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This booklet is subject to revision prior to the start of each semester. All changes are effective immediately, unless they constitute a substantive disruption of a student’s program. In such cases, specific guidance should be sought from the Engineering Concentration Committee.
Mission Statements

"The mission of Brown University is to serve the community, the nation, and the world by discovering, communicating, and preserving knowledge and understanding in a spirit of free inquiry, and by educating and preparing students to discharge the offices of life with usefulness and reputation. We do this through a partnership of students and teachers in a unified community known as a University-college."

In support of the University's overall mission, the mission of Brown Engineering is to:

Brown University's School of Engineering educates future leaders in the fundamentals of engineering in an environment of world-class research. We stress an interdisciplinary approach and a broad understanding of underlying global issues. Collaborations across the campus and beyond strengthen our development of technological advances that address challenges of vital importance to us all.

The Brown Engineering Curriculum - the Big Picture

Consider the major problems that confront our world today: economic development, global warming, limited energy resources, affordable health care. These problems are fundamentally engineering problems; their resolution relies on the development of new technologies and new industries that address the needs of an interdependent and complex world.

Our society needs engineers who can lead in an increasingly competitive, fully integrated, world economy. Engineering is a discipline that brings a deep understanding of physical principles, material behavior, information technology, mathematical modeling, and design practices to the problems that challenge our society. Moreover, Brown engineers develop the tools to understand and assess the economic, environmental, political, and ethical implications of their technical work. Preparing engineers to take broad leadership roles in the future is the unique strength of the Brown program, made possible only by the high potential of students who choose to study here and by our highly committed faculty.

Innovation in science and technology is the dominant source of growth in the world economy. Today's radically new and emerging technologies have the potential to create entirely new industries and to render established ones obsolete. Brown's Engineering Curriculum is guided by a forward-thinking philosophy that prepares students to take leadership roles in these new industries in the coming years.
To prepare students for leadership in such a profession, Brown offers an Engineering Curriculum for the Bachelor of Science (Sc.B.) degree that:

- encourages students to commit to lifelong learning in order to address new societal needs and to take advantage of rapid advances in science and technology;
- enables students to explore through a two-year core curriculum that covers the essential elements of mathematics, computing, chemistry, materials, mechanics, electricity and magnetism, thermodynamics, and experimentation in order to develop a firm foundation in the fundamentals that underlie the practice of engineering;
- allows for maximum flexibility by making it possible for students to wait until the end of their second year to choose their concentration in a particular field of engineering;
- follows the core with two years of study in one of the primary engineering fields, with increasing emphasis on real-world applications and design;
- addresses the whole education of a student in order to prepare graduates to have the leadership and communication skills to meet high impact goals of the type bulleted above (the equivalent of nearly three of a student's eight semesters can be used to take advantage of the many excellent courses in the arts, humanities and social sciences);
- supports the development of creative abilities through design projects in nearly all courses, and through opportunities for research experience — both on sponsored research projects and on independent study projects;
- prepares students to work in an interdisciplinary setting, as required in the workplace, because of the inherently multidisciplinary nature of many of today's problems - this preparation is a natural outcome of studying and working in the highly collaborative, interdisciplinary environment at Brown, facilitated by the lack of traditional departmental boundaries within Engineering.

We recognize that students with interests in less technically-oriented engineering careers, or even in non-engineering professions, may not be interested in the Bachelor of Science degree and may be better-served by the Bachelor of Arts (A.B.) degree options described in this booklet. In this regard it is interesting to note that the National Academy of Engineering recently published a book, *The Engineer of 2020: Visions of Engineering in the New Century*, which posits that by 2020 the engineering degree will surpass the liberal arts degree as the degree-of-choice in preparing for other professions. In particular, an engineering degree is viewed as providing an excellent foundation for business, marketing, law, and medicine. Moreover, analytical problem-solving approaches learned in engineering can be of value in any career.

Whether you are interested in an Sc.B. degree or an A.B. degree, our faculty is committed to helping you realize your educational objectives.

Larry Larson, Dean of Engineering
The Nuts and Bolts of the Brown Engineering Curriculum

The School of Engineering offers concentrations in biomedical, chemical and biochemical, computer, electrical, materials, and mechanical engineering. Civil Engineering is currently offered to students in the classes of 2015 and 2016. Students entering Brown with the class of 2017 with interests in Structural Engineering can pursue an enhanced Structures track within the ABET-accredited Mechanical Engineering program. Students interested in Environmental Problems and Planning are directed to the ABET-accredited program in Chemical and Biochemical Engineering and to the new (non-accredited) program in Environmental Engineering.

All of these programs are described in detail in this booklet and lead to a Bachelor of Science in Engineering (Sc.B.). We also have other degree programs including a Bachelor of Arts degree in Engineering, a Bachelor of Arts in Environmental Engineering, and a combined Sc.B. program in Engineering and Physics. The School also offers an innovative and unique program in Entrepreneurship and Technology Management as part of the new University concentration in Business, Entrepreneurship, and Organization (BEO).

During their first two years at Brown, each Engineering student is assigned an Engineering Advisor to help them design their academic program. For the last two years, each student has a Concentration Advisor who handles all the concentrators in a particular program. Any questions regarding these programs can be addressed to the concentration advisors (listed on Page 36), the Chair of the Engineering Concentration Committee (Prof. Iris Bahar), the Director of Engineering Undergraduate Programs (Prof. Rashid Zia), the Senior Associate Dean of Engineering (Prof. Rod Beresford), or the Dean of Engineering (Prof. Larry Larson). Brown is a major research university with a fundamental commitment to quality undergraduate education. Brown's educational philosophy emphasizes breadth in the Liberal Arts as well as strong preparation within an area of concentration. The following six major aspects of the Brown Engineering educational philosophy are consistent with this overall concept.

The Core Curriculum
Brown University engineers are exceptionally well prepared to practice engineering in an age of rapidly changing technology. Two-thirds of our four-year Sc.B. Engineering 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.

Focus on Fundamentals
Brown Engineering stresses the basic scientific principles that underlie present and future engineering practice. Emphasis is placed on mathematics, basic physical principles, and engineering fundamentals. While the focus is on applied science rather than technical training, most Brown undergraduates also gain valuable technical experience through independent study and close relationships with research faculty.

Faculty Excellence
The Brown Engineering faculty is well known for its expertise in research and the application of technology. All lecture courses are taught by professors who, in addition to being leading researchers in their respective fields, consider undergraduate teaching of utmost importance. Professors encourage free and open discussion in and out of the classroom.
Additional Help for Undergraduates
In recognition of the importance of personal attention at the peer level, undergraduate students play a role in advising new students and being role models. Mentoring for all core courses in engineering is available from graduate students and through a tutorial program staffed by undergraduates from the engineering honor society, Tau Beta Pi.

Engineering Independent Study Projects
Students in the upper level program are heavily involved with projects in engineering design and application, both computationally and in the laboratory. At first, each student is carefully guided in the application of what he or she has learned, but eventually each will do one or more projects that require independent judgment and provide a capstone experience. In the Independent Study Program, qualified seniors may undertake a significant research project that may result in an Honors thesis. These students perform substantive work and receive practical, hands-on engineering experience.

Liberal Arts Emphasis
As part of a pluralistic university, Engineering students take many classes outside of the School of Engineering. One of the major strengths of this program is the accessibility of a wide variety of courses in the arts, humanities, and social sciences. Students can select interesting courses in all areas of human endeavor ranging from the Classics to Urban Studies, from Economics to Theater Arts, from Africana Studies to Philosophy. The freedom of Brown's curriculum encourages experimentation and adventure in learning. Our students enjoy interaction with peers from all disciplines and backgrounds and participate in the activities of the large and diverse life of an Ivy League University.
SUMMARY OF UNDERGRADUATE DEGREE PROGRAMS

The School of Engineering offers four-year programs leading to the degrees of Bachelor of Science (Sc.B.) or Bachelor of Arts (A.B.). In addition, the University offers the opportunity to take a five-year combined degree program leading to an Sc.B. degree in Engineering and an A.B. degree in another (technical or non-technical) field. We also offer an integrated five-year program leading to the Sc.B. degree in Engineering after four years, and the Master of Science (Sc.M.) degree in Engineering at the end of the fifth year. Within each of these degree programs, students can select a set of courses that emphasizes the field of engineering of greatest interest to them.

Nine concentration programs leading to the degree of Bachelor of Science in various fields of engineering are offered. These programs are referred to as “Regular Concentration Programs,” and are described below. Seven of these regular Sc.B. concentration programs are ABET-accredited degree programs in the following fields of engineering: Biomedical, Chemical and Biochemical, Civil, Computer, Electrical, Materials, and Mechanical Engineering. The other two (non-accredited) programs are the new degree in Environmental Engineering and the interdepartmental Sc.B. in Engineering and Physics.

Other concentration programs leading to the Bachelor of Science or Bachelor of Arts degrees in Engineering may be designed by individual students in consultation with a faculty advisor in order to meet particular educational objectives. These programs must meet the general requirements for concentration programs in the School of Engineering. Students interested in one of these individualized programs should consult with an Engineering faculty member willing to serve as advisor to that particular independent program and obtain the approval of the Engineering Concentration Committee.

In addition to the concentration requirements, degree candidates must meet the University requirements by passing 30 courses for four-year degrees and 38 courses for five-year degrees, and by meeting University writing requirements. Students should consult the most current Brown University Bulletin or Course Announcement for details on the requirements regarding the number of courses to be completed for the various degrees.

Each of the regular concentration programs has been designed to provide students with ample opportunity for the selection of courses from outside of the physical sciences, mathematics, and engineering. It is also important that each student’s program include sufficient preparation in the arts, humanities, and social sciences. For the accredited Sc.B. degrees, there is a minimum requirement of four courses in the humanities and social sciences, as well as consideration of how the “non-engineering” portion of the student’s program complements the technical portion.

Accreditation

Seven Bachelor of Science programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. These are the programs in Biomedical, Chemical and Biochemical, Civil, Computer, Electrical, Materials, and Mechanical Engineering. Within each of these concentration programs there are several options, each of which is accredited. The Engineering and Physics program is intended for students interested in a stronger physics foundation, and continuing on to graduate studies. There are currently no plans to seek ABET accreditation for this Sc.B. program.

The current curricular requirements and guidelines of ABET for accredited Sc.B. concentrations include:

1. one year of a combination of college level mathematics and basic sciences (some with experimental experience);
2. one and one-half years of engineering topics;
3. a general education component that complements the technical content.

In the context of the Brown program, one year is the equivalent of eight courses.

The ABET Criteria for Accrediting Engineering Programs define a number of important outcomes that students should obtain by the time of graduation:

---

1 Civil Engineering is available only to classes of 2015 and 2016
(a) an ability to apply knowledge of mathematics, science, and engineering;
(b) an ability to design and conduct experiments, as well as to analyze and interpret data;
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
(d) an ability to function on multidisciplinary teams;
(e) an ability to identify, formulate, and solve engineering problems;
(f) an understanding of professional and ethical responsibility;
(g) an ability to communicate effectively;
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
(i) a recognition of the need for, and an ability to engage in, life-long learning;
(j) a knowledge of contemporary issues;
(k) an ability to use the techniques, skills, and modern engineering tools; necessary for engineering practice.

