OPERATIONS RESEARCH

Contact Information

Computational and Applied Mathematics
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Operations Research (OPRE) is a major offered by the Computational and Applied Mathematics Department. The 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.

Bachelor's Program

- 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/)

Operations Research does not currently offer an academic program at the graduate level.

Chair

Illya V. Hicks

Professors

Maarten V. de Hoop
Matthias Heinkenschloss
Illya V. Hicks
Beatrice M. Rivière
Andrew J. Schaefer
Richard A. Tapia

Assistant Professor

Jesse Chan

Professors Emeriti

Robert E. Bixby
Steven J. Cox
Sam H. Davis, Jr.
John E. Dennis
Henry H. Rachford, Jr.
Danny C. Sorensen
William W. Symes
Chao-Cheng Wang
Yin Zhang

Lecturers

Anastasiya Protasov
Charles Puelz
Mohammad Sarraf Joshaghani

Pfeiffer Postdoctoral Instructors

Mario Bencomo
Tyler Perini

Professor, Joint Appointment

John Edward Akin

Adjunct Professors

Richard Carter
Amr El-Bakry
Roland Glowinski
Detlef Hohl
Hector Klie

Adjunct Associate Professors

Edward Castillo
C. David Fuller

Adjunct Assistant Professors

Sebastian Acosta
Randy Davila
David T. Fuentes
Paul Hand
Taewoo Lee
Craig Rusin

For Rice University degree-granting programs:
To view the list of official course offerings, please see Rice's Course Catalog (https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata)
To view the most recent semester's course schedule, please see Rice's Course Schedule (https://courses.rice.edu/admweb/!SWKSCAT.cat)

Computational & Applied Mathematics (CAAM)

CAAM 210 - INTRODUCTION TO ENGINEERING COMPUTATION
Short Title: INTRO TO ENG COMPUTATION
Department: Computational & Applied Math
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. 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: Computational & Applied Math
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.

CAAM 335 - MATRIX ANALYSIS
Short Title: MATRIX ANALYSIS
Department: Computational & Applied Math
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: Computational & Applied Math
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 378 - INTRODUCTION TO OPERATIONS RESEARCH AND OPTIMIZATION
Short Title: INTRO TO O.R. AND OPTIMIZATION
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 Mutually Exclusive: Cannot register for CAAM 420 if student has credit for CAAM 520.

CAAM 421 - LOGISTICS AND SUPPLY CHAIN MANAGMENT
Short Title: LOG & SUPPLY CHAIN MANAGMENT
Department: Computational & Applied Math
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
Description: Inventory management: EOQ, newsvendor, reorder point order quantity, multi-echelon models. Scheduling, distribution & location models. Vehicle routing problems. Supply chain coordination. Sustainability in supply chains. Graduate/Undergraduate Equivalency: INDE 561. Mutually Exclusive: Cannot register for CAAM 421 if student has credit for INDE 561.

CAAM 423 - PARTIAL DIFFERENTIAL EQUATIONS I
Short Title: PARTIAL DIFFERENTIAL EQNS I
Department: Computational & Applied Math
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: 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 Green's functions. Potential theory, Dirichlet and Neumann problems. Asymptotic methods: the method of stationary phase, geometrical optics, regular and singular perturbation methods. Cross-list: MATH 423. Graduate/Undergraduate Equivalency: CAAM 523. Recommended Prerequisite(s): MATH 321 AND MATH 322 Mutually Exclusive: Cannot register for CAAM 423 if student has credit for CAAM 523.

CAAM 435 - DYNAMICAL SYSTEMS
Short Title: DYNAMICAL SYSTEMS
Department: Computational & Applied Math
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 355 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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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
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 550. Mutually Exclusive: Cannot register for CAAM 453 if student has credit for CAAM 550.

CAAM 454 - ITERATIVE METHODS FOR SYSTEMS OF EQUATIONS AND UNCONSTRAINED OPTIMIZATION
Short Title: SYST OF EQNS & UNCONST OPTIM
Department: Computational & Applied Math
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 467 - OPTIMIZATION METHODS IN FINANCE
Short Title: OPT METHODS IN FINANCE
Department: Computational & Applied Math
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: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 - DISCRETE-EVENT SIMULATION
Short Title: DISCRETE-EVENT SIMULATION
Department: Computational & Applied Math
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
Description: Modeling complex stochastic systems arising in manufacturing, distribution, and service systems. Event queues. Random number generation. Input and output analysis. Introduction to optimization via simulation. Students will use specialized software as well as general programming languages to build realistic simulation models. Graduate/Undergraduate Equivalency: INDE 573. Mutually Exclusive: Cannot register for CAAM 485 if student has credit for INDE 573.

