Computer Science

Computer science is now a critical tool for pursuing an ever-broadening range of topics, from outer space to the workings of the human mind. In most areas of science and in many liberal arts fields, cutting-edge work depends increasingly on computational approaches. The undergraduate program at Brown is designed to combine breadth in practical and theoretical computer science with depth in specialized areas. These areas range from traditional topics, such as analysis of algorithms, artificial intelligence, databases, distributed systems, graphics, mobile computing, networks, operating systems, programming languages, robotics and security, to novel areas including games and scientific visualization.

Our requirements are built on a collection of pathways, each representing a well-defined area within computer science. Concentrators interested in particular areas can choose the courses included in particular pathways.

Conversely, concentrators who are unsure of their area of interest but who have particularly enjoyed certain courses can choose pathways that include these concentrations. Students may not use more than two CSCI 1970 courses to complete the requirements for the Sc.B. and one CSCI 1970 course for the A.B. requirements.

Requirements for the Standard Track of the Sc.B. degree

Prerequisites (0-3 courses)
Calculus prerequisite: students must complete or place out of second semester calculus.
- MATH 0100 Introductory Calculus, Part II
- or MATH 0170 Advanced Placement Calculus
- or MATH 0190 Advanced Placement Calculus (Physics/Engineering)

Concentration Requirements

Core-Computer Science:
Select one of the following introductory course Series:

Series A
CSCI 0150 & CSCI 0160 Introduction to Object-Oriented Programming and Computer Science and Introduction to Algorithms and Data Structures

Series B
CSCI 0170 & CSCI 0180 Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction

Series C
CSCI 0190 Accelerated Introduction to Computer Science (and an additional CS course not otherwise used to satisfy a concentration requirement; this course may be CSCI 0180, an intermediate-level course, or an advanced course)

Thirteen CS courses numbered 0220 or higher. **13**

Two complete pathways (at least one core course from each)

Each requires two 1000-level courses as well as one-to-three intermediate courses

One of the courses used in one pathway must be a capstone course (defined below)

The core and related courses used in one pathway may not overlap with those used in another

Additional intermediate courses so that a total of five are taken, with at least one from each of the three categories

One additional 1000-level course that is neither a core nor a related course for the pathways used above

Intermediate Courses

Students must complete the intermediate courses defined for the pathway they choose. In addition, ScB students must take at least one course from each intermediate course category to ensure they span all areas. Taking additional courses beyond those listed for the pathway may be required.

<table>
<thead>
<tr>
<th>Foundations</th>
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</thead>
<tbody>
<tr>
<td>CSCI 0220 Introduction to Discrete Structures and Probability</td>
</tr>
<tr>
<td>CSCI 1010 Theory of Computation</td>
</tr>
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<table>
<thead>
<tr>
<th>Mathematics</th>
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<tbody>
<tr>
<td>CSCI 0530 Coding the Matrix: An Introduction to Linear Algebra for Computer Science</td>
</tr>
<tr>
<td>or MATH 0520 Linear Algebra</td>
</tr>
<tr>
<td>or MATH 0540 Honors Linear Algebra</td>
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<tr>
<td>CSCI 1450 Probability for Computing and Data Analysis</td>
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<td>or APMA 1650 Statistical Inference I</td>
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<tr>
<th>Systems</th>
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<tbody>
<tr>
<td>CSCI 0320 Introduction to Software Engineering</td>
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<td>CSCI 0330 Introduction to Computer Systems</td>
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</table>

Pathways
Completing a pathway entails taking two courses in the pathway of which at least one is a course course for the pathway. One must also take the intermediate courses specified as part of the pathway.