In light of these intended outcomes, the engineering design component of the curriculum includes at least some of the following features: development of student creativity; use of open-ended problems; development and use of design methodology; formulation of design problem statements and specifications; consideration of alternative solutions; feasibility considerations; and detailed system descriptions. It is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact.

Although the great majority of Brown Engineering undergraduates complete an accredited Sc.B. program, carefully designed non-accredited programs can be educationally and professionally advantageous as well. For those students who wish to become registered professional engineers after they have acquired the requisite level of professional experience, an ABET-accredited program is generally desirable. In most states, the completion of an ABET-accredited four-year Sc.B. degree program is among the requirements to qualify for admission to examination at the first level of professional registration. Although many students select an accredited program, students may choose a special concentration program that is tailored to meet their own specific interests and talents. Many exciting and rapidly developing fields of engineering can be entered with a well-designed non-accredited Sc.B. program. Students desiring more information on professional registration should confer with Prof. Eric Suuberg.

Bachelor of Science

The standard concentration requirements for the Sc.B. degree in Engineering are summarized in this brochure. 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. These students may enroll in ENGN 0030 in their first semester. Students without one year of calculus should take MATH 0090, MAT 0100 in their freshman 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.

Current ABET accreditation guidelines specify a requirement for “a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.” This refers primarily to all the courses that are taken outside of the Engineering requirements, particularly humanities and social sciences courses. In addition, ABET-accredited Engineering programs are expected to demonstrate eleven published ABET outcomes (see preceding page). A number of these
outcomes (e.g., (f) through (j)) are in many cases at least partially satisfied by coursework that falls under the “general education component” of the student’s program. Brown ABET-accredited Sc.B. programs must comply with these requirements in the following manner:

1. The minimum number of courses that must be successfully completed to satisfy this requirement is four courses in the humanities and social sciences.

2. At the time their Engineering Concentration Form is completed, each student must discuss with their concentration advisor the humanities and social science courses they have already taken and the remaining courses they plan to take, with respect to how they would contribute to the published ABET outcomes, and how they will complement the technical component of their program. Based on these discussions, each student must prepare a written record describing how their non-Engineering complement of courses fulfills and contributes to the “general education component” as defined by the ABET criteria. This document can be updated as often as necessary, but at the minimum during the Spring semester just prior to certification for graduation, as is normally required for their entire Engineering Concentration Form to reflect the actual complement of courses taken.

The accredited Sc.B. concentrations in Chemical and Biochemical, Civil, Electrical, Materials, and Mechanical Engineering are completed by passing the required engineering common core courses, an advanced science course, plus an additional coherent set of seven courses prescribed for each program. At least five of the seven upper level courses required to complete the concentration must be 1000-level Engineering courses. The accredited programs in Biomedical and Computer Engineering are somewhat similar, except that selected biology and computer science courses, respectively, are substituted for some of the Engineering core courses. The program of each student must first be approved by the Concentration Advisor, and finally by the Engineering Concentration Committee.
Sample Engineering Program including the Common Core

<table>
<thead>
<tr>
<th>SEM.</th>
<th>COURSE</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>I</td>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
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<tr>
<td></td>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
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<tr>
<td></td>
<td>MATH 0190</td>
<td>Calculus</td>
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<tr>
<td></td>
<td>Elective†</td>
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<tr>
<td>II</td>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
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<td></td>
<td>MATH 0200</td>
<td>Intermediate Calculus</td>
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<td></td>
<td>CSCI 0040</td>
<td>Introduction to Scientific Computing</td>
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<tr>
<td></td>
<td>Elective</td>
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<tr>
<td>III</td>
<td>ENGN 0410</td>
<td>Materials Science</td>
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<td></td>
<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
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<tr>
<td></td>
<td>APMA 0330</td>
<td>Applied Mathematics</td>
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<tr>
<td></td>
<td>Elective</td>
<td></td>
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<tr>
<td>IV</td>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
</tr>
<tr>
<td></td>
<td>ENGN 0720</td>
<td>Thermodynamics</td>
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<tr>
<td></td>
<td>APMA 0340</td>
<td>Applied Mathematics</td>
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<tr>
<td></td>
<td>Elective</td>
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<tr>
<td>V</td>
<td>ENGN 0310</td>
<td>Mechanics of Solids and Structures</td>
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<td>ENGN 0810**</td>
<td>Fluid Mechanics</td>
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<td>Advanced Science</td>
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<td>Elective</td>
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<tr>
<td>VI</td>
<td>Upper Level Course</td>
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<td>Upper Level Course</td>
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<td>Elective</td>
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<td>VII</td>
<td>Upper Level Course</td>
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<td>VIII</td>
<td>Upper Level Course</td>
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<td>Elective</td>
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† A minimum of four electives must be in the humanities and social sciences.
* Other CSCI courses may be acceptable; please consult Advisors. The Ch/BioE program does not require a CSCI course. A BIOL course is required instead.
** Depends on specific concentration: Ch/BioE requires 0810; EE and Materials require either 0310 or 0810; Civil and M.E. require both.
*** May be taken in any semester after prerequisites have been satisfied.
Sc.B. CONCENTRATION PROGRAMS

Biomedical Engineering

Concentration Advisor:
Prof. Sean Deoni, Arnold Lab 317A, x3-7664, Sean_C_Deoni@brown.edu

Educational Objectives:
Students graduating from the Biomedical Engineering Undergraduate Program will:
• Be employed in careers of useful service to society, including scientific and technical areas within medicine, industry, and health care delivery.
• Demonstrate the ability to apply the basic principles of engineering and science, as well as problem solving skills and critical thinking, to a broad spectrum of biomedical engineering problems.
• Demonstrate their ability to work in teams, and to effectively communicate and understand the broad social, ethical, economic and environmental consequences of their lifelong education.

The program’s primary emphasis is on building the fundamental principles of biomedical engineering, while allowing students to personalize their curriculum. This focus will prepare students for the diverse aspects of biomedical engineering, as well as diverse careers in areas such as medicine, law, business, and health care delivery.

These objectives address the expected accomplishments of program graduates, primarily in the time period of several years following graduation. The objectives prepare students who will be 1) well versed in the basic sciences of mathematics, physics, and chemistry; 2) fluent in contemporary biology, and comfortable with its reductionist traditions and its movement toward a molecular understanding, and familiar with its experimental assays; 3) educated in the tools and skill-sets of engineers, particularly the ability to quantify, synthesize, and integrate, and able to apply these tools both theoretically and experimentally to living systems and other subject matter in biology; 4) well prepared to complete their education and training in further study at the graduate or professional level, and conditioned to recognize the need for such further work; and 5) endowed with the attributes of an education in a leading liberal arts institution: the ability to think clearly, decide fairly, and communicate effectively.

Concentration Requirements:
The concentration requirements include six elements:

1. Foundation Courses (all required): ENGN 0030, ENGN 0040, MATH 0190 (or MATH 0170)*, MATH 0200 (or Math 0180 or 0350)*, BIOL 0200 (or NEUR 0010)**, APMA 0330 (or APMA 35), CHEM 0330, CHEM 0350, APMA 0650 (or APMA 1650), ENGN 0510, ENGN 0720, ENGN 0810, ENGN 1230, BIOL 0800
   *For students with advanced math backgrounds, one math course can be replaced with CHEM 0360
   **Students with advanced biology backgrounds may replace BIOL 0200/NEUR 0010 with BIOL 0470, BIOL 0530 or other biology courses.

2. Upper-Level Bioengineering Courses (all required): ENGN 1110, ENGN 1210, ENGN 1490

3. Three Additional Upper-Level Bioengineering Courses: Select at least 1 from ENGN 1120, ENGN 1220, ENGN 1400, ENGN 1930B, ENGN 1930N, ENGN 1930R, BIOL 1140, BIOL 1210 and Select at most 2 from, BIOL 1150, BIOL 1800, BIOL 2110, BIOL 2130 (Other courses on approval of concentration advisor).


5. Independent Research (one recommended): ENGN/BIOL 1970 Undergraduate research and design project.

6. Other Humanities and Biology Courses: Open electives (premeds should take CHEM0360, BIOL0280, and two biology lab courses including BIOL0800).
# Sample Biomedical Engineering Plan

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSES</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>I</td>
<td>ENGN 0030 MATH 0190 CHEM 0330 Elective</td>
<td>Introduction to Engineering AP Calculus Equilibrium, Rate, and Structure</td>
</tr>
<tr>
<td>II</td>
<td>ENGN 0040 MATH 0200 BIOL 0200 (or NEUR 1) Elective</td>
<td>Dynamics and Vibrations Intermediate Calculus The Foundation of Living Systems</td>
</tr>
<tr>
<td>III</td>
<td>APMA 0330 BIOL 0800 ENGN 0510 Elective</td>
<td>Methods of Applied Mathematics Physiology Electricity and Magnetism</td>
</tr>
<tr>
<td>IV</td>
<td>ENGN 0720 CHEM 0350 APMA 0650 Elective</td>
<td>Thermodynamics Organic Chemistry Essential Statistics</td>
</tr>
<tr>
<td>V</td>
<td>ENGN 0810 ENGN 1490 ENGN 1230 Elective</td>
<td>Fluid Mechanics Biomaterials Instrumentation Design</td>
</tr>
<tr>
<td>VI</td>
<td>ENGN1110 Biomedical Engineering Elective Elective Elective</td>
<td>Biotransport (3 of 12 listed courses)</td>
</tr>
<tr>
<td>VII</td>
<td>ENGN 1930L ENGN 1210 Biomedical Engineering Elective Elective</td>
<td>BME Research/Design Biomechanics (3 of 12 listed courses)</td>
</tr>
<tr>
<td>VIII</td>
<td>Biomedical Engineering Elective ENGN 1971 Elective Elective</td>
<td>(3 of 12 listed courses) Independent Research/Design</td>
</tr>
</tbody>
</table>
Chemical and Biochemical Engineering

Concentration Advisor:
Prof. Andrew Peterson, B&H 247, x3-2153, Andrew_Peterson@brown.edu

Educational Objectives:
We expect our Chemical and Biochemical Engineering program graduates to:

I. 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;

II. 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;

III. 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.

Concentration Requirements:
The concentration draws on the common core of the engineering program, and students will take courses in the chemical and biological sciences in addition to upper-level chemical engineering courses. The requirements are:

1. Common core program for the Sc.B., excluding ENGN 0310 and CSCI 0040; plus BIOL 0200.

2. An upper-level, seven-course sequence consisting of ENGN 1110, 1120*, 1130*, 1140 and 1710 (*Note: ENGN 1120 and 1130 are offered in alternate years only.); plus CHEM 0350 (organic chemistry); plus one additional elective chemistry course from the set of CHEM 0360, 0400, 0500, 1140, 1150, 1160, 1170 or another advanced chemistry course approved by the Concentration Advisor.

