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: 2

<table>
<thead>
<tr>
<th>Series A</th>
<th>CSCI 0150 &amp; CSCI 0160</th>
<th>Introduction to Object-Oriented Programming and Computer Science and Introduction to Algorithms and Data Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series B</td>
<td>CSCI 0170 &amp; CSCI 0180</td>
<td>Computer Science: An Integrated Introduction and Computer Science: An Integrated Introduction</td>
</tr>
<tr>
<td>Series C</td>
<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>

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) ²

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

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.

Pathways

Completing a pathway entails taking two courses in the pathway of which at least one is a course for the pathway. One must also take the intermediate courses specified as part of the pathway. Certain graduate courses can also satisfy pathway requirements, see the CS Pathway page for more info: [http://cs.brown.edu/degrees/undergrad/concentrating-in-cs/concentration-handbook/](http://cs.brown.edu/degrees/undergrad/concentrating-in-cs/concentration-handbook/)

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
- or CSCI 1270: Database Management Systems

Related Courses

- CSCI 1310: Fundamentals of Computer 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 ENGN 1640: Design of Computing Systems
Intermediate Courses
CSCI 0330 Introduction to Computer Systems
or CSCI 0300 Fundamentals of 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 1260 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 1951X Formal Proof and Verification

Related Courses
CSCI 1270 Database Management Systems
or CSCI 1380 Distributed Computer Systems
or CSCI 1650 Software Security and Exploitation
or CSCI 1680 Computer Networks
or CSCI 1951I CS for Social Change
or CSCI 1951T Surveying VR Data Visualization Software for Research

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
or CSCI 0300 Fundamentals of 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

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

or CSCI 1470 Deep Learning
or CSCI 1951R Introduction to Robotics

Related Courses
CSCI 1550 Probabilistic Methods in Computer Science
or CSCI 1951A Data Science
or CSCI 1951C Designing Humanity Centered Robots
or ENGN 1610 Image Understanding

Intermediate Courses
CSCI 1450 Advanced Introduction to Probability for Computing and Data Science
or APMA 1650 Honors Statistical Inference I
or APMA 1655 Honors 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

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
or CSCI 1951X Formal Proof and Verification

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 1951G Optimization Methods in Finance

Intermediate Courses
CSCI 1010 Theory of Computation
CSCI 1450 Advanced Introduction to Probability for Computing and Data Science
or APMA 1650 Statistical Inference I
or APMA 1655 Honors 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 1680 Computer Networks
or CSCI 1730 Design and Implementation of Programming Languages
or CSCI 1800 Cybersecurity and International Relations
or CSCI 1805 Computers, Freedom and Privacy

Intermediate Courses
Core Courses

CSCI 0330  Introduction to Computer Systems
or CSCI 0300  Fundamentals of Computer Systems

CSCI 0220  Introduction to Discrete Structures and Probability (Or Probability and Statistics (see options below))
or CSCI 1450  Advanced Introduction to Probability for Computing and Data Science
or APMA 1650  Statistical Inference I
or APMA 1655  Honors Statistical Inference I

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 1290  Computational Photography
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

Related Courses

CSCI 1950N  2D Game Engines
or CSCI 1470  Deep Learning
or CSCI 1950U  Topics in 3D Game Engine Development
or ENGN 1610  Image Understanding
or CLPS 1520  Computational Vision
or DATA 1200  Reality Remix - Experimental VR

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

COMPUTER ARCHITECTURE: studies the design, construction, and analysis of computer architecture and hardware

Core Courses

ENGN 1630  Digital Electronics Systems Design
or ENGN 1640  Design of Computing Systems
or ENGN 1650  Embedded Microprocessor Design

Related Courses

CSCI 1600  Real-Time and Embedded Software
or CSCI 1760  Multiprocessor Synchronization
or ENGN 1600  Design and Implementation of Digital Integrated Circuits

Intermediate Course

CSCI 0330  Introduction to Computer Systems
or CSCI 0300  Fundamentals of Computer Systems

COMPUTATIONAL BIOLOGY: studies the foundations and applications of algorithms for analyzing biological data and processes

Core Courses

CSCI 1810  Computational Molecular Biology
CSCI 1820  Algorithmic Foundations of Computational Biology
CSCI 1850  Deep Learning in Genomics

Related Courses

CSCI 1420  Machine Learning
or CSCI 1430  Computer Vision

or CSCI 1951A  Data Science
or CLPS 1520  Data Science
CSCI 1470  Deep Learning

Intermediate Courses

CSCI 0220  Introduction to Discrete Structures and Probability
CSCI 1010  Theory of Computation
CSCI 1450  Advanced Introduction to Probability for Computing and Data Science
or APMA 1650  Statistical Inference I
or APMA 1655  Honors Statistical Inference I

DESIGN: studies the design, construction, and analysis of processes at the interface between humans and systems

Core Courses

CSCI 1300  User Interfaces and User Experience
or CSCI 1370  Virtual Reality Design for Science
or CSCI 1951C  Designing Humanity Centered Robots

Related Courses

CSCI 1230  Introduction to Computer Graphics
or CSCI 1320  Creating Modern Web & Mobile Applications
or CSCI 1600  Real-Time and Embedded Software
or CSCI 1900  csciStartup
or CSCI 1951A  Data Science
or CSCI 1951I  CS for Social Change
or CSCI 1951T  Surveying VR Data Visualization Software for Research
or CSCI 1951V  Hypertext/Hypermedia Seminar: The Web Was Not the Beginning and the Web Is Not the End
or ENGN 1931I  Design of Robotic Systems
or VISA 1720  Physical Computing

Intermediate Courses

CSCI 0320  Introduction to Software Engineering
or CSCI 0330  Introduction to Computer Systems

CSCI 1450  Advanced Introduction to Probability for Computing and Data Science
or APMA 1650  Statistical Inference I
or APMA 1655  Honors Statistical Inference I

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 shopping period of the student's seventh semester.

1 Students wishing to go directly from CSCI 0111 to CSCI 0180 (without CSCI 0112) will need to successfully complete additional exercises to receive an instructor override code for CSCI 0180.
2 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.
3 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 Standard Track of the A.B. degree

Prerequisites (0-3 courses)

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 (9 courses)

Core Computer Science:

Select one of the following 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)

Series D

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.

## No more than four arts, humanities, and social science oriented CS courses (currently CSCI 1250, 1280, 1370, 1900, 1905, and 1870) may be used for concentration credit.

1 Students wishing to go directly from CSCI 0111 to CSCI 0180 (without CSCI 0112) will need to successfully complete additional exercises to receive an instructor override code for CSCI 0180.

Requirements for the Professional Track of the both the Sc. B. and A.B. degrees.

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

Students must complete full-time professional experiences doing work that is related to their concentration programs, totaling 2-6 months, whereby each internship must be at least one month in duration in cases where students choose to do more than one internship experience. Such work is normally done at a company, but may also be at a university under the supervision of a faculty member.

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.