SYSTEMS: studies the design, construction, and analysis of modern, multi-faceted computing systems

Core Courses
- CSCI 1380 Distributed Computer Systems
- or CSCI 1670 Operating Systems
- or CSCI 1680 Computer Networks

Related Courses
- CSCI 1270 Database Management Systems
- or CSCI 1320 Creating Modern Web & Mobile Applications
- or CSCI 1600 Real-Time and Embedded Software
- or CSCI 1650 Software Security and Exploitation
- or CSCI 1660 Introduction to Computer Systems Security
- or CSCI 1730 Design and Implementation of Programming Languages
- or CSCI 1760 Multiprocessor Synchronization
- or CSCI 1950Y Logic for Systems
- or ENGN 1640 Design of Computing Systems

Intermediate Courses
- CSCI 0330 Introduction to Computer Systems
- CSCI 0220 Introduction to Discrete Structures and Probability
- or CSCI 0320 Introduction to Software Engineering

SOFTWARE PRINCIPLES: studies the design, construction, and analysis of modern software systems

Core Courses
- CSCI 1280 Compilers and Program Analysis
- or CSCI 1320 Creating Modern Web & Mobile Applications
- or CSCI 1600 Real-Time and Embedded Software
- or CSCI 1730 Design and Implementation of Programming Languages
- or CSCI 1950Y Logic for Systems

Related Courses
Core Courses
CSCI 1270 Database Management Systems
or CSCI 1380 Distributed Computer Systems
or CSCI 1650 Software Security and Exploitation

Intermediate Courses
CSCI 0220 Introduction to Discrete Structures and Probability
CSCI 0320 Introduction to Software Engineering
CSCI 0330 Introduction to Computer Systems (Data)

DATA: Studies the management and use of large data collections
Core Courses
CSCI 1270 Database Management Systems
or CSCI 1420 Machine Learning
or CSCI 1951A Data Science

Related Courses
CSCI 1550 Probabilistic Methods in Computer Science
or CSCI 1580 Information Retrieval and Web Search
or ECON 1660 Big Data

Intermediate Courses
CSCI 0320 Introduction to Software Engineering
or CSCI 0330 Introduction to Computer Systems
MATH 0520 Linear Algebra
or MATH 0540 Honors Linear Algebra
or CSCI 0530 Coding the Matrix: An Introduction to Linear Algebra for Computer Science
CSCI 1450 Probability for Computing and Data Analysis
or APMA 1650 Statistical Inference I
or APMA 1655 Statistical Inference I

ARTIFICIAL INTELLIGENCE / MACHINE LEARNING: studies the theory and application of algorithms for making decisions and inferences from rules and data
Core Courses
CSCI 1410 Artificial Intelligence
or CSCI 1420 Machine Learning
or CSCI 1430 Computer Vision
or CSCI 1460 Computational Linguistics

Related Courses
CSCI 1550 Probabilistic Methods in Computer Science
or CSCI 1580 Information Retrieval and Web Search
or CSCI 1951A Data Science
or CSCI 1951C Designing Humanity Centered Robots
or CSCI 1951K Algorithmic Game Theory
or ENGN 1610 Image Understanding

Intermediate Courses
CSCI 1450 Probability for Computing and Data Analysis
or APMA 1650 Statistical Inference I
or APMA 1655 Statistical Inference I

THEORY: students the foundations of models and algorithms for computing in various contexts
Core Courses
CSCI 1510 Introduction to Cryptography and Computer Security
or CSCI 1550 Probabilistic Methods in Computer Science

or CSCI 1570 Design and Analysis of Algorithms
or CSCI 1760 Multiprocessor Synchronization

Related Courses
CSCI 1590 Introduction to Computational Complexity
or CSCI 1810 Computational Molecular Biology
or CSCI 1820 Algorithmic Foundations of Computational Biology
or CSCI 1950H Computational Topology
or CSCI 1950Y Logic for Systems
or CSCI 1951G Optimization Methods in Finance
or CSCI 1951K Algorithmic Game Theory

Intermediate Courses
CSCI 1010 Theory of Computation
CSCI 1450 Probability for Computing and Data Analysis
or APMA 1650 Statistical Inference I
or APMA 1655 Statistical Inference I
MATH 0520 Linear Algebra
or MATH 0540 Honors Linear Algebra
or CSCI 0530 Coding the Matrix: An Introduction to Linear Algebra for Computer Science

