

APPLIED MATHEMATICS

The Department of Applied Mathematics in the College of Arts and Sciences offers a range of courses and research opportunities in many areas, including computational mathematics, mathematical biology, nonlinear phenomena, physical applied mathematics, and probability and statistics. Each of these areas is described below.

Course codes for this program include APPM and STAT.

Computational Mathematics

The study of computational mathematics has grown rapidly over the past 15 years and has allowed mathematicians to answer questions and develop insights not possible only 20-30 years ago. Modern computational methods require an in-depth knowledge of a variety of mathematical subjects which include linear algebra, analysis, ordinary and partial differential equations, asymptotic analysis, elements of harmonic analysis, and nonlinear equations.

Since computers are invaluable tools for an applied mathematician, students are expected to attain a highly professional level of computer literacy and gain a substantial knowledge of operating systems and hardware.

Computational mathematics courses include the study of computational linear algebra, optimization, numerical solution of ordinary and partial differential equations, solution of nonlinear equations as well as advanced seminars in wavelet and multi-resolution analysis.

Mathematical Biosciences

Recent advances in our ability to quantitatively study biological phenomena have provided a tremendous number of exciting opportunities for applied mathematicians. The careful modeling, analysis and simulation of these systems using the standard tools of applied mathematics has led to novel and non-intuitive insights into biology.

Furthermore, deeper understanding of the inherently complex and multiscale nature of biological systems, in many cases, requires the development of new mathematical tools, techniques and methodologies (a challenge to which applied mathematics is particularly well suited). Research areas in APPM encompass immunology, infectious diseases, cardiology, neuroscience, and population genetics.

See the Mathematical Biology Group page (<http://mathbio.colorado.edu>)

Mathematical Geosciences

Mathematical geosciences encompass quantitative modeling, analysis and simulation of all aspects of the Earth system. Our faculty's research intersects a broad range of geosciences: from the geodynamo to ocean circulation, from computational methods for seismic imaging to the impacts of weather on epidemiology, from tsunamis to stochastic weather generators. The complex and multiscale nature of geophysical systems, in many cases, requires the development of new mathematical models and simulation strategies, a challenge to which applied mathematics is particularly well suited.

Appropriate coursework includes analysis and computation, probability and statistics, as well as background courses in one of the sciences or engineering fields in which one intends to do research.

Nonlinear Waves and Dynamical Systems

In recent years there has been an explosion of interest in the study of nonlinear waves and dynamical systems with analytical results often motivated by the use of computers. The faculty in the Program is actively and intensively involved in this growing field; research areas include integrable and near-integrable systems, conservative and dissipative chaos, as well as numerical computation.

Topics of interest include solitons, dispersive shock waves, integrable systems, cellular automata, pattern formation, qualitative structure and bifurcation theory, onset of chaos and turbulence, analytic dynamics and transport phenomena. Program courses in this field include dynamical systems, nonlinear wave motion and many advanced seminars.

Suitable background courses are: analysis, computation, partial differential equations and methods in applied mathematics. Valuable supplemental courses include mechanics and fluid dynamics.

Physical Applied Mathematics

Physical Applied Mathematics is a term which generally refers to the study of mathematical problems with direct physical application. This area of research is intrinsically interdisciplinary. In addition to mathematical analysis, it requires a deep understanding of the underlying applications area, and usually requires knowledge and experience in numerical computation.

The Program's affiliated faculty have a wide variety of expertise in various areas of application, e.g. atmospheric and fluid dynamics, theoretical physics, plasma physics, genetic structure, etc. The course requirements of the Program are designed to provide students with a foundation for their study (analysis and computation).

The Program also requires supplemental courses in one of the science or engineering fields which are needed to begin doing thesis research in physical applied mathematics.

See the Dispersive Hydrodynamics Lab (<https://www.colorado.edu/amath/dispersive-hydrodynamics-lab>) page, APPM's own fluid dynamics laboratory.

Statistics and Applied Probability

Almost all natural phenomena in the technological, biological, physical and social sciences have random components. Applied probability is the application of probabilistic methods to understand the random elements in real-life problems. Statistics is the science of using data, which typically arises from the randomness inherent in nature, to gain new knowledge.

Research areas of the applied math and affiliated faculty exhibit this interplay between mathematics and real-life problems. Areas of current interest include optimization of stochastic networks; the study of stochastic processes and stochastic differential equations in hydrology and telecommunications; probabilistic models and statistical tests based on these models, in genetics and RNA sequencing; extreme value theory in estimation of maximal wind speeds.

