AMS

Applied Mathematics and Statistics

AMS 500: Responsible Conduct of Research and Scholarship (RCRS)
This course is designed to introduce students to the major issues in the ethics of science and research. Using a combination of readings-written and web-based-videos, and case discussion, students will investigate the moral values intrinsic to science and the professional and social values with which scientists must comply. Each class will begin with an introductory lecture or video followed by discipline-based, small group discussions with the participation of an AMS faculty member.
S/U grading
May be repeated for credit.

AMS 501: Differential Equations and Boundary Value Problems I
3 credits, Letter graded (A, A-, B+, etc.)

AMS 502: Differential Equations and Boundary Value Problems II
Analytic solution techniques for, and properties of solutions of, partial differential equations, with concentration on second order PDEs. Techniques covered include: method of characteristics, separation of variables, eigenfunction expansions, spherical means. Green's functions and fundamental solutions, and Fourier transforms. Solution properties include: energy conservation, dispersion, dissipation, existence and uniqueness, maximum and mean value principles. Spring
3 credits, Letter graded (A, A-, B+, etc.)

AMS 503: Applications of Complex Analysis
A study of those concepts and techniques in complex function theory that are of interest for their applications. Pertinent material is selected from the following topics: harmonic functions, calculus of residues, conformal mapping, and the argument principle. Application is made to problems in heat conduction, potential theory, fluid dynamics, and feedback systems. Spring
3 credits, Letter graded (A, A-, B+, etc.)

AMS 504: Foundations of Applied Mathematics
An introductory course for the purpose of developing certain concepts and techniques that are fundamental in modern approaches to the solution of applied problems. An appropriate selection of topics is based on the concepts of metric spaces, compactness, sequences and convergence, continuity, differentiation and integration, function sequences, contraction mapping theorem. Strong emphasis on proofs.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 505: Applied Linear Algebra
Review of matrix operations. Elementary matrices and reduction of general matrices by elementary operations, canonical forms, and inverses. Applications to physical problems. Offered as AMS 505 or HPH 695.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 507: Introduction to Probability
The topics include sample spaces, axioms of probability, conditional probability and independence, discrete and continuous random variables, jointly distributed random variables, characteristics of random variables, law of large numbers and central limit theorem, Markov chains.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 508: Analytical Methods for Applied Mathematics and Statistics
Review of techniques of multivariate calculus, convergence and limits, matrix analysis, vector space basics, and Lagrange multipliers.
Prerequisite: A course in linear algebra and in multivariate calculus
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 510: Analytical Methods for Applied Mathematics and Statistics
Review of techniques of multivariate calculus, convergence and limits, matrix analysis, vector space basics, and Lagrange multipliers.
Prerequisite: A course in linear algebra and in multivariate calculus
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 511: Foundations of Quantitative Finance
Introduction to capital markets, securities pricing and modern portfolio theory, including the organization and operation of securities market, the Efficient Market Hypothesis and its implications, the Capital Asset Pricing Model, the Arbitrage Pricing Theory and more general factor models. Common stocks and their valuation, statistical analysis, and portfolio selection in a single-period, mean-variance context will be explored along with its solution as a quadratic program. Fixed income securities and their valuation, statistical analysis, and portfolio selection. Discussion of the development and use of financial derivatives. Introduction to risk neutral pricing, stochastic calculus and the Black-Scholes Formula. Whenever practical examples will use real market data.
Numerical exercises and projects in a high-level programming environment will also be assigned.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 512: Capital Markets and Portfolio Theory
Development of capital markets and portfolio theory in both continuous time and multi-period settings. Utility theory and its application to the determination of optimal consumption and investment policies. Asymptotic growth under conditions of uncertainty. Applications to problems in strategic asset allocation over finite horizons and to problems in public finance. Whenever practical, examples will use real market data. Numerical exercises and projects in a high-level programming environment will also be assigned.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 513: Financial Derivatives and Stochastic Calculus
Further development of derivative pricing theory including the use of equivalent martingale measures, the Girsanov Theorem, the Radon-Nikodym Derivative, and a deeper, more general understanding of the Arbitrage Theorem. Numerical approaches to solving stochastic PDE's will be further developed. Applications involving interest rate sensitive securities and more complex options will be introduced. Whenever practical examples will use real market data. Numerical exercises and projects in a high-level programming environment will also be assigned. Prerequisite: AMS 511. 3 Credits
3 credits, Letter graded (A, A-, B+, etc.)

