APPLIED MATH (APPM)

Courses

APPM 1235 (4) Pre-Calculus for Engineers
Prepares students for the challenging content and pace of the calculus sequence required for all engineering majors. Covers algebra, trigonometry and selected topics in analytical geometry. Prepares students for the calculus courses offered for engineering students. Requires students to engage in rigorous work sessions as they review topics that they must be comfortable with to pursue engineering course work. Structured to accustom students to the pace and culture of learning encountered in engineering math courses. For more information about the math placement referred to in the "Enrollment Requirements", please contact your academic advisor. Formerly GEEN 1235.
Equivalent - Duplicate Degree Credit Not Granted: MATH 1021 or MATH 1150
Requisites: Requires an ALEKS math exam taken in 2016 or earlier, or placement into pre-calculus based on your admissions data and/or CU Boulder coursework.

APPM 1236 (1) Precalculus Work Group
Develops and enhances problem solving skills for students enrolled in APPM 1235. Course is conducted in a collaborative learning environment with students working in groups under the guide of a facilitator.
Requisites: Requires enrollment in corequisite course of APPM 1235.

APPM 1340 (4) Calculus 1 with Algebra, Part A
Studies selected topics in analytical geometry and calculus: rates of change of functions, limits, derivatives and their applications. This course and APPM 1345 together are equivalent to APPM 1350. The sequence of this course and APPM 1345 is specifically designed for students whose manipulative skills in the techniques of high school algebra and precalculus may be inadequate for APPM 1350. For more information about the math placement referred to in the "Enrollment Requirements", please contact your academic advisor.
Requisites: Requires prerequisite course of APPM 1235 or MATH 1021 or MATH 1150 or MATH 1160 (minimum grade C-) or an ALEKS math exam taken in 2016 or earlier, or placement into pre-calculus based on your admissions data and/or CU Boulder coursework.
Additional Information: Arts Sci Gen Ed: Quantitative Reasoning Math

APPM 1345 (4) Calculus 1 with Algebra, Part B
Continuation of APPM 1340. Studies selected topics in calculus: derivatives and their applications, integration, differentiation and integration of transcendental functions. Algebraic and trigonometric topics are studied throughout, as needed.
Equivalent - Duplicate Degree Credit Not Granted: APPM 1350 or ECON 1088 or MATH 1081 or MATH 1300 or MATH 1310 or MATH 1330
Requisites: Requires prerequisite course of APPM 1340 (minimum grade C-).

APPM 1350 (4) Calculus 1 for Engineers
Topics in analytical geometry and calculus including limits, rates of change of functions, derivatives and integrals of algebraic and transcendental functions, applications of differentiations and integration. Students who have already earned college credit for calculus 1 are eligible to enroll in this course if they want to solidify their knowledge base in calculus 1. For more information about the math placement referred to in the "Enrollment Requirements", contact your academic advisor.
Equivalent - Duplicate Degree Credit Not Granted: APPM 1345 or ECON 1088 or MATH 1081 or MATH 1300 or MATH 1310 or MATH 1330
Requisites: Requires prerequisite course of APPM 1235 or MATH 1021 or MATH 1150 or MATH 1160 or MATH 1300 (minimum grade C-) or an ALEKS math exam taken in 2016 or earlier, or placement into calculus based on your admissions data and/or CU Boulder coursework.
Additional Information: GT Pathways: GT-MA1 - Mathematics
Arts Sci Core Curr: Quant Reasn Mathmat Skills
Arts Sci Gen Ed: Quantitative Reasoning Math

APPM 1351 (1) Calculus 1 Work Group
Provides problem-solving assistance to students enrolled in APPM 1350. Student groups work in collaborative learning environment. Student participation is essential.
Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Requires enrollment in corequisite course of APPM 1350 or APPM 1345.

APPM 1360 (4) Calculus 2 for Engineers
Continuation of APPM 1350. Focuses on applications of the definite integral, methods of integration, improper integrals, Taylor's theorem, and infinite series.
Equivalent - Duplicate Degree Credit Not Granted: MATH 2300
Requisites: Requires prerequisite course of APPM 1345 or APPM 1350 or MATH 1300 (minimum grade C-).

APPM 1361 (1) Calculus 2 Work Group
Provides problem solving assistance for students enrolled in APPM 1360. Conducted in a collaborative learning environment. Student work groups solve calculus problems with assistance of facilitator.
Requisites: Requires enrollment in corequisite course of APPM 1360.

APPM 1390 (1) A Game for Calculus
Coaches students to implement study strategies geared specifically toward APPM Calculus in a structured, supportive, small group environment. Department consent required.
Repeatable: Repeatable for up to 3.00 total credit hours.