SECURITY: studies the design, construction, analysis, and defense of techniques to protect systems, data, and communications
Core Courses
CSCI 1510 Introduction to Cryptography and Computer Security
or CSCI 1660 Introduction to Computer Systems Security
or CSCI 1650 Software Security and Exploitation

Related Courses
CSCI 1320 Creating Modern Web & Mobile Applications
or CSCI 1380 Distributed Computer Systems
or CSCI 1670 Operating Systems
or CSCI 1730 Design and Implementation of Programming Languages
or CSCI 1800 Cybersecurity and International Relations
or CSCI 1950Y Logic for Systems
or CSCI 1951B Virtual Citizens or Subjects? The Global Battle Over Governing Your Internet

Intermediate Courses
CSCI 0330 Introduction to Computer Systems
CSCI 1010 Theory of Computation
CSCI 0220 Introduction to Discrete Structures and Probability

VISUAL COMPUTING: studies the creation, interaction, and analysis of images and visual information, including animation and games
Core Courses
CSCI 1230 Introduction to Computer Graphics
or CSCI 1250 Introduction to Computer Animation
or CSCI 1280 Intermediate 3D Computer Animation
or CSCI 1300 User Interfaces and User Experience
or CSCI 1370 Virtual Reality Design for Science
or CSCI 1430 Computer Vision
or CSCI 1950T Advanced Animation Production
or CSCI 2240 Interactive Computer Graphics

Related Courses
CSCI 1950N 2D Game Engines
or CSCI 1950U Topics in 3D Game Engine Development
or ENGN 1610 Image Understanding
**Intermediate Courses**

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<td>CSCI 1600</td>
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<tr>
<td>or CSCI 1760</td>
<td>Multiprocessor Synchronization</td>
</tr>
<tr>
<td>or ENGN 1600</td>
<td>Design and Implementation of VLSI Systems</td>
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**Intermediate Course**

CSCI 0330  Introduction to Computer Systems

**Core Courses**

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<td>ENGN 1630</td>
<td>Digital Electronics Systems Design</td>
</tr>
<tr>
<td>or ENGN 1640</td>
<td>Design of Computing Systems</td>
</tr>
<tr>
<td>or ENGN 1650</td>
<td>Embedded Microprocessor Design</td>
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**Computational Biology**

**Related Courses**

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<tr>
<td>CSCI 1840</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>or CSCI 1951A</td>
<td>Data Science</td>
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<td>or CLPS 1520</td>
<td>Computational Vision</td>
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<td>Theory of Computation</td>
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**Design**

**Core Courses**

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<tr>
<td>CSCI 1300</td>
<td>User Interfaces and User Experience</td>
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<tr>
<td>or CSCI 1370</td>
<td>Virtual Reality Design for Science</td>
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<td>or CSCI 1951C</td>
<td>Designing Humanity Centered Robots</td>
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<td>or CSCI 1951A</td>
<td>Data Science</td>
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<tr>
<td>or CSCI 1900</td>
<td>cssiStartup</td>
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<tr>
<td>or VISA 1720</td>
<td>Physical Computing</td>
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</table>

**Self-Designed:** This pathway is modeled after the Brown programs for designing one’s own concentration. Students electing this pathway must write a proposal for their pathway and have it approved by an advisor and the director of undergraduate studies. The proposal must meet the breadth and overall course requirements. This must be done by the end of the shopping period for the student’s seventh semester.

1. Capstone: a one-semester course, taken in the student’s last undergraduate year, in which the student (or group of students) use a significant portion of their undergraduate education, broadly interpreted, in studying some current topic in depth, to produce a culminating artifact such as a paper or software project.

2. Certain 1000-level courses may be used to fill the additional 1000-level course requirements for both the AB and ScB. No more than one such course may be used for the AB concentration and no more than three for the ScB concentration. A list of approved non-CS courses is on our web page. Unless explicitly stated on our web page, such non-CS courses may not be used as part of pathways.

