to pursue distinctive multidisciplinary scientific and technical careers beginning with either entry-level computer engineering positions in industry or graduate study in computer engineering and related fields; (2) to participate on multidisciplinary teams that cooperate in applying problem-solving skills and critical and independent thinking to a broad range of projects that can produce the technical innovations aimed at satisfying the future needs of society. The student outcomes of this program are the ABET (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

The Computer Engineering concentration shares much of the core with the other engineering programs, but is structured to include more courses in computer science and a somewhat different emphasis in mathematics.

1. Core Courses:
   - ENGN 0030 Introduction to Engineering
   - ENGN 0040 Dynamics and Vibrations
   - ENGN 0510 Electricity and Magnetism
   - ENGN 0520 Electrical Circuits and Signals
   - APMA 1650 Statistical Inference I
   - MATH 0190 Advanced Placement Calculus (Physics/Engineering)
   - MATH 0200 Intermediate Calculus (Physics/Engineering)
   - MATH 0180 Intermediate Calculus
   - MATH 0350 Honors Calculus
   - APMA 0330 Methods of Applied Mathematics I, II
   - APMA 0350 Applied Ordinary Differential Equations
   - CHEM 0330 Equilibrium, Rate, and Structure
   - ENGN 0410 Materials Science

Select one of the following series (Other CSCI courses subject to approval):
   - CSCI 0150 & CSCI 0160 Introduction to Object-Oriented Programming and Computer Science and Introduction to Algorithms and Data Structures
   - CSCI 0170 & CSCI 0180 Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction
   - CSCI 0190 Accelerated Introduction to Computer Science (and one additional CSCI course subject to approval)

2. Advanced Core:
   - MATH 0520 Linear Algebra

3. Civil Engineering Specialty Options (Complete one of the following two course specialty sequences)
   3a. Structures
      - ENGN 1380 Design of Civil Engineering Structures
      - ENGN 1310 Planning and Design of Systems
      - ENGN 1370 Advanced Engineering Mechanics
      - ENGN 1740 Computer Aided Visualization and Design
      - ENGN 1750 Advanced Mechanics of Solids
      - ENGN 1860 Advanced Fluid Mechanics

3b. Environmental Problems
   - ENGN 1130 Phase and Chemical Equilibria
   - ENGN 1310 Planning and Design of Systems

4. Capstone Design
   - ENGN 1930D Large Scale Engineering Design Project

*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21

Computer Engineering Track:

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Computer Engineering program are to prepare graduates: (1) to pursue distinctive multidisciplinary scientific and technical careers beginning with either entry-level computer engineering positions in industry or graduate study in computer engineering and related fields; (2) to participate on multidisciplinary teams that cooperate in applying problem-solving skills and critical and independent thinking to a broad range of projects that can produce the technical innovations aimed at satisfying the future needs of society. The student outcomes of this program are the ABET (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

The Computer Engineering concentration shares much of the core with the other engineering programs, but is structured to include more courses in computer science and a somewhat different emphasis in mathematics.

1. Core Courses:
   - ENGN 0030 Introduction to Engineering
   - ENGN 0040 Dynamics and Vibrations
   - ENGN 0510 Electricity and Magnetism
   - ENGN 0520 Electrical Circuits and Signals
   - APMA 1650 Statistical Inference I
   - MATH 0190 Advanced Placement Calculus (Physics/Engineering)
   - MATH 0200 Intermediate Calculus (Physics/Engineering)
   - MATH 0180 Intermediate Calculus
   - MATH 0350 Honors Calculus
   - APMA 0330 Methods of Applied Mathematics I, II
   - APMA 0350 Applied Ordinary Differential Equations
   - CHEM 0330 Equilibrium, Rate, and Structure
   - ENGN 0410 Materials Science

