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 the standard Bachelor of Arts (A.B.) program and eight Bachelor of Science (Sc.B.) degree programs. Of these, the Sc.B. programs in biomedical, chemical, computer, electrical, environmental, materials, and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org/). The engineering physics program is also offered, but is not accredited by ABET. 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 requirements for concentration 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.

Please note that all students concentrating in Engineering need to file a concentration declaration using the University’s ASK advising system. This declaration must first be reviewed by the relevant Concentration Advisor and then approved by the Director of Undergraduate Studies after assuring compliance with all relevant program and accreditation requirements.

Mathematics Requirements

Since mathematics is a cornerstone of all engineering programs, there is naturally significant attention given to early preparation in mathematics in all of the engineering concentrations. It is recognized that students entering Brown will have different levels of mathematics preparation, and the following is offered as general guidance, though the actual choices of courses should be made in consultation with a freshman advisor. Mathematics 0190, 0200 is the preferred sequence of courses to be taken in the freshman year. Students who would prefer a more introductory level calculus sequence may start in MATH 0100 and take MATH 0200 or MATH 0180 in their second semester. Students without secondary school level preparation in calculus should consider taking the sequence MATH 0090, MATH 0100 in their first year, and should begin their sequence of engineering courses with ENGN 0030 in the sophomore year.

Students who have taken Advanced Placement (AP) courses in high school and/or have shown proficiency through Advanced Placement examinations are often able to APMA 0330 and/or APMA 0340 prior to academic year 2021-22. If a student has advanced placement credit (e.g., placing out of MATH 0190 or MATH 0200), it is quite common for them to enroll in 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). Note that in addition to the above options, the student with advanced placement in calculus courses may choose to enroll early in APMA 0350 and APMA 0360 which are normally taken in the sophomore year (not all engineering concentrations require APMA 0360, so the choices should be guided by the concentration guidelines below).

Note: Students who completed APMA 0330 or APMA 0340 prior to academic year 2021-22 may count those courses as satisfying the APMA 0350 and/or APMA 0360 requirements.

The student with advanced placement credit for MATH 0190 or MATH 0200 also has the further option of replacing the math course with an advanced-level science course, subject to the approval of the Concentration Advisor.

Advanced Placement

Courses that have been taken at the secondary school level are typically only used for placement into the appropriate course level at Brown. The examples of how this can be done in mathematics are given above, and there are other instances (such as in selection of the appropriate introductory chemistry course) where AP credit is considered. It should be noted, however, that advanced placement credits cannot be used to substitute for any Engineering concentration requirements; they are instead used to ensure that students are placed into the correct level of courses.

Transfer Credits

Some students will also complete courses at other universities during the time they are Brown students (sometimes during summers while they are not in residence at Brown; sometimes during a junior semester abroad). 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). In addition to the general rules governing such transfers, there are specific rules governing courses that will be offered as satisfying Engineering concentration requirements.

If the course proposed for transfer credit is offered by another department at Brown (i.e., that it carries a course number that does not start with ENGN), then the equivalent of the course must be established by that other department. This is done by submitting a formal request through the ASK system (https://ask.brown.edu/transfer_credits/information/index). Once this approval has been received from the other department, the student’s internal transcript will show the equivalence and the course in question can be shown in the Engineering concentration declaration as having been completed elsewhere. If the equivalence to a Brown course is not approved, then there may still be “unassigned credit” given for the course. In this case, the situation relative to how it does or does not count for concentration credit needs to be discussed with the Concentration Advisor. In rare cases, students may petition the Engineering Concentration Committee to use courses that do not have an equivalent offered at Brown in order 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.

If the student wishes to transfer a course taken outside of Brown that would normally carry an Engineering course number, the sequence is a bit different. First, the student needs to fill out an Engineering Transfer Credit Approval Request (see https://engineering.brown.edu/undergraduate/concentrations/concentration-options/study-abroad). Then the student needs to fill out an Engineering Transfer Credit Approval Request through the ASK system, as described above. This process ensures that the transcript will capture the equivalence of the externally completed course.

