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, Sc.B. programs in biomedical, chemical, 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: Students who are 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 requirements for concentration programs in the School of Engineering. Students interested in an individualized program also has consultation 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/academics/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 who would prefer a more introductory level calculus course may start in MATH 0100 and take MATH 0200 or MATH 0180 in second semester. Students without one year of secondary school level preparation in mathematics should take MATH 0090. MATH 0100 in their first year at Brown. Any student who places into MATH 0190 will also have the option of replacing that calculus course with ENGN 0090 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 credit for MATH 0190 or MATH 0200 also has the option of replacing that calculus 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 concentration 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

A student may petition the Concentration Adviser 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. 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 Adviser. (For courses taken elsewhere, the credit must be officially transferred.) Students wishing to make substitutions of a broader nature should consult their Concentration Adviser for assistance with drafting their petition to the Engineering Concentration Committee, which may be approved by a majority vote.

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 students 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 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. The minimum
four-course humanities and social sciences requirement for the Sc.B. in Engineering cannot be met by advanced placement credit.

**Special Concentrations**

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 adviser, 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 ScB engineering concentrations; (iii) a detailed description of any independent study courses used for concentration credit, signed by the faculty adviser 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 two full-time professional experiences, lasting two to four months each (or two part-time experiences of equivalent total effort), doing work that is related to their concentration programs. Such work is normally done within an industrial organization, but may also be done at a university under the supervision of a faculty member. For the work to be considered related to a concentration program, the job responsibilities must make use of the material from one or more courses of the concentration (regardless of whether the student has taken those courses or not at the time of the internship). 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 topics from 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.

**Chemical Engineering Track:**

The Chemical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Chemical 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 engineering or related fields; or to successfully pursue other careers that benefit from the analytical or quantitative skills acquired through the Brown ChE Program; (2) to effectively apply the principles of chemical 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 (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 Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
<td></td>
</tr>
<tr>
<td>or ENGN 0031</td>
<td>Honors Introduction to Engineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
<td></td>
</tr>
<tr>
<td>ENGN 0410</td>
<td>Materials Science</td>
<td></td>
</tr>
<tr>
<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
<td></td>
</tr>
<tr>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
<td></td>
</tr>
<tr>
<td>ENGN 0720</td>
<td>Thermodynamics</td>
<td></td>
</tr>
<tr>
<td>ENGN 0810</td>
<td>Fluid Mechanics</td>
<td></td>
</tr>
<tr>
<td>BIOL 0200</td>
<td>The Foundation of Living Systems</td>
<td></td>
</tr>
<tr>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
<td></td>
</tr>
<tr>
<td>MATH 0190</td>
<td>Advanced Placement Calculus (Physics/Engineering)</td>
<td></td>
</tr>
<tr>
<td>or MATH 0170</td>
<td>Advanced Placement Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 0200</td>
<td>Intermediate Calculus (Physics/Engineering)</td>
<td></td>
</tr>
<tr>
<td>or MATH 0180</td>
<td>Intermediate Calculus</td>
<td></td>
</tr>
<tr>
<td>or MATH 0350</td>
<td>Honors Calculus</td>
<td></td>
</tr>
<tr>
<td>APMA 0330</td>
<td>Methods of Applied Mathematics I, II</td>
<td></td>
</tr>
<tr>
<td>or APMA 0350</td>
<td>Applied Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>APMA 0340</td>
<td>Methods of Applied Mathematics I, II</td>
<td></td>
</tr>
<tr>
<td>or APMA 0360</td>
<td>Applied Partial Differential Equations I</td>
<td></td>
</tr>
</tbody>
</table>

2. Upper-Level Chemical & Biochemical Engineering Curriculum

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1110</td>
<td>Transport and Biotransport Processes</td>
<td></td>
</tr>
<tr>
<td>ENGN 1120</td>
<td>Reaction Kinetics and Reactor Design</td>
<td></td>
</tr>
<tr>
<td>ENGN 1130</td>
<td>Chemical Engineering Thermodynamics</td>
<td></td>
</tr>
<tr>
<td>ENGN 1710</td>
<td>Heat and Mass Transfer</td>
<td></td>
</tr>
<tr>
<td>CHEM 0350</td>
<td>Organic Chemistry</td>
<td></td>
</tr>
<tr>
<td>Advanced Chemistry elective course ^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 0360</td>
<td>Organic Chemistry</td>
<td></td>
</tr>
<tr>
<td>or CHEM 0400</td>
<td>Biophysical and Bioinorganic Chemistry</td>
<td></td>
</tr>
<tr>
<td>or CHEM 0500</td>
<td>Inorganic Chemistry</td>
<td></td>
</tr>
<tr>
<td>or CHEM 1140</td>
<td>Physical Chemistry: Quantum Chemistry</td>
<td></td>
</tr>
<tr>
<td>Advanced Natural Sciences elective course ^3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Capstone Design Course</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Computer Engineering concentration shares much of the core with the computer science, and a somewhat different emphasis in mathematics. Other engineering programs, but is structured to include more courses in the humanities and social sciences.