Select one of the following series (Other CSCI courses subject to approval):
   - CSCI 0150 & CSCI 0160 Introduction to Object-Oriented Programming and Computer Science and Introduction to Algorithms and Data Structures
   - CSCI 0170 & CSCI 0180 Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction
   - CSCI 0190 Accelerated Introduction to Computer Science (and one additional CSCI course subject to approval)

2. Advanced Core:
   - MATH 0520 Linear Algebra

or MATH 0540 Honors Linear Algebra
   - CSCI 0330 Introduction to Computer Systems
   - ENGN 1570 Linear System Analysis
   - ENGN 1630 Digital Electronics Systems Design

3. Specialty Courses: (Complete one of the following 5-course specialty sequences)
   3a. For the Computer Specialty:
      - ENGN 1620 Analysis and Design of Electronic Circuits
      - ENGN 1640 Design of Computing Systems
      - ENGN 1580 Communication Systems
      - ENGN 1600 Design and Implementation of Very Large-Scale Integrated Systems
      - ENGN 1650 Embedded Microprocessor Design
      - ENGN 1680 Design and Fabrication of Semiconductor Devices
      - ENGN 2910A Advanced Computer Architecture
      - ENGN 2912E Low Power VLSI System Design
      - ENGN 2911X Reconfigurable Computing

Select two of the following (other CSCI courses subject to approval):
   - CSCI 0320 Introduction to Software Engineering
   - CSCI 1230 Introduction to Computer Graphics
   - CSCI 1270 Database Management Systems
   - CSCI 1380 Distributed Computer Systems
   - CSCI 1410 Applied Artificial Intelligence
   - CSCI 1480 Building Intelligent Robots
   - CSCI 1570 Design and Analysis of Algorithms
   - CSCI 1670 Operating Systems
   - CSCI 1680 Computer Networks
   - CSCI 1730 Design and Implementation of Programming Languages
   - CSCI 1760 Multiprocessor Synchronization
   - CSCI 1900 csciStartup

3b. For the Multimedia Signal Processing Specialty:
   - APMA 1170 Introduction to Computational Linear Algebra
   - CSCI 0330 Introduction to Computer Systems
   - ENGN 1570 Linear System Analysis
   - ENGN 1630 Digital Electronics Systems Design

Select two or three of the following (other ENGN courses subject to approval):
   - ENGN 1580 Communication Systems
   - ENGN 1610 Image Understanding
   - ENGN 2500 Medical Image Analysis
   - ENGN 2520 Pattern Recognition and Machine Learning
   - ENGN 2530 Digital Signal Processing
   - ENGN 2560 Computer Vision

Select one or two of the following (other CSCI courses subject to approval):
   - CSCI 0320 Introduction to Software Engineering
   - CSCI 1230 Introduction to Computer Graphics
   - CSCI 1290 Computational Photography
   - CSCI 1410 Applied Artificial Intelligence
   - CSCI 1420 Machine Learning
   - CSCI 1430 Computer Vision
   - CSCI 1460 Computational Linguistics
   - CSCI 1570 Design and Analysis of Algorithms

4. Capstone Design

Total Credits 21

*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21
1. Core Courses:

ENGN 0030  Introduction to Engineering  1
ENGN 0040  Dynamics and Vibrations  1
ENGN 0410  Materials Science  1
ENGN 0510  Electricity and Magnetism  1
ENGN 0520  Electrical Circuits and Signals  1
ENGN 0720  Thermodynamics  1
ENGN 0310  Mechanics of Solids and Structures  1
or ENGN 0810  Fluid Mechanics  1
CHEM 0330  Equilibrium, Rate, and Structure  1
MATH 0190  Advanced Placement Calculus (Physics/Engineering)  1
or MATH 0170  Advanced Placement Calculus  1
MATH 0200  Intermediate Calculus (Physics/Engineering)  1
or MATH 0180  Intermediate Calculus  1
or MATH 0350  Honors Calculus  1
APMA 0330  Methods of Applied Mathematics I, II  1
or APMA 0350  Applied Ordinary Differential Equations  1
APMA 0340  Methods of Applied Mathematics I, II  1
or APMA 0360  Methods of Applied Mathematics I, II  1
CSCI 0150  Introduction to Object-Oriented Programming and Computer Science  1
or CSCI 0040  Introduction to Scientific Computing and Problem Solving  1
or CSCI 0170  Computer Science: An Integrated Introduction  1
or CSCI 0190  Accelerated Introduction to Computer Science  1

