GRADUATE STUDY *at*

RICE

GRADUATE STUDY IN COMPUTATIONAL AND APPLIED MATHEMATICS

RICE UNIVERSITY

WWW.CAAM.RICE.EDU

FOR ADMISSION IN 2017

The Department of Computational and Applied Mathematics (CAAM) graduate program offers a wide-ranging curriculum of instruction and research in applied mathematics, numerical analysis and scientific computation. Interdisciplinary work is a key component of this program. Accordingly, CAAM faculty and students collaborate with researchers in other university departments and with government and industry scientists in bringing the best modern mathematical and computational techniques to bear on important contemporary scientific and technical problems.

Students in the program must achieve sophistication in modeling and in finding techniques for obtaining information from the resulting models. To do this, the student must obtain a sound grounding in underlying mathematical theory, become acquainted with a variety of mathematical methods and techniques that experience has shown to be useful in practice and attain an appropriate level of mastery of computational methods.

Students who have graduated from CAAM often work in academia, industry, or government research laboratories—usually as members of teams with scientists, engineers and computer scientists. They are concerned with both the modeling of a system under study and the process of finding solutions in forms that guide the analysis, enhance the understanding, and aid the design of that system.

FACULTY/CURRENT RESEARCH

Jesse Chan. Assistant Professor. Ph.D. (2013) University of Texas, Austin. Dr. Chan's research interests lie in the intersection of high order finite element methods and high performance computing. His work focuses on the development, theory, and implementation of numerical methods for partial differential equations, with an emphasis on performance for many-core and accelerator architectures. He is also interested in other aspects of finite element methods, such as stabilization, adaptivity, and geometry representation.

Steven J. Cox. Professor. Ph.D. (1988) Rensselaer Polytechnic Institute. Dr. Cox works on inverse problems and model reduction in the context of building tractable, yet biophysically and anatomically honest, computational platforms for exploring large neuronal networks in the hippocampus.

Maarten V. de Hoop. Simons Chair in Computational and Applied Mathematics and Earth Science. Ph.D. (1992) Delft University of Technology, the Netherlands. Dr. de Hoop's research interests include scattering, imaging and inverse problems, theoretical and computational seismology; multi-dimensional imaging, inverse scattering and tomography; nonlinear inverse boundary value problems; direct and iterative reconstruction, and geometric inverse problems.

Adrianna Gillman. Assistant Professor. Ph.D. (2011) University of Colorado at Boulder. Dr. Gillman's research interests lie in the intersection of numerical analysis, linear algebra and the modeling of physical phenomena. Her work focuses on the development of high accuracy methods for solving partial differential equations. These techniques are designed such that the computational cost scales linearly (or nearly linearly) with respect to the number of discretization points. Thus far, fast algorithms of this type have been applied mostly to elliptic partial differential equations. Dr. Gillman is interested in extending these methods to a larger collection of applications such as Stokes' flow and metamaterials.

Paul Hand. Assistant Professor. Ph.D. (2009) New York University. Dr. Hand's research interests are in signal recovery under indirect and noisy measurements. He works on the development and analysis of novel recovery algorithms. His research involves convex optimization, information theory, statistical inference, random matrix theory, and numerical simulation. His work is inspired by problems in data science, machine learning, and compressed sensing.

Matthias Heinkenschloss. Professor. Ph.D. (1991) University of Trier. Dr. Heinkenschloss's research interests are the development, analysis, and application of numerical methods for optimization problems governed by partial differential equations (PDE). These problems arise in many science and engineering applications where the underlying processes are modeled by PDEs and where inputs into these processes have to be chosen to improve their outputs or process parameters have to be estimated from observations.

Illya V. Hicks. Professor. Ph.D. (2000) Rice University. Dr. Hicks' research interests are in combinatorial optimization, graph theory and integer programming. Some applications of interest are social networks, cancer treatment and network design. His current research is focused on using graph decompositions to solve NP-complete problems. He also teaches courses related to discrete optimization.

Wen Huang. Pfeiffer Postdoctoral Instructor. Ph.D. (2014) Florida State University. Dr. Huang's current interests are optimization on Riemannian manifolds and its applications, including elastic shape analysis, soft dimension reduction for independent component analysis, synchronization of rotations, phase retrieval problem, computations of symmetric positive definite matrices, and role model problems; the theoretical and algorithmic aspects of large data-driven problems, and algorithms for phylogenetic and shape analysis. He developed software, called TreeScaper, for phylogenetic analysis and a C++ toolbox, ROPTLIB, for Riemannian optimization.