Substitutions for Required Courses

Students may petition the Engineering Concentration Committee to substitute a course in place of a defined concentration 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 needed to meet accreditation requirements. If the substitution involves taking an equal or higher level course in substantially the same area, whether at Brown or elsewhere, it can be approved by the Concentration Advisor without requiring a formal petition to the Concentration Committee. (For courses taken elsewhere, the credit must be officially transferred as described above.) Students wishing to make substitutions of a broader nature should consult their Concentration Advisor for assistance in drafting their petition to the Engineering Concentration Committee. Such petitions may be approved by a majority vote of the Committee.

Standard Program for the A.B. Degree

Please note that the A.B. degree program is not accredited by ABET. 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.

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 0130, ENGN 0900, ENGN 0930A, ENGN 0930C, ENGN 0130, ENGN 1010, ENGN 1931Q, ENGN 1931W, ENGN 2110, ENGN 2120, ENGN 2130, ENGN 2140, ENGN 2150, ENGN 2160, ENGN 2180. 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 0350, as well as at least one college-level science course from the general areas of chemistry (except CHEM 0100), life sciences, physics, or geological sciences. A programming course is also recommended, but not required. The entire program is subject to approval by an Engineering Concentration Advisor and the Director of Undergraduate Programs in Engineering. Note: Students who completed APMA 0330 prior to academic year 2021-22 may count that course as satisfying the APMA 0350 requirement.

**Standard Program 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 prepared to practice engineering in an age of 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 basic 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. The minimum four-course humanities and social sciences requirement for the Sc.B. in Engineering cannot be met by advanced placement credit.

**Special Sc.B. Concentrations (non-accredited):**

In addition to the standard programs described above, students may also petition the Engineering Concentration Committee to pursue a special engineering Sc.B. degree of their own design. Such special Sc.B. programs are not ABET-accredited. Students with a special concentration will receive an Sc.B. degree in engineering, but a specific area of specialization will not be noted on their transcript. A special Sc.B. concentration is intended to prepare graduates for advanced study in engineering or for professional practice, but in an area that is not covered by one of the existing Sc.B. programs. Accordingly, special concentration programs are expected to consist of a coherent set of courses with breadth, depth and rigor comparable to an accredited degree. A total of 21 engineering, mathematics, and basic science courses are required. The program must include at least 3 courses in mathematics, at least 2 courses in physical or life sciences; and at least 12 courses in engineering. At least five of the engineering courses must be upper level courses, and one must be a capstone design course or independent study, which must be advised or co-advised by a member of the regular engineering faculty. Note that not all Engineering courses may be used to meet Sc.B. requirements: for example, the courses not allowed to count toward the A.B. will not qualify. Petitions should be prepared in consultation with an engineering faculty advisor, who will submit the petition to the Engineering Concentration Committee. Petitions must include: (i) a statement of the objectives of the degree program, and an explanation of how the courses in the program meet these objectives; (ii) course descriptions for any courses in the program that are not part of standard Sc.B. Engineering concentrations; (iii) a detailed description of any independent study courses used for concentration credit, signed by the faculty advisor for this course; and (iv) an up-to-date internal transcript.

**Professional Tracks**

While we do not give course credit for internships, we officially recognize their importance via the optional Professional Tracks. The requirements for the professional tracks include all those of the standard tracks, as well as the following: Students must complete full-time professional experiences (or part-time experiences of equivalent total effort) doing work that is related to their concentration programs, totaling 2-6 months, whereby each internship must be at least one month in duration in cases where students choose to do more than one internship experience. Such work is normally done at a company, but may also be at a university under the supervision of a faculty member. Internships that take place between the end of the fall and the start of the spring semesters cannot be used to fulfill this requirement. On completion of each professional experience, the student must write and upload to ASK a reflective essay about the experience addressing the following prompts:

- Describe the organization you worked in and the nature of your responsibilities.
- Which courses were put to use in your work?
- Which topics, in particular, were important?
- In retrospect, which courses should you have taken before embarking on your work experience?
- What are the top three of these courses that would have helped you if you had been more familiar with them?
- What topics would have been helpful in preparation for this work experience that you did not learn at Brown?
- What did you learn from the experience that probably could not have been picked up from course work?
- Is the sort of work you did something you would like to continue doing once you graduate? Explain.
- Would you recommend your work experience to other Brown students? Explain.