APPM 1650 (4) Python for Math and Data Science Applications
Uses Python to teach the fundamentals of computer programming with an emphasis on mathematical and statistical applications. Topics will include data types, data structures, iteration, visualization, and simulations. Techniques covered will be applicable to many scientific and technical fields. No prior programming experience is required. Formerly offered as a special topics course.
Requisites: Requires prerequisite or corequisite courses of APPM 1350 or APPM 1345 or MATH 1300 or MATH 1310 (all minimum grade C-).

APPM 2340 (4) Calculus 3 for Statistics and Data Science
Covers vectors and vector analysis, partial derivatives and the multivariable Taylor theorem, and multiple integrals. Introduces matrices and statistical applications.
Requisites: Requires prerequisite courses APPM 1360 or MATH 2300 (both minimum grade C-).

APPM 2350 (4) Calculus 3 for Engineers
Covers multivariable calculus, vector analysis, and theorems of Gauss, Green, and Stokes.
Equivalent - Duplicate Degree Credit Not Granted: MATH 2400
Requisites: Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).

APPM 2351 (1) Calculus 3 Work Group
Provides problem solving assistance to students enrolled in APPM 2350. Conducted in a collaborative learning environment. Student work groups solve calculus problems with the assistance of a facilitator.
Requisites: Requires enrollment in corequisite course of APPM 2350.

APPM 2360 (4) Introduction to Differential Equations with Linear Algebra
Introduces ordinary differential equations, systems of linear equations, matrices, determinants, vector spaces, linear transformations, and systems of linear differential equations.
Equivalent - Duplicate Degree Credit Not Granted: both MATH 2130 and MATH 3430
Requisites: Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).

APPM 2361 (1) Differential Equations Work Group
Provides problem solving assistance to students enrolled in APPM 2360. Conducted in a collaborative learning environment. Student work in groups solve ordinary differential equations and linear algebra problems with the assistance of a facilitator.
Requisites: Requires corequisite course of APPM 2360.

APPM 2450 (1) Calculus 3 Computer Lab
Selected topics in analytic geometry and calculus with a focus on symbolic computation using Mathematica.
Requisites: Requires a corequisite course of APPM 2350.

APPM 2460 (1) Differential Equations Computer Lab
Selected topics in differential equations and linear algebra with a focus on symbolic computation using MATLAB.
Requisites: Requires enrollment in a corequisite course of APPM 2360.

APPM 2720 (1-3) Open Topics in Lower Division Applied Mathematics
Provides a vehicle for the development and presentation of new topics that are accessible to lower division Applied Mathematics students. These topics have the potential to be incorporated into the core APPM curriculum.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Requires prerequisite course of APPM 1350 or MATH 1300 (minimum grade C-).
Grading Basis: Letter Grade

APPM 2750 (4) Java: Training, Mathematical Algorithms, and Mobile Apps
Preparatory course for Java programming. Provides necessary background for Java language: basic object-oriented concepts, analysis, and design. Learn to create Java applets, applications and mobile apps, create graphic context, and identify the key features of Java foundation classes as well as other Java-related technology. Material is taught in the context of mathematical algorithms from calculus. Department enforced requisite, knowledge of a programming language.
Requisites: Requires prerequisite course of APPM 1350 or MATH 1300 (minimum grade C-).

APPM 3010 (3) Chaos in Dynamical Systems
Introduces undergraduate students to chaotic dynamical systems. Topics include smooth and discrete dynamical systems, bifurcation theory, chaotic attractors, fractals, Lyapunov exponents, synchronization and networks of dynamical systems. Applications to engineering, biology and physics will be discussed.
Requisites: Requires prerequisite course of APPM 2360 or MATH 3430 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 3050 (3) Scientific Computing in Matlab
Topics covered include: approximations in computing, computer arithmetic, interpolation, matrix computations, nonlinear equations, optimization, and initial-value problems with emphasis on the computational cost, efficiency, and accuracy of algorithms. The problem sets are application-oriented with examples taken from orbital mechanics, physics, genetics, and fluid dynamics.
Requisites: Requires prerequisite course of APPM 2360 or MATH 3430 (minimum grade C-).

APPM 3170 (3) Discrete Applied Mathematics
Introduces students to ideas and techniques from discrete mathematics that are widely used in science and engineering. Mathematical definitions and proofs are emphasized. Topics include formal logic notation, proof methods; set theory, relations; induction, well-ordering; algorithms, growth of functions and complexity; integer congruences; basic and advanced counting techniques, recurrences and elementary graph theory. Other selected topics may also be covered.
Requisites: Requires a prerequisite of APPM 1360 or MATH 2300 (all minimum grade C-).