Matthew G. Knepley. Assistant Professor. Ph.D. (2000) Purdue University. Dr. Knepley's research focuses on the interplay between scalable solvers and robust discretizations for PDE and BIE. He has worked on mathematical models for solute-solvent interaction, preconditioning for linear and nonlinear solvers, general representations for unstructured meshes and data, parallel mesh algorithms, and optimization for high performance architectures. He is one of the principal developers of the PETSc libraries for computational science, and works closely with application scientists in crustal dynamics, deep earth geodynamics, and bioelectrostatics.

Tianyu Qiu. Pfeiffer Postdoctoral Instructor. Ph.D. (2016) University of Delaware. Dr. Qiu's research is in the area of numerical partial differential equations. His research primarily focuses on time domain boundary integral equations ranging from the analysis of the integral equations to the development of accurate and robust algorithms for approximating the solutions of the integral equations. Applications of this work include acoustics, heat diffusion and electromagnetism.

Béatrice M. Rivière. Noah G. Harding Chair and Professor. Ph.D. (2000) University of Texas at Austin. Dr. Rivière's research includes the development, analysis and implementation of accurate numerical methods for solving a wide range of partial differential equations. In particular, she is interested in the highly flexible discontinuous Galerkin finite element methods. Current applications under consideration are complex flow and transport phenomena and multiphysics problems coupling porous media problems with computational fluid dynamics problems. Another current research interest is the mathematical modeling of intestinal edema and its effect on the normal contraction of the intestine.

Andrew J. Schaefer. Noah G. Harding Chair and Professor. Ph.D. (2000) Georgia Institute of Technology. Dr. Schaefer's research interests span the theoretical, computational and applied aspects of stochastic optimization. In particular, he is interested in solving large-scale stochastic integer programs, and exploiting the special structure of various classes of stochastic optimization problems. His applied interests are primarily in modeling physiological progression and optimizing treatment strategies for various diseases, including end-stage liver disease, HIV and influenza, among others. Dr. Schaefer has received numerous awards for his research, including an NSF CAREER award and the Rice University Outstanding Young Engineering Alumnus award. Dr. Schaefer has placed ten former PhD students and post-docs at leading research institutions.

William W. Symes. Noah G. Harding Chair and Professor. Ph.D. (1975) Harvard University. The principal focus of Dr. Symes's current research is deducing the internal structure of the Earth from the pattern of reflected echoes (seismograms) recorded on the Earth's surface in response to natural or manmade sources of energy. The two major goals of his research are to determine how much information about the subsurface actually is present in seismic data and to devise computational methods to extract this information and present it in a useful way. This research involves the use of traditional tools from theoretical seismology, as well as numerical methods for partial differential equations, numerical optimization theory and nonlinear analysis.

Richard A. Tapia. University Professor and Maxfield–Oshman Professor. Ph.D. (1967) University of California at Los Angeles. Dr. Tapia's research is in numerical analysis and optimization theory. His current interests include interior-point methods for linear and nonlinear programming. He has authored numerous papers and coauthored two books and serves as an advisor to many national organizations and programs in the areas of minority education and minority involvement in science and engineering. Tapia was a 2010 awardee of the National Medal of Science, the highest honor bestowed by the United States government on scientists and engineers. More recently he was awarded the 2014 National Science Foundation prestigious Vannevar Bush Award. He has two professional conferences named in his honor recognizing his contributions to diversity: Richard Tapia Celebration of Diversity in Computing conference and the Blackwell-Tapia Conference. Professor Tapia is director of Rice's Center for Excellence and Equity in Education. He is also a member of the National Academy of Engineering.

Travis Thompson. Pfeiffer Postdoctoral Instructor. Ph.D. (2013) Texas A&M University. Dr. Thompson's research is in numerical partial differential equations. The primary focus of his research interests are the analysis and design of finite element methods. Current applications of his work include continuous and porous fluid dynamics, the life sciences, and high-performance computing.

CAMPUS VISIT

We encourage you to visit Rice at any time for a firsthand look at the department and the beautiful, tree-lined campus near the heart of historic Houston. If you apply and are admitted, you may be invited to visit the campus later at departmental expense. During your time here, you will not only visit with faculty, but usually you will be hosted by current graduate students from whom you can learn more about graduate life and lifestyles in Houston. In the meantime, feel free to contact the department with any questions you may have about its programs or the university.

ADMISSION

www.caam.rice.edu/grad_program.html

Admission to graduate study in the Department of Computational and Applied Mathematics is open to qualified students holding bachelor's or master's degrees (or their equivalent) in engineering; mathematics; or physical, biological, mathematical or behavioral sciences. Each application will be individually evaluated by the faculty of the department. A complete application folder should include the quantitative, verbal and analytical scores from the Graduate Record Examination, all transcripts, evidence of proficiency in English (such as the TOEFL) where appropriate and four letters of recommendation.