The reflective essays are subject to the approval of the student's Concentration Advisor.

Entry to the Professional Track requires a simple application form to be completed by the student and approved by the Concentration Advisor at the time of the concentration declaration. If the student has not yet declared a concentration, the form may be approved by the Chair of the Concentration Committee. The Concentration Advisor will certify that all Professional Track students have completed the necessary internships and will grant approval for the associated reflective essays. All other requirements remain identical to those in the standard tracks in the concentrations.

**Degrees with Honors in Engineering**

Honors are granted by the University to students whose work in a field of concentration has demonstrated superior quality and culminated in an "Honors Thesis of Distinction." Honors recipients in the School of Engineering must meet the following criteria: (1) Demonstrate a strong academic record (60% A's or "S with Distinction" in their concentration through the seventh semester); (2) Propose and execute an independent research project under the guidance of a faculty member; (3) Complete a written thesis to the satisfaction of the Honors Program Committee; (4) Give a scientific/technical presentation at the Undergraduate Research Symposium in the spring semester; and (5) Fulfill all deadlines for applying for or completing honors to the satisfaction of his/her research advisor and the Honors Program Committee.

**Chemical Engineering Track**

The Chemical Engineering program is accredited by the Engineering Accreditation Commission of ABET: [http://www.abet.org](http://www.abet.org)
The objectives of the Brown University Chemical Engineering Sc.B. Program are to produce graduates who will: (1) apply their knowledge of engineering, science, mathematics, and liberal arts to successful careers and leadership roles in industry, government, or academia; (2) apply independent, critical, and integrative thinking to a broad range of complex, multidisciplinary problems, and effectively communicate their solutions to broad audiences of society in an ethical, safe, sustainable, and environmentally responsible manner. The student outcomes of this program are the ABET (1) - (7) 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:

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Select one of the following series (other CSCI courses subject to approval):

1. CSCI 0150 Introduction to Object-Oriented Programming and Computer Science
2. CSCI 0200 Program Design with Data Structures and Algorithms
3. CSCI 0170 Computer Science: An Integrated Introduction

Total Credits: 21

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

1 Students who completed APMA 0330 and/or APMA 0340 prior to AY2021-22 may count these as satisfying the APMA 0350 and/or APMA 0360 requirements.

2 ENGN 1120 and 1130 are only offered in alternate years.
3 An advanced chemistry course approved by Concentration Advisor; the courses listed have been preapproved for this requirement.
4 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.

Computer Engineering Track

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org (http://www.abet.org/). The Program Educational Objectives (PEOs) of the CE undergraduate program strives to prepare graduates who: (1) will succeed as leaders in the computer engineering and technology industry and in research and development positions within industry and academia; (2) will work effectively in a range of roles to solve problems with global, economic, environmental and societal impacts; and (3) will pursue lifelong learning through advanced degrees and professional development opportunities throughout their chosen career. The student outcomes of this program are the ABET (1) - (7) 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.

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2. CSCI 0200 Program Design with Data Structures and Algorithms
3. CSCI 0170 Computer Science: An Integrated Introduction

AND

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</tr>
<tr>
<td>CSCI 0200</td>
<td>Program Design with Data Structures and Algorithms</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CSCI 0170</td>
<td>Computer Science: An Integrated Introduction</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