APPM 3310 (3) Matrix Methods and Applications
Introduces linear algebra and matrices with an emphasis on applications, including methods to solve systems of linear algebraic and linear ordinary differential equations. Discusses vector space concepts, decomposition theorems, and eigenvalue problems.
Equivalent - Duplicate Degree Credit Not Granted: MATH 2130 and MATH 2135
Requisites: Requires prerequisite course of APPM 2340 or APPM 2350 or APPM 2360 or MATH 2400 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 3350 (3) Advanced Engineering Calculus
Extends the treatment of engineering mathematics beyond the topics covered in Calculus 3 and differential equations. Topics include non-dimensionalization, elementary asymptotics and perturbation theory, Reynold's transport theorem and extensions of Leibnitz's rule, as applied to continuum conservation equations, Hamiltonian formulations, Legendre and Laplace transforms, special functions and their orthogonality properties.
Requisites: Requires prerequisite course of APPM 2350 or MATH 2400 and APPM 2360 (all minimum grade C-).

APPM 3570 (3) Applied Probability
Studies axioms, counting formulas, conditional probability, independence, random variables, continuous and discrete distribution, expectation, joint distributions, moment generating functions, law of large numbers and the central limit theorem.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 3810 or MATH 4510 STAT 3100
Requisites: Requires a prerequisite or corequisite course of APPM 2350 or APPM 2340 or MATH 2400 (prereq minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 3650 (3) Algorithms and Data Structures in Python
Covers data structures (stacks, queues, linked lists, hash tables, heaps), algorithms (divide and conquer, sorting, greedy, graph, dynamic programming), and asymptotic complexity with an emphasis on applied math topics. Assignments will include programming projects written in Python
Requisites: Requires prerequisite courses of (APPM 1650 or ASTR 2600 or PHYS 2600) and (APPM 1360 or MATH 2300) (minimum grade C-).

APPM 4120 (3) Introduction to Operations Research
Studies linear and nonlinear programming, the simplex method, duality, sensitivity, transportation and network flow problems, some constrained and unconstrained optimization theory, and the Kuhn-Tucker conditions, as time permits.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5120 and MATH 4120 and MATH 5120
Requisites: Requires a prerequisite course of APPM 3310 or MATH 2130 or MATH 2135 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4320 (3) Introduction to Dynamics on Networks
Introduces modern approaches to model and analyze dynamical processes on complex networks. Many dynamical processes such as epidemic propagation, opinion formation, synchronization, and cascading processes take place on complex social or technological networks. This course will introduce the tools to understand the interplay between network structure and the outcome of these dynamical processes. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5320
Requisites: Requires prerequisite courses of APPM 2360 and APPM 3310 (all minimum grade C-).
Grading Basis: Letter Grade

APPM 4350 (3) Methods in Applied Mathematics: Fourier Series and Boundary Value Problems
Reviews ordinary differential equations, including solutions by Fourier series. Physical derivation of the classical linear partial differential equations (heat, wave, and Laplace equations). Solution of these equations via separation of variables, with Fourier series, Fourier integrals, and more general eigenfunction expansions.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5350
Requisites: Requires prerequisite courses of APPM 2350 or MATH 2400 and APPM 2360 (all minimum grade C-) and a prerequisite or corequisite course of APPM 3310 (prereq minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4360 (3) Methods in Applied Mathematics: Complex Variables and Applications
Introduces methods of complex variables, contour integration and theory of residues. Applications include solving partial differential equations by transform methods, Fourier and Laplace transforms and Reimann-Hilbert boundary-value problems, conformal mapping to ideal fluid flow and/or electrostatics.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5360
Requisites: Requires prerequisite courses of APPM 2350 or MATH 2400 and APPM 2360 (all minimum grade C-) and a prerequisite or corequisite course of APPM 3310 (prereq minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4370 (3) Computational Neuroscience
Applies mathematical and computational methods to neuroscience. Techniques from linear algebra, differential equations, introductory dynamical systems, probability, stochastic processes, model validation, and machine learning will be learned and used. Neuroscience topics include neural spiking, network dynamics, probabilistic inference, learning, and plasticity. Will learn how the brain uses computational principles to enact decision making, vision, and memory. Recommended background includes linear algebra, differential equations, probability, and programming. Students will hone programming skills in MATLAB/Python and TensorFlow.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5370
Requisites: Requires prerequisite courses of APPM 2360 and APPM 3310 (all minimum grade C-).
Recommended: Prerequisite APPM 3570/STAT 3100, STAT 2600 or CSCI 3022.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4380 (3) Modeling in Applied Mathematics
An exposition of a variety of mathematical models arising in the physical and biological sciences. Students' modeling projects are presented in class. Topics may include: GPS navigation, medical imaging, ocean waves, and computerized facial recognition.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5380
Requisites: Requires prerequisite courses of APPM 2350 or MATH 2400 and APPM 2360 (all minimum grade C-).
Recommended: Prerequisites APPM 3310 and APPM 4350 and APPM 4650.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4390 (3) Modeling in Mathematical Biology
Investigates how complex systems in biology can be studied using applied mathematics. Examines several case studies which include topics from microbiology, enzyme reaction kinetics, neuroscience, ecology, epidemiology, physiology and bioengineering.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5390
Requisites: Requires prerequisite courses of APPM 2360 and APPM 3310 or MATH 3130 or MATH 3135 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4440 (3) Undergraduate Applied Analysis 1
Provides a rigorous treatment of topics covered in Calculus 1 and 2. Topics include convergent sequences; continuous functions; differentiable functions; Darboux sums, Riemann sums, and integration; Taylor and power series and sequences of functions.
Requisites: Requires prerequisite courses of APPM 2350 or MATH 2400 and APPM 2360 (all minimum grade C-) and a prerequisite or corequisite course of APPM 3310 (prereq minimum grade C-).