2. Upper-Level Electrical Engineering Curriculum  4

ENGN 1570  Linear System Analysis  1
ENGN 1620  Analysis and Design of Electronic Circuits  1
ENGN 1630  Digital Electronics Systems Design  1
PHYS 0790  Physics of Matter  1
or PHYS 1410 Quantum Mechanics A  1

3. Electrical Engineering Specialty Option: (Complete one of the following 3-course specialty sequences)  3

3a. Bioelectrical Engineering

ENGN 1230; and one of (ENGN 1220, ENGN 1930B, ENGN 2500 or ENGN 2912L); and one additional course from the following (ENGN 1220, ENGN 1610, ENGN 1930B, ENGN 2500, ENGN 2912L, CLPS 1491, CLPS 1520, NEUR 1680 or NEUR 2110)

3b. Communications Systems

ENGN 1580; and (ENGN 1560 or ENGN 1690); and one additional course from the following (ENGN 1560, ENGN 1610, ENGN 1640, ENGN 1650, ENGN 1690 or ENGN 2530)

3c. Computer Engineering

CSCI 0330; and ENGN 1640; and one additional course from the following (ENGN 1580, ENGN 1600, ENGN 1610, ENGN 1650 or ENGN 2530)

3d. Multimedia Signal Processing

ENGN 2530 or ENGN 1610; and two additional courses from the following (ENGN 1580, ENGN 1610, ENGN 1640, ENGN 1650, ENGN 2500, ENGN 2530, ENGN 2540, ENGN 2560 or CSCI 1230)

3e. Microelectronic Systems

ENGN 1600; ENGN 1640; and one additional course from the following (ENGN 1590, ENGN 1680, ENGN 2530 or ENGN 2912K)

3f. Solid State Electronics and Photonics

ENGN 1590; (ENGN 1560 or ENGN 1690); and one additional course from the following ENGN 1450, ENGN 1560, ENGN 1600, ENGN 1680, ENGN 1690, ENGN 1931A or PHYS 1420)

4. Capstone Design

ENGN 1650 Embedded Microprocessor Design  1
or ENGN 1000 Projects in Engineering Design

*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits  21

1 Or 1000-level Physics course subject to concentration advisor approval.

2 Subject to approval by the concentration advisor, an independent study course (ENGN1970/1971) may be used to fulfill the Engineering Capstone Design requirement. To qualify for such approval, the independent study project must: (1) contain a significant and definable design component; (2) be based on the knowledge and skills acquired in earlier course work, (3) incorporate appropriate engineering standards; and (4) address multiple realistic constraints. To request approval, please complete the online form available at: http://www.brown.edu/academics/engineering/undergraduate-study

Environmental Engineering Track:

The Environmental Engineering program began in 2013. The program has not been reviewed by ABET and is not ABET-accredited. The education objectives of the Environmental Engineering program are to prepare graduates: (1) to apply in practice the knowledge obtained in school within industry, government, or private practice; (2) to work toward sustainable solutions in a wide array of technical specialties; (3) to pursue lifelong learning through continuing education and/or advanced degrees in environmental engineering. The student outcomes of this program are the ABET (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