3. One approved, upper-level elective course in the natural sciences, generally selected from the specific areas of chemistry, physics, life sciences, geological sciences and materials science, but with the possibility of other choices as well. For suggestions of acceptable courses that fulfill this requirement, see the Concentration Advisor.

Program Options:
For students who desire further specialization, attention is drawn to the following thematic groupings of elective courses (Note: some of these suggested courses may require additional prerequisites):

Biochemical Engineering/Biotechnology:
Engineering 1210, 1220, 1230, 1490; Biomed 0200, 0470, 0530, 0800, 1050, 1090, etc.

Computer Applications in Chemical Processing:
Engineering 1570, 1580, 1640, 1740; Computer Science 0150, 0160, 0330, etc.

Electronics Applications in Chemical Processing:
Engineering 1590, 1600, 1620, 1630, 1680, 1690.

Energy Production and Conversion:
Engineering 1700, 1720, 1930U.

Environmental Issues and Pollution Prevention:
Engineering 1340, Environmental Studies 0110, 0490, 1400, 1410; Biomed 0420; Economics 1350; Geological Sciences 0220, 0230, 1370, 1950A, 1960J,

Materials Processing and Synthesis
Engineering 1410, 1420, 1440, 1450, 1470, 1480; Physics 0790.

Technology Entrepreneurship
Engineering 1010, 1930G, 1930H
Special Note for Students Interested in Medical School:
The standard Chemical and Biochemical Engineering Program itself affords an excellent opportunity for students to pursue in-depth study of relevant chemistry courses, such as organic chemistry, and also permits study of biology subjects as introductory and/or advanced science courses within the standard program. It is for this reason that over the years a number of students have chosen Chemical and Biochemical Engineering as a pre-medical concentration. A list of some of the courses from which relevant electives may be chosen has been given above, but additional options are also certainly possible. Students interested in pursuing this aspect of the program are advised to consult the Concentration Advisor as early as possible, in order to allow maximum flexibility in designing a course of study. Students are also urged to check with the Pre-Med and Health Care Advising office (www.brown.edu/Administration/Dean_of_the_College/hco/) as soon as possible for more specific career planning advice.

Special Note for Students Interested in Chemical Technology Business and Entrepreneurship:
The standard Chemical and Biochemical Engineering Program itself affords an excellent background for students who wish to enter the commercial world. In addition to the courses mentioned above, Brown offers a unique 5th year masters Program in Innovation Management and Entrepreneurship (PRIME), for which additional information may be found at www.engin.brown.edu/graduate/PRIME.htm. If a student is interested in pursuing this option, there can be an advantage to begin planning in the second semester of junior year. Interested students should speak to Professor Eric Suuberg.
### Sample Chemical Engineering Plan

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSES</th>
<th>DESCRIPTION</th>
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</thead>
</table>
| I        | ENGN 0030  
MATH 0190  
CHEM 0330  
Elective | Introduction to Engineering  
AP Calculus  
Equilibrium, Rate, and Structure |
| II       | ENGN 0040  
MATH 0200  
BIOL 0200 or CHEM 0350  
Elective | Dynamics and Vibrations  
Intermediate Calculus  
Found. Living Systems or Organic Chem. |
| III      | APMA 0330  
ENGN 0510  
ENGN 0410  
Elective | Methods of Applied Mathematics  
Electricity and Magnetism  
Materials Science |
| IV       | APMA 0340  
ENGN 0720  
ENGN 0520  
Elective | Applied Mathematics  
Thermodynamics  
Electrical Circuits and Signals |
| V        | ENGN 0810  
ENGN 1130* (Fall 2015, Fall 2017)  
Elective  
Elective | Fluid Mechanics  
Phase and Chemical Equilibria |
| VI       | ENGN 1710  
ENGN 1110  
Elective  
Elective | Heat and Mass Transfer  
Transport and Biotransport Processes |
| VII      | ENGN 1120* (Fall 2014, Fall 2016)  
Elective  
Elective  
Elective | Chemical & Biochemical Reactor Design |
| VIII     | ENGN 1140  
Elective  
Elective  
Elective | Chemical Process Design |

Of the listed Electives, one must be an advanced chemistry course, one must be an upper level natural science course, and one must be either BIOL 0200 or CHEM 0350 (whichever was not taken in freshman year). In certain instances, some students elect to defer the ENGN 0510/0520 sequence until junior year (semesters V and VI) such that they may take the organic chemistry sequence CHEM 0350/0360 in semesters II and III; if you are considering this option, it should be discussed with your advisor.

*ENGN 1120 and ENGN 1130 are offered in the fall semester in alternate years.*
Civil Engineering: Available to students entering in the classes of 2015 and 2016

IMPORTANT ANNOUNCEMENT: Civil Engineering as a standalone ABET accredited program will continue to be available to all to students in the classes of 2015 and 2016.

Students entering in the class of 2017 with interest in Structural Engineering will be able to concentrate in this discipline though a Structures track within the ABET-accredited Mechanical Engineering program.

Students interested in Environmental Problems and Planning are directed to the ABET-accredited program in Chemical and Biochemical Engineering and to the non-accredited program in Environmental Engineering.

Concentration Advisor:
Prof. Janet Blume, University Hall 407, x3-2313, Janet_Blume@brown.edu

Educational Objectives:
The educational objectives of the Civil Engineering Program at Brown University are based on the mission of the institution, the possibilities that exist for a relatively small program, the capabilities and aspirations of the students, and regular surveys of how well our curriculum is serving our graduates. From these considerations we have established the following educational objectives.

1. We expect our graduates 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. We expect our graduates to adapt to changing opportunities, both in engineering and in other professional and business pursuits.

3. We expect our graduates to be ethically responsible, to engage in lifelong learning, and to be of service to the engineering community and to society at large.

Concentration Requirements:
The common core program for the Sc.B. in Engineering, including an advanced science course as well as Engineering 0310 AND 0810. The requirement for the advanced science course is met by taking either Geological Sciences 1580 or 1590.

For students interested in Structures, the following courses must be included:
   Engineering 1300, 1340, 1360, 1380, and 1940D (Large Scale Engineering Project), plus one additional course to be chosen from Engineering 1310, 1370, 1740, 1750, and 1860.

For students interested in Environmental Problems and Planning, the following courses must be included:
   Engineering 1130, 1300, 1310, 1340, 1360, and 1940D (Large Scale Engineering Project). Attention is called to the following courses as particularly relevant technical electives: Engineering 1110, 1380, 1710, 1740, and 1860.
## Sample Civil Engineering Plan

<table>
<thead>
<tr>
<th>SEM.</th>
<th>COURSE</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
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<tr>
<td></td>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
</tr>
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<td></td>
<td>MATH 0190</td>
<td>AP Calculus</td>
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<td>I</td>
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<tr>
<td>II</td>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
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<tr>
<td></td>
<td>MATH 0200</td>
<td>Intermediate Calculus</td>
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<tr>
<td></td>
<td>CSCI0040</td>
<td>Introduction to Scientific Computing</td>
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<td></td>
<td>Elective</td>
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<tr>
<td>III</td>
<td>ENGN 0410</td>
<td>Materials Science</td>
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<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
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<td></td>
<td>APMA 0330</td>
<td>Applied Mathematics</td>
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<tr>
<td>IV</td>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
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<td>ENGN 0720</td>
<td>Thermodynamics</td>
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<td></td>
<td>APMA 0340</td>
<td>Applied Mathematics</td>
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<td>Elective</td>
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<td>V</td>
<td>ENGN 0310</td>
<td>Mechanics of Solids and Structures</td>
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<td>ENGN 0810</td>
<td>Fluid Mechanics</td>
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<tr>
<td>VIII</td>
<td>ENGN 1930 D</td>
<td>Large Scale Engineering Project</td>
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</table>

† A minimum of four electives must be in the humanities and social sciences.

* May be taken in any semester after prerequisites have been satisfied.
Computer Engineering

Concentration Advisor:
Prof. Pedro Felzenszwalb, B&H 355, x3-1431, pff@brown.edu

Educational Objectives:
The objectives of the computer engineering program are to produce engineers who:
- 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.
- 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.

Concentration Requirements:
This 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. There are four elements to the concentration:

1. Computer Engineering basic core (11): ENGN 0030, 0040, 0510, 0520; MATH 0190, 0200 (or 0170, 0180); APMA 0330 (or 0350), APMA 1650; one of CHEM 0330 or ENGN 0410; CSCI 0150, 0160 (or 0170, 0180), (or 0040, 0190).

2. Computer Engineering advanced core (4): MATH0520, CSCI 0330, ENGN 1570, ENGN 1630

3. Computer Engineering specialties (5):
   a. Computer Specialty: ENGN 1620 and ENGN1640; one of ENGN 1580, 1600, 1650, 1680, 2530, 2910A, P, W; 2911C, G, X, Y, (or other ENGN courses, subject to approval); two of CSCI 0320, 1230, 1270, 1380, 1410, 1480, 1570, 1670, 1680, 1730, 1760, 1900, or other CS courses, subject to approval.
   b. Multimedia Signal Processing Specialty: APMA 1170; two of ENGN 1580, 1610, 2500, 2520, 2530, 2540, 2560, 2570, 2910X; one of CSCI 0320, 1230, 1410, 1460, 1570, 1900, or other CSCI courses, subject to approval; plus one more course from the above list.

4. Capstone Course / Independent Study:
   ENGN 1970/1971, an independent study relevant to the specialty selected by the student. For the Computer Systems Specialty, ENGN1650 may be used as the Capstone, but then cannot be counted for the ENGN choice above in 3a. The independent study project should provide students with exposure to current research topics. In order to assure satisfactory progress in their independent study, students enrolled will meet at least bi-weekly with their advisors and give two oral reports to the group during the semester. A final written report will also be required. In addition, students will meet as a group with faculty to share ideas and help nurture an environment of collaborative research.
## Sample Computer Engineering Plan

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<tr>
<th>SEMESTER</th>
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<tbody>
<tr>
<td>I</td>
<td>ENGN 0030, MATH 0190, CSCI 0170, Elective</td>
<td>Introduction to Engineering AP Calculus</td>
</tr>
<tr>
<td>II</td>
<td>ENGN 0040, MATH 0200, CSCI 0180, Elective</td>
<td>Dynamics and Vibrations, Intermediate Calculus</td>
</tr>
<tr>
<td>III</td>
<td>ENGN 0510, APMA 0330, CHEM 0330 or ENGN 0410, Elective</td>
<td>Electricity and Magnetism, Methods of Applied Mathematics (selected chemistry content)</td>
</tr>
<tr>
<td>IV</td>
<td>ENGN 0520, MATH 0520, Elective, Elective</td>
<td>Electrical Circuits and Signals, Linear Algebra</td>
</tr>
<tr>
<td>V</td>
<td>ENGN 1570, ENGN 1630, CSCI 0310 or CSCI 0330, Elective</td>
<td>Linear Systems Analysis, Digital Electronics, Computer Systems</td>
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<tr>
<td>VI</td>
<td>Specialty Elective, Specialty Elective, Elective, Elective</td>
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<tr>
<td>VII</td>
<td>APMA 1650, Specialty Elective or capstone, Specialty elective, Elective</td>
<td>Statistical Inference</td>
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<tr>
<td>VIII</td>
<td>Specialty Elective or capstone, Specialty Elective, Elective, Elective</td>
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</tr>
</tbody>
</table>

* A minimum of four electives must be in the humanities and social sciences.

