COMPUTATIONAL APPLIED MATHEMATICS AND OPERATIONS RESEARCH

Contact Information
Computational Applied Mathematics and Operations Research
https://www.caam.rice.edu/
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The department of Computational Applied Mathematics and Operations Research offers undergraduate majors in Computational and Applied Mathematics, and Operations Research. The coursework within the Computational and Applied Mathematics (CAAM) major provides foundations applicable to the many fields of engineering, physical sciences, life sciences, behavioral and social sciences, and computer science. CAAM majors receive training in foundational mathematics for newly developed algorithms in data science and training in all aspects of computation from algorithmic analysis to cost-accuracy performance. CAAM majors can plan a course of study consistent with their particular interests.

The coursework within the Operations Research (OPRE) major offers undergraduate students an education that emphasizes models for decision-making in complex systems, and tools for making the best possible decisions. The Operations Research major will provide students with both a deep set of analytical skills and contextual knowledge of important problem domains, such as healthcare and energy. Program graduates will have the knowledge and tools to help companies and governments make the best possible decisions in changing and uncertain environments.

At the graduate level, the department oversees two advanced professional degree programs. The Master of Computational and Applied Mathematics (MCAAM) is a professional degree program designed for students interested in a technical career path in industry or business. Similarly, the Master of Industrial Engineering (MIE) is a professional degree program designed to provide students with a deep set of analytical and engineering skills to make data-driven decisions needed in every major economic sector. The Computational and Applied Mathematics MA and PhD program concentrates on research. Faculty research interests fall in the four general areas of numerical analysis and scientific computing; numerical methods for partial differential equations; operations research and optimization; and mathematical modeling in physical, biological, or behavioral sciences.

A further advanced interdisciplinary degree program in computational science and engineering (CSE) addresses the current need for sophisticated computation in both engineering and the sciences. For more information, see Computational Science and Engineering (https://ga.rice.edu/programs-study/departments-programs/engineering/computational-science-engineering/)..

Bachelor’s Programs
- Bachelor of Arts (BA) Degree with a Major in Computational and Applied Mathematics (https://ga.rice.edu/programs-study/departments-programs/engineering/computational-applied-mathematics-operations-research/computational-applied-mathematics-ba/)
- Bachelor of Arts (BA) Degree with a Major in Operations Research (https://ga.rice.edu/programs-study/departments-programs/engineering/operations-research/operations-research-ba/)

Minor
- Minor in Computational and Applied Mathematics (https://ga.rice.edu/programs-study/departments-programs/engineering/computational-applied-mathematics-operations-research/computational-applied-mathematics-minor/)

Master’s Programs
- Master of Computational and Applied Mathematics (MCAAM) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/computational-applied-mathematics-operations-research/computational-applied-mathematics-mcaam/)
- Master of Industrial Engineering (MIE) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/industrial-engineering/industrial-engineering-mie/#outcomestext)
- Master of Arts (MA) Degree in the field of Computational and Applied Mathematics

Doctoral Program
- Doctor of Philosophy (PhD) Degree in the field of Computational and Applied Mathematics (https://ga.rice.edu/programs-study/departments-programs/engineering/computational-applied-mathematics-operations-research/computational-applied-mathematics-phd/)

* Although students are not normally admitted to a Master of Arts (MA) degree program, graduate students may earn the MA as they work towards the PhD.

Chair
Illya V. Hicks

Professors
Maarten V. de Hoop
Matthias Heinkenschloss
Illya V. Hicks
Guodong Pang
Beatrice M. Rivièrè
Andrew J. Schaefer
Richard A. Tapia
Computational & Applied Mathematics (CAAM)

CAAM 210 - INTRODUCTION TO ENGINEERING COMPUTATION
Short Title: INTRO TO ENG COMPUTATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Modeling, Simulation, and Visualization via MATLAB. Numerical methods: Newton’s method in one and several dimensions. Gaussian elimination and optimization. Application to problems in science and engineering. Lectures are held Monday and Wednesdays. In a laboratory component held on Fridays, students work in small groups on computational projects led by a Rice Learning Assistant. Fall/Spring semester: meeting 3 times per week (50min each meeting) Summer semester: meeting 5 times per week (65min each meeting) OR refer to the current schedule. Recommended Prerequisite(s): MATH 101.

CAAM 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Topics and credit hours vary each semester. Contact department for current semester’s topic(s). Repeatable for Credit.

CAAM 334 - MATRIX ANALYSIS FOR DATA SCIENCE
Short Title: MATRIX ANALYSIS DATA SCIENCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Solution of linear systems and linear least squares problems. Eigenvalue problem and singular value decomposition. Introduction to gradient based methods. Applications to data science. Recommended Prerequisite(s): (MATH 212 or MATH 222) and (CAAM 210 or COMP 140 or STAT 405) Mutually Exclusive: Cannot register for CAAM 334 if student has credit for CAAM 335.
Prerequisite(s): MATH 212 and (CAAM 335 OR MATH 211 OR MATH 355).

Basic solution methods for these optimization models. Recommended:

Linear programming duality and its modeling implications. Overview of nonlinear, stochastic and integer programming, as well as networks. Models using linear, stochastic, and probabilistic techniques for initial and boundary value problems arising in diffusion and wave propagation phenomena. Recommended Prerequisite(s): (MATH 212 or MATH 222) and (COMP 140 or CAAM 210) Mutually Exclusive: Cannot register for CAAM 335 if student has credit for CAAM 334.