1. Core Courses:

ENGN 0030  Introduction to Engineering  1
ENGN 0040  Dynamics and Vibrations  1
ENGN 0410  Materials Science  1
ENGN 0510  Electricity and Magnetism  1
ENGN 0520  Electrical Circuits and Signals  1
ENGN 0720  Thermodynamics  1
ENGN 0310  Mechanics of Solids and Structures  1
or ENGN 0810  Fluid Mechanics  1
CHEM 0330  Equilibrium, Rate, and Structure  1
MATH 0190  Advanced Placement Calculus (Physics/Engineering)  1
or MATH 0170  Advanced Placement Calculus  1
MATH 0200  Intermediate Calculus (Physics/Engineering)  1
or MATH 0180  Intermediate Calculus  1
or MATH 0350  Honors Calculus  1
APMA 0330  Methods of Applied Mathematics I, II  1
or APMA 0350  Applied Ordinary Differential Equations  1
APMA 0340  Methods of Applied Mathematics I, II  1
or APMA 0360  Methods of Applied Mathematics I, II  1
CSCI 0150  Introduction to Object-Oriented Programming and Computer Science  1
or CSCI 0040  Introduction to Scientific Computing and Problem Solving  1
or CSCI 0170  Computer Science: An Integrated Introduction  1
or CSCI 0190  Accelerated Introduction to Computer Science  1

1. Core Courses:

ENGN 0030  Introduction to Engineering  1
ENGN 0040  Dynamics and Vibrations  1
ENGN 0410  Materials Science  1
ENGN 0510  Electricity and Magnetism  1
ENGN 0720  Thermodynamics  1
ENGN 0810  Fluid Mechanics  1
BIOL 0200  The Foundation of Living Systems  1
CHEM 0330  Equilibrium, Rate, and Structure  1
ENVS 0490  Environmental Science in a Changing World  1
MATH 0190  Advanced Placement Calculus (Physics/Engineering)  1
or MATH 0170  Advanced Placement Calculus  1
MATH 0200  Intermediate Calculus (Physics/Engineering)  1
or MATH 0180  Intermediate Calculus
or MATH 0350  Honors Calculus
APMA 0330  Methods of Applied Mathematics I, II  1
or APMA 0350  Applied Ordinary Differential Equations
APMA 0650  Essential Statistics  1
or APMA 1650  Statistical Inference I

Total Credits  21

1 Subject to approval by the concentration advisor, an independent study course (ENGN1970/1971) may be used to fulfill the Engineering Capstone Design requirement. To qualify for such approval, the independent study project must: (1) contain a significant and definable design component; (2) be based on the knowledge and skills acquired in earlier course work, (3) incorporate appropriate engineering standards; and (4) address multiple realistic constraints. To request approval, please complete the online form available at: http://www.brown.edu/academics/engineering/undergraduate-study

Materials Engineering Track:
The Materials Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Materials Engineering program are to prepare graduates: (1) to pursue multidisciplinary scientific and technical careers beginning with entry-level engineering positions in industry or graduate study in materials science and engineering and related fields; (2) to apply an engineering problem-solving approach combined with a broad appreciation for the liberal arts to inform and develop their understanding of current societal needs and values to achieve leadership positions in their chosen fields of endeavor. The student outcomes of this program are the (a) - (k) Student Outcomes as defined by the "ABET Criteria for Accrediting Engineering Programs" (available online at http://www.abet.org/accreditation-criteria-policies-documents/).

1. Core Courses:
ENGN 0030  Introduction to Engineering  1
ENGN 0040  Dynamics and Vibrations  1
ENGN 0410  Materials Science  1
ENGN 0510  Electricity and Magnetism  1
ENGN 0520  Electrical Circuits and Signals  1
ENGN 0720  Thermodynamics  1
ENGN 0310  Mechanics of Solids and Structures  1
or ENGN 0810  Fluid Mechanics
CHEM 0330  Equilibrium, Rate, and Structure  1
MATH 0190  Advanced Placement Calculus (Physics/Engineering)  1
or MATH 0170  Advanced Placement Calculus
MATH 0200  Intermediate Calculus (Physics/Engineering)  1
or MATH 0180  Intermediate Calculus
or MATH 0350  Honors Calculus
APMA 0330  Methods of Applied Mathematics I, II  1
or APMA 0350  Applied Ordinary Differential Equations
APMA 0340  Methods of Applied Mathematics I, II  1
CHEM 0350  Organic Chemistry  1
or CSCI 0040  Introduction to Scientific Computing and Problem Solving
or CSCI 0150  Introduction to Object-Oriented Programming and Computer Science
or CSCI 0170  Computer Science: An Integrated Introduction
or CSCI 0190  Accelerated Introduction to Computer Science