The graduate program is designed for students seeking the professional degree of Master of Computational and Applied Mathematics or the research degrees of Master of Arts or Doctor of Philosophy. It normally takes two years to obtain a master's and an additional two to four years for the doctorate.

The professional degree emphasizes the applied aspects of mathematics and is intended for persons who seek careers as practitioners rather than primarily as researchers. Further information about this degree may be obtained from the department.

FOR MORE INFORMATION:

Rice University Department
of Computational and Applied
Mathematics–MS 134
P.O. Box 1892
Houston, Texas 77251-1892
Phone: 713-348-4657 • Fax: 713-348-5318
E-mail: CAAM_gradapps@rice.edu
Web site: www.caam.rice.edu

Yin Zhang. Professor. Ph.D. (1987) State University of New York, Stony Brook. Dr. Zhang's research interests are in the design, analysis and implementation of computer algorithms for solving optimization-related practical problems. His research works span from interior-point methods for linear and conic programming to efficient algorithms for image, signal and data processing. He authored or coauthored various Matlab software packages, including one that has evolved into MATLAB's official linear program solver. Dr. Zhang's most recent activities include scalable algorithms for some eigenvalue problems, and new models and algorithms for data clustering.

PROFESSORS EMERITUS

Robert E. Bixby. Noah G. Harding Professor Emeritus. Ph.D. (1972) Cornell University. Dr. Bixby conducts research in linear and integer programming. He is best known for his development of the CPLEX linear programming routines. Professor Bixby is a member of the National Academy of Engineering.

John E. Dennis Jr. Noah G. Harding Professor Emeritus. Ph.D. (1966) University of Utah, Salt Lake City. Dr. Dennis's research is primarily in the design and analysis of practical computer algorithms for nonlinear optimization problems. He is co-author of *Numerical Methods for Unconstrained Optimization and Nonlinear Equations*.

Danny C. Sorensen. Noah G. Harding Chair and Professor Emeritus. Ph.D. (1977) University of California at San Diego. Dr. Sorensen's research interests are in computational mathematics with emphasis on numerical linear algebra and parallel computing. He also has worked extensively in the area of nonlinear numerical optimization. His current interests are in model order reduction of dynamical systems. Dr. Sorensen has led the development of ARPACK, a state-of-the-art package for solving large eigenvalue problems on high-performance computers.

RESEARCH COMPUTING FACILITIES

The needs of computational and applied mathematics research are met by a collection of dedicated research systems, including high-end Linux workstations and a variety of high-performance research systems.

COMPUTATIONAL SCIENCE AND ENGINEERING DEGREE

The Computational Science and Engineering degree program (CSE), a mechanism for initiating the interdisciplinary research required to advance computational science, is directed by CAAM Professor Danny C. Sorensen. The program offers the Ph.D. and a professional master's degree to students in the Departments of Computational and Applied Mathematics, Biochemistry and Cell Biology, Chemical Engineering, Computer Science, Earth Science, Electrical and Computer Engineering, Environmental Science and Engineering and Statistics.

FINANCIAL ASSISTANCE

Most students admitted to our Ph.D. program are guaranteed four years of funding, which covers the costs of tuition and includes a stipend for living expenses, subject to good academic standing. Additionally, a limited number of teaching assistantships are available for advanced students with academic career inclinations. Rice's Office of Financial Aid also offers various financial aid options.

RESEARCH SEMINARS

The CAAM Department offers a very rich research environment to its graduate students. Events include colloquia, graduate student seminars, SIAM student chapter meetings, and various research seminars.

ALUMNI

Our graduate program can be tailored to a student's career ambitions, whether that be academia, government research laboratories, or industry. For a list of our alumni and their places of employment, see http://www.caam.rice.edu/alumni.html.

STUDENT CHAPTERS

Students can join the SIAM chapter and the AWM chapter and take advantage of their various activities during the year.

SUMMER INTERNSHIPS

Many of the students do a Summer internship with the local industries (oil and gas companies, financial institutions or medical laboratories) and with the national laboratories.