APPM 4450 (3) Undergraduate Applied Analysis 2
Continuation of APPM 4440. Study of multidimensional analysis including n-dimensional Euclidean space, continuity and uniform continuity of functions of several variables, differentiation, linear and nonlinear approximation, inverse function and implicit function theorems, and a short introduction to metric spaces.
Requisites: Requires prerequisite course of APPM 4440 or MATH 3001 (minimum grade C-).

APPM 4490 (3) Theory of Machine Learning
Presents the underlying theory behind machine learning in proofs-based format. Answers fundamental questions about what learning means and what can be learned via formal models of statistical learning theory. Analyzes some important classes of machine learning methods. Specific topics may include the PAC framework, VC-dimension and Rademacher complexity.
Requisites: Requires prerequisite course of APPM 4440 (minimum grade C-).
Recommended: Prerequisite CSCI 5622 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4510 (3) Data Assimilation in High Dimensional Dynamical Systems
Develops and analyzes approximate methods of solving the Bayesian inverse problem for high-dimensional dynamical systems. After briefly reviewing mathematical foundations in probability and statistics, the course covers the Kalman filter, particle filters, variational methods and ensemble Kalman filters. The emphasis is on mathematical formulation and analysis of methods.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5510, STAT 4250 and STAT 5250
Requisites: Requires prerequisite courses of APPM 3310 and APPM 3570 or STAT 3100 or MATH 4510 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4515 (3) High-Dimensional Probability for Data Science
Provides students with an exposition of the most recent methods of high-dimensional probability for the analysis of high dimensional datasets. Applications include randomized algorithms and high-dimensional random models of datasets.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5515
Requisites: Requires prerequisite courses of APPM 3310 and APPM 3570 (minimum grade C-).

APPM 4530 (3) Stochastic Analysis for Finance
Studies mathematical theories and techniques for modeling financial markets. Specific topics include the binomial model, risk neutral pricing, stochastic calculus, connection to partial differential equations and stochastic control theory.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5530, STAT 4230 and STAT 5230
Requisites: Requires prerequisite courses of APPM 3310 and APPM 3570, or STAT 3100, or MATH 4510 (all minimum grade C-).

APPM 4560 (3) Markov Processes, Queues, and Monte Carlo Simulations
Brief review of conditional probability and expectation followed by a study of Markov chains, both discrete and continuous time, including Poisson point processes. Queuing theory, terminology and single queue systems are studied with some introduction to networks of queues. Uses Monte Carlo simulation of random variables throughout the semester to gain insight into the processes under study.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5560 and STAT 4100
Requisites: Requires prerequisite courses of APPM 3570 or STAT 3100 or MATH 4510 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

APPM 4565 (3) Random Graphs
Introduces mathematical techniques, including generating functions, the first- and second-moment method and Chernoff bounds to study the most fundamental properties of the Erdos-Renyl model and other celebrated random graph models such as preferential attachment, fixed degree distribution, and stochastic block models.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5565
Requisites: Requires prerequisite APPM 3570 or MATH 4510 (both minimum grade C).

APPM 4600 (4) Numerical Methods and Scientific Computing
Provides an introduction to numerical analysis and scientific computing. Numerical analysis topics include root finding, interpolation, quadrature, linear system solution techniques, and techniques for approximating eigenvalues. Scientific computing topics include code development and repository management in addition to an introduction to shared and distributed memory computing. Involves hands-on learning with weekly group interactions and a final project including a report and in-class presentation.
Requisites: Requires prerequisite course of APPM 3310 (minimum grade C-).
Recommended: Prerequisite knowledge of a programming language such as Python, and C++.