CAAM 335 - MATRIX ANALYSIS

Short Title: MATRIX ANALYSIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Equilibria and the solution of linear systems and linear least squares problems. Eigenvalue problem and its application to solve dynamical systems. Singular value decomposition and its application. Recommended Prerequisite(s): (MATH 212 or MATH 222) and (COMP 140 or CAAM 210) Mutually Exclusive: Cannot register for CAAM 335 if student has credit for CAAM 334.

CAAM 336 - DIFFERENTIAL EQUATIONS IN SCIENCE AND ENGINEERING

Short Title: DIFF EQUATIONS SCI & ENG
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Classical and numerical solution techniques for ordinary and partial differential equations. Fourier series and the finite element method for initial and boundary value problems arising in diffusion and wave propagation phenomena. Recommended Prerequisite(s): (MATH 212 or MATH 222) AND CAAM 210.

CAAM 375 - INTRODUCTION TO OPERATIONS RESEARCH AND OPTIMIZATION

Short Title: INTRO TO O.R. AND OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Formulation of mathematical models of complex decisions arising in management, economics, and engineering. Models using linear, nonlinear, stochastic and integer programming, as well as networks. Linear programming duality and its modeling implications. Overview of basic solution methods for these optimization models. Recommended Prerequisite(s): MATH 212 and (CAAM 335 OR MATH 211 OR MATH 355).

CAAM 382 - STOCHASTIC MODELS

Short Title: STOCHASTIC MODELS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 102 or MATH 106
Description: Fundamentals of stochastic modeling. Topics include discrete & continuous time Markov models, Poisson processes, renewal theory, queueing systems, reliability, Markov decision processes, optimal design and control. Recommended Prerequisite(s): (STAT 280 or 305 or 310 or 315) and MATH 212 and (CAAM 210 or COMP 140) and (CAAM 335 or MATH 355)

CAAM 415 - THEORETICAL NEUROSCIENCE: FROM CELLS TO LEARNING SYSTEMS

Short Title: THEORETICAL NEUROSCIENCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: We present the theoretical foundations of cellular and systems neuroscience from distinctly quantitative point of view. We develop the mathematical and computational tools as they are needed to model, analyze, visualize and interpret a broad range of experimental data. Cross-list: ELEC 488, NEUR 415. Graduate/Undergraduate Equivalency: CAAM 615. Recommended Prerequisite(s): CAAM 210 or MATH 211 or CAAM 335 or MATH 355. Mutually Exclusive: Cannot register for CAAM 415 if student has credit for CAAM 615.

CAAM 416 - NEURAL COMPUTATION

Short Title: NEURAL COMPUTATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: How does the brain work? Understanding the brain requires sophisticated theories to make sense of the collective actions of billions of neurons and trillions of synapses. Word theories are not enough; we need mathematical theories. The goal of this course is to provide an introduction to the mathematical theories of learning and computation by neural systems. These theories use concepts from dynamical systems (attractors, oscillations, chaos) and concepts from statistics (information, uncertainty, inference) to relate the dynamics and functions of neural networks. We will apply these theories to sensory computation, learning and memory, and motor control. Students will learn to formalize and mathematically answer questions about neural computations, including “what does a network compute?”, "how does it compute?", and "why does it compute that way?" Prerequisites: knowledge of calculus, linear algebra, and probability and statistics. Cross-list: ELEC 489, NEUR 416.
CAAM 419 - COMPUTATIONAL SCIENCE I
Short Title: COMPUTATIONAL SCIENCE I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Scientific programming using high level languages, including C, Fortran, and C++. Emphasis on use of numerical libraries. Basic techniques of project planning, source management, documentation, program construction, i/o, visualization. Object-oriented design for numerical computing. Grading and assignments would be different between the 400/500 level. Graduate/Undergraduate Equivalency: CAAM 519. Recommended Prerequisite(s): (CAAM 210 and CAAM 335) or CAAM 453. Mutually Exclusive: Cannot register for CAAM 419 if student has credit for CAAM 519.

CAAM 420 - COMPUTATIONAL SCIENCE II
Short Title: COMPUTATIONAL SCIENCE II
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Theory and application of the message passing interface for programming scientific computing applications. Introduction to the architecture and programming of multicore and massively parallel processors, including general purpose graphics processing units, Insight for designing efficient numerical algorithms to improve parallelization of memory access and utilization of non-uniform memory architectures. Application interfaces include OpenMP, MPI, CUDA, OpenCL, and parallel numerical algorithm libraries. Grading and assignments would be different between the 400/500 level. Instructor Permission Required. Graduate/Undergraduate Equivalency: CAAM 520. Recommended Prerequisite(s): CAAM 419 Mutual Exclusive: Cannot register for CAAM 420 if student has credit for CAAM 520.