2. Upper-Level Materials Engineering Curriculum
ENGN 1410  Physical Chemistry of Solids  1
ENGN 1420  Kinetics Processes in Materials Science and Engineering  1
ENGN 1440  Mechanical Properties of Materials  1
PHYS 0790  Physics of Matter  1
or CHEM 1140  Physical Chemistry: Quantum Chemistry

Three of the following:  3
ENGN 1450  Properties and Processing of Electronic Materials
ENGN 1470  Structure and Properties of Nonmetallic Materials
ENGN 1480  Metallic Materials
ENGN 1490  Biomaterials

2. Advance Science Courses
GEOL 1370  Environmental Geochemistry  1
or GEOL 1580  Quantitative Elements of Physical Hydrology
BIOL 0415  Microbes in the Environment (or an approved alternative Natural Science Course)  1
or BIOL 0420  Principles of Ecology

3. Environmental Engineering Specialty Options (Complete one of the following five course sequences):  5

3a. Chemistry Specialty
At least three of the following:
ENGN 1110  Transport and Biotransport Processes
ENGN 1130  Phase and Chemical Equilibria
ENGN 1340  Water Supply and Wastewater Treatment
ENGN 1710  Heat and Mass Transfer
ENGN 1931P  Fuels, Energy, Power and the Environment
ENGN 1930U  Renewable Energy Technologies
Up to one of the following:
ENGN 0310  Mechanics of Solids and Structures
or ENGN 0520  Electrical Circuits and Signals
Up to one of the following:
CSCI 0040  Introduction to Scientific Computing and Problem Solving
or CHEM 0350  Organic Chemistry
or ENVS 1400  Sustainable Design in the Built Environment
or ENVS 1570  Guts of the City: Perspectives on Urban Infrastructure and Environmental Planning (URBN 1570)

3b. Energy Specialty
At least three of the following:
ENGN 1340  Water Supply and Wastewater Treatment
ENGN 1710  Heat and Mass Transfer
ENGN 1860  Advanced Fluid Mechanics
ENGN 1930U  Renewable Energy Technologies
ENGN 1931F  Introduction to Power Engineering
ENGN 1931A  Photovoltaics Engineering
ENGN 1931P  Fuels, Energy, Power and the Environment
Up to one of the following:
ENGN 0310  Mechanics of Solids and Structures
or ENGN 0520  Electrical Circuits and Signals
Up to one of the following:
CSCI 0040  Introduction to Scientific Computing and Problem Solving
or ENVS 1400  Sustainable Design in the Built Environment
or ENVS 1570  Guts of the City: Perspectives on Urban Infrastructure and Environmental Planning (URBN 1570)
or ENGN 1930U  Renewable Energy Technologies

4. Capstone Design  1
ENGN 1000  Projects in Engineering Design
or ENGN 1140  Chemical Process Design
* In addition to program requirements above, students must take four courses in the humanities and social sciences.
3. Capstone Design ²
ENGN 1000 Projects in Engineering Design 1

* In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21

1 These courses are taken in either the junior or senior year. Note that ENGN 1470 is offered on a rotating basis in the fall semester of alternate years, and ENGN 1480 and ENGN 1450 are offered in the spring semester of alternate years.

