# Applied Mathematics-Computer Science

The Sc.B. concentration in Applied Math-Computer Science provides a foundation of basic concepts and methodology of mathematical analysis and computation and prepares students for advanced work in applied mathematics, computer science, and data science. Concentrators must complete courses in mathematics, applied math, computer science, and an approved English writing course. While the concentration in Applied Math-Computer Science allows students to develop the use of quantitative methods in thinking about and solving problems, knowledge that is valuable in all walks of life, students who have completed the concentration have pursued graduate study, computer consulting and information industries, and scientific and statistical analysis careers in industry or government. This degree offers a standard track and a professional track.

## Standard Program for the Sc.B. degree.

**Prerequisites – the equivalent of two semesters of single-variable calculus**

A second semester of single-variable calculus is not an enforced requirement for our concentration, but it is a required prerequisite for many of our courses. At Brown, the second semester of calculus is taught in one of MATH 0100, MATH 0170, or MATH 0190.

**Requirements – 17 courses** [1,2]

**Completion of one APMA pairing** [3]

**Mathematical Requirements – 8 courses**

| | | |
|---|---|---|
| MATH 0180 | Multivariable Calculus [4] | 1 |
| or MATH 0200 | Multivariable Calculus (Physics/Engineering) | |
| or MATH 0350 | Multivariable Calculus With Theory | |
| MATH 0520 | Linear Algebra [4] | 1 |
| or MATH 0540 | Linear Algebra With Theory | |
| or CSCI 0530 | Coding the Matrix: An Introduction to Linear Algebra for Computer Science | |
| or APMA 1170 | Introduction to Computational Linear Algebra | |
| APMA 0350 | Applied Ordinary Differential Equations [5] | 1 |
| APMA 0360 | Applied Partial Differential Equations I [6] | 1 |
| APMA 1160 | An Introduction to Numerical Optimization | 1 |
| or APMA 1170 | Introduction to Computational Linear Algebra | |
| or APMA 1180 | Introduction to Numerical Solution of Differential Equations | |
| or APMA 1690 | Computational Probability and Statistics | |
| or APMA 1740 | Recent Applications of Probability and Statistics | |
| Two approved 1000-level or higher APMA courses. The APMA pairing must be completed. [3,7,8] | | 2 |
| One 1000-level or higher APMA or MATH course [7,8] | | 1 |

**Computer Science Requirements – 8 courses** [2]

| | | |
|---|---|---|
| Select one of the following introductory course sequences | | 2 |
| CSCI 0150 & CSCI 0200 | Introduction to Object-Oriented Programming and Computer Science and Program Design with Data Structures and Algorithms | |
| CSCI 0170 & CSCI 0200 | Computer Science: An Integrated Introduction and Program Design with Data Structures and Algorithms | |
| CSCI 0111 & CSCI 0200 | Computing Foundations: Data and Program Design with Data Structures and Algorithms [2] | |
| CSCI 0190 and one CSCI course numbered 0200 or higher | | |
| Select one foundational course in each of three of the following four clusters: | | 3 |
| a. Algorithms/Theory Foundations | | |
| CSCI 0500 | Data Structures, Algorithms, and Intractability: An Introduction | |
| CSCI 1010 | Theory of Computation | |
| CSCI 1550 | Probabilistic Methods in Computer Science | |
| CSCI 1570 | Design and Analysis of Algorithms | |
| b. AI/Machine Learning/Data Science Foundations | | |
| CSCI 0410 | Foundations of AI | |
| CSCI 1410 | Artificial Intelligence | |
| CSCI 1411 | Foundations in AI | |
| CSCI 1420 | Machine Learning | |
| CSCI 1430 | Computer Vision | |
| CSCI 1460 | Computational Linguistics | |
| CSCI 1470 | Deep Learning | |
| CSCI 1850 | Deep Learning in Genomics | |
| CSCI 1951A | Data Science | |
| c. Systems Foundations [9] | | |
| CSCI 0300 | Fundamentals of Computer Systems | |
| CSCI 0320 | Introduction to Software Engineering | |
| CSCI 0330 | Introduction to Computer Systems | |
| d. Probability [8, 10] | | |
| APMA 1655 | Honors Statistical Inference I | |
| APMA 1650 | Statistical Inference I | |
| CSCI 1450 | Advanced Introduction to Probability for Computing and Data Science | |
| MATH 1210 | Probability | |
| MATH 1610 | Probability | |
| Three approved 1000-level or higher CSCI courses, which cannot include arts/policy/humanities courses [11] | | 3 |
| **Additional Requirements – 1 course** | | **1** |
| One approved capstone in computer science or applied mathematics taken in the student's senior year. [12] | | |
| **Total Credits** | | **17** |

1 A required course may be replaced by a more advanced course with concentration advisor approval. No course may be used to satisfy more than one of the required 17 concentration credits. Transfer credits and courses receiving placement credit notation can satisfy concentration credit as long as they appear on the Brown internal transcript. At most 3 post-matriculation transfer credits (such as study abroad courses or summer courses at another institution) can be used for concentration credit. Pursuing honors will require 18 courses – these 17 along with two semesters of independent study courses for the honors research project, one of which can be used to satisfy the capstone concentration requirement. For students with multiple concentrations: calculus, linear algebra, one intro CSCI course, and at most two additional courses can be used for concentration credit in the other concentration(s).

2 Students who take the CSCI 0111, CSCI 0112, CSCI 0200 sequence will effectively need an additional course (CSCI 0112) to complete the concentration. Students wishing to go directly from CSCI 0111 to CSCI 0200 (without CSCI 0112) will need to successfully complete additional exercises to receive an instructor override code for CSCI 0200.