CAAM 421 - LOGISTICS AND SUPPLY CHAIN MANAGEMENT
Short Title: LOG & SUPPLY CHAIN MANAGEMENT
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 378 and CAAM 382

CAAM 423 - PARTIAL DIFFERENTIAL EQUATIONS I
Short Title: PARTIAL DIFFERENTIAL EQUATIONS I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level

CAAM 435 - DYNAMICAL SYSTEMS
Short Title: DYNAMICAL SYSTEMS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Existence and uniqueness for solutions of ordinary differential equations and difference equations, linear systems, nonlinear systems, stability, periodic solutions, bifurcation theory. Theory and theoretical examples are complemented by computational, model driven examples from biological and physical sciences. Cross-list: MATH 435. Recommended Prerequisite(s): (MATH 212 or MATH 221) and (CAAM 335 or MATH 335 or MATH 354) and (MATH 302 or MATH 321 or MATH 331)
Course URL: math.rice.edu (http://math.rice.edu)

CAAM 436 - MODELING MATHEMATICAL PHYSICS
Short Title: MODELING MATHEMATICAL PHYSICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Derivation and properties of solutions of the partial differential equations of continuum physics. Basic concepts of continuum mechanics, ideal fluids, Navier-Stokes equations, linear elasticity, acoustics, basic principles of thermodynamics, Newtonian heat flow, porous flow, Maxwell's equations, electrical circuits. Graduate/Undergraduate Equivalency: CAAM 535. Recommended Prerequisite(s): CAAM 336. Mutually Exclusive: Cannot register for CAAM 436 if student has credit for CAAM 535.
CAAM 440 - APPLIED MATRIX ANALYSIS
Short Title: APPLIED MATRIX ANALYSIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: A second course in matrix analysis that presents advanced theoretical results alongside motivating applications. Topics include: properties of Hermitian, positive definite, nonnegative and stochastic matrices; Perron-Frobenius Theorem; spectral perturbation theory; singular value inequalities; generalized eigenvalue problems; functions of matrices; Lyapunov, Sylvester, and Riccati matrix equations. Applications include dynamical systems, control theory, and Markov chains.

CAAM 452 - NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
Short Title: NUMERICAL METHODS FOR PDES
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course covers various numerical methods for solving partial differential equations: aspects of finite difference methods, finite element methods, finite volume methods, mixed methods, discontinuous Galerkin methods, and meshless methods. Both theoretical convergence and practical implementation of the methods are studied for elliptic and parabolic problems. Cross-list: CEVE 455. Graduate/Undergraduate Equivalency: CAAM 536. Recommended Prerequisite(s): CAAM 336
Mutually Exclusive: Cannot register for CAAM 452 if student has credit for CAAM 536.

CAAM 453 - NUMERICAL ANALYSIS I
Short Title: NUMERICAL ANALYSIS I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CAAM 334 or CAAM 335) and CAAM 336

CAAM 454 - ITERATIVE METHODS FOR SYSTEMS OF EQUATIONS AND UNCONSTRAINED OPTIMIZATION
Short Title: SYST OF EQNS & UNCONST OPTIM
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Iterative methods for linear systems of equations including Krylov subspace methods; Newton and Newton-like methods for nonlinear systems of equations; Gradient and Newton-like methods for unconstrained optimization and nonlinear least squares problems; techniques for improving the global convergence of these algorithms; linear programming duality and primal-dual interior-point methods. Graduate/Undergraduate Equivalency: CAAM 554. Recommended Prerequisite(s): CAAM 453. Mutually Exclusive: Cannot register for CAAM 454 if student has credit for CAAM 554.

CAAM 457 - OPTIMIZATION METHODS IN FINANCE
Short Title: OPT METHODS IN FINANCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 378
Description: Portfolio optimization and asset allocation models. Risk management and option pricing. Deterministic and stochastic optimization approaches, as well as linear and nonlinear approaches will be used to model decisions arising in finance. Graduate/Undergraduate Equivalency: INDE 567. Mutually Exclusive: Cannot register for CAAM 467 if student has credit for INDE 567.

CAAM 467 - OPTIMIZATION METHODS IN FINANCE
Short Title: OPT METHODS IN FINANCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 378
Description: Portfolio optimization and asset allocation models. Risk management and option pricing. Deterministic and stochastic optimization approaches, as well as linear and nonlinear approaches will be used to model decisions arising in finance. Graduate/Undergraduate Equivalency: INDE 567. Mutually Exclusive: Cannot register for CAAM 467 if student has credit for INDE 567.

CAAM 470 - GRAPH THEORY
Short Title: GRAPH THEORY
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Study of the structure and properties of graphs, together with a variety of applications. Includes paths, cycles, trees, connectivity, matchings, colorings, planarity, directed graphs, and algorithms. Some knowledge of linear algebra is recommended. Graduate/Undergraduate Equivalency: CAAM 570. Mutually Exclusive: Cannot register for CAAM 470 if student has credit for CAAM 570.
CAAM 471 - LINEAR AND INTEGER PROGRAMMING
Short Title: LINEAR AND INTEGER PROGRAMMING
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Linear and integer programming involve formulating and solving fundamental optimization models widely used in practice. This course introduces the basic theory, algorithms, and software of linear and integer programming. Topics studied in the linear programming part include polyhedron concepts, simplex methods, duality, sensitivity analysis and decomposition techniques. Building on linear programming, the second part of this course introduces modeling with integer variables and solution methodologies in integer programming including branch-and-bound and cutting-plane techniques. This course will provide a basis for further studies in convex and combinatorial optimization. Graduate/Undergraduate Equivalency: CAAM 571. Recommended Prerequisite(s): CAAM 335 and CAAM 378 Mutually Exclusive: Cannot register for CAAM 471 if student has credit for CAAM 571.