APPM 4610 (3) Numerical Differential Equations
Provides an introduction to the most commonly used techniques for numerically solving boundary value problems and time dependent problems and the corresponding linear systems. Topics include finite difference methods, the finite element method, the spectral method, spectral collocation methods, Euler and Runge-Kutta methods. Scientific computing skills such as advanced code and memory management will be developed. Involves hands-on learning with weekly group interactions and a final project. Department enforced prerequisite: Knowledge of a programming language such as Python, and C++ is required.
Requisites: Requires prerequisite courses of APPM 2360 and APPM 4600 (all minimum grade C-).

APPM 4650 (3) Intermediate Numerical Analysis 1
Focuses on numerical solution of nonlinear equations, interpolation, methods in numerical integration, numerical solution of linear systems, and matrix eigenvalue problems. Stresses significant computer applications and software. Department enforced prerequisite: knowledge of a programming language.
Equivalent - Duplicate Degree Credit Not Granted: MATH 4650
Requisites: Requires a prerequisite course of MATH 3430 or APPM 2360 and APPM 3310 (minimum grade C-).

APPM 4720 (1-3) Open Topics in Applied Mathematics
Provides a vehicle for the development and presentation of new topics that may be incorporated into the core courses in applied mathematics. Department enforced prerequisite: variable, depending on the topic, see instructor.
Equivalent - Duplicate Degree Credit Not Granted: APPM 5720
Repeatable: Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term.

APPM 4840 (1-3) Reading and Research in Applied Mathematics
Introduces undergraduate students to the research foci of the Department of Applied Mathematics. Department enforced prerequisite: variable depending on the topic.
Repeatable: Repeatable for up to 9.00 total credit hours.

APPM 4950 (1-3) Seminar in Applied Mathematics
Introduces undergraduate students to the research foci of the program in applied mathematics. It is also designed to be a capstone experience for the program's majors. Department enforced prerequisite: variable depending on the topic.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

APPM 5120 (3) Introduction to Operations Research
Studies linear and nonlinear programming, the simplex method, duality, sensitivity, transportation and network flow problems, some constrained and unconstrained optimization theory, and the Kuhn-Tucker conditions, as time permits.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4120 and MATH 4120 and MATH 5120
Requisites: Restricted to graduate students only.
Recommended: Prerequisites APPM 3310 OR MATH 2130 OR MATH 2135 or equivalent.

APPM 5320 (3) Introduction to Dynamics on Networks
Introduces modern approaches to model and analyze dynamical processes on complex networks. Many dynamical processes such as epidemic propagation, opinion formation, synchronization, and cascading processes take place on complex social or technological networks. This course will introduce the tools to understand the interplay between network structure and the outcome of these dynamical processes. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4320
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade

APPM 5350 (3) Methods in Applied Mathematics: Fourier Series and Boundary Value Problems
Department enforced prerequsite courses: APPM 2350 or MATH 2400 and APPM 2360 and a prerequisite or corequisite course: APPM 3310 or MATH 2130 or MATH 2135.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4350
Requisites: Restricted to graduate students only.

APPM 5360 (3) Methods in Applied Mathematics: Complex Variables and Applications
Introduces methods of complex variables, contour integration and theory of residues. Applications include solving partial differential equations by transform methods, Fourier and Laplace transforms and Reimann-Hilbert boundary-value problems, conformal mapping to ideal fluid flow and/or electrostatics. Department enforced prerequisites: APPM 2350 or MATH 2400 and APPM 2360 and a prerequisite or corequisite course of APPM 3310 or MATH 3130 or MATH 3135.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4360
Requisites: Restricted to graduate students only.

APPM 5370 (3) Computational Neuroscience
Applies mathematical and computational methods to neuroscience. Techniques from linear algebra, differential equations, introductory dynamical systems, probability, stochastic processes, model validation, and machine learning will be learned and used. Neuroscience topics include neural spiking, network dynamics, probabilistic inference, learning, and plasticity. Will learn how the brain uses computational principles to enact decision making, vision, and memory. Recommended background includes linear algebra, differential equations, probability, and programming. Students will hone programming skills in MATLAB/Python and TensorFlow.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4370
Requisites: Restricted to graduate students only.
Recommended: Prerequisites APPM 2360 and APPM 3310 and STAT 4000 or equivalent courses.