COLLOQUIA

The Department of Computational and Applied Mathematics typically hosts a speaker each Monday during the academic year. The speakers are invited from industrial organizations, government laboratories, other educational institutions and other academic departments at Rice. From time to time, CAAM alumni return to Rice to present talks on their current research projects. Recent speakers in this program include:

Aria Abubakar
Schlumberger

Timothy Atherton
Physics and Astronomy Department
Tufts University

Wolfgang Bangerth
Department of Mathematics
Texas A&M University

Susanne C. Brenner
Department of Mathematics
Louisiana State University

Xiao-Chuan Cai
Department of Computer Science
University of Colorado, Boulder

Constantine Caramanis
Department of Electrical and Computer Engineering
University of Texas at Austin

Michael Damron
School of Mathematics
Georgia Tech

Ryan Glasby
Joint Institute for Computational Sciences
University of Tennessee

Yongpei Guan
Department of Industrial & Systems Engineering
University of Florida

Joonas Ilmavirta
Department of Mathematics and Statistics
University of Jyväskylä

Tobin Isaac
Computing Institute
University of Chicago

Alison Marsden
Department of Pediatrics and Bioengineering
Stanford University

Per-Gunnar Martinsson
Department of Mathematics
University of Colorado, Boulder

Michael O'Neil
Department of Mathematics
NYU Polytechnic and NYU Courant

Benjamin Peherstorfer
Department of Aeronautics & Astronautics
Massachusetts Institute of Technology

Rachel Ward
Department of Mathematics
University of Texas at Austin

Jianlin Xia
Department of Mathematics
Purdue University

REQUIREMENTS FOR THE DEGREE OF MASTER IN COMPUTATIONAL AND APPLIED MATHEMATICS (MCAM)

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.

REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS (M.A)

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

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

REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PH.D.)

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

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

GRADUATE TOPICS IN COMPUTATIONAL AND APPLIED MATHEMATICS

- Analysis
- Applied Functional Analysis
- Applied Matrix Analysis
- Combinatorial Optimization
- Computational Science
- Convex Optimization
- Foundations of Finite Element Methods
- Graph Theory
- Introduction to Random Processes and Applications
- Linear and Integer Programming
- Mathematical Probability
- Numerical Analysis
- Numerical Linear Algebra
- Numerical Methods for Partial Differential Equations
- Numerical Optimization
- Optimization Theory
- Ordinary Differential Equations
- Partial Differential Equations
- Partial Differential Equations of Mathematical Physics
- Theoretical Neuroscience
- Topics in Inverse Problems
- Topics in Nonlinear Programming
- Topics in Numerical Linear Algebra
- Topics in Optimization
- Topics in Numerical Differential Equations

TECHNICAL REPORTS

For a complete list of computational and applied mathematics technical reports, visit www.caam.rice.edu/tech_reports.html.

FOR ADDITIONAL INFORMATION

Rice University homepage: www.rice.edu

Department of CAAM homepage: www.caam.rice.edu

CAAM application page: www.caam.rice.edu/grad_application.html

Interdisciplinary degree in computational science and engineering: http://engrprofmasters.blogs.rice.edu/departments/data-science-and-engineering

Rice Graduate Education for Minorities (RGEM) homepage: tapiacenter.rice.edu/programs/rgem/

Rice University Office of Graduate and Postdoctoral Studies homepage: graduate.rice.edu

Graduate Student Association homepage: gsa.rice.edu

ABOUT RICE AND HOUSTON

Rice is a leading American research university—small, private and highly selective—distinguished by a collaborative, interdisciplinary culture and a global perspective. Only a few miles from downtown Houston, it occupies an architecturally distinctive, 285-acre campus shaded by nearly 4,000 trees. State-of-the-art facilities and laboratories, internationally renowned centers and institutes and one of the country's largest endowments support an ideal learning and living environment.

The university attracts a diverse group of highly talented students and faculty with outstanding graduate and professional programs in the humanities, social sciences, natural sciences, engineering, architecture, music and business. With just 2,663 graduate students and 3,965 undergraduates, it offers an unusual opportunity to forge close relationships with eminent faculty scholars and researchers and the option to tailor graduate programs to specific interests.

Houston offers all the expected educational, cultural and commercial advantages of a large urban center, and more. It is home of the Texas Medical Center, the largest concentration of medical schools, hospitals and research facilities in the world, as well as several other universities. Rice has cooperative programs with the University of Houston, Baylor College of Medicine, the University of Texas Health Science Center and Texas Southern University. Houston is one of the few U.S. cities with resident companies in all four major performing arts—drama, ballet, opera and symphony. It also boasts a museum district featuring exhibits of national and international prominence.

As urban as it is, Houston also is a surprisingly green city. Houstonians enjoy the outdoors in more than 300 municipal parks and 120 open spaces, and many frequent the beach at Galveston Island, only a 45-minute drive away. Other short trips include Austin, the state's capital, and historic San Antonio, both of which are a little more than three hours away.

RICE