CAAM 476 - LARGE-SCALE OPTIMIZATION
Short Title: LARGE-SCALE OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 378 and COMP 215
Description: Decomposition of large-scale linear, nonlinear and integer programs. Minkowski representation of polyhedral. Benders’ and Dantzig-Wolfe decomposition. Relaxations, including Lagrangian relaxation. Examples include multicommodity flow and stochastic linear programs. Design and testing of computational strategies for difficult optimization problems. Students will implement projects in Python and JuMP. Graduate/Undergraduate Equivalency: INDE 546. Mutually Exclusive: Cannot register for CAAM 476 if student has credit for INDE 546.

CAAM 477 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Independent Study, Internship/Practicum, Laboratory, Lecture, Seminar, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Topics and credit hours vary each semester. Contact department for current semester’s topic(s). Repeatable for Credit.

CAAM 480 - PEDAGOGY FOR CAAM 210 RICE LEARNING ASSISTANTS
Short Title: PEDAGOGY FOR RLAs
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course is designed to support Rice Learning Assistants (RLAs) as they instruct their own lab sections of CAAM 210. Topics include analysis of computational science and engineering concepts, issues of problem-based learning (PBL), theories of learning, and fundamental teaching skills. Required for CAAM 210 RLAs. Instructor Permission Required. Repeatable for Credit.

CAAM 485 - SIMULATION MODELING AND ANALYSIS
Short Title: SIM MODELING AND ANALYSIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 382 (may be taken concurrently)
Description: This course introduces simulation techniques that uses statistical sampling, probability models and computational tools to study complex stochastic systems arising in service operations, healthcare, telecommunications, production, logistics, inventory and financial systems. Topics covered include generating random objects (random variables and stochastic processes, discrete-event systems), input and output analysis, steady-state simulation, variance-reduction methods, rare-event simulation, Markov chain Monte Carlo methods, and simulation-based optimization. The course lectures are supplemented with programming components in homework and projects. Graduate/Undergraduate Equivalency: CAAM 586. Recommended Prerequisite(s): MATH 212, (STAT 310 or STAT 311 or STAT 418), (CAAM 334 or CAAM 335), and MATH 302

CAAM 490 - UNDERGRADUATE RESEARCH PROJECTS
Short Title: UNDERGRAD RESEARCH PROJECTS
Department: Comp Appl Math Operations Rsch
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Semester-long undergraduate-level research on a topic in Computational and Applied Mathematics. Instructor Permission Required. Repeatable for Credit.
CAAM 491 - UNDERGRADUATE RESEARCH PROJECTS
Short Title: UNDERGRAD RESEARCH PROJECTS
Department: Comp Appl Math Operations Rsch
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Semester-long undergraduate-level research on a topic in Computational and Applied Mathematics. Instructor Permission Required. Repeatable for Credit.

CAAM 495 - SENIOR DESIGN PROJECT I
Short Title: SENIOR DESIGN PROJECT I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Students engage in team-oriented year-long design projects that utilize modeling, analysis, and scientific computing skills to solve a problem motivated by an application in engineering or the physical, biological, or social sciences. Participants attend regular seminars addressing research techniques and effective written and verbal presentation of mathematics.

CAAM 496 - SENIOR DESIGN PROJECT II
Short Title: SENIOR DESIGN PROJECT II
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CAAM 495
Description: Continuation of CAAM 495. Seminars focus on the presentation of results from design groups and provide guidance on the composition of a substantial project report.

CAAM 497 - LOSING THE PRECIOUS FEW
Short Title: LOSING THE PRECIOUS FEW
Department: Comp Appl Math Operations Rsch
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Lecture
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: The class will read from Tapia's text: Losing the Precious Few: How America Fails to Educate Minorities in Science and Engineering and then discuss in class issues associated with the underrepresentation of Blacks and Hispanics in academic and national science and engineering activities. Topics will include racism, immigration, student admissions, faculty hiring, faculty promotion, the role of minority serving institutions, mistaking foreign minorities for the Precious Few, support issues and leadership.

CAAM 498 - RESEARCH THEMES IN THE MATHEMATICAL SCIENCES
Short Title: RESEARCH THEMES IN MATH. SCI.
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: A seminar course that will cover a selected theme of general research in the mathematical sciences from the perspectives of mathematics, computational and applied mathematics and statistics. The course may be repeated multiple times for credit. Cross-list: MATH 498, STAT 498. Graduate/Undergraduate Equivalency: CAAM 698. Mutually Exclusive: Cannot register for CAAM 498 if student has credit for CAAM 698. Repeatable for Credit.

CAAM 499 - COMPUTATIONAL AND APPLIED MATHEMATICS SEMINAR
Short Title: COMP & APPLIED MATH SEMINAR
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course prepares a student for research in the mathematical sciences on a specific topic. Each section is dedicated to a different topic. Current topics include eigenvalues, model reduction, combinatorial optimization, optimization algorithms, scientific computing, and numerical analysis. The topics may vary each semester. Graduate/Undergraduate Equivalency: CAAM 699. Repeatable for Credit.