APPM 5380 (3) Modeling in Applied Mathematics
An exposition of a variety of mathematical models arising in the physical and biological sciences. Students' modeling projects are presented in class. Topics may include: GPS navigation, medical imaging, ocean waves, and computerized facial recognition. Department enforced prerequisites: APPM 2350 or MATH 2400 and APPM 2360.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4380
Requisites: Restricted to graduate students only.
Recommended: Prerequisites APPM 3310 and APPM 4350 and APPM 4650.

APPM 5390 (3) Modeling in Mathematical Biology
Investigates how complex systems in biology can be studied using applied mathematics. Examines several case studies which include topics from microbiology, enzyme reaction kinetics, neuroscience, ecology, epidemiology, physiology and bioengineering. Department enforced prerequisites: APPM 2360 and APPM 3310 or MATH 2130 or MATH 2135 or instructor consent required.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4390
Requisites: Restricted to graduate students only.

APPM 5430 (3) Methods in Applied Mathematics: Applications of Complex Variables
Reviews basic ideas of complex analysis, including solutions of ODEs and PDEs of physical interest via complex analysis; conformal mapping, including Schwarz-Christoffel transformations and generalizations; computational methods; Riemann-Hilbert problems; topics in asymptotic methods. Department enforced prerequisite: APPM 4360 or APPM 5360.
Requisites: Restricted to graduate students only.

APPM 5440 (3) Applied Analysis 1
Discusses the elements of basic real and complex analysis, Banach spaces, Lp spaces and many relevant inequalities. Includes applications of existence and uniqueness of solutions to various types of ordinary differential equations, partial differential equations, and integral equations. Department enforced prerequisites: APPM 4440 and APPM 4450.
Requisites: Restricted to graduate students only.

APPM 5450 (3) Applied Analysis 2
Continuation of APPM 5440. Department enforced prerequisite: APPM 5440.
Requisites: Restricted to graduate students only.

APPM 5460 (3) Methods in Applied Mathematics: Dynamical Systems and Differential Equations
Introduces the theory and applications of dynamical systems through solutions to differential equations. Covers existence and uniqueness theory, local stability properties, qualitative analysis, global phase portraits, perturbation theory and bifurcation theory. Special topics may include Melnikov methods, averaging methods, bifurcations to chaos and Hamiltonian systems. Department enforced prerequisites: APPM 2360 and APPM 3310 and APPM 4440.
Requisites: Restricted to graduate students only.

APPM 5470 (3) Methods of Applied Mathematics: Partial Differential and Integral Equations
Studies properties and solutions of partial differential equations. Covers methods of characteristics, well-posedness, wave, heat and Laplace equations, Green's functions and related integral equations. Department enforced prerequisites: APPM 4350 or MATH 4470 and APPM 4360 or MATH 3450.
Requisites: Restricted to graduate students only.

APPM 5480 (3) Methods of Applied Mathematics: Approximation Methods
Covers asymptotic evaluation of integrals (stationary phase and steepest descent), perturbation methods (regular and singular methods, and inner and outer expansions), multiple scale methods and applications to differential and integral equations. Department enforced prerequisite: APPM 5470.
Requisites: Restricted to graduate students only.

APPM 5490 (3) Theory of Machine Learning
Presents the underlying theory behind machine learning in proofs-based format. Answers fundamental questions about what learning means and what can be learned via formal models of statistical learning theory. Analyzes some important classes of machine learning methods. Specific topics may include the PAC framework, VC-dimension and Rademacher complexity.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites APPM 4440 and CSCI 5622.

APPM 5510 (3) Data Assimilation in High Dimensional Dynamical Systems
Develops and analyzes approximate methods of solving the Bayesian inverse problem for high-dimensional dynamical systems. After briefly reviewing mathematical foundations in probability and statistics, the course covers the Kalman filter, particle filters, variational methods and ensemble Kalman filters. The emphasis is on mathematical formulation and analysis of methods.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4510, STAT 4250 and STAT 5250
Requisites: Restricted to graduate students only.

APPM 5515 (3) High-Dimensional Probability for Data Science
Provides students with an exposition of the most recent methods of high-dimensional probability for the analysis of high dimensional datasets. Applications include randomized algorithms and high-dimensional random models of datasets.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4515
Requisites: Restricted to graduate students only.
Recommended: Prerequisites APPM 3310 and APPM 3570, or equivalent.

APPM 5530 (3) Stochastic Analysis for Finance
Studies mathematical theories and techniques for modeling financial markets. Specific topics include the binomial model, risk neutral pricing, stochastic calculus, connection to partial differential equations and stochastic control theory.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4530, STAT 5230 and STAT 4230
Requisites: Restricted to graduate students only.
Recommended: Prerequisite previous coursework equivalent to that of APPM 3310 and one of APPM 3570, STAT 3100 or MATH 4510; all with minimum grade of C-.