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 (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.

1. Core Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
<td>1</td>
</tr>
<tr>
<td>or ENGN 0031</td>
<td>Honors Introduction to Engineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
<td></td>
</tr>
<tr>
<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
<td></td>
</tr>
<tr>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
<td></td>
</tr>
<tr>
<td>APMA 1650</td>
<td>Statistical Inference I</td>
<td>1</td>
</tr>
<tr>
<td>or APMA 1655</td>
<td>Statistical Inference I</td>
<td></td>
</tr>
<tr>
<td>or CSCI 1450</td>
<td>Probability for Computing and Data Analysis</td>
<td></td>
</tr>
<tr>
<td>MATH 0190</td>
<td>Advanced Placement Calculus (Physics/ Engineering)</td>
<td>1</td>
</tr>
<tr>
<td>or MATH 0170</td>
<td>Advanced Placement Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 0200</td>
<td>Intermediate Calculus (Physics/ Engineering)</td>
<td>1</td>
</tr>
<tr>
<td>or MATH 0180</td>
<td>Intermediate Calculus</td>
<td></td>
</tr>
<tr>
<td>or MATH 0350</td>
<td>Honors Calculus</td>
<td></td>
</tr>
<tr>
<td>APMA 0330</td>
<td>Methods of Applied Mathematics I, II</td>
<td>1</td>
</tr>
<tr>
<td>or APMA 0350</td>
<td>Applied Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>or APMA 1170</td>
<td>Introduction to Computational Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>or APMA 1710</td>
<td>Information Theory</td>
<td></td>
</tr>
<tr>
<td>or CSCI 0220</td>
<td>Introduction to Discrete Structures and Probability</td>
<td>1</td>
</tr>
<tr>
<td>or CSCI 1570</td>
<td>Design and Analysis of Algorithms</td>
<td></td>
</tr>
<tr>
<td>or MATH 1260</td>
<td>Complex Analysis</td>
<td></td>
</tr>
<tr>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
<td>1</td>
</tr>
<tr>
<td>or ENGN 0410</td>
<td>Materials Science</td>
<td></td>
</tr>
<tr>
<td>or NEUR 0010</td>
<td>The Brain: An Introduction to Neuroscience</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Series</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 0150 &amp; CSCI 0160</td>
<td>Introduction to Object-Oriented Programming and Computer Science and Introduction to Algorithms and Data Structures</td>
<td>2</td>
</tr>
<tr>
<td>CSCI 0170 &amp; CSCI 0180</td>
<td>Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction</td>
<td></td>
</tr>
<tr>
<td>CSCI 0190</td>
<td>Accelerated Introduction to Computer Science (and one additional CSCI course subject to approval)</td>
<td></td>
</tr>
</tbody>
</table>

2. Upper-Level Computer Engineering Curriculum:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1570</td>
<td>Linear System Analysis</td>
<td>1</td>
</tr>
<tr>
<td>ENGN 1630</td>
<td>Digital Electronics Systems Design</td>
<td>1</td>
</tr>
<tr>
<td>ENGN 1640</td>
<td>Design of Computing Systems</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0520</td>
<td>Linear Algebra</td>
<td>1</td>
</tr>
<tr>
<td>or MATH 0540</td>
<td>Honors Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>One advanced Computer Engineering foundations course:</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

One advanced Computer Science course with significant systems programming:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 0330</td>
<td>Introduction to Computer Systems</td>
<td></td>
</tr>
<tr>
<td>or CSCI 0320</td>
<td>Introduction to Software Engineering</td>
<td></td>
</tr>
<tr>
<td>or CSCI 1230</td>
<td>Introduction to Computer Graphics</td>
<td></td>
</tr>
<tr>
<td>or CSCI 1380</td>
<td>Distributed Computer Systems</td>
<td></td>
</tr>
<tr>
<td>or CSCI 1670</td>
<td>Operating Systems</td>
<td></td>
</tr>
<tr>
<td>or CSCI 1680</td>
<td>Computer Networks</td>
<td></td>
</tr>
<tr>
<td>or ENGN 0500</td>
<td>Digital Computing Systems</td>
<td></td>
</tr>
</tbody>
</table>