CAAM 501 - ANALYSIS I
Short Title: ANALYSIS I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Real numbers, completeness, sequences and convergence, compactness, continuity, the derivative, the Riemann integral, fundamental theorem of calculus. Vector spaces, dimension, linear maps, inner products and norms, derivatives in R^d, inverse function theorem, implicit function theorem, multiple integration, change of variable theorem. Instructor Permission Required. Recommended Prerequisite(s): CAAM 501 Mutually Exclusive: Cannot register for CAAM 501 if student has credit for CAAM 401.
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<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Description</th>
<th>Course Level</th>
<th>Credit Hours</th>
<th>Restrictions</th>
<th>Department</th>
<th>Short Title</th>
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<tbody>
<tr>
<td>CAAM 502</td>
<td>ANALYSIS II</td>
<td>Scientific programming using high level languages, including C, Fortran, and C++. Emphasis on use of numerical libraries. Basic techniques of project planning, source management, documentation, program construction, i/o, visualization. Object-oriented design for numerical computing. Grading and assignments would be different between the 400/500 level. Graduate/Undergraduate Equivalency: CAAM 419. Recommended Prerequisite(s): (CAAM 210 and CAAM 335) or CAAM 453. Mutually Exclusive: Cannot register for CAAM 519 if student has credit for CAAM 419.</td>
<td>Graduate</td>
<td>3</td>
<td>Enrollment is limited to Graduate level students.</td>
<td>Comp Appl Math Operations Rsch</td>
<td>ANALYSIS II</td>
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<tr>
<td>CAAM 519</td>
<td>COMPUTATIONAL SCIENCE I</td>
<td>Scientific programming using high level languages, including C, Fortran, and C++. Emphasis on use of numerical libraries. Basic techniques of project planning, source management, documentation, program construction, i/o, visualization. Object-oriented design for numerical computing. Grading and assignments would be different between the 400/500 level. Graduate/Undergraduate Equivalency: CAAM 419. Recommended Prerequisite(s): (CAAM 210 and CAAM 335) or CAAM 453. Mutually Exclusive: Cannot register for CAAM 519 if student has credit for CAAM 419.</td>
<td>Graduate</td>
<td>3</td>
<td>Enrollment is limited to Graduate level students.</td>
<td>Comp Appl Math Operations Rsch</td>
<td>COMPUTATIONAL SCIENCE I</td>
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<tr>
<td>CAAM 520</td>
<td>COMPUTATIONAL SCIENCE II</td>
<td>Scientific programming using high level languages, including C, Fortran, and C++. Emphasis on use of numerical libraries. Basic techniques of project planning, source management, documentation, program construction, i/o, visualization. Object-oriented design for numerical computing. Grading and assignments would be different between the 400/500 level. Graduate/Undergraduate Equivalency: CAAM 419. Recommended Prerequisite(s): (CAAM 210 and CAAM 335) or CAAM 453. Mutually Exclusive: Cannot register for CAAM 519 if student has credit for CAAM 419.</td>
<td>Graduate</td>
<td>3</td>
<td>Enrollment is limited to Graduate level students.</td>
<td>Comp Appl Math Operations Rsch</td>
<td>COMPUTATIONAL SCIENCE II</td>
</tr>
<tr>
<td>CAAM 523</td>
<td>PARTIAL DIFFERENTIAL EQUATIONS I</td>
<td>First order of partial differential equations. The method of characteristics. Analysis of the solutions of the wave equation, heat equation and Laplace's equation. Integral relations and Greens functions. Potential theory, Dirichlet and Neumann problems. Asymptotic methods: the method of stationary phase, geometrical optics, regular and singular perturbation methods. Additional course work is required beyond the undergraduate course requirements. Cross-list: MATH 513. Graduate/Undergraduate Equivalency: CAAM 423. Recommended Prerequisite(s): MATH 321 AND MATH 322 Mutually Exclusive: Cannot register for CAAM 523 if student has credit for CAAM 423.</td>
<td>Graduate</td>
<td>3</td>
<td>Enrollment is limited to Graduate level students.</td>
<td>Comp Appl Math Operations Rsch</td>
<td>PARTIAL DIFFERENTIAL EQNS I</td>
</tr>
<tr>
<td>CAAM 535</td>
<td>MODELING MATHEMATICAL PHYSICS</td>
<td>Theory and application of the message passing interface for programming scientific computing applications. Introduction to the architecture and programming of multicores and massively parallel processors, including general purpose graphics processing units, Insight for designing efficient numerical algorithms to improve parallelization of memory access and utilization of non-uniform memory architectures. Application interfaces include OpenMP, MPI, CUDA, OpenCL, and parallel numerical algorithm libraries. Grading and assignments would be different between the 400/500 level. Instructor Permission Required. Graduate/Undergraduate Equivalency: CAAM 420. Recommended Prerequisite(s): CAAM 519 Mutually Exclusive: Cannot register for CAAM 520 if student has credit for CAAM 420.</td>
<td>Graduate</td>
<td>3</td>
<td>Enrollment is limited to Graduate level students.</td>
<td>Comp Appl Math Operations Rsch</td>
<td>MODELING MATHEMATICAL PHYSICS</td>
</tr>
</tbody>
</table>

2022-2023 General Announcements PDF Generated 11/23/22
CAAM 536 - NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
Short Title: NUMERICAL METHODS FOR PDES
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: This course covers various numerical methods for solving partial differential equations: aspects of finite difference methods, finite element methods, finite volume methods, mixed methods, discontinuous Galerkin methods, and meshless methods. Both theoretical convergence and practical implementation of the methods are studied for elliptic and parabolic problems. May receive credit for only one of the following courses: CAAM 452/CEVE 455/CAAM 536/CEVE 555. Cross-list: CEVE 555. Graduate/Undergraduate Equivalency: CAAM 452. Recommended Prerequisite(s): CAAM 336 Mutually Exclusive: Cannot register for CAAM 536 if student has credit for CAAM 452.