APPM 5560 (3) Markov Processes, Queues, and Monte Carlo Simulations
Brief review of conditional probability and expectation followed by a study of Markov chains, both discrete and continuous time, including Poisson point processes. Queuing theory, terminology and single queue systems are studied with some introduction to networks of queues. Uses Monte Carlo simulation of random variables throughout the semester to gain insight into the processes under study.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4560, STAT 4100 and STAT 5100
Requisites: Restricted to graduate students only.

APPM 5565 (3) Random Graphs
Introduces mathematical techniques, including generating functions, the first- and second-moment method and Chernoff bounds to study the most fundamental properties of the Erdos-Renyl model and other celebrated random graph models such as preferential attachment, fixed degree distribution, and stochastic block models.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4565
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade

APPM 5600 (3) Numerical Analysis 1
Solution of nonlinear algebraic equations, interpolation, integration, approximation, and numerical linear algebra. Department enforced prerequisite: APPM 3310 or MATH 2130 and experience with a scientific programming language.
Requisites: Restricted to graduate students only.

APPM 5610 (3) Numerical Analysis 2
Numerical linear algebra, eigenvalue problems, optimization problems, and ordinary and partial differential equations. Department enforced prerequisite: APPM 5600 or MATH 5600.
Requisites: Restricted to graduate students only.

APPM 5620 (3) Numerical Linear Algebra
Develops and analyzes methods for the solution of square nonsingular linear systems, linear least squares problems, eigenvalue problems, and rank estimation. Direct and iterative methods are covered, as well as methods for dense and sparse problems. Requires solid background in linear algebra and proficiency with scientific computing.
Requisites: Restricted to graduate students only.

APPM 5650 (3) Randomized Algorithms
Investigates modern randomized methods that are used in scientific and numerical computing, in particular randomized matrix approximation methods. Other topics may include stochastic gradient methods and variance reduced versions, compressed sensing, and locality sensitive hashing.
Equivalent - Duplicate Degree Credit Not Granted: STAT 5650
Requisites: Restricted to graduate students only.
Recommended: Prerequisite APPM 4440 or equivalent.

APPM 5720 (1-3) Open Topics in Applied Mathematics
Provides a vehicle for the development and presentation of new topics that may be incorporated into the core courses in applied mathematics. Department enforced prerequisite: variable, depending on the topic, see instructor.
Equivalent - Duplicate Degree Credit Not Granted: APPM 4720
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

APPM 6470 (3) Advanced Partial Differential Equations
Continuation of APPM 5470. Advanced study of the properties and solutions of elliptic, parabolic, and hyperbolic partial differential equations. Topics include the study of Sobolev spaces and variational methods as they relate to PDEs, and other topics as time permits. Department enforced prerequisite: APPM 5470.
Requisites: Restricted to graduate students only.

APPM 6520 (3) Mathematical Statistics
Emphasizes mathematical theory of statistics. Topics include distribution theory, estimation and testing of hypotheses, multivariate analysis, and nonparametric inference, all with emphasis on theory. Department enforced prerequisite: APPM 5520 or MATH 5520.
Requisites: Restricted to graduate students only.

APPM 6550 (3) Introduction to Stochastic Processes
Systematic study of Markov chains and some of the simpler Markov processes including renewal theory, limit theorems for Markov chains, branching processes, queuing theory, birth and death processes, and Brownian motion. Applications to physical and biological sciences. Department enforced prerequisite: MATH 4001 or MATH 4510 or APPM 3570 or APPM 4560 or instructor consent.
Equivalent - Duplicate Degree Credit Not Granted: MATH 6550
Requisites: Restricted to graduate students only.

APPM 6560 (3) Measure-Theoretic Probability
Introduces a series of fundamental concepts and results in probability theory, using rigorous measure-theoretic language. Provides a solid foundation for further studies and research in probability, stochastic processes, statistics, and data science.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites Undergraduate analysis at the level of APPM 4440.

APPM 6570 (3) Stochastic Differential Equations
Devoted to a comprehensive investigation of stochastic differential equations, as well as their important applications in Finance, Physics, and Engineering. Consists of three main topics: stochastic integration, the theory of stochastic differential equations (SDEs), and applications of SDEs.
Recommended: Prerequisite APPM 6560 or MATH/APPM 6550.

APPM 6610 (3) Introduction to Numerical Partial Differential Equations
Covers finite difference, finite element, finite volume, pseudo-spectral, and spectral methods for elliptic, parabolic, and hyperbolic partial differential equations. Department enforced prerequisite: APPM 5600.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite APPM 5610 or graduate numerical linear algebra.