AND
Computer Engineering.
Concentration Advisor if they have appropriate connections to 
courses outside of the list below may also be approved by the 
offered every year. Other 1000- or 2000-level ENGN and CSCI
a CSCI course. Note that some upper-level courses are not
least one must be an ENGN course, and at least one must be
One advanced Computer Science course with significant
One advanced Computer Engineering foundations course:
MATH 0520
ENGN 1630
Design of Computing Systems
1
or MATH 0540
Linear Algebra With Theory
One advanced Computer Engineering foundations course: 1
ENGN 1580
Communication Systems
ENGN 1600
Design and Implementation of Digital
Integrated Circuits
ENGN 1610
Image Understanding
ENGN 1620
Analysis and Design of Electronic Circuits
ENGN 2530
Digital Signal Processing
One advanced Computer Science course with significant
systems programming: 1
CSCI 0330
Introduction to Computer Systems
or ENGN 0500
Digital Computing Systems
or CSCI 0320
Introduction to Software Engineering
or CSCI 1230
Introduction to Computer Graphics
or CSCI 1380
Distributed Computer Systems
or CSCI 1670
Operating Systems
or CSCI 1680
Computer Networks
Select three upper-level Computer Engineering electives. At
least one must be an ENGN course, and at least one must be
a CSCI course. Note that some upper-level courses are not
offered every year. Other 1000- or 2000-level ENGN and CSCI
courses outside of the list below may also be approved by the
Concentration Advisor if they have appropriate connections to
Computer Engineering.2
ENGN 1220
Neuroengineering
ENGN 1450
Properties and Processing of Electronic
Materials
ENGN 1560
Introduction to Applied Electromagnetics
ENGN 1580
Communication Systems
ENGN 1590
Semiconductor Devices
ENGN 1600
Design and Implementation of Digital
Integrated Circuits
ENGN 1610
Image Understanding
ENGN 1620
Analysis and Design of Electronic Circuits
ENGN 1690
Photonics Devices and Sensors
ENGN 1930B
Biomedical Optics
ENGN 1931A
Photovoltaics Engineering
ENGN 1931F
Introduction to Power Engineering
ENGN 1931I
Design of Robotic Systems
ENGN 1931M
Industrial Machine Vision
ENGN 1931Y
Control Systems Engineering
ENGN 2500
Medical Image Analysis
ENGN 2501
Digital Geometry Processing
ENGN 2502
3D Photography
ENGN 2520
Pattern Recognition and Machine
Learning
ENGN 2530
Digital Signal Processing
ENGN 2540
Audio and Speech Processing
ENGN 2560
Computer Vision
ENGN 2610
Physics of Solid State Devices
ENGN 2620
Solid State Quantum and Optoelectronics
ENGN 2910A
Advanced Computer Architecture
ENGN 2911X
Reconfigurable Computing for Machine/
Deep Learning
ENGN 2912B
Scientific Programming in C++
ENGN 2912E
Low Power VLSI System Design
ENGN 2912K
Mixed-Signal Electronic Design
ENGN 2920F
Sensors and Actuators for Real Systems
CSCI 0320
Introduction to Software Engineering
CSCI 1230
Introduction to Computer Graphics
CSCI 1270
Database Management Systems
CSCI 1380
Distributed Computer Systems
CSCI 1410
Artificial Intelligence
CSCI 1420
Machine Learning
CSCI 1430
Computer Vision
CSCI 1470
Deep Learning
CSCI 1480
Building Intelligent Robots
CSCI 1570
Design and Analysis of Algorithms
CSCI 1600
Real-Time and Embedded Software
CSCI 1660
Introduction to Computer Systems
Security
CSCI 1670
Operating Systems
CSCI 1680
Computer Networks
CSCI 1730
Design and Implementation of
Programming Languages
3
ENGN 1650
Embedded Microprocessor Design
or ENGN 1000
Projects in Engineering Design I
or ENGN 1001
Projects in Engineering Design II
4.
Total Credits 21

1 Or Biology course beyond BIOL 0200 subject to Concentration Advisor approval
2 Subject to approval by the Concentration Advisor, the third upper-level elective may optionally be chosen from another department, such as
CLPS, NEUR, PHYS or CHEM, if it has a significant quantitative physical science emphasis.
3 Subject to approval by the Concentration Advisor, an independent study course (ENGN 1972/ENGN 1973) 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 https://engineering.brown.edu/
undergraduate/concentrations/concentration-options/independent-study (https://engineering.brown.edu/undergraduate/concentrations/
concentration-options/independent-study/)