CAAM 540 - APPLIED FUNCTIONAL ANALYSIS
Short Title: APPLIED FUNCTIONAL ANALYSIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 402 or CAAM 502
Description: Hilbert spaces, Banach spaces, spectral theory, and weak topologies with applications to signal processing, control, and partial differential equations. Biennial; Offered in Odd Years. Recommended Prerequisite(s): CAAM 402 and MATH 322.

CAAM 542 - DISCONTINUOUS GALERKIN METHODS FOR SOLVING ENGINEERING PROBLEMS
Short Title: DISCONTINUOUS GALERKIN METHODS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 423 and CAAM 502
Description: Construction and application of numerical algorithms for root finding, interpolation and approximation of functions, quadrature, and the solution of differential equations; fundamentals of computer arithmetic; solution of linear systems, linear least squares problems, and eigenvalue problems via matrix factorizations; Newton and Newton-like methods for nonlinear systems of equations. Computer programming in MATLAB is required. Graduate/Undergraduate Equivalency: CAAM 453. Mutually Exclusive: Cannot register for CAAM 550 if student has credit for CAAM 453.

CAAM 545 - APPLIED AND COMPUTATIONAL MICROLOCAL AND HARMONIC ANALYSIS
Short Title: MICROLOCAL & HARMONIC ANALYSIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 423 and CAAM 502
Description: Introduction to microlocal and harmonic analysis. Oscillatory integrals, Wavefront set, Pseudodifferential and Fourier Integral Operators and their calculus, and basic symplectic geometry. Egorov's theorem and propagation of singularities. Wavepackets, matrix classes and discretization, USFFT and fast curvelet transform. Parametrix construction for wave equations and applications in imaging. Recommended Prerequisite(s): MATH 302, (CAAM 334 or CAAM 335), MATH 401, CAAM 453

CAAM 550 - NUMERICAL ANALYSIS I
Short Title: NUMERICAL ANALYSIS I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 302, (CAAM 334 or CAAM 335), MATH 401
Description: Root finding, interpolation and approximation of functions, quadrature, and the solution of differential equations; fundamentals of computer arithmetic; solution of linear systems, linear least squares problems, and eigenvalue problems via matrix factorizations; Newton and Newton-like methods for nonlinear systems of equations. Connection between multigrid methods and some special architectures of neural networks. Randomized methods for matrix computations: randomized matrix matrix multiplications, randomized SVD, randomized least squares and QR. Recommended Prerequisite(s): CAAM 453 or CAAM 550 or CAAM 553
CAAM 552 - FOUNDATIONS OF FINITE ELEMENT METHODS
Short Title: FINITE ELEMENT METHODS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: This course addresses the theory and implementation of finite element methods. Topics include weak solutions of partial differential equations, Sobolev spaces, approximation theory, convergence and reliability of the numerical methods. Continuous and discontinuous finite element methods are considered.

CAAM 553 - ADVANCED NUMERICAL ANALYSIS I
Short Title: ADV NUMERICAL ANALYSIS I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: Construction and analysis of numerical algorithms for root finding, interpolation and approximation of functions, quadrature, and the solution of differential equations; fundamentals of computer arithmetic; solution of linear systems, least squares problems, and eigenvalue problems via matrix factorizations; the singular value decomposition (SVD) and basic sensitivity analysis. Computer programming in MATLAB is required. This course covers fewer topics than CAAM 453 with greater theoretical depth. Prerequisite CAAM 501 may be taken concurrently with CAAM 553. Instructor Permission Required.

CAAM 554 - ITERATIVE METHODS FOR SYSTEMS OF EQUATIONS AND UNCONSTRAINED OPTIMIZATION
Short Title: SYST OF EQNS & UNCONST OPTIM
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: This course covers the same lecture material as CAAM 454, but fosters greater theoretical sophistication through more challenging problem sets and exams. Graduate/Undergraduate Equivalency: CAAM 454. Recommended Prerequisite(s): CAAM 550 or CAAM 553. Mutually Exclusive: Cannot register for CAAM 554 if student has credit for CAAM 454.

CAAM 555 - ADVANCED NUMERICAL ANALYSIS II
Short Title: ADV NUMERICAL ANALYSIS II
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: This course addresses the theory and implementation of finite element methods. Topics include weak solutions of partial differential equations, Sobolev spaces, approximation theory, convergence and reliability of the numerical methods. Continuous and discontinuous finite element methods are considered.

CAAM 556 - CONVEX OPTIMIZATION
Short Title: CONVEX OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: Convex optimization problems arise in communication, system theory, VLSI, CAD, finance, inventory, network optimization, computer vision, learning, statistics, etc., even though oftentimes convexity may be hidden and unrecognized. Recent advances in interior-point methodology have made it much easier to solve these problems and various solvers are now available. This course will introduce the basic theory and algorithms for convex optimization, as well as its many applications to computer science, engineering, management science and statistics. Biennial; Offered in Odd Years. Recommended Prerequisite(s): CAAM 335 and MATH 321.