Select three upper-level electives from the list below (other ENGN or CSCI courses subject to approval). At least one must be an ENGN course and at least one must be a CSCI course. 4

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1220</td>
<td>Neuroengineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 1450</td>
<td>Properties and Processing of Electronic Materials</td>
<td></td>
</tr>
<tr>
<td>ENGN 1560</td>
<td>Optics</td>
<td></td>
</tr>
<tr>
<td>ENGN 1580</td>
<td>Communication Systems</td>
<td></td>
</tr>
<tr>
<td>ENGN 1590</td>
<td>Introduction to Semiconductors and Semiconductor Electronics</td>
<td>1</td>
</tr>
<tr>
<td>ENGN 1600</td>
<td>Design and Implementation of VLSI Systems</td>
<td></td>
</tr>
<tr>
<td>ENGN 1610</td>
<td>Image Understanding</td>
<td></td>
</tr>
<tr>
<td>ENGN 1620</td>
<td>Analysis and Design of Electronic Circuits</td>
<td></td>
</tr>
<tr>
<td>ENGN 1680</td>
<td>Design and Fabrication of Semiconductor Devices</td>
<td></td>
</tr>
<tr>
<td>ENGN 1690</td>
<td>Photonics Devices and Sensors</td>
<td></td>
</tr>
<tr>
<td>ENGN 1930B</td>
<td>Biomedical Optics</td>
<td></td>
</tr>
<tr>
<td>ENGN 1931A</td>
<td>Photovoltaics Engineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 1931F</td>
<td>Introduction to Power Engineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 1931L</td>
<td>Design of Robotic Systems</td>
<td></td>
</tr>
<tr>
<td>ENGN 1931Y</td>
<td>Control Systems Engineering</td>
<td></td>
</tr>
<tr>
<td>ENGN 1931Z</td>
<td>Interfaces, Information and Automation</td>
<td></td>
</tr>
<tr>
<td>ENGN 2520</td>
<td>Pattern Recognition and Machine Learning</td>
<td></td>
</tr>
<tr>
<td>ENGN 2530</td>
<td>Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>ENGN 2560</td>
<td>Computer Vision</td>
<td></td>
</tr>
<tr>
<td>ENGN 2610</td>
<td>Physics of Solid State Devices</td>
<td></td>
</tr>
<tr>
<td>ENGN 2620</td>
<td>Solid State Quantum and Optoelectronics</td>
<td></td>
</tr>
<tr>
<td>ENGN 2910A</td>
<td>Advanced Computer Architecture</td>
<td></td>
</tr>
<tr>
<td>ENGN 2911X</td>
<td>Reconfigurable Computing for Machine/ Deep Learning</td>
<td>1</td>
</tr>
</tbody>
</table>

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

Note: ENGN 1120 and 1130 are only offered in alternate years.

An advanced chemistry course approved by concentration advisor; the following courses are pre-approved for this requirement.

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.

Total Credits: 21
**Engineering**

ENGN 2912B Scientific Programming in C++
ENGN 2912E Low Power VLSI System Design
CSCI 0320 Introduction to Software Engineering
CSCI 1230 Introduction to Computer Graphics
CSCI 1270 Database Management Systems
CSCI 1300 User Interfaces and User Experience
CSCI 1320 Creating Modern Web & Mobile Applications
CSCI 1380 Distributed Computer Systems
CSCI 1410 Artificial Intelligence
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
CSCI 1760 Multiprocessor Synchronization
CSCI 1900 csciStartup

3. **Capstone Design**

   ENGN 1650 Embedded Microprocessor Design
   or ENGN 1000 Projects in Engineering Design I
   or ENGN 1001 Projects in Engineering Design II

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

   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 1970/ENGN 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.