CAAM 490 - UNDERGRADUATE RESEARCH PROJECTS
Short Title: UNDERGRAD RESEARCH PROJECTS
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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
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: Computational & Applied Math
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: Computational & Applied Math
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.
Course URL: None (http://None)

CAAM 498 - RESEARCH THEMES IN THE MATHEMATICAL SCIENCES
Short Title: RESEARCH THEMES IN MATH. SCI.
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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.

CAAM 502 - ANALYSIS II
Short Title: ANALYSIS II
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Vector spaces of functions, sequences and series, convergence. Continuity and differentiability of functions of several variables, the derivative as a linear map, the contraction mapping principle, fundamental theorems on differential equations, multivariable integration, Stoke's theorem and relatives. Instructor Permission Required. Recommended Prerequisite(s): CAAM 501. Mutually Exclusive: Cannot register for CAAM 502 if student has credit for CAAM 402.

CAAM 508 - NONLINEAR SYSTEMS: ANALYSIS AND CONTROL
Short Title: NONLINEAR SYSTEMS
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Mathematical background and fundamental properties of nonlinear systems: Vector norms, matrix norms, matrix measures, existence and uniqueness of solutions of ordinary differential equations. Linearization, second order systems, periodic solutions, approximate methods. Lyapunov stability: Stability definitions, Lyapunov's direct method, invariance theory, stability of linear systems, Lyapunov's linearization method, converse theorems. Selected topics in nonlinear systems analysis and nonlinear control from: Input/Output stability: Small gain theorem, passivity theorem. Perturbation theory, averaging, and singular perturbations. Feedback linearization control. Other methods in the control of nonlinear systems such as backstepping, sliding mode and other Lyapunov-based design methods. Advanced nonlinear and adaptive robot control. Cross-list: ELEC 508, MECH 508.

CAAM 519 - COMPUTATIONAL SCIENCE I
Short Title: COMPUTATIONAL SCIENCE I
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
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 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.

CAAM 520 - COMPUTATIONAL SCIENCE II
Short Title: COMPUTATIONAL SCIENCE II
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
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 420. Recommended Prerequisite(s): CAAM 519 Mutually Exclusive: Cannot register for CAAM 520 if student has credit for CAAM 420.

CAAM 523 - PARTIAL DIFFERENTIAL EQUATIONS I
Short Title: PARTIAL DIFFERENTIAL EQNS I
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: 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 Green's 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.

CAAM 535 - MODELING MATHEMATICAL PHYSICS
Short Title: MODELING MATHEMATICAL PHYSICS
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course combines basic physical principles with vector calculus to derive many important partial differential equations governing motion of fluids and solids. Topics include stress, strain, idealized fluids, linear elasticity, acoustics, basics of thermodynamics, Navier-Stokes. Graduate/Undergraduate Equivalency: CAAM 436. Recommended Prerequisite(s): CAAM 336 Mutually Exclusive: Cannot register for CAAM 535 if student has credit for CAAM 436.

CAAM 536 - NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
Short Title: NUMERICAL METHODS FOR PDES
Department: Computational & Applied Math
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 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: Computational & Applied Math
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: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course will present the theory and implementation of discontinuous Galerkin methods for partial differential equations common in engineering applications. Two main classes of problems are covered: steady-state and time-dependent elliptic/parabolic and hyperbolic equations. These include (but are not limited to) the Poisson and heat equations, linear wave equations, and nonlinear conservation laws. Recommended Prerequisite(s): CAAM 453 or CAAM 553

CAAM 550 - NUMERICAL ANALYSIS I
Short Title: NUMERICAL ANALYSIS I
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
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 551 - NUMERICAL LINEAR ALGEBRA
Short Title: NUMERICAL LINEAR ALGEBRA
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Direct methods for large, sparse linear systems; regularization of ill-conditioned least squares problems; backward error analysis of basic algorithms for linear equations and least squares, sensitivity and conditioning of linear systems and least square problems; condition estimation. Preconditioned iterative methods for linear systems (CG, GMRES, BiCGstab, QMR); multigrid methods. Matrix theory including spectral decompositions, Schur form, eigenvalue perturbation theory, and the geometry of subspaces. Eigenvalue algorithms, Sylvester and Lyapunov equations, the implicitly shifted QR algorithm, computation of the SVD, generalized eigenvalue problems. Introduction to large scale eigenvalue algorithms. Proficiency in MATLAB and acquaintance with one or more of C, F77, C++, F90 is required. Recommended Prerequisite(s): CAAM 453 or CAAM 553 or CAAM 550

