Computational and Applied Mathematics

The George R. Brown School of Engineering

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Harel Z. Shouval
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Instructors/Lecturers
Thomas Callaghan
Sean S. Hardesty
Susan Margulies
Jennifer Young

Degrees Offered: BA, MCAM, MCSE, MA, PhD

Courses within this major can provide foundations applicable to the many fields of engineering, physical sciences, life sciences, behavioral and social sciences, and computer science. Undergraduate majors have considerable freedom to plan a course of study consistent with their particular interests.

The professional degree (MCAM), for persons interested in practicing within this field, emphasizes general applied mathematics, operations research optimization, and numerical analysis, while the MA and PhD programs concentrate on research. Faculty research interests fall in the four general areas of numerical analysis and computation; physical mathematics; operations research and optimization; and mathematical modeling in physical, biological, or behavioral sciences.

A further advanced degree program in computational science and engineering (CSE) addresses the current need for sophisticated computation in both engineering and the sciences. Such computation requires an understanding of parallel and vector capabilities and a range of subjects including visualization, networking, and programming environments. An awareness of a variety of new algorithms and analytic techniques also is essential to maximizing the power of the new computational tools.

A joint MBA/Master of Engineering degree also is available in conjunction with the Jesse H. Jones Graduate School of Management.

Degree Requirements for BA in Computational and Applied Mathematics

For general university requirements, see Graduation Requirements (Undergraduate Students section, pages 2–5). Students majoring in computational and applied mathematics are required to complete the 52–56 semester hours spelled out in the following program of study.

Introductory Courses: Typically completed during the first two years

CAAM 210 *Introduction to Engineering Computation*
CAAM 335 *Matrix Analysis*
COMP 140 *Computational Thinking** (or COMP 160 or COMP 170)
MATH 101 *Single Variable Calculus I**
MATH 102 *Single Variable Calculus II*
MATH 212 *Multivariable Calculus+*

*Students with prior experience with calculus and/or computational science may replace these classes with 3-credit quantitative electives at the 200-level or above, as approved by a CAAM undergraduate advisor. (These quantitative electives are in addition to the four electives required below.)

+Students may substitute Honors Calculus sequence (MATH 221, 222) for MATH 212.

Entering students should enroll in the most advanced course commensurate with their background; advice is available from the CAAM department during Orientation Week.

Intermediate Courses: Typically completed by the end of the third year

CAAM 336 *Differential Equations in Science and Engineering* (or STAT 310 *Probability and Statistics* or STAT 331 *Applied Probability)*
CAAM 378 *Introduction to Operations Research and Optimization*
CAAM 401 *Analysis I*
CAAM 402 *Analysis II*

Advanced Courses: Typically completed during the fourth year

CAAM 453 *Numerical Analysis I*

and one of the following two courses:

CAAM 454 *Numerical Analysis II* or CAAM 471 *Introduction to Linear and Integer Programming*

Design Project: Typically completed during the fourth year

CAAM 495 *Senior Design Project I*
CAAM 496 *Senior Design Project II*

Electives: Four courses at 300 level or above; two of which must be at the 400-level or above (chosen in consultation with a CAAM undergraduate advisor).

Highly Recommended Electives:

CAAM 415 *Theoretical Neuroscience*
CAAM 420 *Computational Science I*
CAAM 423 *Partial Differential Equations I*
CAAM 436 *Partial Differential Equations of Mathematical Physics*
CAAM 560 *Optimization Theory*
MATH 425 *Integration Theory*
MATH 427 *Complex Analysis*
STAT 431 *Overview of Mathematical Statistics*

Course Requirements for a Minor in Computational and Applied Mathematics

Six classes total (18 credits)

Required classes:

- CAAM 210 *Introduction to Engineering Computation*
- CAAM 335 *Matrix Analysis*

One of the following:

- CAAM 336 *Differential Equations in Science and Engineering*
- CAAM 378 *Introduction to Operations Research and Optimization*

Elective classes:

- Three electives (3 credits each): CAAM courses at the 300 level or above, including at least two classes at the 400 level or above.