2 Students with a strong interest in Computer Engineering and advanced placement credit may elect to take MATH 0200 in the first semester and ENGN 0520 in the second semester.
Electrical Engineering

Concentration Advisors:
Prof. Jacob Rosenstein, B&H 353, x3-2652, Jacob_Rosenstein@brown.edu

Educational Objectives:
The educational objectives of the Electrical Engineering Program at Brown University are based on the mission of the institution to prepare students for careers of useful service to society, and on the mission of the School of Engineering to merge engineering teaching, scholarship, and practice in the pursuit of solutions to human needs.

The objectives of the Electrical Engineering Program are to produce engineers who:
• 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.
• 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.

Concentration Requirements:
Electrical Engineers must complete the common core program for the Sc.B. in Engineering, including either ENGN 0310 or 0810, plus PHYS 0790 or an approved 1000-level Physics course.

Students with a strong interest in Electrical Engineering and advanced placement credit may elect to take MATH 0200 in the first semester and ENGN 0520 in the second semester. Interested Electrical Engineers are also encouraged to take a more intensive computing course (e.g. CSCI 0150, 0170, or 0190) in place of CSCI 0040

In addition to the above, seven more courses must be included in the concentration. Four of these seven courses must be ENGN 1570, 1620, 1630, and a major design project taken either as ENGN 1000, ENGN 1650 or as an Independent Study Course (ENGN 1970 or 1971) relevant to the Electrical Engineering specialty selected by the student. To ensure depth of engineering training, the student shall choose the other three courses to satisfy requirements of a selected specialty as detailed below (note that if ENGN 1650 is used to fulfill the major design project requirement, a different course must be selected as one of the three specialty courses):

Bioelectrical Engineering:
ENGN 1230; at least one from ENGN 1220, 1930B, 2500, or 2912L; and at least one additional course from ENGN 1220, 1610, 1930B, 2500, 2912L, CLPS 1491, 1520, NEUR 1680 or 2110.

Communications Systems:
ENGN 1580; ENGN 1560 or 1690; and at least one additional course from ENGN 1560, 1610, 1640, 1650, 1690, or 2530. APMA 1650 or MATH 1610 is also useful.

Computer Engineering:
CSCI 0330 and ENGN 1640; and at least one additional course from ENGN 1580, 1600, 1610, 1650, or 2530.

Multimedia Signal Processing:
ENGN 2530 or 1610; and at least two additional courses from ENGN 1580, 1610, 1640, 1650, 2500, 2530, 2540, 2560, or CSCI 1230.

Microelectronic Systems:
ENGN 1600 and 1640; and at least one additional course from ENGN 1590, 1680, 2530, or 2912K.

Solid State Electronics and Photonics:
ENGN 1590; ENGN 1560 or 1690; and at least one additional course from ENGN 1450, 1560, 1600, 1680, 1690, 1931A, or PHYS 1420. Students within the Solid State specialty are also encouraged to consider taking PHYS 1410 in place of PHYS 0790.
Please note that advanced courses (e.g. 2000-level graduate courses) in relevant field may also be used to satisfy elective options within these specialization tracks, subject to approval by the Electrical Engineering Concentration Advisor. Other Electrical Engineering specialties based on a coherent selection of at least three 1000-level courses and a major design project with an appropriate faculty advisor may be considered. Such other specialty programs must be approved in advance by the Engineering Concentration Committee.
# Sample Electrical Engineering Plan

<table>
<thead>
<tr>
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<th>COURSE</th>
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<tbody>
<tr>
<td>I</td>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
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<tr>
<td></td>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
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<td></td>
<td>MATH 0190</td>
<td>AP Calculus</td>
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<td>Elective(\d)</td>
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<tr>
<td>II</td>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
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<td></td>
<td>MATH 0200(\d)</td>
<td>Intermediate Calculus</td>
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<td>CSCI0040*</td>
<td>Introduction to Scientific Computing</td>
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<td>III</td>
<td>ENGN 0410</td>
<td>Materials Science</td>
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<td>ENGN 0510</td>
<td>Electricity and Magnetism</td>
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<td>APMA 0330</td>
<td>Applied Mathematics</td>
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<td>IV</td>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
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<td>ENGN 0720</td>
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<td>Applied Mathematics</td>
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<td>V</td>
<td>ENGN 0310 or ENGN 0810</td>
<td>Mechanics of Solids or Fluid Mechanics</td>
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</table>

\(\d\) A minimum of four electives must be in the humanities and social sciences.

* Students interested in more advanced programming can satisfy the CS requirement via CSCI0150, 0170, or 0190

\(\d\) Students with advanced placement credit and a strong interest in Electrical Engineering may elect to take MATH 0200 in the first semester and ENGN 0520 in the second semester.

\(\d\) May be taken in any semester after prerequisites have been satisfied.
Materials Engineering

Concentration Advisor:
Prof. Clyde Briant, B&H 220, x3-5734, Clyde_Briant@brown.edu

Educational Objectives:
The educational objectives of the Materials Engineering Program at Brown University are based on the mission of the institution to prepare students for careers of useful service to society, and on the mission of the School of Engineering to merge engineering teaching, scholarship, and practice in the pursuit of solutions to human needs.

The Materials Engineering Program aims to produce engineers who:

I. 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.

II. 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.

These objectives address the expected accomplishments of program graduates in the years following graduation. Objective 1 describes the immediate goal for the curriculum while objective 2 emphasizes the adaptability and continuing intellectual growth of an engineer working at the highest levels of achievement over a longer term.

Concentration Requirements:
The requirements for concentrators in Materials Engineering are:

1. The common core program for Sc.B. in Engineering, including Engineering 0310 or 0810. For materials concentrators, the required advanced science course must either be Physics 0790 or Chemistry 1140. Materials engineering concentrators may substitute CH00350 for CS0040.

2. All materials concentrators must take the following four courses: ENGN 1410, 1420, 1440, 1000 (or, with permission, Independent Studies in Engineering, ENGN 1970, containing an equivalent design experience relevant to Materials Engineering).

3. At least three of the following four upper level materials courses must be selected:
   Engineering 1450, 1470, 1480, and 1490.
   (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. These courses are taken in either the junior or senior year).

The following upper level courses are recommended:
For student interested in Mechanical Properties and Deformation Behavior of Materials:
   Engineering 1480,1300,1750.
For students interested in Electrical Properties and Applications of Materials to Solid State Electronics:
   Engineering 1450, 1590, 1620, 1680.
For students interested in Chemistry and Materials Processing and Synthesis:
   Engineering 1110, 1470, 1450,1480,1490,1680, and Chemistry 0350, 0360, 0500.
For students interested in Biomaterials:
   Engineering 1210, 1230, 1470, 1490, BIOL 0200, BIOL 1080, BIOL 1090.
Attention is called to graduate courses in materials (with permission of the instructor): ENGN 2400, 2410, 2420, 2430 and 2490.
# Sample Materials Engineering Plan

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<td>MATH 0190</td>
<td>AP Calculus</td>
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<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
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<td>MATH 0200</td>
<td>Intermediate Calculus</td>
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<td>CSCI0040 $^5$</td>
<td>Introduction to Scientific Computing</td>
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<td>ENGN 0410</td>
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<td>ENGN 0520</td>
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</table>

$^1$ A minimum of four electives must be in the humanities and social sciences.
$^5$ CH350 Organic Chemistry may be substituted for CS0040

* May be taken in any semester after prerequisites have been satisfied.
**Mechanical Engineering**

**Concentration Advisor:**
Prof. Christian Franck, B&H 739, x3-2863, Christian_Franck@brown.edu

**Educational Objectives:**
Graduates of the Mechanical Engineering program will

- Pursue scientific and technical careers beginning with either graduate study in mechanical engineering and related fields or mechanical engineering positions in industry.
- 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.

**Concentration Requirements:**
The common engineering core program for the Sc.B. in Engineering, including: a chemistry course (CHEM 0330), an approved computer science course, an approved advanced science course, and a minimum of four courses in the humanities and social sciences, as well as both ENGN 0310 and ENGN 0810. Students with a strong interest in Mechanical Engineering may elect to take ENGN 0310 in their sophomore year, by postponing ENGN 0510 to their junior year. The recommended advanced science course is Physics 0790 for all options except Biomechanics and Structural Mechanics. Humanities courses should develop an awareness of contemporary issues and provide a general education necessary to practice engineering in a societal context. To ensure breadth, they should be taken from at least two different departments. Six upper level courses should be selected from the following options:

**Aerospace Applications:**
Engineering 1000, 1370, 1700, 1720 and 1860, plus one course selected from among 1710, 1740, or 1750. Attention is called to the graduate level courses ENGN 2810 and 2820.

**Biomechanics:**
Engineering 1000, 1210, 1230 and 1370, plus at least one course from among ENGN 1700, 1710, and 1860, plus one additional course from this group or from among ENGN 1220, 1490, 1740, 1750, and 1930R. BI0800 is the recommended advanced science course.

**Energy Conversion and Fluid and Thermal Systems:**
Engineering 1000, 1700, 1710, 1720, and 1860, plus either Engineering 1370 or 1750. Attention is also called to Engineering 1310, 1340 and 1740.

**Engineering Mechanics:**
Engineering 1370, 1750 and 1860, plus two design courses from among Engineering 1000, 1380, 1720, 1740, 1760, or 1930M, plus one course from among ENGN 1300, 1360, 1420, 1700, 1710. Attention is also called to Applied Mathematics 1060, 1330, and 1340, and to graduate level courses ENGN 2010, 2020, 2210, 2220 and 2810.

**Mechanical Systems: Dynamics, Materials and Design:**
Engineering 1000, 1370, 1750 and 1760, plus at least one course from among ENGN 1700, 1710 (recommended), 1720, and 1860, plus one additional course from this group or from among ENGN 1230, 1300, 1380, 1420, 1620, and 1740. Attention is also called to the graduate level courses 2210 and 2220.

**Structural Mechanics**
ENGN 1300, 1370, 1380, plus one course from among ENGN 1740, 1750, 1760, plus ENGN 1710, 1860. In addition, the advanced science course should be one from among GEOL 1450, GEOL 1560, GEOL 1590, GEOL 1600.