**Requirements for the Professional Track of the Sc.B. degree.**

The requirements for the professional track include all of those in the standard track, as well as the following:

- Students must complete two two-to-four-month full-time professional experiences, doing work that is related to their concentration programs. Such work is normally done within an industrial organization, but may also be at a university under the supervision of a faculty member.

On completion of each professional experience, the student must write and upload to ASK a reflective essay about the experience addressing the following prompts, to be approved by the student’s concentration advisor:

- Which courses were put to use in your summer’s work? Which topics, in particular, were important?
- In retrospect, which courses should you have taken before embarking on your summer experience? What are the topics from these courses that would have helped you over the summer if you had been more familiar with them?
- Are there topics you should have been familiar with in preparation for your summer experience, but are not taught at Brown? What are these topics?
- What did you learn from the experience that probably could not have been picked up from course work?
- Is the sort of work you did over the summer something you would like to continue doing once you graduate? Explain.
- Would you recommend your summer experience to other Brown students? Explain.

**Requirements for the Standard Track of the A.B. degree.**

**Prerequisites (0-3 courses)**

Students must complete or place out of second semester calculus.

<table>
<thead>
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<th>Course Code</th>
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<tbody>
<tr>
<td>MATH 0100</td>
<td>Introductory Calculus, Part II</td>
</tr>
<tr>
<td>or MATH 0170</td>
<td>Advanced Placement Calculus</td>
</tr>
<tr>
<td>or MATH 0190</td>
<td>Advanced Placement Calculus (Physics/Engineering)</td>
</tr>
</tbody>
</table>

**Concentration Requirements (9 courses)**

Core Computer Science:

Select one of the following series:

**Series A**

<table>
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<tr>
<th>Course Code</th>
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<tr>
<td>CSCI 0150</td>
<td>Introduction to Object-Oriented Programming and Computer Science</td>
</tr>
<tr>
<td>&amp; CSCI 0160</td>
<td>and Introduction to Algorithms and Data Structures</td>
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**Series B**

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</table>
### Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction

#### Series C

<table>
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<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CSCI 0190</td>
<td>Accelerated Introduction to Computer Science (and an additional CS course not otherwise used to satisfy a concentration requirement; this course may be CSCI 0180, an intermediate-level course, or an advanced course)</td>
</tr>
</tbody>
</table>

Seven CS courses numbered 0220 or higher

## One complete pathway (see ScB for pathways)

- Requires two 1000-level courses as well as one-to-three intermediate courses
- Additional intermediate courses so that a total of three are taken with at least one in each of two different intermediate-course categories (see the ScB requirements for a listing of these categories)
- One additional 1000-level course that is neither a core nor a related course for the pathways used above
- Of the remaining two courses, at least one must be at the 1000-level or higher (i.e., one may be an intermediate course not otherwise used as part of the concentration). One course may be an approved 1000-level course from another department. Unless explicitly stated in a pathway, such non-CS courses may not be used as part of pathways.

## Requirements for the Professional Track of the A.B. degree.

The requirements for the professional track include all those of the standard track, as well as the following:

- Students must complete two two-to-four-month full-time professional experiences, doing work that is related to their concentration programs. Such work is normally done within an industrial organization, but may also be at a university under the supervision of a faculty member.

On completion of each professional experience, the student must write and upload to ASK a reflective essay about the experience addressing the following prompts, to be approved by the student's concentration advisor:

- Which courses were put to use in your summer's work? Which topics, in particular, were important?
- In retrospect, which courses should you have taken before embarking on your summer experience? What are the topics from these courses that would have helped you over the summer if you had been more familiar with them?
- Are there topics you should have been familiar with in preparation for your summer experience, but are not taught at Brown? What are these topics?
- What did you learn from the experience that probably could not have been picked up from course work?
- Is the sort of work you did over the summer something you would like to continue doing once you graduate? Explain.
- Would you recommend your summer experience to other Brown students? Explain.
Font Notice

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

Helvetica was used instead of Arial.

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