Degree Requirements for MCAM, MA, and PhD in Computational and Applied Mathematics

Admission—Admission to graduate study in computational and applied mathematics is open to qualified students holding bachelor's or master's degrees (or their equivalent) in engineering; mathematics; or the physical, biological, mathematical, or behavioral sciences. Department faculty evaluate the previous academic record and credentials of each applicant individually. For general information, see Graduate Degrees (Graduate Students section, pages 3–4) and Admission to Graduate Study (Graduate Students section, pages 2–3).

Applicants should be aware that it normally takes two years to obtain a master's degree and an additional two to four years for the doctoral degree.

MCAM Program—This professional degree program emphasizes the applied aspects of mathematics. The MCAM degree requires satisfactory completion of at least 30 semester hours of course work approved by the department.

MA Program—For an MA in computational and applied mathematics, students must:

- Complete at least 30 semester hours at the graduate level, including five courses in computational and applied mathematics, in addition to thesis work
- Produce an original thesis acceptable to the department
- Perform satisfactorily on a final public oral examination on the thesis

For students working toward the PhD, successful performance on the master's thesis may fulfill the PhD thesis proposal requirements upon approval by the thesis committee.

PhD Program—For a PhD in computational and applied mathematics, students must:

- Complete a course of study approved by the department to establish a broad foundation in applied mathematics
- Perform satisfactorily on qualifying examinations and reviews
- Produce an original thesis acceptable to the department
- Perform satisfactorily on a final public oral examination on the thesis

Financial Assistance—Graduate fellowships, research assistantships, and graduate scholarships are available and are awarded on the basis of merit

to qualified students. Current practice in the department is for most doctoral students in good standing to receive some financial aid.

Degree Requirements for Master's in Computational Science and Engineering (MCSE)

Recognizing the ubiquity of sophisticated computational needs in many modern professions, the Departments of Computational and Applied Mathematics, Computer Science, and Statistics have established a professional master's degree program in computational science and engineering (MCSE). This program provides a resource for training and expertise in modern computational techniques that will find application in a wide range of industries and technical and managerial functions within them.

The MSCE curriculum emphasizes computational mathematics for science and engineering applications, scientific data analysis and visualization, high-performance computing, and software development tools for parallel and vector computers. The elective courses in the curriculum allow for the application of these techniques to any area of scientific or engineering specialization.

The program is administered by a faculty committee from the Departments of Computational and Applied Mathematics, Computer Science, and Statistics. Applicants should have a background comparable to an engineering or science bachelor's degree, with adequate training in engineering mathematics, statistical foundations, and programming methodology. They will apply directly to the MCSE program, and admitted students will work with their faculty advisors to develop study plans that meet the program requirements while allowing them to pursue individual specialization interests. The MCSE program requires a minimum of 36 hours of advanced study to be approved by the faculty committee. Details on course of study are found on the program website.

Degree Requirements for PhD in Computational Science and Engineering

CSE Program Area—Recognizing the increasing reliance of modern science and engineering on computation as an aid to research, development, and design, the Department of Computational and Applied Mathematics, in conjunction with the Departments of Biochemistry and Cell Biology, Earth Science, Computer Science, Chemical and Biomolecular Engineering, Electrical and Computer Engineering, Civil and Environmental Engineering, and Statistics, has established an advanced degree program in computational science and engineering (CSE). The program focuses on modern computational techniques and provides a resource for training and expertise in this area.

The program is administered by a faculty committee chosen by the deans of engineering and natural sciences. The Computational Science Committee (CSC) helps students design an appropriate course of study and sets the examination requirements.

Students may enter the CSE program either directly or indirectly through one of the participating departments (see list above). In all cases, however, students must fulfill the admissions requirements of their associated department. Students then meet the normal requirements for graduate study within that department in every way (including teaching and other duties), except that the curriculum and examination requirements are set by the CSC.

Study at the doctoral level seeks to advance the field through original research. For general university requirements, see Graduate Degrees (Graduate Students section, pages 3–4). For the PhD in computational science and engineering, students must:

- Complete a course of study approved by the CSC, including at least two courses outside the major area
- Perform satisfactorily on preliminary and qualifying examinations and reviews
- Produce an original thesis acceptable to the CSC
- Perform satisfactorily on a final public oral examination on the thesis

See CAAM in the Courses of Instruction section.