2 Subject to approval by the concentration advisor, an independent study course (ENGN1970/1971) may be used to fulfill the Engineering Capstone Design requirement. To qualify for such approval, the independent study project must: (1) contain a significant and definable design component; (2) be based on the knowledge and skills acquired in earlier course work, (3) incorporate appropriate engineering standards; and (4) address multiple realistic constraints. To request approval, please complete the online form available at: http://www.brown.edu/academics/engineering/undergraduate-study

Mechanical Engineering Track:
The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Mechanical Engineering program are to prepare graduates: (1) to pursue scientific and technical careers beginning in earlier course work, (3) incorporate appropriate engineering standards; and (4) address multiple realistic constraints. To request approval, please complete the online form available at: http://www.brown.edu/academics/engineering/undergraduate-study

1. Core Courses:
ENGN 0030 Introduction to Engineering 1
ENGN 0040 Dynamics and Vibrations 1
ENGN 0310 Mechanics of Solids and Structures 1
ENGN 0410 Materials Science 1
ENGN 0510 Electricity and Magnetism 1
ENGN 0520 Electrical Circuits and Signals 1
ENGN 0720 Thermodynamics 1
ENGN 0810 Fluid Mechanics 1
CHEM 0330 Equilibrium, Rate, and Structure 1
MATH 0190 Advanced Placement Calculus (Physics/Engineering) 1
or MATH 0170 Advanced Placement Calculus
or MATH 0200 Intermediate Calculus (Physics/Engineering) 1
or MATH 0180 Intermediate Calculus
or MATH 0350 Honors Calculus
APMA 0330 Methods of Applied Mathematics I, II 1
or APMA 0350 Applied Ordinary Differential Equations
APMA 0340 Methods of Applied Mathematics I, II 1
or APMA 0360 Methods of Applied Mathematics I, II
CSCI 0040 Introduction to Scientific Computing and Problem Solving 1
or CSCI 0150 Introduction to Object-Oriented Programming and Computer Science
or CSCI 0170 Computer Science: An Integrated Introduction
or CSCI 0190 Accelerated Introduction to Computer Science

2. Upper-Level Mechanical Engineering Curriculum 7

2a. Aerospace Applications
PHYS 0790 Physics of Matter 1

ENGN 1370 Advanced Engineering Mechanics
ENGN 1700 Jet Engines and Aerospace Propulsion
ENGN 1720 Design of Engines and Turbines or ENGN 1760 Design of Space Systems
ENGN 1860 Advanced Fluid Mechanics

One of the following:
ENGN 1710 Heat and Mass Transfer
or ENGN 1300 Structural Analysis
or ENGN 1740 Computer Aided Visualization and Design
or ENGN 1750 Advanced Mechanics of Solids

Capstone Design ²
ENGN 1000 Projects in Engineering Design
or ENGN 1930 Industrial Design
or ENGN 1931 Design of Mechanical Assemblies

2b. Biomechanics
BIOL 0800 Principles of Physiology 1
ENGN 1210 Biomechanics
ENGN 1230 Instrumentation Design
ENGN 1370 Advanced Engineering Mechanics

One of the following courses:
ENGN 1700 Jet Engines and Aerospace Propulsion
or ENGN 1710 Heat and Mass Transfer
or ENGN 1860 Advanced Fluid Mechanics

One of the following courses:
ENGN 1220 Neuroengineering
or ENGN 1300 Structural Analysis
or ENGN 1490 Biomaterials
or ENGN 1740 Computer Aided Visualization and Design
or ENGN 1750 Advanced Mechanics of Solids

Capstone Design
ENGN 1000 Projects in Engineering Design ²
or ENGN 1930 Industrial Design
or ENGN 1931 Design of Mechanical Assemblies

2c. Energy Conversion: Fluids and Thermal Systems
PHYS 0790 Physics of Matter 1
ENGN 1700 Jet Engines and Aerospace Propulsion
ENGN 1710 Heat and Mass Transfer
ENGN 1720 Design of Engines and Turbines
ENGN 1860 Advanced Fluid Mechanics