CAAM 558 - INTRO TO PARTIAL DIFFERENTIAL EQUATION BASED SIMULATION AND OPTIMIZATION
Short Title: PDE SIMULATION AND OPTIM
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Description: Introduction to the theory and numerical methods for the solution of elliptic partial differential equations (PDEs) and optimization problems governed by these PDEs. Topics include functional analysis, well-posedness of elliptic problems, optimality conditions for PDE constrained optimization problems and finite element discretizations. Recommended Prerequisite(s): CAAM 554
CAAM 470 - SIGNAL RECOVERY: THEORY AND SIMULATION
Short Title: SIGNAL RECOVERY
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course introduces the theory and numerical algorithms for several fundamental signal recovery tasks. Topics include L1 minimization, sparse regression, compressed sensing, orthogonal matching pursuit, proximal operators, ADMM algorithms, Iterative Reweighted Least Squares. Nuclear norm minimization, matrix completion, robust Principal Component Analysis. Recommended Prerequisite(s): CAAM 378 or MATH 302 or STAT 310.

CAAM 570 - GRAPH THEORY
Short Title: GRAPH THEORY
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Study of the structure and properties of graphs, together with a variety of applications. Includes paths, cycles, trees, connectivity, matchings, colorings, planarity, directed graphs, and algorithms. Some knowledge of linear algebra is recommended. This course covers the same lecture material as CAAM 470, but fosters greater theoretical sophistication through more challenging problem sets and exams on the graduate side. Graduate/Undergraduate Equivalency: CAAM 470. Mutually Exclusive: Cannot register for CAAM 570 if student has credit for CAAM 470.

CAAM 571 - LINEAR AND INTEGER PROGRAMMING
Short Title: LINEAR AND INTEGER PROGRAMMING
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: General theory and approaches for solving combinatorial optimization problems are studied. Specific topics include basic polyhedral theory, minimum spanning trees, shortest paths, network flow, matching and matroids. The course also covers the traveling salesman problem. A student may not receive credit for both CAAM 471 and CAAM 571. Mutually Exclusive: Cannot register for CAAM 571 if student has credit for CAAM 471.

CAAM 574 - COMBINATORIAL OPTIMIZATION
Short Title: COMBINATORIAL OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course covers the same lecture material as CAAM 471, but fosters greater theoretical sophistication through more challenging problem sets and exams. Graduate/Undergraduate Equivalency: CAAM 471. Mutually Exclusive: Cannot register for CAAM 571 if student has credit for CAAM 471.

CAAM 581 - MATHEMATICAL PROBABILITY I
Short Title: MATHEMATICAL PROBABILITY I
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate

CAAM 583 - INTRODUCTION TO RANDOM PROCESSES AND APPLICATIONS
Short Title: INTRO RANDOM PROCESSES & APPL
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Review of basic probability; Sequences of random variables; Random vectors and estimation; Basic concepts of random processes; Random processes in linear systems, expansions of random processes; Wiener filtering; Spectral representation of random processes, and white-noise integrals. Cross-list: ELEC 533, STAT 583.
CAAM 585 - STOCHASTIC OPTIMIZATION
Short Title: STOCHASTIC OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 571
Description: Stochastic optimization models arise in many contexts. This course focuses on stochastic programs, including stochastic integer programs and multi-stage stochastic programs. It will emphasize the interplay between theory and computational approaches.

CAAM 586 - STOCHASTIC SIMULATION: ALGORITHMS AND ANALYSIS
Short Title: STOCHASTIC SIMULATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Simulation methods and algorithms to modeling and analysis of real-world complex stochastic systems. Generating random objects (random variables and stochastic processes, discrete-event systems), input and output analysis, steady-state simulation, variance-reduction methods, rare-event simulation, Markov chain Monte Carlo methods, simulation-based optimization. This course discusses simulation algorithms and their analysis for applications in operations research (service operations, healthcare, queueing, networks, inventory, finance). It is supplemented by practical programming exercises. Graduate/Undergraduate Equivalency: CAAM 485. Recommended Prerequisite(s): MATH 212, (STAT 310 or STAT 311 or 418), (CAAM 334 or CAAM 335), CAAM 382, MATH 302

CAAM 590 - INDEPENDENT STUDY
Short Title: GRADUATE RESEARCH PROJECTS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Semester-long graduate-level research on a topic in Computational and Applied Mathematics. Instructor Permission Required. Repeatable for Credit.

CAAM 591 - GRADUATE RESEARCH PROJECTS
Short Title: GRADUATE RESEARCH PROJECTS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Semester-long graduate-level research on a topic in Computational and Applied Mathematics. Instructor Permission Required. Repeatable for Credit.

CAAM 600 - THESIS WRITING
Short Title: THESIS WRITING
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Assists the student in preparation of the CAAM MA/PhD thesis and in other writing projects. Structure of a scientific paper, effective approaches to technical writing, building literature review, results, and discussion sections, how to write a good abstract, oral presentation skills. Prerequisite: Advisor approval of topic and consent of the instructor(s). Instructor Permission Required. Repeatable for Credit.

CAAM 615 - THEORETICAL NEUROSCIENCE I: BIOPHYSICAL MODELING OF CELLS AND CIRCUITS
Short Title: THEORETICAL NEUROSCIENCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: We present the theoretical foundations of cellular and systems neuroscience from distinctly quantitative point of view. We develop the mathematical and computational tools as they are needed to model, analyze, visualize and interpret a broad range of experimental data. Additional course work required beyond the undergraduate course requirements. Cross-list: ELEC 588, NEUR 615. Graduate/Undergraduate Equivalency: CAAM 415. Mutually Exclusive: Cannot register for CAAM 615 if student has credit for CAAM 415.

