COMP. & 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: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Lecture, Laboratory, Seminar
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
Prerequisite(s): MATH 212 or (MATH 222 and CAAM 210) or COMP 140 or STAT 405
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. 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 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
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
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Formulation and solution of mathematical models in management, economics, engineering and science applications in which one seeks to minimize or maximize an objective function subject to constraints, including models in linear, nonlinear and integer programming; basic solution methods for these optimization models; problem solving using a modeling language and optimization software. Recommended Prerequisite(s): MATH 212 and (CAAM 335 OR MATH 211 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 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

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): CAAM 210 AND MATH 212 AND (CAAM 335 OR MATH 355) AND (MATH 302 OR MATH 321).

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 477 - SPECIAL TOPICS

Short Title: SPECIAL TOPICS
Department: Computational & Applied Math
Grade Mode: Standard Letter
Course Type: Internship/Practicum, 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 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 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. Mutually Exclusive: Cannot register for CAAM 499 if student has credit for 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, Stokes'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

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. Recommended Prerequisite(s): (CAAM 210 and CAAM 335) or CAAM 453. Mutually Exclusive: Cannot register for CAAM 519 if student has credit for CAAM 420.

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. Instructor Permission Required. Recommended Prerequisite(s): CAAM 519

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 521 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. Recommended Prerequisite(s): CAAM 336 Mutually Exclusive: Cannot register for CAAM 536 if student has credit for CAAM 452.
CAAM 450 - 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 401 (may be taken concurrently) or CAAM 501
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, 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 450 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
Prerequisite(s): CAAM 453 or CAAM 553 or CAAM 550
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.

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
Prerequisite(s): CAAM 501 may be taken concurrently with CAAM 501
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
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 - NUMERICAL ANALYSIS II
Short Title: NUMERICAL 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: 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 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 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. 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. 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  
**Corequisite:** 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: 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 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:** 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. Cross-list: ESCI 643. 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 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 644 - 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: Seminar, Lecture, Laboratory, Internship/Practicum  
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. Mutually Exclusive: Cannot register for CAAM 699 if student has credit for 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.