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* ENGN 1931D (Design of Mechanical Assemblies) ENGN 1930M (Industrial Design) may be substituted for ENGN1000. Independent study courses with a significant design component may also be substituted, with approval from the Engineering Concentration Advisor.
# Sample Mechanical Engineering Plan

<table>
<thead>
<tr>
<th>SEM.</th>
<th>COURSE</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>I</td>
<td>ENGN 0030</td>
<td>Introduction to Engineering</td>
</tr>
<tr>
<td></td>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
</tr>
<tr>
<td></td>
<td>MATH 0190</td>
<td>AP Calculus</td>
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<tr>
<td></td>
<td>Elective†</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>ENGN 0040</td>
<td>Dynamics and Vibrations</td>
</tr>
<tr>
<td></td>
<td>MATH 0200</td>
<td>Intermediate Calculus</td>
</tr>
<tr>
<td></td>
<td>CSCI0040</td>
<td>Introduction to Scientific Computing</td>
</tr>
<tr>
<td>III</td>
<td>ENGN 0410</td>
<td>Materials Science</td>
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<tr>
<td></td>
<td>ENGN 0510*</td>
<td>Electricity and Magnetism</td>
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<tr>
<td></td>
<td>APMA 0330</td>
<td>Applied Mathematics</td>
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<tr>
<td></td>
<td>Elective</td>
<td></td>
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<tr>
<td>IV</td>
<td>ENGN 0520</td>
<td>Electrical Circuits and Signals</td>
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<tr>
<td></td>
<td>ENGN 0720</td>
<td>Thermodynamics</td>
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<tr>
<td></td>
<td>APMA 0340</td>
<td>Applied Mathematics</td>
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<tr>
<td></td>
<td>Elective</td>
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<tr>
<td>V</td>
<td>ENGN 0310*</td>
<td>Mechanics of Solids and Structures</td>
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<td></td>
<td>ENGN 0810</td>
<td>Fluid Mechanics</td>
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<td></td>
<td>Advanced Science**</td>
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<tr>
<td>VI</td>
<td>Upper Level Course</td>
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<td>Upper Level Course</td>
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<td>Elective</td>
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<tr>
<td>VII</td>
<td>Upper Level Course</td>
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<td></td>
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<td></td>
<td>Elective</td>
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</tbody>
</table>

† A minimum of four electives must be in the humanities and social sciences.

* Students with an interest in ME can take ENGN 0310 in their sophomore year and ENGN 0510 in their junior year.

** May be taken in any semester after prerequisites have been satisfied
Sc.B. in Engineering and Physics (non-accredited)

Concentration Advisors:
Engineering: Prof. Alexander Zaslavsky, B&H 222, x3-1406, Alexander_Zaslavsky@brown.edu
Physics: Prof. Robert Pelcovits, B&H 333, x3-1432, Robert_Pelcovits@brown.edu

Our aim in creating this combined concentration, sponsored jointly by the School of Engineering and the Department of Physics, is to ensure that students take a significant portion of the usual Engineering and Physics program, obtain substantial laboratory experience, and take several upper-level elective courses, focusing on applied material. The program is designed so that students can take either the standard Physics or Engineering programs during their freshman and sophomore years and then switch to this combined program.

Concentration Requirements:
The total number of courses required for the program is 19. (We assume that a student begins his or her mathematics courses at Brown with Math 0190 or its equivalent. Students who begin in Math 0200 or equivalent are encouraged but not required to take an additional upper-level mathematics course.)

The courses are as follows:

- Physics 0050-0060, or Physics 0070-0160, or Engineering 0030-0040.
- Math 0170-0180 (or, equivalently, Math 0190-0200) and three additional higher-level math, applied math, or mathematical physics (Phys 0720) courses.
- Computer Science 0040 or higher-level programming course like Computer Science 0150.
- Physics 0470, 1510 or Engineering 0510, 1560.
- Physics 0500 or Engineering 1370.
- Physics 1410-1420.
- Physics 1530 or Engineering 0720.
- Engineering 1620.
- One course from the following: Engineering 0310, Engineering 0810, Chemistry 0330 or a Physics course on Continuum Mechanics.
- One course from the following: Engineering 1690, Engineering 0410, Physics 0560.
- One course from the following: Physics 1560, Engineering 1590, or a 2000-level Engineering or Physics course as approved by the concentration advisor.
- A thesis under the supervision of a Physics faculty member (Physics 1990) or Engineering faculty member (Engineering 1970/1971). Students are also encouraged to consider taking courses dealing with philosophical, ethical or political aspects of science and technology.

To accommodate the diverse preparation of individual students, variations of the above sequences and their prerequisites are possible with permission of the appropriate concentration advisor and the instructors involved. We recommend that each student’s degree program be submitted for prior approval (typically in semester four) and scrutinized for compliance (in semester seven) by one faculty member from the Department of Physics and one faculty member from the School of Engineering.
Environmental Engineering (non-accredited)

Concentration Advisor:
Prof. Indrek Külaots, B&H 735, x3-2674, Indrek_Kulaots@brown.edu

Educational Objectives:
The educational objectives of program are the following:
- to engage in practice the knowledge obtained in school within industry, government, or private practice,
- to work toward sustainable solutions in a wide array of technical specialties,
- to pursue lifelong learning through continuing education and/or advanced degrees in environmental engineering.

Concentration Requirements:
The program enables graduates to specialize in one of the two sub-disciplines, either energy or chemistry. Each sub-discipline has similar common core course requirements (courses listed in section 1 below) and approved courses in earth science and in biology (courses listed in section 2). Each sub-discipline features its own upper level engineering and science course requirements (courses listed in section 3) and approved capstone design course (section 4).

1. Environmental engineering common core courses, total 13 courses
   MATH 0190, MATH 0200, APMA 0330, ENVS 1110 (or APMA0650 or 1650), CHEM 0330, BIOL 0200, ENVS 0490, ENGN 0030, ENGN 0040, ENGN 0410, ENGN 0510, ENGN 0720, ENGN 0810.

2. Approved required courses in Earth sciences and in Biology, total 2 courses
   a) in Earth sciences, select 1 course
      GEOL 1580, GEOL 1370, (or approved alternative)
   b) in Biology, select 1 course
      BIOL 0415, BIOL 0420, (or approved alternative)

3. Approved required courses in Engineering or in Sciences, total 5 courses from which at least 4 should be engineering courses and at least 4 should be 1000 level
   a) chemistry sub-discipline
      CHEM 0350, ENGN 0310, ENGN 0520, ENGN 1110, ENGN 1130, ENGN 1340, ENGN 1710, ENGN 1860, ENGN 1931P, ENGN 1930U, CSCI 0004 (or equivalent), ENVS 1570, ENVS 1400 (or other approved upper-level ENVS or BIOL courses)
   b) energy sub-discipline
      ENGN 0310, ENGN 0520, ENGN 1340, ENGN 1710, ENGN 1860, ENGN 1930U, ENGN 1931F, ENGN 1931A, ENGN 1931P, CSCI 0004 (or equivalent), ENVS 1570, ENVS 1400 (or other approved upper-level ENVS or BIOL courses)

4. Approved capstone design course, total 1 course
   ENGN 1000, ENGN 1140 (or approved alternative design course or independent study)

5. Courses in Humanities and Social Sciences as electives, total 4 courses
   To ensure breadth, no more than two courses can be in the same department

   NOTE: the curriculum will be regularly reviewed to accommodate any changes in the ENVS, GEOS or BIOL courses that are required by this concentration.
### Sample Environmental Engineering Plan

<table>
<thead>
<tr>
<th>SEM.</th>
<th>COURSE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>ENGN 0030&lt;br&gt;CHEM 0330&lt;br&gt;MATH 0190&lt;br&gt;Elective†</td>
<td>Introduction to Engineering&lt;br&gt;Equilibrium, Rate, and Structure&lt;br&gt;AP Calculus</td>
</tr>
<tr>
<td>II</td>
<td>ENGN 0040&lt;br&gt;MATH 0200&lt;br&gt;BIOL 0200&lt;br&gt;Elective</td>
<td>Dynamics and Vibrations&lt;br&gt;Intermediate Calculus&lt;br&gt;Foundations of Biology</td>
</tr>
<tr>
<td>III</td>
<td>ENVS 0490&lt;br&gt;ENGN 0510&lt;br&gt;APMA 0330&lt;br&gt;Elective</td>
<td>Environmental science in changing world&lt;br&gt;Electricity and Magnetism&lt;br&gt;Applied Mathematics</td>
</tr>
<tr>
<td>IV</td>
<td>ENGN 0720&lt;br&gt;ENVE 1110&lt;br&gt;Approved required course6&lt;br&gt;Elective</td>
<td>Thermodynamics&lt;br&gt;Statistics</td>
</tr>
<tr>
<td>V</td>
<td>ENGN 0810&lt;br&gt;ENGN 0410&lt;br&gt;Approved required course&lt;br&gt;Elective</td>
<td>Fluid Mechanics&lt;br&gt;Materials Science</td>
</tr>
<tr>
<td>VI</td>
<td>Approved required course&lt;br&gt;Approved required course&lt;br&gt;Elective&lt;br&gt;Elective</td>
<td></td>
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<tr>
<td>VII</td>
<td>Approved capstone design course&lt;br&gt;Approved required course&lt;br&gt;Elective&lt;br&gt;Elective</td>
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<tr>
<td>VIII</td>
<td>Approved required course&lt;br&gt;Approved required course&lt;br&gt;Elective&lt;br&gt;Elective</td>
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</table>

† A minimum of four electives must be in the humanities and social sciences.

6 Approved required courses must include a course in earth sciences, a course in biology related to environment, a course in statistical methods and at least four engineering upper level courses.
Bachelor of Arts

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 Engineering 0030 and 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 so that the student specializes in one particular engineering discipline, with careful attention to the pre-requisites of the 1000-level courses. Please note that not all engineering courses can be used to satisfy the engineering course requirement for the AB degree. For example, ENGN 0020, 0090, 0900, 0930, and 1010 cannot be used to satisfy the engineering course requirement for the A.B. degree. For this reason, it is essential that the set of courses be developed through consultation with the concentration advisor.

The program must also require preparation in Mathematics equivalent to Mathematics 0200 and Applied Mathematics 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 Chemistry 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 the Engineering AB concentration advisor and the Engineering Concentration Chair.

Bachelor of Arts in Engineering with a focus in Environmental Studies

This program is offered in cooperation with the Environmental Studies Program and is intended for students who want to prepare for positions and/or graduate programs in environmental policy, planning, and regulation. The first year should be generally similar to that of the Sc.B. in Engineering and preferably include ENVS 0110, Environmental Issues, which is the prerequisite for the other Environmental Studies courses. It is suggested that students interested in this option begin with careful planning of the curriculum in consultation with a Freshman Engineering advisor when they arrive for their first semester. Toward the end of the freshman year, the student should design the Engineering portion of the program so that it complies with the Bachelor of Arts (A.B.) degree as described above. Recommendations for the two 1000-level engineering courses are ENGN 1130 and 1340. The program should be developed in consultation with an Engineering faculty advisor, and is subject to review by the Engineering Concentration Committee.