Appropriate coursework includes analysis, probability and statistics, as well as background courses in one of the sciences or engineering fields in which one intends to do research.

For more information on courses and research opportunities, visit the Department of Applied Mathematics website (catalog.colorado.edu/)

graduate/colleges-schools/arts-sciences/programs-study/applied-mathematics/www.colorado.edu/amath).

Master's Degree

- Applied Mathematics - Master of Science (MS)
(catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/applied-mathematics/applied-mathematics-master-science-ms)
- Applied Mathematics - Professional Master of Science (MSAM)
(catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/applied-mathematics/applied-mathematics-professional-master-science-msam)

Doctoral Degree

- Applied Mathematics - Doctor of Philosophy (PhD)
(catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/applied-mathematics/applied-mathematics-doctor-philosophy-phd)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ablowitz, Mark J. (https://experts.colorado.edu/display/fisid_100691)
Professor; PhD, Massachusetts Institute of Technology

Appelö, Daniel (https://experts.colorado.edu/display/fisid_159438)
Associate Professor; PhD, KTH Royal Institute of Technology (Sweden)

Bebernes, Jerrold
Professor Emeritus

Becker, Stephen R. (https://experts.colorado.edu/display/fisid_154263)
Assistant Professor; PhD, California Institute of Technology

Beylkin, Gregory (https://experts.colorado.edu/display/fisid_100437)
Professor; PhD, New York University

Bhat, Yermal Sujeet (https://experts.colorado.edu/display/fisid_146506)
Instructor; PhD, University of Florida

Bortz, David Matthew (https://experts.colorado.edu/display/fisid_143348)
Associate Professor; PhD, North Carolina State University

Chang, Silva
Instructor

Clauset, Aaron (https://experts.colorado.edu/display/fisid_147554)
Associate Professor; PhD, University of New Mexico

Cole, Justin T.
Instructor; PhD, Florida State University

Corcoran, Jem (https://experts.colorado.edu/display/fisid_118142)
Associate Professor; PhD, Colorado State University

Cox, Murray William (https://experts.colorado.edu/display/fisid_153192)
Instructor; PhD, Texas A&M University

Cox, Rachel
Lecturer

Curry, James H. (https://experts.colorado.edu/display/fisid_105730)
Professor; PhD, University of California, Berkeley

Dougherty, Anne Margaret (https://experts.colorado.edu/display/fisid_101349)
Senior Instructor, Associate Chair; PhD, University of Wisconsin–Madison

Dukic, Vanja (https://experts.colorado.edu/display/fisid_148718)
Professor; PhD, Brown University

Easton, Robert
Professor Emeritus

Fornberg, Bengt (https://experts.colorado.edu/display/fisid_108048)
Professor; PhD, University of Uppsala (Sweden)

Grooms, Ian G. (https://experts.colorado.edu/display/fisid_155588)
Assistant Professor; PhD, University of Colorado Boulder

Hallowell, Susan
Lecturer; PhD, University of Pennsylvania

Hoefer, Mark (https://experts.colorado.edu/display/fisid_154264)
Associate Professor; PhD, University of Colorado Boulder

Huang, Yu-Jui (https://experts.colorado.edu/display/fisid_157746)
Assistant Professor; PhD, University of Michigan Ann Arbor

Iacocca, Ezio
Instructor; PhD, University of Gothenburg (Sweden)

Julien, Keith (https://experts.colorado.edu/display/fisid_108913)
Professor, Chair; PhD, University of Cambridge (England)

Kilpatrick, Zachary Peter (https://experts.colorado.edu/display/fisid_155782)
Assistant Professor, Visiting Assistant Professor; PhD, University of Utah

Kish, Jonathan
Lecturer; PhD, University of Colorado Boulder

Kleiber, William Paul (https://experts.colorado.edu/display/fisid_151943)
Assistant Professor; PhD, University of Washington

Li, Congming (https://experts.colorado.edu/display/fisid_100647)
Professor; PhD, New York University

Lindsey, Daniel Seneca
Lecturer

Lladser, Manuel E. (https://experts.colorado.edu/display/fisid_134170)
Associate Professor; PhD, The Ohio State University

Lyles, Danielle (https://experts.colorado.edu/display/fisid_157883)
Instructor; PhD, Cornell University

Manteuffel, Thomas A.
Professor Emeritus

McCormick, Steven
Professor Emeritus

Meiss, James D. (https://experts.colorado.edu/display/fisid_103702)
Professor; PhD, University of California, Berkeley