**Electrical Engineering Track:**

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The education objectives of the Electrical Engineering program are to prepare graduates: (1) to pursue distinctive multidisciplinary scientific and technical careers beginning with either entry-level electrical engineering positions in industry or graduate study in electrical 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 (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
   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 0810 Fluid Mechanics
   or CSCI 0160 Introduction to Algorithms and Data Structures
   or CSCI 0180 Computer Science: An Integrated Introduction
   CHEM 0330 Equilibrium, Rate, and Structure
   MATH 0190 Advanced Placement Calculus (Physics/Engineering)
   or MATH 0170 Advanced Placement Calculus
   MATH 0200 Intermediate Calculus (Physics/Engineering)
   or MATH 0180 Intermediate Calculus
   or MATH 0350 Honors Calculus
   APMA 0330 Methods of Applied Mathematics I, II
   or APMA 0350 Applied Ordinary Differential Equations
   APMA 0340 Methods of Applied Mathematics I, II
   or APMA 0360 Applied Partial Differential Equations I
   or APMA 1650 Statistical Inference I
   or APMA 1710 Information Theory
   or MATH 0520 Linear Algebra
   or MATH 0540 Honors Linear Algebra
   CSCI 0150 Introduction to Object-Oriented Programming and Computer Science
   or CSCI 0040 Introduction to Scientific Computing and Problem Solving
   or CSCI 0111 Computing Foundations: Data
   or CSCI 0170 Computer Science: An Integrated Introduction
   or CSCI 0190 Accelerated Introduction to Computer Science
   or APMA 0160 Introduction to Scientific Computing
   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 groups:**

   At least one advanced Electrical Engineering foundations course:
   ENGN 1230 Instrumentation Design
   ENGN 1580 Communication Systems
   ENGN 1590 Introduction to Semiconductors and Semiconductor Electronics
   ENGN 1600 Design and Implementation of VLSI Systems
   ENGN 1610 Image Understanding
   ENGN 1640 Design of Computing Systems
   Up to two other Electrical Engineering Courses
   ENGN 1220 Neuroengineering
   ENGN 1560 Optics
   ENGN 1650 Embedded Microprocessor Design
   ENGN 1680 Design and Fabrication of Semiconductor Devices
   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 1931Y Control Systems Engineering
   ENGN 1931Z Interfaces, Information and Automation
Up to one interdisciplinary engineering science course:
- CLPS 1491  Neural Modeling Laboratory
- CLPS 1520  Computational Vision
- CSCI 0330  Introduction to Computer Systems
- ENGN 1370  Advanced Engineering Mechanics
- ENGN 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:
- ENGN 1650  Embedded Microprocessor Design
- or ENGN 1000  Projects in Engineering Design I
- or ENGN 1001  Projects in Engineering Design II

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 0190</td>
<td>Advanced Placement Calculus (Physics/Engineering)</td>
</tr>
<tr>
<td>or MATH 0170</td>
<td>Advanced Placement Calculus</td>
</tr>
<tr>
<td>MATH 0200</td>
<td>Intermediate Calculus (Physics/Engineering)</td>
</tr>
<tr>
<td>or MATH 0180</td>
<td>Intermediate Calculus</td>
</tr>
<tr>
<td>or MATH 0350</td>
<td>Honors Calculus</td>
</tr>
<tr>
<td>APMA 0330</td>
<td>Methods of Applied Mathematics I, II</td>
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<tr>
<td>or APMA 0350</td>
<td>Applied Ordinary Differential Equations</td>
</tr>
<tr>
<td>APMA 0650</td>
<td>Essential Statistics</td>
</tr>
<tr>
<td>or APMA 1650</td>
<td>Statistical Inference I</td>
</tr>
</tbody>
</table>

2. Advance Science Courses
- GEOL 1370  Environmental Geochemistry
- or GEOL 1310  Global Water Cycle
- or GEOL 1330  Global Environmental Remote Sensing
- or GEOL 1520  Ocean Circulation and Climate
- or GEOL 1960B  Special Topics in Geological Sciences: Physical Hydrology

- BIOL 0415  Microbes in the Environment (or an approved alternative Natural Science Course)
- or BIOL 0420  Principles of Ecology

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

1. Core Courses:
- ENGN 0030  Introduction to Engineering
  
- ENGN 0040  Dynamics and Vibrations
- ENGN 0410  Materials Science
- ENGN 0490  Fundamentals of Environmental Engineering
- ENGN 0510  Electricity and Magnetism
- or ENGN 0520  Electrical Circuits and Signals
- ENGN 0720  Thermodynamics
- ENGN 0810  Fluid Mechanics
- BIOL 0200  The Foundation of Living Systems
- CHEM 0330  Equilibrium, Rate, and Structure

2. Advance Science Courses
- or ENGN 0520  Electrical Circuits and Signals

Environmental Engineering Track:

Brown's Environmental Engineering program was launched in 2013. The first graduates completed the program with the Sc.B. degree in Environmental Engineering in Spring 2017. The program has graduated Sc.B. degree recipients every year since then. The program will seek accreditation from the Engineering Accreditation Commission of ABET during Brown's upcoming review period in 2020-2021 when the rest of the School of Engineering's existing accredited programs will be reviewed.