3 To complete an APMA pairing, students must complete two 1000-level or higher APMA courses that adhere to a common theme. These courses can appear anywhere in the declaration. APMA 1910, 1920, and research/independent study courses are not allowed. Themes can be broadly defined and are subject to concentration advisor approval. Examples include:

- Probability and statistics: APMA 1080, APMA 1200, APMA 1650/APMA 1655, APMA 1660, APMA 1690, APMA 1710, APMA 1720, APMA 1740/ APMA 2610, APMA 1860, APMA

1930V, APMA 1930W, APMA 1930X, APMA 1941D, APMA 1941E, APMA 2630, APMA 2640, APMA 2670,APMA 2680
- Differential equations and dynamical systems: APMA 1070, APMA 1180, APMA 1330, APMA 1360, APMA 1930P, APMA 1941G, APMA 2070, APMA 2190, APMA 2200, APMA 2550, APMA 2560, APMA 2570, APMA 2580B
- Scientific computing and optimization: APMA 1210, APMA 1160, APMA 1170, APMA 1180, APMA 1940Y, APMA 2070, APMA 2560, APMA 2580B, APMA 2580C
- Operations research: APMA 1200, APMA 1210
- Applications in biology: APMA 1070, APMA 1080, APMA 1930P, APMA 1930Y

[4] APMA 0260 can substitute for the multivariable calculus and/or the linear algebra requirements. If it is used as a substitute for both requirements, then students must take one additional approved 1000-level APMA or MATH course not used elsewhere for concentration credit. APMA 1910, 1920, MATH 1090, 1910 are not allowed.

[5] APMA 0330 or MATH 1110 may be used in place of APMA 0350. If MATH 1110 is used, then the concentration must include at least four 1000-level APMA courses (not including APMA 1910, 1920 or research/independent study courses). These can appear anywhere in the declaration.

[6] APMA 0340 or MATH 1120 may be used in place of APMA 0360. If MATH 1120 is used, then the concentration must include at least four 1000-level APMA courses (not including APMA 1910, 1920 or research/independent study courses). These can appear anywhere in the declaration.

[7] APMA 1910, 1920, MATH 1090, 1910 and research/independent study courses are not allowed. At most one of APMA 1001, MATH 1000, MATH 1001 can be used for concentration credit.

[8] At most one of APMA 1650, APMA 1655, CSCI 1450, MATH 1210, MATH 1610 can be used for concentration credit.

[9] At most one of CSCI 0300, CSCI 0330 can be used for concentration credit.

[10] APMA 1655 is recommended. Higher-level courses in probability can satisfy this requirement with concentration advisor approval. The following courses are automatically approved: APMA 1080, APMA 1200, APMA 1660, APMA 1690, APMA 1710, APMA 1740/ APMA 2610, APMA 2630, APMA 2640.

[11] Non-CSCI courses and arts, humanities, or social science CS courses cannot be used for concentration credit even if they are allowed as part of a pure CS concentration (currently CSCI 1250, 1280, 1360, 1370, 1800, 1805, 1870, 1952B, 1952X, 2002, 2952S).

[12] The capstone can be one of the courses that completes the APMA pairing. Completing a capstone during the junior year might be allowed in exceptional cases for which completion during the senior year is impossible, such as the student's faculty research mentor not being on campus during the student's senior year, but this requires prior approval from the concentration advisor and the Director of Undergraduate Studies in CS. The following options can be used to satisfy this requirement:
- A pre-approved course that satisfies the APMA Sc.B. capstone requirement: currently APMA 1360, APMA 193*/194* (where * is any combination of numbers and letters; these are the APMA senior seminars).
- A directed research/independent study course from the APMA 1970/1971 series that is used for undergraduate research and is approved by the concentration advisor.
- Completion of a CS Sc.B. capstone as described in the CS Concentration Handbook at this link (https://cs.brown.edu/degrees/undergrad/concentrating-in-cs/concentration-handbook/). Usually, this involves taking one of the approved CS capstone courses at this link (https://cs.brown.edu/degrees/undergrad/concentrating-in-cs/concentration-requirements-2020/capstone/) and registering the capstone with the instructor of the course and with the CS department using the capstone registration form at this link (https://drive.google.com/file/d/1YYK7u4ccB0II52yxXiEI6sMwA7LZMrGy/view/). Depending on the course it may require the completion of an additional project.
- For students pursuing honors in APMA-CS, one of the two required semesters of independent study courses can be used to fulfill the capstone requirement.

## Professional Tracks

The requirements for the professional tracks include all those of each of the standard tracks, 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. Internships that take place between the end of the fall and the start of the spring semesters cannot be used to fulfill this requirement.

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

## Honors

Concentrators that demonstrate excellence in grades and in undergraduate research can be awarded departmental honors. Honors students with primary advisors in Applied Math should follow the guidelines, requirements, and deadlines for honors as described in the bulletin for Applied Math concentrators (https://bulletin.brown.edu/the-college/concentrations/apma/) and as published on the APMA departmental website (https://appliedmath.brown.edu/academics/undergraduate-program/honors/). Honors students with primary advisors in Computer Science should follow the guidelines, requirements, and deadlines for honors as described in the bulletin for Computer Science concentrators (https://bulletin.brown.edu/the-college/concentrations/comp/) and as published on the CS departmental website (https://cs.brown.edu/degrees/undergrad/concentrating-in-cs/honors/). Students wishing to do honors research with a non-APMA or CS advisor should contact the Directors of Undergraduate Studies in APMA and CS to discuss options.