Electrical Engineering Track
The Electrical Engineering program is accredited by the Engineering
Accreditation Commission of ABET: http://www.abet.org. The Program
Educational Objectives (PEOs) of the Electrical Engineering Sc.B.
Program are to prepare the graduates: (1) to leverage their knowledge
of mathematics, science, engineering, and liberal arts to succeed as
leaders in engineering and technology industries and in R&D positions
in industry and academia; (2) to build broad knowledge and experience
in interdisciplinary research and project management, and to apply
critical thinking skills in developing and evaluating technological solutions
addressing societal needs. The student outcomes of this program are the
ABET (1) - (7) 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
- or ENGN 0031: Honors Introduction to Engineering
- or ENGN 0032: Introduction to Engineering: Design
- ENGN 0040: Dynamics and Vibrations
- ENGN 0410: Materials Science
- ENGN 0510: Electricity and Magnetism
- ENGN 0520: Electrical Circuits and Signals
- ENGN 0720: Thermodynamics
- ENGN 0310: Mechanics of Solids and Structures
  - or ENGN 0500: Digital Computing Systems
  - or ENGN 0810: Fluid Mechanics
  - or CSCI 0200: Program Design with Data Structures and Algorithms
- CHEM 0330: Equilibrium, Rate, and Structure
  - or MATH 0520: Linear Algebra
  - or MATH 0540: Linear Algebra With Theory
  - or APMA 0360: Applied Partial Differential Equations I
- MATH 0190: Single Variable Calculus, Part II (Physics/Engineering)
  - or MATH 0100: Single Variable Calculus, Part II
- MATH 0200: Multivariable Calculus (Physics/Engineering)
  - or MATH 0180: Multivariable Calculus
  - or MATH 0350: Multivariable Calculus With Theory
- APMA 0350: Applied Ordinary Differential Equations
- APMA 1650: Mathematical Statistics I
  - or APMA 1710: Information Theory
  - or CSCI 1450: Introduction to Probability for Computing and Data Science
- CSCI 0150: Introduction to Computer Science
  - or CSCI 0111: Computer Science: An Application Perspective
  - or CSCI 0170: Computer Science: An Integrated Introduction
  - or CSCI 0190: Computer Science: An Integrated Survey
  - or APMA 0160: Information Theory
  - or ENGN 1931Z: Interfaces, Information and Automation

2. Upper-Level Electrical Engineering Curriculum

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

3. Electrical Engineering Specialization - Complete at least three courses from the following:

- ENGR 1320: Instrumentation Design
- ENGR 1580: Communication Systems
- ENGR 1590: Semiconductor Devices
- ENGR 1600: Design and Implementation of Digital Integrated Circuits
- ENGR 1610: Image Understanding
- ENGR 1640: Design of Computing Systems
- Up to two other Electrical Engineering courses
- ENGR 1930: Biomedical Optics
- ENGR 1931: Photovoltaics Engineering
- ENGR 1931A: Introduction to Power Engineering
- ENGR 1931L: Design of Robotic Systems
- ENGR 1931Y: Control Systems Engineering
- ENGR 1932Z: Interfaces, Information and Automation

Up to one interdisciplinary engineering science course:

- CLPS 1491: NeuroEngineering
- CLPS 1520: Computation Vision
- ENGR 1370: Advanced Engineering Mechanics
- ENGR 1450: Properties and Processing of Electronic Materials
- NEUR 2110: Statistical Neuroscience
- PHYS 1420: Quantum Mechanics B

4. Capstone Design: At least one course from the following:

- ENGR 1650: Embedded Microprocessor Design
- or ENGR 1000: Projects in Engineering Design I
- or ENGR 1001: Projects in Engineering Design II

Total Credits: 21

Environmental Engineering Track

The Environmental Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. Within a few years of graduation, graduates of the Brown Environmental Engineering (EnvE) Program will: (1) Engage in continued learning through professional development, professional licensure, and service to the profession and society; (2) Achieve leadership positions or roles that advance environmental engineering practice; and (3) Pursue and successfully obtain an advanced graduate or professional degree in environmental engineering or a related discipline. The student outcomes of this program are intended to be those enumerated in items (1) - (7) 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:

- ENGR 0030: Introduction to Engineering
- or ENGR 0031: Honors Introduction to Engineering
- or ENGR 0032: Introduction to Engineering: Design
- ENGR 0040: Dynamics and Vibrations
ENGN 0410  Materials Science  1
or ENGN 1490  Biomaterials

ENGN 0490  Fundamentals of Environmental Engineering  1

CSCI 0111  Computing Foundations: Data  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
or ENGN 0500  Digital Computing Systems
or ENGN 0510  Electricity and Magnetism
or ENGN 0520  Electrical Circuits and Signals

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  Single Variable Calculus, Part II (Physics/Engineering)  1
or MATH 0100  Single Variable Calculus, Part II

MATH 0200  Multivariable Calculus (Physics/Engineering)  1
or MATH 0180  Multivariable Calculus
or MATH 0350  Multivariable Calculus With Theory

APMA 0350  Applied Ordinary Differential Equations  1
or APMA 0360  Applied Partial Differential Equations

APMA 1650  Statistical Inference I  1
or APMA 1655  Honors Statistical Inference I

2. Advanced Science Courses

EEPS 1370  Environmental Geochemistry  1
or EEPS 0850  Weather and Climate
or EEPS 1310  Global Water Cycle
or EEPS 1320  Introduction to Geographic Information Systems for Environmental Applications
or EEPS 1330  Global Environmental Remote Sensing
or EEPS 1430  Principles of Planetary Climate
or EEPS 1520  Ocean Circulation and Climate
or EEPS 1710  Remote Sensing of Earth and Planetary Surfaces

Biol 0420  Principles of Ecology  1
or Biol 0480  Evolutionary Biology
or Biol 0500  Cell and Molecular Biology
or Biol 0800  Principles of Physiology
or Biol 1470  Conservation Biology

3. Upper-Level Environmental Engineering Curriculum  2

ENGN 1340  Water Supply and Treatment Systems - Technology and Sustainability  1

Plus four advanced engineering courses from the list below  4

ENGN 1110  Transport and Biotransport Processes
ENGN 1120  Reaction Kinetics and Reactor Design
ENGN 1130  Chemical Engineering Thermodynamics
ENGN 1342  Groundwater Flow and Transport
ENGN 1700  Fluid Mechanics of Aerospace and Energy Systems
ENGN 1710  Principles of Heat Transfer
ENGN 1860  Advanced Fluid Mechanics
ENGN 1931P  Energy and the Environment
ENGN 1930U  Renewable Energy Technologies
ENGN 1931R  The Chemistry of Environmental Pollution
ENGN 2911P  Fate and Transport of Environmental Contaminants

Or any other course approved by the Concentration Advisor

4. Capstone Design  3

ENGN 1150  Environmental Engineering Design

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

Total Credits  21

1 Students who completed APMA 0330 and/or APMA 0340 prior to AY2021-22 may count these as satisfying the APMA 0350 and/or APMA 0360 requirements.
2 Or any other advanced Engineering course approved by the Concentration Advisor.
3 Subject to approval by the Concentration Advisor, an independent study course (ENG 1972/ENG 1973) 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 https://engineering.brown.edu/undergraduate/concentrations/concentration-options/independent-study (https://engineering.brown.edu/undergraduate/concentrations/concentration-options/independent-study/)
4 Students in Classes of 2022, 2023, and 2024 may satisfy this requirement with APMA 0650 if taken in Spring 2021 or earlier.