The education objectives of the program are: (1) to pursue scientific or technical careers starting with the entry-level positions in industry to in graduate study in environmental engineering; (2) to demonstrate their ability to solve problems related to environmental pollution, protection, and sustainability. 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:
- ENGN 0030  Introduction to Engineering
  
- ENGN 0040  Dynamics and Vibrations
- ENGN 0410  Materials Science
- ENGN 0490  Fundamentals of Environmental Engineering
- ENGN 0510  Electricity and Magnetism
- or ENGN 0520  Electrical Circuits and Signals
- ENGN 0720  Thermodynamics
- ENGN 0810  Fluid Mechanics
- BIOL 0200  The Foundation of Living Systems
- CHEM 0330  Equilibrium, Rate, and Structure

2. Advance Science Courses
- or ENGN 0520  Electrical Circuits and Signals

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

3a. Chemistry Specialty
- ENGR 1110  Transport and Biotransport Processes
- ENGR 1130  Chemical Engineering Thermodynamics
- ENGR 1340  Water Supply and Treatment Systems - Technology and Sustainability
- ENGR 1710  Heat and Mass Transfer
- ENGR 1860  Advanced Fluid Mechanics
- ENGR 1931P  Fuels, Energy and the Environment
- ENGR 1930U  Renewable Energy Technologies
- ENGR 2911P  Fate and Transport of Environmental Contaminants

3b. Energy Specialty
- ENGR 0310  Mechanics of Solids and Structures
- or ENGR 0520  Electrical Circuits and Signals

2. Advance Science Courses
- or ENGR 0520  Electrical Circuits and Signals

At least three of the following:
- ENGR 1340  Water Supply and Treatment Systems - Technology and Sustainability
- ENGR 1710  Heat and Mass Transfer
- ENGR 1860  Advanced Fluid Mechanics
- ENGR 1930U  Renewable Energy Technologies
- ENGR 1931F  Introduction to Power Engineering
- ENGR 1931A  Photovoltaics Engineering
- ENGR 1931P  Fuels, Energy and the Environment
- ENGR 2911P  Fate and Transport of Environmental Contaminants

Up to one of the following:
- CSCI 0040  Introduction to Scientific Computing and Problem Solving (or approved science elective)
- or CSCI 0150  Introduction to Object-Oriented Programming and Computer Science
- or CSCI 0170  Computer Science: An Integrated Introduction

At least three of the following:
- ENGR 1340  Water Supply and Treatment Systems - Technology and Sustainability
- ENGR 1710  Heat and Mass Transfer
- ENGR 1860  Advanced Fluid Mechanics
- ENGR 1930U  Renewable Energy Technologies
- ENGR 1931F  Introduction to Power Engineering
- ENGR 1931A  Photovoltaics Engineering
- ENGR 1931P  Fuels, Energy and the Environment
- ENGR 2911P  Fate and Transport of Environmental Contaminants
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 (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/).

Total Credits 21

1. Core Courses:
- ENGN 0030 Introduction to Engineering 1
- or ENGN 0031 Honors 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 Applied Partial Differential Equations I 1
- or MATH 0520 Linear Algebra 1
- or APMA 1210 Operations Research: Deterministic Models 1
- or APMA 1650 Statistical Inference I 1
- CHEM 0350 Organic Chemistry 1
- or CSCI 0040 Introduction to Scientific Computing and Problem Solving 1

or CSCI 0150 Introduction to Object-Oriented Programming and Computer Science 1
or CSCI 0170 Computer Science: An Integrated Introduction 1
or CSCI 0190 Accelerated Introduction to Computer Science 1
or ENGN 1230 Instrumentation Design 1
or ENGN 1740 Computer Aided Visualization and Design 1
or ENGN 1750 Advanced Mechanics of Solids 1
or APMA 0160 Introduction to Scientific Computing 1

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 0350 Organic Chemistry 1
or CHEM 1140 Physical Chemistry: Quantum Chemistry 1

Three of the following: 3
- ENGN 1450 Properties and Processing of Electronic Materials 3
- ENGN 1470 Structure & Properties of Nonmetallic Materials 1
- ENGN 1475 Soft Materials 1
- ENGN 1480 Metallic Materials 1
- ENGN 1490 Biomaterials 1