AMS 514: Computational Finance
Review of foundations: stochastic calculus, martingales, pricing, and arbitrage. Basic principles of Monte Carlo and the efficiency and effectiveness of simulation estimators. Generation of pseudo- and quasi-random numbers with sampling methods and applications. Variance reduction techniques such as control variates, antithetic variates, stratified and Latin hypercubing sampling, and importance sampling. Discretization methods including first and second order methods, trees, jumps, and barrier crossings. Applications in pricing American options, interest rate sensitive derivatives, mortgage-backed securities and risk management. Depending on practical examples will use real market data. Extensive numerical exercises and projects in a general programming environment will also be assigned.
3 credits, Letter graded (A, A-, B+, etc.)
AMS 515: Case Studies in Machine Learning and Finance
The course will cover applications of Quantitative Finance to risk assessment, portfolio management, cash flow matching, securities pricing and other topics. Particular attention will be paid to machine learning approaches, such as neural networks and support vector machines, data collection and analysis, the design and implementation of software. We will study differences between theory and practice in model application, including in-sample and out-of-sample analysis.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 516: Statistical Methods in Finance
The course introduces statistical methodologies in quantitative finance. Financial applications and statistical methodologies are intertwined in all lectures. The course will cover regression analysis and applications to the Capital Asset Pricing Model and multifactor pricing models, principal components and multivariate analysis, statistical methods for financial time series; value at risk, smoothing techniques and estimation of yield curves, and estimation and modeling of volatilities. Prerequisite: AMS 507 3 credits, ABCF grading
3 credits, Letter graded (A, A-, B+, etc.)

AMS 517: Quantitative Risk Management
The course will cover structural and reduced-form approach to pricing credit default, Markovian models (or rating-based) pricing methods, statistical inference of relative risks, counting process, correlated (or dependent) default times, copula methods and pricing models for CDOs. Prerequisite: AMS 507 and AMS 511 3 credits, ABCF grading
3 credits, Letter graded (A, A-, B+, etc.)

AMS 518: Advanced Stochastic Models, Risk Assessment, and Portfolio Optimization
The course provides a thorough treatment of advanced risk measurement and portfolio optimization, extending the traditional approaches to these topics by combining distributional models with risk or performance measures into one framework. It focuses on, among others, the fundamentals of probability metrics and optimization, new approaches to portfolio optimization and a variety of essential risk measures. Numerical exercises and projects in a high-level programming environment will be assigned. Prerequisite: AMS 512 or AMS 516 or AMS 522

AMS 519: Internship in Quantitative Finance
Supervised internship in financial institution. Students will typically work at a trading desk, in an asset management group, or in a risk management group. Students will be supervised by a faculty member and a manager at their internship site. Written and oral reports will be made to both supervisors. Offered every semester, 3-6 credits, ABCF grading
3-6 credits, Letter graded (A, A-, B+, etc.)
May be repeated 2 times FOR credit.

AMS 520: Machine Learning in Quantitative Finance
This course will merge ML and traditional quantitative finance techniques employed at investment banks, asset management, and securities trading firms. It will provide a systematic introduction to statistical learning and machine learning methods applied in Quantitative Finance. The topics discussed in the course will broadly fall into four categories which (as time permits) will be discussed in this order: Probabilistic Modeling, feedforward neural networks, Sequential Learning, and Reinforcement Learning. Prerequisite: AMS 572 & AMS 595 (or AMS 561 or based on Python knowledge per Instructor Consent)
3 credits, Letter graded (A, A-, B+, etc.)