Meyer, Francois Georges (https://experts.colorado.edu/display/fisid_115559)
Professor; PhD, INRIA (France)

Monzon, Lucas
Instructor

Norris, Jan Adam (https://experts.colorado.edu/display/fisid_101412)
Senior Instructor; PhD, University of Colorado Boulder

Nychka, Douglas William (https://experts.colorado.edu/display/fisid_152604)
Professor Adjoint

Oscamou, Maribeth
Scholar in Residence; MS, University of Colorado Boulder

Pouquet, Annick
Adjunct Faculty; PhD, Université Nice Sophia Antipolis (France)

Restrepo, Juan G. (https://experts.colorado.edu/display/fisid_145811)
Associate Professor; PhD, University of Maryland, College Park

Rodriguez, Nancy
Assistant Professor

Rumanov, Igor E. (https://experts.colorado.edu/display/fisid_149299)
Lecturer

Segur, Harvey (https://experts.colorado.edu/display/fisid_102287)
Professor; PhD, University of California, Berkeley

Thaler, Eric R. (https://experts.colorado.edu/display/fisid_155505)
Instructor; PhD, University of Colorado Boulder

Vance, Eric (https://experts.colorado.edu/display/fisid_158342)
Associate Professor; PhD, Duke University

Williams, Sandy
Lecturer

Zaharatos, Brian R. (https://experts.colorado.edu/display/fisid_156225)
Instructor; MS, Colorado School of Mines

Courses

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. Department enforced prerequisite: APPM 2130 or MATH 2135 or MATH 2135.

Equivalent - Duplicate Degree Credit Not Granted: APPM 4120 and MATH 4120 and MATH 5120

Requisites: Restricted to graduate students only.

APPM 5250 (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 and APPM 5510

Requisites: Restricted to graduate students only.

APPM 5350 (3) Methods in Applied Mathematics: Fourier Series and Boundary Value Problems

Department enforced prerequisite 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 Riemann-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

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, L_p 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 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 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 4230 and STAT 5230

Requisites: Restricted to graduate students only.

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-Renyi 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 5570 (3) Statistical Methods

Covers basic statistical concepts with accompanying introduction to the R programming language. Topics include discrete and continuous probability laws, random variables, expectation and variance, central limit theorem, testing hypothesis and confidence intervals, linear regression analysis, simulations for validation of statistical methods and applications of methods in R.

Equivalent - Duplicate Degree Credit Not Granted: APPM 4570

Requisites: Restricted to graduate students only.

APPM 5580 (3) Introduction to Statistical Learning

Consists of applications and methods of statistical learning. Covers multiple linear regression, classification, regularization, splines, tree-based methods, support vector machines and unsupervised learning.

Equivalent - Duplicate Degree Credit Not Granted: APPM 4580

Requisites: Requires prerequisite course of APPM 4570 or APPM 5570 (minimum grade C-). Restricted to graduate students only.

APPM 5590 (3) Statistical Modeling

Introduces methods, theory and applications of statistical models, from linear models (simple and multiple linear regression), to hierarchical linear models. Topics such as estimation, residual diagnostics, goodness of fit, transformations, and various strategies for variable selection and model comparison will be discussed in depth. Examples and exercises will be demonstrated using statistical software. Department enforced prerequisite: APPM 4570 or APPM 4520 or MATH 4520 or instructor consent required.

Equivalent - Duplicate Degree Credit Not Granted: APPM 4590

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 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 APPM 5560 and 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.

Requisites: Restricted to graduate students only.

APPM 6940 (1) Master's Candidate for Degree

Requisites: Restricted to graduate students only.

Grading Basis: Pass/Fail

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 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.

STAT 5000 (3) Statistical Methods and Application I

Introduces exploratory data analysis, probability theory, statistical inference, and data modeling. Topics include discrete and continuous probability distributions, expectation, laws of large numbers, central limit theorem, statistical parameter estimation, hypothesis testing, and regression analysis. Considerable emphasis on applications in the R programming language.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4000

Requisites: Restricted to graduate students only.

Grading Basis: Letter Grade

STAT 5010 (3) Statistical Methods and Applications II

Expands upon statistical techniques introduced in STAT 4000. Topics include modern regression analysis, analysis of variance (ANOVA), experimental design, nonparametric methods, and an introduction to Bayesian data analysis. Considerable emphasis on application in the R programming language.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4010

Requisites: Requires prerequisite STAT 5000 (minimum grade C-)

Grading Basis: Letter Grade

STAT 5100 (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 APPM 4560

Requisites: Restricted to graduate students only.