APPM 6640 (3) Multigrid Methods
Develops a fundamental understanding of the principles and techniques of the multigrid methodology, which is a widely used numerical approach for solving many problems in such diverse areas as aerodynamics, astrophysics, chemistry, electromagnetics, hydrology, medical imaging, meteorology/oceanography, quantum mechanics, and statistical physics.
Requisites: Restricted to graduate students only.

APPM 6900 (1-6) Independent Study
Introduces graduate students to research foci of the Department of Applied Mathematics.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

APPM 6920 (1-3) Professional Internship
This class provides a structure for Applied Mathematics graduate students to receive academic credit for internships with industry partners that have an academic component to them suitable for graduate-level work. Participation in the program will consist of an internship agreement between a student and an industry partner who will employ the student in a role that supports the academic goals of the internship. Instructor participation will include review of internship agreement, facilitation of mid-term and final assessments of student performance, and support for any academic-related issues that may arise during the internship period.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to Applied Mathematics (APPM) graduate students only.
Grading Basis: Letter Grade

APPM 6930 (1-3) Professional Master's Culminating Experience
Provides an opportunity for an Applied Mathematics Professional Master¿s student to complete their Culminating Experience (CE) project with an advisor. Before enrolling, the student is expected to have an advisor who has agreed to guide a proposed CE project.
Requisites: Restricted to Applied Mathematics professional master's degree (AMEN-MSAM) students only.
Grading Basis: Letter Grade

APPM 6940 (1) Master's Candidate for Degree
Requisites: Restricted to graduate students only.

APPM 6950 (1-6) Master's Thesis
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

APPM 7100 (3) Mathematical Methods in Dynamical Systems
Covers dynamical systems defined by mappings and differential equations. Hamiltonian mechanics, action-angle variables, results from KAM and bifurcation theory, phase plane analysis, Melnikov theory, strange attractors, chaos, etc.
Requisites: Requires prerequisite course of APPM 5460 (minimum grade D-). Restricted to graduate students only.

APPM 7300 (3) Nonlinear Waves and Integrable Equations
Includes basic results associated with linear dispersive wave systems, first-order nonlinear wave equations, nonlinear dispersive wave equations, solitons, and the methods of the inverse scattering transform. Department enforced prerequisites: APPM 4350 and APPM 4360.
Requisites: Restricted to graduate students only.

APPM 7400 (1-3) Topics in Applied Mathematics
Provides a vehicle for the development and presentation of new topics with the potential of being incorporated into the core courses in applied mathematics.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

APPM 7900 (1-3) Independent Study
Introduces graduate students to research foci of the Department of Applied Mathematics.
Requisites: Restricted to graduate students only.

APPM 8000 (1) Colloquium in Applied Mathematics
Introduces graduate students to the major research foci of the Department of Applied Mathematics.
Requisites: Restricted to Applied Mathematics (APPM) graduate students only.

APPM 8100 (1) Seminar in Dynamical Systems
Introduces advanced topics and research in dynamical systems.
Requisites: Restricted to Applied Mathematics (APPM) graduate students only.

APPM 8300 (1-3) Nonlinear Waves Seminar
Introduces the core methods in the analysis of nonlinear partial differential and integral equations or systems to graduate students. Provides a vehicle for the development, presentation, and corporative research of new topics in PDE and analysis.
Requisites: Requires prerequisite course of APPM 5440 (minimum grade D-). Restricted to Applied Mathematics (APPM) graduate students only.

APPM 8400 (1) Mathematical Biology Seminar
Introduces advanced topics and research in mathematical and computational biology. Instructor consent required.
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade

APPM 8500 (1) Statistics, Optimization and Machine Learning Seminar
Research-level seminar that explores the mathematical foundations of machine learning, in particular how statistics and optimization give rise to well-founded and efficient algorithms.
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade

APPM 8600 (1) Seminar in Computational Mathematics
Introduces advanced topics and research in computational mathematics.
Requisites: Restricted to Applied Mathematics (APPM) graduate students only.

APPM 8700 (1) Mathematical Geosciences Seminar
Research-level seminar that explores applications of mathematical and statistical modeling, analysis, and computation in the geosciences. Provides a vehicle for the development, presentation, and dissemination of new topics in the mathematical geosciences. Formerly offered as a special topics course.
Repeatable: Repeatable for up to 3.00 total credit hours.
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade

APPM 8990 (1-10) Doctoral Dissertation
All doctoral students must register for no fewer than 30 hours of dissertation credit as part of the requirements for the degree. No more than 10 credit hours may be taken in any one semester.
Repeatable: Repeatable for up to 30.00 total credit hours.
Requisites: Restricted to graduate students only.