In addition to ENVS 0110, a minimum of three other courses should be selected from Environmental Studies courses, Biology and Medicine 0420, Geological Sciences 0220, and Applied Mathematics 1650, 1660. The Environmental Studies portion of the program should be prepared with the help of an Environmental Studies Faculty Advisor.

Students who have strong environmental interests, but who wish to pursue an Sc.B. concentration in Engineering should either pursue an ScB in Environmental Engineering, or one of the other ScB programs, with relevant environmental courses as electives. In particular, attention is called to Environmental Studies 0110, 0410, 0510, 1350 (or Economics 1350), 1410, 1920, BIOL 0420, 1490 (or Applied Mathematics 1070), and Geological Sciences 0580, 1580, 1710.

Bachelor of Arts in Business, Entrepreneurship, and Organizations (BEO)

The BEO Program is a multidisciplinary, multi-track undergraduate concentration in Business, Entrepreneurship, and Organizations, Sponsored by the Departments of Economics and Sociology, and the School of Engineering, this concentration offers students a coordinated, integrated, and synergistic approach to teaching and learning about commerce, organizational theory, entrepreneurship, and technological innovation. BEO places specific emphasis on the formation, growth, and organization of new ventures, innovation in commercial applications, financial markets and the marketplace, and management and organizational theory. Students will learn the methodological approaches of economics, sociology, engineering, and entrepreneurship to study for-profit and nonprofit enterprises in the national and global economic context.

Students focus their course of study on one of the following three tracks within the program:

- Business Economics
- Entrepreneurship and Technology Management
- Organizational Studies
The School of Engineering is responsible for the *Entrepreneurship and Technology Management* track. Students who successfully complete this program in any of the three tracks will receive an A.B. degree in Business, Entrepreneurship and Organizations.

The starting point for concentrators in the Technology Track of BEO is Engineering 0030. In addition to this course, students interested in the *Entrepreneurship and Technology Management* track are required to take a six course sequence in engineering/science subjects, in order to develop depth in a technical field. The particulars of this program track may be found at coe.brown.edu/concentration/entrepreneurship.html.

**Bachelor of Science and Bachelor of Arts**

Students who wish to combine the study of engineering with study in the arts, humanities, or social sciences can arrange a five-year program leading to an Sc.B. in Engineering and an A.B. in a non-technical field. Such a program must meet all requirements for an Sc.B. degree in Engineering, as well as all requirements for an A.B. degree with concentration in the non-technical field. Normally, the first-year courses in such a program would include Engineering 0030 and 0040 and Mathematics 0190, 0200 (or 0090, 0100). The other courses usually taken by Sc.B. students concentrating in engineering, such as Chemistry 0330, would be postponed until the second year of study.

The program should be developed through consultation with an engineering faculty advisor to be certain that proper attention is paid to the sequential nature of the engineering curriculum in postponing various courses in order to spread the customary four-year Sc.B. in engineering program over a five-year period.

**Bachelor of Science and Master of Science in Engineering**

Undergraduates in engineering with high academic standing may enter an integrated program leading to the award of a master of science degree at the end of the academic year following receipt of the bachelor of science degree. They will also normally include, in their senior year, courses designated as “Primarily for Graduates” in the Brown University Bulletin. During the fifth year, the student in the integrated program can achieve an unusually strong academic program for the master of science degree. Work toward the doctorate, for those so inclined and qualified, would be facilitated by this program. The master of science degree granted under this program is available as either the thesis or non-thesis option. General requirements for the master of science degree are given in the Brown University Bulletin.

**Program in Innovation Management and Entrepreneurship (PRIME)**

In addition to the above option for pursuing a master’s degree in a traditional engineering field, students in Brown’s engineering programs can elect to pursue an integrated program leading to the master of science in Innovation Management and Entrepreneurship. The details of this program are offered at [http://www.brown.edu/academics/engineering/prime/](http://www.brown.edu/academics/engineering/prime/). The PRIME master’s degree focuses on developing science and engineering graduates’ skills so as to prepare them to more efficiently participate in a complex and highly competitive technology-driven economy, by focusing on the processes for developing embryonic ideas from technical fields into bases of commercial activity. PRIME is a year-long program that supplements the student’s technical background with a background in key aspects of business and entrepreneurship. It emphasizes the global business environment by supplementing the courses offered here at Brown with a trip to a foreign country to learn about the working of entrepreneurial processes in different economic settings.

**Undergraduate Teacher Education Program**

For students interested in a career in education, the School of Engineering and Department of Education has established an Undergraduate Teacher Education Program for students concentrating in any of the engineering disciplines (A.B. or Sc.B.). Graduates are certified by the State of Rhode Island to enter careers as primary or secondary school science teachers. The graduates of the program are uniquely qualified to teach science in an engaging, technology-based and application-oriented setting. The program builds on the strong commitment of the engineering faculty students to outreach programs in K-12 education.

The program is not a concentration program. Students graduate with an engineering degree, but must also take the following courses from the Education Department in addition to their engineering requirements:
• EDUC 0900: Field work and seminar in High School Education
• One Education Foundations course.
• EDUC 1450: Psychology of Teaching
• EDUC 2060: Methods of Teaching (summer between semester VI and VII) - includes practice teaching
• EDUC 1070: Student Teaching
• EDUC 1080: Analysis of Teaching seminar

The engineering courses for the Teacher Education Program must include ENGN 0510, Electricity and Magnetism, and Physics 0790, the Physics of Matter. Students interested in the program formally apply during the fall of their Junior year, but are encouraged to speak with Professor Rashid Zia as early as possible during their Brown career.

Students Interested in Architecture

Students contemplating the possibility of pursuing a degree in architecture after finishing their undergraduate program at Brown can prepare themselves by taking selected courses in Visual Arts, Engineering, and History of Art and Architecture at Brown, as well as certain courses at RISD. A foundation in structural analysis and design can be obtained by taking the following sequence of courses in Engineering: 0030, 0310, 1300, 1380. (It is noted that the upper level courses carry a mathematics prerequisite through Applied Mathematics 0340.) Additional Engineering courses of interest are: Engineering 0040, 0410, 0720, 0810, 1360, 1740.

Since the pre-architecture program is not one of the standard engineering concentrations, it can be quite flexible. It can be pursued as part of one of the standard Engineering Sc.B. programs (most typically Civil Engineering), as an Engineering A.B. program, and even as a non-engineering concentration, as long as proper attention is paid to fulfilling the prerequisites for the courses involved.

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 rather than taking the specific courses listed for the Freshman year (see page 8 for a sample listing). Some very advanced students may actually start with the courses listed for Semester III, as arranged during freshman week with their Freshman Advisor (an Engineering Faculty member) on an individual basis. Note: Advanced Placement unlike transfer credit for university level courses, cannot be used to satisfy any concentration requirement.

Students must take one college-level chemistry course at Brown. Those students who have good high school preparation in chemistry should take Chemistry 0330 — especially if they are likely to concentrate in Biomedical, Chemical and Biochemical, or Materials Engineering. Students with very little preparation in chemistry may prepare for Chemistry 0330 via self-study or Chemistry 0100. However, Chemistry 0100 does not satisfy the “college-level chemistry” requirement of the Engineering programs. Students who place out of Chemistry 0330 must successfully complete another higher level Chemistry course in order to receive course credit for Chemistry 0330.

Our ABET accredited programs specify that students 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), Applied Math 1170 (Numerical Analysis), Applied Math 1210 (Operations Research), or Applied Math 1650 (Statistical Inference). However, the student with advanced placement credit for 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.

Students can enroll in ENGN 0030 if they are taking Math 0100 concurrently (or are beyond that level). Those in Math 0090 cannot take ENGN 0030 until they reach that level. The minimum four-course humanities and social sciences requirement for the Sc.B. in Engineering cannot be met by advanced placement.
**Honors**

According to the Brown University Faculty Rules, “The University shall, at graduation, grant Honors to students whose work in a field of concentration has demonstrated superior quality and culminated in an Honors Thesis of Distinction.” Eligibility for the honors program in The School of Engineering is determined based on the student’s academic performance at the end of the first semester of the senior year. Students may apply for admission to the Honors Program on a form available in the Engineering Student Affairs Office. The application must be submitted to that office prior to November 10 of the student’s senior year.

The application form includes a section on academic performance and another section on the proposal for the candidate’s Honors Thesis. The proposed thesis project must be endorsed by an Engineering faculty member who will also act as the Honors Advisor to that student. The minimum grade point average for admission to the Engineering Honors Program is 3.4/4.0 on graded coursework. This GPA will normally be calculated based on the courses that are required to satisfy engineering concentration requirements and which are listed on the applicant’s approved engineering concentration form. No more than one of the required engineering courses may be independent studies (ENGN1970/1971) and courses not taken for a grade will not be included in the GPA calculation. It is expected that, whenever possible, honors candidates will have taken nearly all the required technical courses (other than EN0030) in their concentration for a grade. The Honors application form will be reviewed by the Honors Committee to determine admission to the Honors Program.

Honors work may be fulfilled in part by work done during the senior year in an “Independent Studies in Engineering” course (ENGN 1970/1971). In such cases, course credit will also be given to the student upon successful completion of the independent studies course(s). The requirements for the Honors Program may also be fulfilled without enrolling in a course, in which case it will carry no course credit. A written thesis, in the required format, must be submitted to the honors committee. The honors committee consists of the Honors Chair, appointed by the School of Engineering, the student’s honors research faculty advisor, and a faculty (or appropriate equivalent) reader. The thesis defense will be scheduled with the Engineering Student Affairs Office near the end of the spring semester. The thesis defense consists of a public presentation followed by questions from the honors committee and/or the general audience. Please note that all Honors requirements must be successfully completed no later than the beginning of the Reading Period of the spring semester in order to receive Honors at graduation.

Admission to the Honors Program does not guarantee that a student will receive Honors upon graduation. Recommendation for this distinction by the School of Engineering requires that the candidate continues to demonstrate academic excellence in the spring semester, completes an “Honors Thesis of Distinction,” and successfully defends his/her thesis in an oral examination. It is only when all three of these requirements have been fulfilled that a recommendation for Honors will be submitted to the College Curriculum Council of Brown University. Additional details on the Honors program and forms are available in the Engineering Student Affairs Office.