STAT 5230 (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, APPM 5530 and STAT 4230

Requisites: Restricted to graduate students only.

STAT 5250 (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 APPM 5510

Requisites: Restricted to Graduate, Graduate Nondegree and non sponsored students only.

STAT 5430 (3) Spatial Statistics

Introduces the theory of spatial statistics with applications. Topics include basic theory for continuous stochastic processes, spatial prediction and kriging, simulation, geostatistical methods, likelihood and Bayesian approaches, spectral methods and an overview of modern topics such as nonstationary models, hierarchical modeling, multivariate processes, methods for large datasets and connections to spines.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4430

Requisites: Restricted to graduate students only.

STAT 5520 (3) Introduction to Mathematical Statistics

Examines point and confidence interval estimation. Principles of maximum likelihood, sufficiency, and completeness: tests of simple and composite hypotheses, linear models, and multiple regression analysis if time permits. Analyzes various distribution-free methods. Department enforced prerequisite: one semester calculus-based probability course, such as MATH 4510 or APPM 3570.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4520 and MATH 4520 and MATH 5520

Requisites: Restricted to graduate students only.

STAT 5530 (3) Mathematical Statistics

Covers the theory of estimation, confidence intervals, hypothesis testing, and decision theory. In particular, it covers the material of APPM 5520 in greater depth, especially the topics of optimality and asymptotic approximation. Additional topics include M-estimation, minimax tests, the EM algorithm, and an introduction to Bayesian estimation and empirical likelihood techniques. Recommended Prerequisite is a one-semester calculus-based probability course such as MATH 4510 or APPM 3570. Credit not granted for APPM 5530 and STAT 5520 or MATH 5520.

STAT 5540 (3) Introduction to Time Series

Studies basic properties, trend-based models, seasonal models modeling and forecasting with ARIMA models, spectral analysis and frequency filtration. Department enforced prerequisite: APPM 5520 or MATH 5520.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4540 and MATH 4540 and MATH 5540

Requisites: Restricted to graduate students only.

STAT 5610 (3) Statistical Learning

Consists of applications and methods of statistical learning. Reviews multiple linear regression and then covers classification, regularization, splines, tree-based methods, support vector machines, unsupervised learning and Gaussian process regression.

Requisites: Restricted to graduate students only.

STAT 5630 (3) Computational Bayesian Statistics

Introduces Bayesian statistics, normal and non-normal approximation to likelihood and posteriors, the EM algorithm, data augmentation, and Markov Chain Monte Carlo (MCMC) methods. Additionally, introduces more advanced MCMC algorithms and requires significant statistical computing. Examples from a variety of areas, including biostatistics, environmental sciences, and engineering, will be given throughout the course.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4630

Requisites: Requires prerequisite course of APPM 4520 or STAT 4520 or MATH 4520 (minimum grade C-).

Recommended: Prerequisite prior programming and basic statistical modeling experience is required.

STAT 5680 (3) Statistical Collaboration

Educates and trains students to become effective interdisciplinary collaborators by developing the communication and collaboration skills necessary to apply technical statistics and data science skills to help domain experts answer research questions. Topics include structuring effective meetings and projects; communicating statistics to non-statisticians; using peer feedback, self-reflection and video analysis to improve collaboration skills; creating reproducible statistical workflows; working ethically.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4680

Requisites: Requires a prerequisite course of STAT 5520 or MATH 5520 (minimum grade C-). Restricted to graduate students only.

Grading Basis: Letter Grade

STAT 5690 (2) Advanced Statistical Collaboration

Educates and trains students to become advanced interdisciplinary collaborators by developing and refining the communication, collaboration and technical statistics and data science skills necessary to collaborate with domain experts to answer research questions. Students work on multiple projects. Discussions center on technical skills necessary to solve research problems and video analysis to improve communication and collaboration skills.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4690

Requisites: Requires prerequisite course of STAT 4680 or STAT 5680 (minimum grade C-). Restricted to graduate students only.

Grading Basis: Letter Grade

STAT 5700 (3) Philosophical and Ethical Issues in Statistics

Introduces students to philosophical issues that arise in statistical theory and practice. Topics include interpretations of probability, philosophical paradigms in statistics, inductive inference, causality, reproducible, and ethical issues arising in statistics and data analysis.

Equivalent - Duplicate Degree Credit Not Granted: STAT 4700

Grading Basis: Letter Grade