Computational and Applied Mathematics

The George R. Brown School of Engineering

Chair
John E. Dennis

Professors
John Edward Akin (joint: MEMS)
Michael M. Carroll (joint: MEMS)
Steven J. Cox
Danny C. Sorensen
William W. Symes
Richard A. Tapia

Professors Emeriti
Robert E. Bixby
Sam H. Davis (joint: CENG)
Angelo Miele (joint: MEMS)
Paul E. Pfeiffer
Chao-Cheng Wang (joint: MEMS)

Associate Professors
Liliana Borcea
Nathaniel Dean
Matthias Heinkenschloss
Yin Zhang

Assistant Professors
Mark Embree
Petr Kloucek

Adjunct Professors
J. Bee Bednar
Richard Carter
Evin Joyce Cramer
Elmer Eisner
Roland Glowinski
Richard P. Kendall
Emilio J. Nuñez
Donald W. Peaceman
Michael B. Ray
Jacques R. Tabanou
Phuong A. Vu

Adjunct Associate Professors
Amr El-Bakry
Michael W. Trosset

Adjunct Assistant Professors
Charles Audet
Aladin M. Boriek

Lecturer
Michael Pearlman

Faculty Fellows
Alan Carle
Michael Fagan

Degrees Offered: B.A., M.C.A.M., M.C.S.E., M.A., Ph.D.

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 (M.C.A.M.), for persons interested in practicing within this field, emphasizes general applied mathematics, operations research and optimization, and numerical analysis, while the M.A. and Ph.D. 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 (C.S.E.) 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 is also essential to maximizing the power of the new computational tools.

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

Degree Requirements for B.A. in Computational and Applied Mathematics

Students majoring in computational and applied mathematics are required to complete the 51 semester hours spelled out in the following program of study.

Introductory Courses: Typically completed during the first two years

MATH 101 and 102 *Single Variable Calculus I* and *II*
(or honors equivalent)
MATH 211 *Ordinary Differential Equations and Linear Algebra*
MATH 212 *Multivariable Calculus*
COMP 110 *Computation in Science and Engineering*
CAAM 210 or 211 *Introduction to Engineering Computation*

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

CAAM 321 *Introduction to Real Analysis*
CAAM 322 *Introduction to Real Analysis II*
CAAM 335 *Matrix Analysis*
CAAM 336 *Differential Equations in Science and Engineering*
(or STAT 310 *Probability and Statistics* or STAT 331 *Applied Probability)*

Advanced Courses: Two full-year sequences chosen from the following 5 areas

Numerical Analysis
CAAM 451 *Numerical Linear Algebra*
CAAM 453 *Numerical Analysis and Ordinary Differential Equations*

Operations Research
CAAM 471 *Linear Programming*
CAAM 475 *Integer and Combinatorial Optimization*

Optimization
CAAM 454 *Optimization Problems in Computational Engineering and Science*
CAAM 460 *Optimization Theory*

Differential Equations
CAAM 436 *Partial Differential Equations I*
CAAM 437 *Partial Differential Equations II*

Scientific Computation
CAAM 420 *Computational Science I*
CAAM 421 *Computational Science II*

Electives
At least 3 courses, at or above the 300 level, selected upon consultation with the CAAM undergraduate adviser. The department strongly recommends that majors include ENGL 308 *Engineering Communications* among their electives.

Degree Requirements for M.C.A.M., M.A., and Ph.D. 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 (pages 60–65) and Admission to Graduate Study (pages 65–66).

Applicants should be aware that it normally takes one to two years to obtain a master's degree and three to five years to obtain a doctorate (a master's degree is not a prerequisite for the doctoral degree).

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

M.A. Program. For an M.A. in computational and applied mathematics, students must:

- Complete at least 30 semester hours at the graduate level, including 5 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 Ph.D. degree, successful performance on the thesis proposal fulfills the master's thesis requirement.

Ph.D. Program. For a Ph.D. in computational and applied mathematics, students must:

- Complete a course of study approved by the department, including at least 2 courses outside the major area
- Perform satisfactorily on preliminary and 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 M.C.S.E. and Ph.D. in Computational Science and Engineering

C.S.E. 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 Engineering, Electrical and Computer Engineering, Environmental Science and Engineering, and Statistics, has established an advanced degree program in an area called computational science and engineering (C.S.E.). The program focuses attention on modern computational techniques and provides a resource of training and expertise in this area.

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

Students may enter the C.S.E. 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 one department, which acts as 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.

M.C.S.E. Program. This program's intent is to produce professional experts in scientific computing able to work as part of an interdisciplinary research team. Training is concentrated in state-of-the-art numerical methods, high-performance computer architectures, use of software development tools for parallel and vector computers, and the application of these techniques to at least one scientific or engineering area. For general university requirements, see Graduate Degrees (pages 60–65).

For the M.C.S.E. degree, students must complete at least 30 semester hours of course work approved by the CSC; no more than 2 of the courses may be taken at the 300 level, taken outside the C.S.E. program area, or satisfied by transfer credit. Each student's program of study must meet the requirements listed below. Modification of requirements can be requested by petition.

Required Courses

COMP 412 *Compiler Construction*
(or ELEC 425 *Computer Systems Architecture)*
CAAM 420 *Computational Science I* (taken as soon as possible)
CAAM 421 *Computational Science II* (taken as soon as possible)

1 course from the following:

CAAM 451 *Numerical Linear Algebra*
CAAM 452 *Computational Methods for Differential Equations*
CAAM 453 *Numerical Analysis—Ordinary Differential Equations*
CAAM 454 *Optimizing Problems in Computational Engineering and Science*
CAAM 471 *Linear Programming*

Computational Science Electives

4 courses selected from an approved list of COMP or CAAM courses (at least 2 courses at the 500 level)

Open Electives

2 approved courses other than CAAM or COMP courses at the 300 level or above (a computational project taken within a participating department also satisfies this requirement)

Application Areas

An appropriate sequence of courses from a participating application area at the 300 level or above

Ph.D. Program. Study at the doctoral level seeks to advance the field through original research. For general university requirements, see Graduate Degrees (pages 60–65). For the Ph.D. in computational science and engineering, students must:

- Complete a course of study approved by the CSC, including at least 2 courses outside the major area
- Perform satisfactorily on preliminary and qualifying examinations and reviews
- Complete 2 courses or a reading examination on an approved foreign language
- Produce an original thesis acceptable to the CSC
- Perform satisfactorily on a final public oral examination on the thesis

See CAAM (pages 279–283) in the Courses of Instruction section.