**Advising and Transfers**

The Engineering faculty strongly believes that advising is important for students throughout their undergraduate years at Brown. Entering students who indicate an interest in concentrating in Engineering are assigned an Engineering faculty advisor, with whom they meet for discussion during orientation week. Students who transfer into Engineering after beginning their studies at Brown, or who transfer from another University, should consult the Dean of Engineering who will assign him or her to a faculty advisor in Engineering. Students are responsible for meeting regularly with their assigned faculty advisor to discuss their academic program to be taken during the first two years. The responsibility for initiating contact for each meeting lies with the student. Students needing assistance beyond what they may receive from their Engineering faculty advisor should contact the Director of Engineering Undergraduate Programs or the Associate Dean for Academic Programs.

**Transfer Credit**

Students who have successfully completed college courses elsewhere may apply to the University for transfer credit. (See the Brown University Bulletin for procedures, or contact the Dean of the College.)

Transfer courses that are used to meet concentration requirements must be approved by the student’s concentration advisor, and must be described briefly on the student’s concentration electronic 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 ABET credit hour 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 concentration committee.

It is the policy of the School of Engineering that students who graduate from Brown with an Engineering degree have completed most of the Engineering portion of their program while in residence as a matriculated student at Brown University. (This includes courses completed abroad under the auspices of the Brown Office of International Programs.) Therefore, the use of a “large number” of transfer or concentration credits to complete a Brown Engineering degree after the student has left Brown, is discouraged. Rather than placing an absolute limit on the number and types of such courses or credits that will be accepted towards a Brown Engineering degree, each such case will be reviewed by the Engineering Concentration Committee which will make a recommendation to the Engineering Executive Committee of what course credits to accept or deny, on an individual basis. The Engineering Executive Committee will make the final decision in such cases.

**Special Concentrations**

Most regular concentrations allow some flexibility in the selection of courses beyond the second year. If the listed concentration requirements do not include a combination of courses that satisfies a student's educational objectives, then he or she is invited to submit a proposed alternative program to the Engineering Concentration Committee for consideration as a “Special Concentration.” Students with a special concentration will receive an ScB degree in engineering, but a specific area of specialization will not be noted on their transcript.

A “Special” ScB 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 ScB 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, and should not be substantially similar to an existing concentration. 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 ScB requirements: for example, ENGN 0020, 0090, 0900, 0930, and 1010 do not qualify. The program should be complemented by at least four courses in humanities and social sciences.

Petitions should be prepared in consultation with a faculty advisor, who will submit the petition to the concentration committee. Faculty members who may act as independent concentration advisors are listed in the last section of this booklet. 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 advisor for this course; and (iv) an up-to-date internal transcript.

**Concentration Forms**

Students should consult with the appropriate Engineering Concentration Advisor(s) by their fourth semester. During their fourth semester, students must file a declaration of concentration using the electronic form available at [https://concentration.engin.brown.edu](https://concentration.engin.brown.edu) (The Dean of the College concentration form does NOT need to be completed to declare an engineering concentration). A printed copy of the “Engineering Concentration Form,” should also be filed with the Engineering Student Affairs Office (Barus & Holley Room 307).

Through the submission of the form, a student indicates his or her candidacy for either an A.B. or an Sc.B. degree in Engineering, and selects a particular field of Engineering for concentration. In making this selection, each student is encouraged to consult with faculty members in his or her areas of interest — especially members of the Engineering Concentration Committee who are responsible for advising in these
areas. If a regular concentration is selected, then the student is automatically assigned to the corresponding Concentration Advisor.

The complete concentration program must be prepared using the electronic Engineering Concentration Form, available at https://concentration.engin.brown.edu/ (the form requires Internet Explorer). Your username and password for this system are the same as those used for the undergraduate engineering facility. Note that for security reasons, a secure or VPN connection to the Brown network is needed to access the form. If you have trouble, please try connecting to the site from the instructional computer facility – it will work from there. The electronic system will automatically print a hard-copy of the School of Engineering form, which should be filed with the Student Affairs Office.

A concentration program is not officially approved until it has received electronic approval by the Chairman of the Concentration Committee. Approval by an individual Concentration Advisor does not constitute final official approval of the program. Students may change their sequence of courses at any time after filing a concentration form. To do so, they should consult the appropriate concentration advisor to ensure that the revised plan meets requirements, and updated and resubmit their electronic concentration form. The revised form must be re-approved by both the concentration advisor and the Concentration Committee chair. Students who fail to file revised forms are following unapproved programs that may not meet degree requirements. Students who decide to switch their area of concentration must also re-file the Registrar’s form to ensure their University transcripts are updated.

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 ABET credit hour 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 concentration committee.

Study Abroad

As in all fields of study at Brown University, it is possible for students to pursue study abroad in Engineering. The Office of International Programs (OIP, J.W. Wilson Rm 420) maintains a library of courses of study, including some Engineering disciplines, in various foreign universities. Several programs have been designed with engineering students in mind, including those in Spain (Santander), in France (Ecole Central Paris) and in Germany (Dresden, offered through a partnership with Boston University). Engineering students have also successfully organized study abroad at universities in several other countries, including England, Australia, New Zealand, Brazil, etc. Any student interested in study abroad should begin planning and acquiring information as early as possible. Applications for Study Abroad must be made through OIP.

In order to obtain transfer and/or concentration credit for any course taken at a foreign university, it must be transferable to the Brown curriculum. To meet this requirement, it is necessary for the student to obtain as much information as possible about the course; that is, the course syllabus, the course textbook(s), information about the course laboratory component, the number of hours the course meets, the duration of the course, and the grading system. This information should be conveyed to the appropriate faculty member(s) at Brown currently teaching the corresponding course(s) in the curriculum in order to obtain pre-approval for the proposed course(s). It is essential that pre-approval of each of the courses proposed for transfer and/or concentration credit be obtained, so that there is reasonable assurance that appropriate credit will be awarded at Brown upon satisfactory completion. Engineering Concentration Advisors should be consulted as early as possible regarding any plans for study abroad for a preliminary assessment of the transferability of proposed course(s), and to identify the appropriate faculty member(s) to be consulted for pre-approval. Because of language problems, differences in university calendars, etc., it is not always possible to certify a foreign course that satisfies the requirements of an individual Brown course completely. In such cases, the foreign course(s), together with a component of a course at Brown (a laboratory, for example) may be used to fulfill the requirements.
ADVISORS

Engineering Concentration Committee and Concentration Advisors

The current Concentration Advisors, who are all members of the Engineering Concentration Committee, are as follows:

Iris Bahar (Chair, Engineering Concentration Committee), B&H 322, x3-1430  
Janet Blume (Civil Engineering), University Hall 407, x3-2313  
Cylde Briant (Materials Engineering), B&H 220, x3-5734  
Sean Deoni (Biomedical Engineering), Arnold Lab 317A, x3-7664  
Pedro Felzenszwalb (Computer Engineering), B&H 355, x3-1531  
Christian Franck (Engineering A.B. Programs and Mechanical Engineering), B&H 739, x3-2863  
Indrek Külaots (Environmental Engineering), B&H 739, x3-2674  
Andrew Peterson (Chemical and Biochemical Engineering), B&H 247, x3-2153  
Jacob Rosenstein (Electrical Engineering), B&H 353, x3-2652  
Alexander Zaslavsky (Engineering & Physics), B&H 222, x3-1406  
Rashid Zia (Director of Undergraduate Programs), B&H 237, x3-6351

Special Program Advisors

Jennifer Franck, Brian Sheldon, Gabriel Taubin, and Anita Shukla (Honors Program)  
Eric Suuberg (BEO Program and Fifth year PRIME program)  
Rashid Zia (UTEP Undergraduate Teacher Preparation Program)

* For the five-year A.B./Sc.B. program, see the appropriate Sc.B. Concentration Advisor listed above.  
** For the five year combined ScB/MS, please see the appropriate Sc.B. Concentration Advisor listed above, as well as the Graduate Concentration Advisor for that discipline.

Student Chapter Advisors

Indrek Kulaots (American Institute of Chemical Engineers, AIChE)  
Kenneth Breuer (American Society of Mechanical Engineers, ASME)  
Christopher Bull (Better World by Design)  
Anubhav Tripathi (Biomedical Engineering Society, BMES)  
Christopher Bull (Brown Building Society, BBS)  
Rick Fleeter (CubeSat)  
Christopher Bull (Engineers Without Borders, EWB)  
Christopher Bull (FSAE Car Team)  
Jacob Rosenstein (Institute of Electrical and Electronics Engineers, IEEE)  
Jennifer Casasanto and Barrett Hazeltine (National Society of Black Engineers, NSBE)  
David Targan (Sigma Xi)  
Kareen Coulombe and Anita Shukla (Society of Women Engineers, SWE)  
Rashid Zia (Tau Beta Pi)  
Jodie Gill, Office of the Dean of the College (Women in Science and Engineering, WISE)
THE FACULTY

Biomedical Engineering

Borton, David A., Ph.D., Brown University
Neuroengineering, neuromotor disease, and neuroprosthetics.

Breuer, Kenneth, Ph.D., Massachusetts Institute of Technology
Microfluidics, Biomechanics, animal swimming and flight.

Coulombe, Kareen, Ph.D., University of Washington
Cardiac tissue engineering, muscle mechanics, stem cell biology, and regenerative medicine.

Daniels, Jerry D., Ph.D., University of California at Berkeley
Neural networks, genetic algorithms, visual physiology, eye movements, development of the nervous system, bio-instrumentation.

Deoni, Sean, Ph.D., University of Western Ontario
Magnetic Resonance Imaging (MRI), MRI of brain development in infancy, white matter alteration in Multiple Sclerosis, Alzheimer’s Disease and other neurological disorders, motion correction in MRI

Hochberg, Leigh, M.D., Ph.D., Emory University
Developing technologies to restore the communication, mobility, and independence of people with neurologic disease, injury, or limb loss.

Coulombe, Kareen, Ph.D., University of Washington
Cardiac tissue engineering, muscle mechanics, stem cell biology, and regenerative medicine.

Mathiowitz, Edith, Ph.D., Weizmann Institute of Science
Drug and gene delivery, biomaterials, bioadhesion, tissue engineering, liquid crystals.

Morgan, Jeffrey R., Ph.D., Harvard University
Gene therapy/tissue engineering; retroviral-mediated gene transfer; cellular/molecular biology of skin/wound healing; genetic diseases of the skin; cell transplantation and cell-based drug delivery.

Palmore, G. Tayhas R., Ph.D., Massachusetts Institute of Technology
Molecular crystals, biological fuel cells, biomaterials.

Powers, Thomas R., Ph.D., University of Pennsylvania
Molecular and cellular biomechanics.

Richardson, Peter D., Ph.D., D.Sc., F.R.S., University of London
Biomedical fluid mechanics.

Anita Shukla, Ph.D., Massachusetts Institute of Technology
Biomaterials, self-assembly, drug delivery, regenerative medicine.

Tripathi, Anubhav, Ph.D., City University of New York, New York
Biomolecular transport and reaction, Disease Diagnostics and detection, Microfluidics

Wong, Ian, Ph.D., Stanford University
Biomaterials, nanofabrication, 3D printing, directed self-assembly, polymer physics.