AMS 521: Bayesian Methods in Finance
In the first part of the course, we will cover programming in Python, from its basic libraries up to the implementation of advanced deep learning models such as CNNs, RNNs, GNNs, and Transformer networks. The practical success of many of these models in high-dimensional problems such as image processing, playing GO, or protein folding comes from the predefined regularities in the underlying low-dimensional geometric structure of the data. Therefore in the second part of the course, we will extend the aforementioned deep learning models and their implementations to graphs and manifolds in spatial and spectral domains. The focus will be on the implementation of the models in Python and their practical applications.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 522: Modern Computational Data Analytics
This course introduces the tools for the analysis of big data sets on server machines. It teaches how to store, preprocess, analyze and visualize data arriving at high volume and velocity. In the first part of the course, we will cover programming in Python, from its basic libraries to more advanced methods for Big data analytics, and machine learning. Emphasis will be on the implementation in Python and practical hands-on examples. Next, we will learn essential Shell scripting and terminal window commands for computations on server machines. We will introduce database management systems and SQL querying. In the second part of the course, we will discuss code version control and collaboration solutions in GitHub and GitHub Actions, microservices, containers (Docker and Kubernetes), API gateways, and other tools necessary in a professional data science pipeline.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 523: Mathematics of High Frequency Finance
Elements of real and complex linear spaces. Fourier series and transforms, the Laplace transform and z-transform. Elements of complex analysis including Cauchy theory, residue calculus, conformal mapping and Mobius transformations. Introduction to convex sets and analysis in finite dimensions, the Legendre transform and duality. Examples are given in terms of applications to high frequency finance.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 524: Modern Computational Data Analytics
This course introduces the tools for the analysis of big data sets on server machines. It teaches how to store, preprocess, analyze and visualize data arriving at high volume and velocity. In the first part of the course, we will cover programming in Python, from its basic libraries to more advanced methods for Big data analytics, and machine learning. Emphasis will be on the implementation in Python and practical hands-on examples. Next, we will learn essential Shell scripting and terminal window commands for computations on server machines. We will introduce database management systems and SQL querying. In the second part of the course, we will discuss code version control and collaboration solutions in GitHub and GitHub Actions, microservices, containers (Docker and Kubernetes), API gateways, and other tools necessary in a professional data science pipeline.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 525: Modern Computational Data Analytics
This course introduces the tools for the analysis of big data sets on server machines. It teaches how to store, preprocess, analyze and visualize data arriving at high volume and velocity. In the first part of the course, we will cover programming in Python, from its basic libraries to more advanced methods for Big data analytics, and machine learning. Emphasis will be on the implementation in Python and practical hands-on examples. Next, we will learn essential Shell scripting and terminal window commands for computations on server machines. We will introduce database management systems and SQL querying. In the second part of the course, we will discuss code version control and collaboration solutions in GitHub and GitHub Actions, microservices, containers (Docker and Kubernetes), API gateways, and other tools necessary in a professional data science pipeline.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 526: Modern Computational Data Analytics
This course introduces the tools for the analysis of big data sets on server machines. It teaches how to store, preprocess, analyze and visualize data arriving at high volume and velocity. In the first part of the course, we will cover programming in Python, from its basic libraries to more advanced methods for Big data analytics, and machine learning. Emphasis will be on the implementation in Python and practical hands-on examples. Next, we will learn essential Shell scripting and terminal window commands for computations on server machines. We will introduce database management systems and SQL querying. In the second part of the course, we will discuss code version control and collaboration solutions in GitHub and GitHub Actions, microservices, containers (Docker and Kubernetes), API gateways, and other tools necessary in a professional data science pipeline.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 527: Modern Computational Data Analytics
This course introduces the tools for the analysis of big data sets on server machines. It teaches how to store, preprocess, analyze and visualize data arriving at high volume and velocity. In the first part of the course, we will cover programming in Python, from its basic libraries to more advanced methods for Big data analytics, and machine learning. Emphasis will be on the implementation in Python and practical hands-on examples. Next, we will learn essential Shell scripting and terminal window commands for computations on server machines. We will introduce database management systems and SQL querying. In the second part of the course, we will discuss code version control and collaboration solutions in GitHub and GitHub Actions, microservices, containers (Docker and Kubernetes), API gateways, and other tools necessary in a professional data science pipeline.
3 credits, Letter graded (A, A-, B+, etc.)
AMS 528: Numerical Analysis III

An introduction to scientific computation, this course considers the basic numerical techniques designed to solve problems of physical and engineering interest. Finite difference methods are covered for the three major classes of partial differential equations: parabolic, elliptic, and hyperbolic. Practical implementation will be discussed. The student is also introduced to the important packages of scientific software algorithms. AMS 528 may be taken whether or not the student has completed AMS 526 or AMS 527.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 530: Principles in Parallel Computing

This course is designed for both academic and industrial scientists interested in parallel computing and its applications to large-scale scientific and engineering problems. It focuses on the three main issues in parallel computing: analysis of parallel hardware and software systems, design and implementation of parallel algorithms, and applications of parallel computing to selected problems in physical science and engineering. The course emphasizes hands-on practice and understanding of algorithmic concepts of parallel computing.

Prerequisite: A course in basic computer science such as operating systems or architectures or some programming experience.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 531: Laboratory Rotations in Computational Biology

This is a two semester course in which first year Ph.D. students spend at least 8 weeks in each of three different laboratories actively participating in the research of participating Computational Biology Faculty. At the end of each rotation, students give a presentation of their lab activates and accomplishments. The primary goal of rotations is to help students choose a research advisor and to help faculty members choose students. Students register for AMS 531 in both the Fall and Spring semesters of the first year.

0-3 credits, S/U grading

May be repeated for credit.