Materials Engineering Track

The Materials Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The Program Educational Objectives PEOs of the Materials Engineering Sc.B. Program are to are to prepare the graduates: (1) To build on the knowledge gained in their undergraduate program in terms of strong engineering fundamentals, a specific strength in materials engineering, advanced written and verbal communication, and societal awareness and engagement, as well as new knowledge learned in their first years of employment or graduate school, to move toward positions of responsibility, leadership, and influence in the field; and (2) to be viewed as outstanding engineering leaders, whether in start-ups or multinational corporations or academia, in terms of technical competence and in their understanding of an engineer’s responsibility to society and to ethical behavior. Through this reputation they will be having a significant organizational influence in their work. The student outcomes of this program are the (1) - (7) 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
or ENGN 0031  Honors Introduction to Engineering
or ENGN 0032  Introduction to Engineering: Design

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  Single Variable Calculus, Part II (Physics/Engineering)  1
or MATH 0100  Single Variable Calculus, Part II

MATH 0200  Multivariable Calculus (Physics/Engineering)  1
or MATH 0180  Multivariable Calculus
or MATH 0350  Multivariable Calculus With Theory

APMA 0350  Applied Ordinary Differential Equations  1
or APMA 0360  Applied Partial Differential Equations
The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The Program Educational Objectives of the Mechanical Engineering program are to prepare the graduates: (1) to pursue careers as creative and innovative mechanical engineers in industry or academia; (2) to advance the frontiers of their field; and (3) to discharge their offices in a professional and responsible manner. The student outcomes of this program are the (1) - (7) 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:

<table>
<thead>
<tr>
<th>Course</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
</tr>
<tr>
<td>or ENGN 0031</td>
<td>Honors Introduction to Engineering</td>
</tr>
<tr>
<td>or ENGN 0032</td>
<td>Introduction to Engineering: Design</td>
</tr>
<tr>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
</tr>
<tr>
<td>ENGN 0310</td>
<td>Mechanics of Solids and Structures</td>
</tr>
<tr>
<td>ENGN 0410</td>
<td>Materials Science</td>
</tr>
<tr>
<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
</tr>
<tr>
<td>ENGN 0720</td>
<td>Thermodynamics</td>
</tr>
<tr>
<td>ENGN 0810</td>
<td>Fluid Mechanics</td>
</tr>
<tr>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
</tr>
<tr>
<td>MATH 0190</td>
<td>Single Variable Calculus, Part II (Physics/Engineering)</td>
</tr>
<tr>
<td>or MATH 0100</td>
<td>Single Variable Calculus, Part II</td>
</tr>
<tr>
<td>MATH 0200</td>
<td>Multivariable Calculus (Physics/Engineering)</td>
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<td>or MATH 0180</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>or MATH 0350</td>
<td>Multivariable Calculus With Theory</td>
</tr>
<tr>
<td>APMA 0350</td>
<td>Applied Ordinary Differential Equations</td>
</tr>
<tr>
<td>APMA 0360</td>
<td>Applied Partial Differential Equations</td>
</tr>
<tr>
<td>CSCI 0111</td>
<td>Computing Foundations: Data</td>
</tr>
<tr>
<td>or CSCI 0150</td>
<td>Introduction to Object-Oriented Programming and Computer Science</td>
</tr>
<tr>
<td>or CSCI 0170</td>
<td>Computer Science: An Integrated Introduction</td>
</tr>
<tr>
<td>or CSCI 0190</td>
<td>Accelerated Introduction to Computer Science</td>
</tr>
<tr>
<td>or ENGN 1230</td>
<td>Instrumentation Design</td>
</tr>
<tr>
<td>or ENGN 1740</td>
<td>Computer Aided Visualization and Design</td>
</tr>
<tr>
<td>or ENGN 1750</td>
<td>Advanced Mechanics of Solids</td>
</tr>
<tr>
<td>or APMA 0160</td>
<td>Introduction to Scientific Computing</td>
</tr>
</tbody>
</table>

2. Upper-Level Mechanical Engineering Curriculum:

Complete at least 6 courses from the following groups:

- Mechanical Systems: At least one course from:
  - ENGN 1300 Structural Analysis
  - ENGN 1370 Advanced Engineering Mechanics
  - ENGN 1735 Vibration of Mechanical Systems
  - ENGN 1750 Advanced Mechanics of Solids

- Fluids/Thermal Systems: At least one course from:
  - ENGN 1860 Advanced Fluid Mechanics
  - ENGN 1700 Fluid Mechanics of Aerospace and Energy Systems
  - ENGN 1710 Principles of Heat Transfer