Chemical and Biochemical Engineering

Hurt, Robert H., Sc.D., Massachusetts Institute of Technology
Carbon materials, mesogenic materials, nanotoxicology, nanomaterials in the environment, graphene-based materials

Palmore, G. Tayhas R., Ph.D., Massachusetts Institute of Technology
Electrochemical energy conversion, biochemical sensing

Peterson, Andrew, Ph.D., Massachusetts Institute of Technology
Heterogeneous catalysis, electronic structure theory, sustainable fuels

Sheldon, Brian W., Sc.D., Massachusetts Institute of Technology
Carbon materials, chemical vapor deposition, composites, battery technologies

Suuberg, Eric M., Sc.D., Massachusetts Institute of Technology
Kinetics, combustion, carbons, energy/environmental issues

Tripathi, Anubhav, Ph.D., City University of New York
Microfluidics, Biofluidics, Nanotechnology, Rheology, Complex Fluids.

Vlahovska, Petia, Ph.D., Yale University
Complex fluids, colloid and surface science, soft matter
**Computer Engineering**

Bahar, R. Iris, Ph.D., University of Colorado
  Computer engineering, computer-aided design for VLSI.

Felzenszwalb, Pedro F., Ph.D., Massachusetts Institute of Technology
  Computer vision, artificial intelligence, machine learning, algorithms.

Kimia, Benjamin B., Ph.D., McGill University
  Computer vision and image processing, artificial intelligence.

Reda, Sherief, Ph.D., University of California, San Diego
  Design Automation techniques for VLSI digital circuits and DNA arrays

Rosenstein, Jacob, Ph.D., Columbia University
  Mixed-signal electronics, instrumentation, electrophysiology, nanopore sensors, embedded systems, VLSI, sensor interfaces, microfluidics.

Silverman, Harvey F., Ph.D., Brown University
  Digital signal processing, speech recognition and analysis, computer architecture, microphone-array systems, nonlinear optimization.

Taubin, Gabriel, Ph.D., Brown University
  Computer vision, computer graphics, geometric modeling, mesh signal processing, geometry compression, smart cameras, smart sensor networks, embedded systems.

**Electrical Engineering**

Bahar, R. Iris, Ph.D., University of Colorado
  Computer engineering, computer-aided design for VLSI.

Beresford, J. Roderic, Ph.D., Columbia University
  Molecular beam epitaxy, electronic materials and devices.

Daniels, Jerry D., Ph.D., University of California at Berkeley
  Neural networks, genetic algorithms, visual physiology, eye movements, development of the nervous system, bio-instrumentation.

Deoni, Sean, Ph.D., University of Western Ontario
  Magnetic Resonance Imaging (MRI), MRI of brain development in infancy, white matter alteration in Multiple Sclerosis, Alzheimer’s Disease and other neurological disorders, motion correction in MRI

Hochberg, Leigh, Ph.D., Emory University
  Translational Neuroscience Interests: Brain-Computer Interfaces, Neurotechnology.

Kimia, Benjamin B., Ph.D., McGill University
  Computer vision and image processing, artificial intelligence.

Larson, Lawrence, Ph.D., University of Southern California
  Wireless communications, Semiconductor devices, high-frequency circuits, communications systems.

Nurmikko, Arto V., Ph.D., University of California at Berkeley
  Photonic device technology, nanoelectronics, neural circuits.

Pacifici, Domenico, Ph.D., University of Catania, Italy
  Silicon-based microphotonics, nanophotonics, plasmonics. Nanoengineered materials and devices for information, sensing and energy-harvesting applications.

Reda, Sherief, Ph.D., University of California, San Diego
  Design Automation techniques for VLSI digital circuits and DNA arrays

Rosenstein, Jacob, Ph.D., Columbia University
  Mixed-signal electronics, instrumentation, electrophysiology, nanopore sensors, embedded systems, VLSI, sensor interfaces, microfluidics.

Silverman, Harvey F., Ph.D., Brown University
  Digital signal processing, speech recognition and analysis, computer architecture, microphone-array systems, nonlinear optimization.

Taubin, Gabriel, Ph.D., Brown University
  Computer vision, computer graphics, geometric modeling, mesh signal processing, geometry compression, smart cameras, smart sensor networks, embedded systems.

Xu, J.M. (Jimmy), Ph.D, University of Minnesota
  Nano and molecular engineering, optoelectronics, semiconductor lasers, quantum electronics.
Zaslavsky, Alexander, Ph.D., Princeton University
Physics and technology of semiconductor nanostructures and devices.

Zia, Rashid, Ph.D., Stanford University
Nanophotonics, metamaterials, solid-state emitters, and quantum optics.

**Environmental Engineering**

Hurt, Robert H., Sc.D., Massachusetts Institute of Technology
Carbon materials, mesogenic materials, nanotoxicology, nanomaterials in the environment, graphene-based materials

Kulaots, Indrek, Ph.D., Brown University
No cost carbonized bio-wastes for environmental clean up, porous structures in graphene family materials, sustainable use of conventional energy resources, reuse of byproducts in energy conversion processes

Palmore, G. Tayhas R., Ph.D., Massachusetts Institute of Technology
Electrochemical energy conversion, biochemical sensing

Peterson, Andrew, Ph.D., Massachusetts Institute of Technology
Heterogeneous catalysis, electronic structure theory, sustainable fuels

Suuberg, Eric M., Sc.D., Massachusetts Institute of Technology
Kinetics, combustion, carbons, energy/environmental issues

**Materials Engineering**

Briant, Clyde L., Sc.D., Columbia University
Physical metallurgy, materials processing, refractory metals, high strain-rate deformation.

Chason, Eric, Ph.D., Harvard University
Thin film evolution, *in situ* diagnostics, computer simulation.

Hurt, Robert H., Sc.D., Massachusetts Institute of Technology
Energy and environmental technology, combustion, carbon materials.

Kingon, Angus, Ph.D., University of South Africa
Nonvolatile memories, silicon logic devices, dielectric materials, cellular devices, and microwave systems.

Kumar, K. S., Ph.D., Drexel University
Composites, intermetallics, physical metallurgy, materials processing, high temperature mechanical behavior.

Padture, Nitin P., Ph.D., Lehigh University
Advanced ceramics, composites, coatings, nanomaterials, synthesis/processing, characterization, mechanical behavior, thermal and electronic properties.

Paine, David C., Ph.D., Stanford University
Synthesis and characterization of electronic materials, ultra-high pressure methods, rapid thermal CVD, electron microscopy, X-ray diffractometry, optical and electrical characterization.

Palmore, G. Tayhas R., Ph.D., Massachusetts Institute of Technology
Molecular crystals, biological fuel cells, biomaterials.

Sheldon, Brian W., Sc.D., Massachusetts Institute of Technology
Synthesis and processing of advanced ceramics and diamond films, oxidation of high-temperature materials.

Anita Shukla, Ph.D., Massachusetts Institute of Technology
Biomaterials, self-assembly, drug delivery, regenerative medicine.

Tripathi, Anubhav, Ph.D., City University of New York
Microfluidics, Biofluidics, Nanotechnology, Rheology, Complex Fluids.

van de Walle, Axel, Ph.D., Massachusetts Institute of Technology
Computational materials science, energy materials, first-principles calculations, nanomaterials, phase diagrams, thermodynamics.

Wong, Ian, Ph.D., Stanford University
Biomaterials, nanofabrication, 3D printing, directed self-assembly, polymer physics.
Mechanical Engineering

Blume, Janet A., Ph.D., California Institute of Technology
Finite deformation solid mechanics, constitutive equations.

Bower, Allan F., Ph.D., Cambridge University
Computational mechanics of structural and energy storage materials.

Breuer, Kenneth, Ph.D., Massachusetts Institute of Technology
Microfluidics, Animal swimming and flight. Energy Harvesting

Franck, Christian, Ph.D., California Institute of Technology
Experimental Cell Mechanics, physics of soft materials, 3D microscopy, experimental micromechanics.

Gao, Huajian, Ph.D., Harvard University
Biomechanics, nanomechanics, mechanics of thin films, mechanics of hierarchical materials, fracture mechanics.

Guduru, Pradeep R., Ph.D., California Institute of Technology
Experimental Mechanics at micron and nanometer scales, micro-sensors, dynamic deformation and fracture.

Henann, David, Ph.D., Massachusetts Institute of Technology
Theoretical and computational mechanics, granular materials, soft materials.

Kesari, Haneesh, Ph.D., Stanford University
Analytical and experimental mechanics, structural biomaterials.

Kim, K. S., Ph.D., Brown University
Nano- and micro-mechanics of solids, adhesion, experimental mechanics.

Liu, Joseph T. C., Ph.D., California Institute of Technology
Aerodynamic noise, hydrodynamic stability, turbulent shear flows.

Mandre, Shreyas, Ph.D., University of British Columbia
Fluid-structure interaction, wetting and interfacial flows, heat and mass transport.

Powers, Thomas R., Ph.D., University of Pennsylvania
Molecular and cellular biomechanics, soft condensed matter physics.

Richardson, Peter D., Ph.D., D.Sc., F.R.S., University of London
Biomedical fluid mechanics.

Vlahovska, Petia, Ph.D., Yale University
Physico-chemical hydrodynamics, complex fluids, cellular biophysics

Faculty Emeriti

Calo, Joseph M., Ph.D., Princeton University
Applied chemical kinetics, energy/environmental technology, carbon materials.

Caswell, Bruce, Ph.D., Stanford University
Flow of viscoelastic fluids, heat transfer.

Clifton, Rodney J., Ph.D., Carnegie Institute of Technology
Dynamic plasticity, dynamic fracture, mechanics of biological tissues, experimental mechanics.

Cooper, David B., Ph.D., Columbia University
Computer vision, pattern recognition, communication and information sciences.

Dobbins, Richard A., Ph.D., Princeton University
Aerosol dynamics, combustion, heat and mass transfer.

Freund, L. B., Ph.D., Northwestern University

Glicksman, Maurice, Ph.D., University of Chicago
Electrical and optical properties of semiconductors, semiconducting devices.

Hazeltine, Barrett, Ph.D., University of Michigan
Management of technology, technology in development, engineering education, digital systems.

Karlsson, Sture K. F., Ph.D., The Johns Hopkins University
Stability of flows, stratified flows, laser velocimetry, origins of turbulence, flow of blood.

Morse, Theodore F., Ph.D., Northwestern University
Laser processing of materials, optical fibers/sensors.
Pearson, Allan E., Ph.D., Columbia University
   Control theory, system modeling and parameter identification
Richman, Marc, Sc.D., Massachusetts Institute of Technology
   Structure and properties of materials, microscopy, ceramics, failure analysis.
   Optical properties of solids, properties of amorphous semiconductors and metals.
Weiner, Jerome H., Ph.D., Columbia University
   Dislocation dynamics, rate theory, polymers.
Wolovich, William A., Ph.D., Brown University
   Linear multivariable systems, robust control system design, robotics