

SCIENTIFIC COMPUTING

Department Website:

<https://www.haverford.edu/scientific-computing>

Many disciplines in the natural and social sciences include a significant sub-discipline that is explicitly computational. Examples include astronomy, biology, chemistry, economics, and physics. In some fields, such as biology, the use of computation has become so widespread that basic literacy in computation is increasingly important and may soon be required.

The Concentration in Scientific Computing gives students an opportunity to develop a basic facility with the tools and concepts involved in applying computation to a scientific problem, and to explore the specific computational aspects of their own major disciplines.

Learning Goals

As students progress through the curriculum, they will:

- learn to read, write, and debug code in at least one programming language, using idioms appropriate to the major field of study.
- apply computational reasoning to a broad set of problems.
- learn tools and concepts required to computationally approach scientific problems within the discipline of their major.
- appreciate trade-offs and limitations of computational approaches to problem solving (e.g., accuracy vs. computation time, approximations needed to make real-world problems calculable, numerical errors inherent to computations themselves).

Haverford's Institutional Learning Goals are available on the President's website, at <http://hav.to/learninggoals>.

Curriculum

Three of the six courses required for the concentration focus on general issues of computing (see Requirements A and B below): two of these serve as an introduction to computer science and programming, and the third focuses on the use of computation within a specific scientific discipline. Students then choose the remaining three courses from a list of electives (see Requirement C), using at least two to connect their computational work with their major (recall that 2-3 courses for a concentration must also count toward the student's major). Finally, the student must also complete

a project-based experience, possibly during the completion of one of the courses (Requirement D).

Students majoring in astronomy, biology, chemistry, economics, mathematics, and physics should consult the relevant sections of the Catalog for information about the relationship of this concentration to their courses of study.

Given the abundance of math, physics, chemistry, and computer science courses listed under Requirements B and C, students with these majors should have no problem choosing courses (though one of the coordinators of the concentration should be consulted during this selection). Example "Requirement C" tracks for majors in astronomy, biology, chemistry, and economics are available, but a student may of course choose other courses (in consultation with one of the coordinators).

Concentration Requirements

The concentration consists of six credits that fall into four categories of requirements, denoted (A), (B), (C), (D). These are merely categorical labels, and we have no intention of expressing a time-ordered sequence. In fact, we anticipate that many students in fields other than computer science will take at least one course in the (B) and/or (C) requirements before discovering an interest in the concentration, and then take courses to satisfy the other requirements afterward.

The six courses should be selected from the following list and approved by the student's concentration advisor. Of the six credits required for the concentration, no more than two of the courses in (B) or (C) may count towards both the concentration and the student's major. (Also, per College rules, students may not count among the 32 course credits required for graduation any course that substantially repeats the content of another course already completed, even though the course numbers may suggest an advancing sequence. For example, both introductory computer science courses, CMSC H105 and CMSC B109, cannot be taken for credit.)

Categories of Requirements

Category A

Year-long introduction to computer science and programming, that may consist of (CMSC H105 and CMSC H106) or (CMSC B109 and CMSC B113) or (CMSC H107). CMSC H107 can be taken upon successful completion of either: CMSC H104 or CMSC B115 or the CS placement exam."

Category B

One course involving regular programming assignments and becoming familiar with discipline-

specific programming idioms, chosen from the following list:

Code	Title	Credits
ASTR H204	Introduction to Astrophysics	1.00
ASTR H341	Advanced Topics: Observational Astronomy	1.0
ASTR H344		1.0
CMSC H207	Data Science and Visualization	1.0
BIOL H311	Advanced Genetic Analysis	0.5
CMSC H287	High Performance Scientific Computing	1.0
CMSC H208	Speech Synthesis and Recognition	1.0
CMSC/LING H325	Computational Linguistics	1.0
CHEM H304	Statistical Thermodynamics and Kinetics	1.0
CHEM H305	Quantum Chemistry	1.0
MATH H222	Scientific Computing: Continuous Systems	1.0
MATH S066	Stochastic and Numerical Methods	1.0
PHYS/ASTR H304	Computational Physics	1.0
CHEM H352	Topics in Biophysical Chemistry: Macromolecular Crystallography	0.50
MATH B325	Advanced topics in Applied Mathematics	

Category C

Three credits worth of electives in which real-world phenomena are investigated using computation, at a significant level as determined by the standards of that discipline. At least one of these three credits must come from a 300-level course or courses (not senior research). A normative route in the sciences would be for a student to take two taught courses on this list and apply one credit of senior research to this requirement. Alternatively, students whose senior work is not computational but who still wish to pursue the concentration can complete three taught courses from this list. These courses should be drawn from the following list:

Code	Title	Credits
Any of the courses on the (B) list above		
BIOL H357	(Topics in Protein Science)	0.5
BIOL H301	Advanced Lab in Biology Sem 2 (Bioinformatics Superlab)	1.00
CHEM B322	Advanced Physical Chemistry: Mathematical Modeling & Natural Processes	1.0
CMSC H235	Information and Coding Theory	1.0
CMSC/LING H325	Computational Linguistics	1.0
ECON H324	Advanced Econometrics	1.0
MATH H204/B210	Differential Equations	1.0
MATH H210	Linear Optimization	1.0

MATH H361	Applied Multivariate Statistical Analysis	1.00
MATH H394	Advanced Topics in Computer Science and Discrete Math	1.0
MATH H397	Advanced Topics in Applied Mathematics: Models for Dynamic Processes	1.0
MATH H382/B308	Mathematical Modeling and Differential Equations	1.00
MATH S056	Modeling	1.0
Up to 1 credit of senior research if the project has a significant focus on scientific computing ¹		1.0
MATH H396	Advanced Topics: Probability and Statistics	1.00
STAT H203	Statistical Methods and their Applications	1.00

¹ e.g., ASTR H404, BIOL H40x, CHEM H361, CMSC H480, MATH H399, PHYS H41x

Category D:

Some part of completion of the concentration must include a project-based experience in which computation is applied to investigate a real-world phenomenon, e.g.,

- A senior thesis/experience with significant scientific computing component, or
- A summer research experience, or
- A multi-week project for a course that may (or may not) be one of the three electives that fulfill requirement (C)

Concentration Coordinators and Departmental Representatives

Jane Chandlee

Linguistics representative; Associate Professor and Haverford Chair of Linguistics (TriCo)

Daniel Grin

Physics representative; Assistant Professor of Physics and Astronomy

Andrea Lommen

Astronomy representative; The John Farnum Professor; Professor of Physics and Astronomy

Casey Londergan

Chemistry representative; Professor and Chair of Chemistry

Robert Manning

Mathematics representative; Professor of Mathematics and Statistics; William H. and Johanna A. Harris Chair of Computational Science

Sara Mathieson

Computer Science representative; Assistant
Professor of Computer Science

Eric Miller

Biology representative; Assistant Professor of
Biology