- Capstone: At least one course from the following must be taken in the final two semesters:
  - ENGN 1000 Projects in Engineering Design I
  - ENGN 1001 Projects in Engineering Design II
  - ENGN 1930L Biomedical Engineering Design and Innovation

Design Electives: Up to two courses from:

- ENGN 1230 Instrumentation Design
- ENGN 1740 Computer Aided Visualization and Design

Bioengineering Electives: Up to two courses from:

- ENGN 1210 Biomechanics
- ENGN 1220 Neuroengineering
- ENGN 1490 Biomaterials

Robotic and Control Systems Electives: Up to two courses from:

- ENGN 1931I Design of Robotic Systems
- ENGN 1931Y Control Systems Engineering

3. Engineering Capstone:

- ENGN 1931Y Control Systems Engineering

Mechanical Engineering Track

The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The Program Educational Objectives of the Mechanical Engineering program are to prepare the graduates: (1) to pursue careers as creative and innovative mechanical engineers in industry or academia; (2) to advance the frontiers of their field; and (3) to discharge their offices in a professional and responsible manner. The student outcomes of this program are the (1) - (7) Student Outcomes as defined by the “ABET Criteria for Accrediting Engineering Programs” available online at http://www.abet.org/accreditation-criteria-policies-documents/
Engineering Analysis and Computation Electives: Up to two courses from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1840</td>
<td>Numerical Methods in Scientific Computing</td>
</tr>
<tr>
<td>ENGN 1950</td>
<td>Advanced Engineering Optimization</td>
</tr>
</tbody>
</table>

Energy and Environmental Engineering Electives: Up to two courses from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1930U</td>
<td>Renewable Energy Technologies</td>
</tr>
<tr>
<td>ENGN 1931P</td>
<td>Energy and the Environment</td>
</tr>
</tbody>
</table>

Interdisciplinary Electives: Up to one course from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1620</td>
<td>Analysis and Design of Electronic Circuits</td>
</tr>
<tr>
<td>or ENGN 1340</td>
<td>Water Supply and Treatment Systems - Technology and Sustainability</td>
</tr>
<tr>
<td>or ENGN 1440</td>
<td>Mechanical Properties of Materials</td>
</tr>
<tr>
<td>or ENGN 1470</td>
<td>Composite Materials</td>
</tr>
<tr>
<td>or ENGN 1570</td>
<td>Linear System Analysis</td>
</tr>
<tr>
<td>or ENGN 1931F</td>
<td>Introduction to Power Engineering</td>
</tr>
<tr>
<td>or ENGN 1931Z</td>
<td>Interfaces, Information and Automation</td>
</tr>
</tbody>
</table>

3. Upper Level, Advanced Science Course: At least one course from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 0790</td>
<td>Physics of Matter</td>
</tr>
<tr>
<td>or BIOL 0800</td>
<td>Principles of Physiology</td>
</tr>
<tr>
<td>or CHEM 0350</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>or CHEM 1140</td>
<td>Physical Chemistry: Quantum Chemistry</td>
</tr>
<tr>
<td>or EEPS 1450</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>or EEPS 1370</td>
<td>Environmental Geochemistry</td>
</tr>
</tbody>
</table>

4. General Education Requirement: At least four approved courses must be taken in humanities and social sciences

Total Credits 21

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1 ENGN 1490 may be substituted if taken in Sophomore year.
2 Students who completed APMA 0330 and/or APMA 0340 prior to AY 2021-22 may count these as satisfying the APMA 0350 and/or APMA 0360 requirements. Other advanced courses in Mathematics or Applied Mathematics may be substituted with approval of the Concentration Advisor.
3 Subject to approval by the concentration advisor, an independent study course (ENGN 1972/ENGN 1973) 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 https://engineering.brown.edu/undergraduate/concentrations/concentration-options/independent-study (https://engineering.brown.edu/undergraduate/concentrations/concentration-options/independent-study/)
4 Other advanced alternative courses can be used with the approval of the Concentration Advisor.
5 Other non-introductory courses in physics, chemistry, neuroscience, geology, and biology are allowed.