CAAM 552 - FOUNDATIONS OF FINITE ELEMENT METHODS
Short Title: FINITE ELEMENT METHODS
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
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: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 401 (may be taken concurrently) or CAAM 501 (may be taken concurrently)
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: Computational & Applied Math
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 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 558 - INTRO TO PARTIAL DIFFERENTIAL EQUATION BASED SIMULATION AND OPTIMIZATION
Short Title: PDE SIMULATION AND OPTIM
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CAAM 501 and CAAM 553
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 560 - OPTIMIZATION THEORY
Short Title: OPTIMIZATION THEORY
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Derivation and application of necessity conditions and sufficiency conditions for constrained optimization problems.

CAAM 564 - NUMERICAL OPTIMIZATION
Short Title: NUMERICAL OPTIMIZATION
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Numerical algorithms for constrained optimization problems in engineering and sciences, including simplex and interior-point methods for linear programming, penalty, barrier, augmented Lagrangian and SQP methods for nonlinear programming. Recommended Prerequisite(s): CAAM 560 (may be taken concurrently) and CAAM 454.

CAAM 565 - CONVEX OPTIMIZATION
Short Title: CONVEX OPTIMIZATION
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
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 567 - SIGNAL RECOVERY: THEORY AND SIMULATION
Short Title: SIGNAL RECOVERY
Department: Computational & Applied Math
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 568 - INDUSTRIAL AND APPLIED DATA SCIENCE AND CONTROL THEORY
Short Title: DATA SCIENCE & CONTROL THEORY
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This graduate level course presents a pragmatic introduction to the foundational theory of data science and optimal control along with multiple practical applications. It includes modern (post-1990) aspects of data science driven by massively more data and computer power such as deep neural networks. Dynamical systems and optimal control methods are deeply impacted by these developments, and the course includes relevant sections on nonlinear control and reinforcement learning. It is supplemented by practical programming exercises to be completed every week by all students. Several industrial-strength applications from the energy sector are discussed in appropriate detail. Recommended Prerequisite(s): Equivalent of advanced course work in computer programming (e.g. COMP 321), calculus (e.g. MATH 212), statistics or probability theory (e.g. STAT 331), linear algebra (e.g. CAAM 334 or 335). Proficiency in MATLAB (course programming language) or Python (alternative to MATLAB available to course participants).

CAAM 570 - GRAPH THEORY
Short Title: GRAPH THEORY
Department: Computational & Applied Math
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: Computational & Applied Math
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 574 - COMBINATORIAL OPTIMIZATION
Short Title: COMBINATORIAL OPTIMIZATION
Department: Computational & Applied Math
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 474 and CAAM 574. Mutually Exclusive: Cannot register for CAAM 574 if student has credit for CAAM 474.

CAAM 581 - MATHEMATICAL PROBABILITY I
Short Title: MATHEMATICAL PROBABILITY I
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Measure-theoretic foundations of probability. Open to qualified undergraduates. Required for PhD students in statistics. Cross-list: STAT 581.

CAAM 583 - INTRODUCTION TO RANDOM PROCESSES AND APPLICATIONS
Short Title: INTRO RANDOM PROCESSES & APPL
Department: Computational & Applied Math
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: Computational & Applied Math
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 590 - INDEPENDENT STUDY
Short Title: GRADUATE RESEARCH PROJECTS
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 COMPUTATIONL SCIENCE
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 651 - TOPICS IN NUMERICAL LINEAR ALGEBRA
Short Title: TOPICS IN NUM LINEAR ALGEBRA
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 664 - TOPICS IN NONLINEAR PROGRAMMING
Short Title: TOPICS NONLINEAR PROGRAMMING
Department: Computational & Applied Math
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 677 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Computational & Applied Math
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: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

CAAM 698 - RESEARCH THEMES IN THE MATHEMATICAL SCIENCES
Short Title: RESEARCH THEMES IN MATH. SCI.
Department: Computational & Applied Math
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: Computational & Applied Math
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: Computational & Applied Math
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 and Applied Mathematics: CAAM

Undergraduate Degree Description and Code

- Bachelor of Arts degree: BA

Undergraduate Major Description and Code

- Major in Operations Research: OPRE

CIP Code and Description [1]

- **OPRE** Major/Program: CIP Code/Title: *14.3701 - Operations Research*

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