One of the following courses:
ENGN 1750 Advanced Mechanics of Solids
or ENGN 1300 Structural Analysis
or ENGN 1370 Advanced Engineering Mechanics

Capstone Design
ENGN 1000 Projects in Engineering Design ²
or ENGN 1930 Industrial Design
or ENGN 1931 Design of Mechanical Assemblies

2d. Engineering Mechanics
PHYS 0790 Physics of Matter 1
ENGN 1370 Advanced Engineering Mechanics
ENGN 1710 Heat and Mass Transfer
ENGN 1750 Advanced Mechanics of Solids
ENGN 1860 Advanced Fluid Mechanics

One of the following: ³
ENGN 1300 Structural Analysis
or ENGN 1360 Soil Mechanics and Principles of Foundation Engineering
or ENGN 1420 Kinetics Processes in Materials Science and Engineering
| or ENGN 1700 Jet Engines and Aerospace Propulsion | or ENGN 1740 Computer Aided Visualization and Design |
| ENGN 1000 Projects in Engineering Design |
| or ENGN 1380 Design of Civil Engineering Structures |
| or ENGN 1720 Design of Engines and Turbines |
| or ENGN 1760 Design of Space Systems |
| or ENGN 1930 Industrial Design |
| or ENGN 1931 Design of Mechanical Assemblies |

2e. Mechanical Systems: Dynamics, Materials, and Design

| PHYS 0790 Physics of Matter 1 |
| ENGN 1370 Advanced Engineering Mechanics |
| ENGN 1750 Advanced Mechanics of Solids |

One of the following courses:

| ENGN 1380 Design of Civil Engineering Structures |
| or ENGN 1720 Design of Engines and Turbines |
| or ENGN 1760 Design of Space Systems |

One or two of the following courses:

| ENGN 1700 Jet Engines and Aerospace Propulsion |
| or ENGN 1710 Heat and Mass Transfer |
| or ENGN 1720 Design of Engines and Turbines |
| or ENGN 1860 Advanced Fluid Mechanics |

Capstone Design 2

| ENGN 1000 Projects in Engineering Design |
| or ENGN 1930 Industrial Design |
| or ENGN 1931 Design of Mechanical Assemblies |

Up to one of the following:

| ENGN 1230 Instrumentation Design |
| or ENGN 1300 Structural Analysis |
| or ENGN 1380 Design of Civil Engineering Structures |
| or ENGN 1440 Mechanical Properties of Materials |
| or ENGN 1620 Analysis and Design of Electronic Circuits |
| or ENGN 1740 Computer Aided Visualization and Design |

2f. Structural Mechanics

| PHYS 0790 Physics of Matter 1 |
| ENGN 1300 Structural Analysis |
| ENGN 1370 Advanced Engineering Mechanics |
| ENGN 1710 Heat and Mass Transfer |
| ENGN 1860 Advanced Fluid Mechanics |

One of the following courses:

| ENGN 1740 Computer Aided Visualization and Design |
| or ENGN 1750 Advanced Mechanics of Solids |
| or ENGN 1760 Design of Space Systems |

Capstone Design

ENGN 1380 Design of Civil Engineering Structures

*In addition to program requirements above, students must take four courses in the humanities and social sciences.

Total Credits 21

1. Or another advanced science course, subject to concentration advisor approval.

2. Subject to approval by the concentration advisor, an independent study course (ENGN1970/1971) may be used to fulfill the Engineering Capstone Design requirement. To qualify for such approval, the independent study project must: (1) contain a significant and definable design component; (2) be based on the knowledge and skills acquired in earlier course work, (3) incorporate appropriate engineering standards; and (4) address multiple realistic constraints. To request approval, please complete the online form available at: http://www.brown.edu/academics/engineering/undergraduate-study

3. An ENGN course of equivalent level may be substituted subject to concentration advisor approval.