3. Capstone Design: 2
- ENGN 1000 Projects in Engineering Design I 1
- or ENGN 1001 Projects in Engineering Design II 1
- or ENGN 1930L Biomedical Engineering Design and Innovation 3

* 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 1450, ENGN 1475, ENGN 1470 and ENGN 1480 are typically offered in 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 with either graduate study in mechanical engineering and related fields or mechanical engineering positions in industry; (2) to work on interdisciplinary teams that make use of the engineering problem solving method and a broad background in the liberal arts to address societal needs. 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 1
- ENGN 0040 Dynamics and Vibrations 1
- ENGN 0310 Mechanics of Solids and Structures 1
- or ENGN 0410 Honors Introduction to Engineering 1
- or CHEM 0350 Organic Chemistry 1
- or CHEM 1140 Physical Chemistry: Quantum Chemistry 1

Three of the following: 3
- ENGN 1450 Properties and Processing of Electronic Materials 3
- ENGN 1470 Structure & Properties of Nonmetallic Materials 1
- ENGN 1475 Soft Materials 1
- ENGN 1480 Metallic Materials 1
- ENGN 1490 Biomaterials 1

Total Credits 21

1 These courses are taken in either the junior or senior year. Note that ENGN 1450, ENGN 1475, ENGN 1470 and ENGN 1480 are typically offered in 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

1 or CHEM 0350 Organic Chemistry 1
or CHEM 1140 Physical Chemistry: Quantum Chemistry 1

* In addition to program requirements above, students must take four courses in the humanities and social sciences.
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 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 Applied Partial Differential Equations I 1
CSCI 0040 Introduction to Scientific Computing and Problem Solving 1
or CSCI 0111 Computing Foundations: Data 1
or CSCI 0150 Introduction to Object-Oriented Programming and Computer Science 1
or CSCI 0170 Computer Science: An Integrated Introduction 1
or CSCI 0190 Accelerated Introduction to Computer Science 1
or APMA 0160 Introduction to Scientific Computing 1
or ENGN 1931Z Interfaces, Information and Automation 1

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 1750 Advanced Mechanics of Solids

Fluids/Thermal Systems: At least one course from:
- ENGN 1860 Advanced Fluid Mechanics
- ENGN 1700 Jet Engines and Aerospace Propulsion
- ENGN 1710 Heat and Mass 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 1930T Aircraft Design
- ENGN 1930M Industrial Design
- ENGN 1931D Design of Mechanical Assemblies
- ENGN 1380 Design of Civil Engineering Structures
- ENGN 1720 Design of Thermal Engines
- ENGN 1760 Design of Space Systems

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

Engineering Analysis and Computation Electives: up to two courses from:
- ENGN 1840 Numerical Methods in Engineering
- ENGN 1950 Advanced Engineering Optimization

Energy and Environmental Engineering Electives: up to two courses from:
- ENGN 1930U Renewable Energy Technologies
- ENGN 1931P Fuels, Energy and the Environment

Interdisciplinary Electives: up to one course from:
- ENGN 1620 Analysis and Design of Electronic Circuits
- or ENGN 1340 Water Supply and Treatment Systems - Technology and Sustainability
- or ENGN 1440 Mechanical Properties of Materials
- or ENGN 1470 Structure & Properties of Nonmetallic Materials
- or ENGN 1570 Linear System Analysis
- or ENGN 1931F Introduction to Power Engineering
- or ENGN 1931X Instrumentation for Research: A Biomaterials/ Materials Project Laboratory
- or ENGN 1931Z Interfaces, Information and Automation

3. Upper Level, Advanced Science Course: at least one course from:
- PHYS 0790 Physics of Matter
- or BIOL 0800 Principles of Physiology
- or CHEM 0350 Organic Chemistry
- or CHEM 1140 Physical Chemistry: Quantum Chemistry
- or GEOL 1450 Structural Geology
- or GEOL 1370 Environmental Geochemistry

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

Total Credits 21

1 ENGN 1490 may be substituted if taken in Sophomore year.
2 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 1970/ENGN 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.
4 ENGN 1931Z may replace CSCI 0040 or meet an elective requirement, but not both.
5 Other non-introductory courses in physics, chemistry, neuroscience, geology, or biology may be substituted with the permission of the concentration advisor.
Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

- Helvetica was used instead of Arial.

The editor may contact Leepfrog for a draft with the correct fonts in place.