CAAM 620 - TOPICS IN COMPUTATIONAL SCIENCE
Short Title: TOPICS IN COMPUTATIONAL SCIENCE
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 640 - OPTIMIZATION WITH SIMULATION CONSTRAINTS
Short Title: OPTIMIZATION W/SIM CONSTRAINTS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Recommended Prerequisite(s): CAAM 564. Repeatable for Credit.
CAAM 641 - TOPICS IN INVERSE PROBLEMS
Short Title: TOPICS IN INVERSE PROBLEMS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Theoretical, computational and practical issues for inverse problems in science and engineering. Selected topics will vary depending on instructor and student interests. Instructor Permission Required. Repeatable for Credit.

CAAM 642 - TOPICS IN SEISMIC IMAGING
Short Title: TOPICS IN SEISMIC IMAGING
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 643 - TOPICS IN GEOMATHEMATICS
Short Title: TOPICS IN GEOMATHEMATICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Recommended Prerequisite(s): CAAM 335 and CAAM 336 Repeatable for Credit.

CAAM 645 - TOPICS IN OPTIMIZATION
Short Title: TOPICS IN OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 646 - TOPICS IN NONLINEAR PROGRAMMING
Short Title: TOPICS NONLINEAR PROGRAMMING
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year.

CAAM 647 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Laboratory, Internship/Practicum, Lecture, Seminar, Independent Study, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate or Visiting Graduate level students.
Course Level: Graduate
Description: Content varies from year to year.

CAAM 651 - TOPICS IN NUMERICAL LINEAR ALGEBRA
Short Title: TOPICS IN NUM LINEAR ALGEBRA
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Selected topics will vary depending on instructor and student interests. Derivation and analysis of Krylov and subspace iteration methods for large eigenvalue problems (Lanczos, Arnoldi, Jacobi-Davidson algorithms); preconditioning for linear systems and eigenvalue problems (incomplete LU, domain decomposition, multigrid); convergence analysis including potential theory and pseudospectra. Applications: regularization of discrete inverse problems; dimension reduction for large dynamical control systems; effects on non-normality on behavior of dynamical systems and iterative processes. Recommended Prerequisite(s): CAAM 551. Repeatable for Credit.

CAAM 652 - TOPICS IN NUMERICAL DIFFERENTIAL EQUATIONS
Short Title: TOPICS IN NUM DIFF EQNS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 654 - TOPICS IN OPTIMIZATION
Short Title: TOPICS IN OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 655 - TOPICS IN NUMERICAL DIFFERENTIAL EQUATIONS
Short Title: TOPICS IN NUM DIFF EQNS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 656 - TOPICS IN OPTIMIZATION
Short Title: TOPICS IN OPTIMIZATION
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Content varies from year to year. Instructor Permission Required. Repeatable for Credit.

CAAM 657 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Laboratory, Internship/Practicum, Lecture, Seminar, Independent Study, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate or Visiting Graduate level students.
Course Level: Graduate
Description: Content varies from year to year.

CAAM 658 - RESEARCH THEMES IN THE MATHEMATICAL SCIENCES
Short Title: RESEARCH THEMES IN MATH. SCI.
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A seminar course that will cover a selected theme of general research in the mathematical sciences from the perspectives of mathematics, computational and applied mathematics and statistics. The course may be repeated multiple times for credit. Cross-list: MATH 698, STAT 698. Graduate/Undergraduate Equivalency: CAAM 498. Mutually Exclusive: Cannot register for CAAM 698 if student has credit for CAAM 498. Repeatable for Credit.
CAAM 699 - COMPUTATIONAL AND APPLIED MATHEMATICS SEMINAR
Short Title: COMP & APPLIED MATH SEMINAR
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-9
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course prepares a student for research in the mathematical sciences on a specific topic. Each section is dedicated to a different topic. Current topics include bioinformatics, biomathematics, computational finance, simulation driven optimization, data simulation, and spectral optimization in rational mechanics. The topics may vary each semester. Instructor Permission Required. Graduate/Undergraduate Equivalency: CAAM 499. Repeatable for Credit.

CAAM 800 - RESEARCH AND THESIS
Short Title: RESEARCH AND THESIS
Department: Comp Appl Math Operations Rsch
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course is for CAAM MA or PhD students working on their thesis research. Repeatable for Credit.

Description and Code Legend
Note: Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:

Course Catalog/Schedule
• Course offerings/subject code: CAAM

Department Description and Code
• Computational Applied Mathematics and Operations Research: CMOR

Undergraduate Degree Description and Code
• Bachelor of Arts degree: BA

Undergraduate Major Descriptions and Codes
• Major in Computational and Applied Mathematics: CAAM
• Major in Operations Research: OPRE

Undergraduate Minor Description and Code
• Minor in Computational and Applied Mathematics: CAMT

Graduate Degree Descriptions and Codes
• Master of Arts degree: MA
• Master of Computational and Applied Mathematics degree: MCAAM
• Master of Industrial Engineering degree: MIE
• Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code
• Degree Program in Computational and Applied Mathematics: CAAM
• Degree Program in Industrial Engineering: INDE

1 Classification of Instructional Programs (CIP) 2020 Codes and Descriptions from the National Center for Education Statistics: https://nces.ed.gov/ipeds/cipcode/