AMS 532: Journal Club in Computational Biology

The goal of this course is for students to hone critical reading and analytic skills through discussions of literature in the area of Computational Biology. Participants take turn being a "discussion leader" who informally guides the group through a peer-reviewed manuscript for which all Journal Club members will have to read in advance of the meeting. Meetings in the Spring semester will include in Person Training (IPT) in Responsible conduct of Research and Scholarship (RCRS) on topics that comprise (1) Integrity in Scholarship, (2) Scientific Misconduct, (3) Mentoring, (4) Ownership and Authorship, (5) Plagiarism, (6) Data Management, (7) Journalism and Science, (8) Human Subjects, and (9) Laboratory Animals.

0-1 credits, S/U grading

May be repeated for credit.

AMS 533: Numerical Methods and Algorithms in Computational Biology

An in-depth survey of many of the key techniques used in diverse aspects of computational biology. A major focus of this class is on how to successfully formulate a statement of the problem to be solved, and how that formulation can guide in selecting the most suitable computational approach. Examples will be drawn from a wide range of problems in biology, including molecular modeling, biochemical reaction networks, microscopy and systems biology. No prior knowledge of biology is required.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 534: Introduction to Systems Biology

This course is geared towards teaching essential concepts and computational skills in Systems Biology. The course is centered upon two key programming languages: Matlab for modeling applications and the R language for statistical analysis and sequence manipulation.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 535: Introduction to Computational Structural Biology and Drug Design

This course will provide an introduction to Computational Structural Biology with application to Drug Design. Methods and applications that use computation to model biological systems involved in human disease will be emphasized. The course aims to foster collaborative learning and will consist of presentations by the instructor, guest lecturers, and by course participants with the goal of summarizing key, methods, topics, and papers relevant to Computational Structural Biology. Grades are based on the quality of the presentations, participation in class discussion, attendance, quizzes, and a final exam.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 536: Molecular Modeling of Biological Molecules

This computer-based lab course is designed for students who wish to gain hands-on experience modeling biological molecules at the atomic level. In conjunction with individual interests, Molecular Mechanics, Molecular dynamics, Monte Carlo, Docking (virtual screening), or Quantum Mechanics software packages can be used to study relevant biological systems (s). Projects will include setup, execution, and analysis. Course participants will give literature presentations relevant to the simulations being performed and a final project report will be required. Familiarity with Unix (Linux) is desirable but not mandatory.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 537: Biological Dynamics and Networks

This course will provide a solid foundation in key theoretical concepts for the study of dynamics in biological systems and networks at different scales ranging from the molecular level to metabolic and gene regulatory networks. Topics of this course include but are not limited to: Physical kinetics; Diffusion/Smoluchowski; Random flights; Waiting times; Poisson; Brownian ratchets; Chemical kinetics; Transition states; Stability, bifurcations, pattern development; Noise in cells: intrinsic and Extrinsic; Feedback; Biological Oscillators; Recurrence, period doubling, chaos; Networks; Topologies; Degree distribution, betweenness; Models of nets: Erdos-Renyi, scale-free, social, Watts-Strogatz, agents; Robustness, highly-optimized tolerance, bowties, epidemics; Biological networks: Protein-protein nets, regulatory and metabolic nets; Known biological circuits and their behaviors; How networks evolve: Preferential attachment, rewiring; Power laws; Fluxed through networks; Information and communication, entropy; Metabolic flux analysis; Artificial and Natural selection for traits; Darwinian evolution; Population dynamics.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 538: Methods in Neuronal Modeling

Presentation of the mathematical modeling approach to information processing in nervous systems, from the level of individual ionic channels to large-scale neuronal networks. The course covers kinetic models of synaptic transmission, cable theory and compartment
models for neurons, multiple channels and calcium dynamics, spike-train analysis and modeling small neuron networks.

3 credits, Letter graded (A, A-, B+, etc.)

May be repeated for credit.

AMS 539: Introduction to Physical and Quantitative Biology

This course is a seminar series organized by the Laufer Center for Physical and Quantitative Biology and is aimed at any incoming graduate students who might be interested in doing research in computational, mathematical or physical biology. Each seminar will be given by a different faculty member about their research and will span a range of topics including computational cell biology and evolutionary models.

0-1 credits, S/U grading

AMS 540: Linear Programming


3 credits, Letter graded (A, A-, B+, etc.)

AMS 542: Analysis of Algorithms

Techniques for designing efficient algorithms, including choice of data structures, recursion, branch and bound, divide and conquer, and dynamic programming. Complexity analysis of searching, sorting, matrix multiplication, and graph algorithms. Standard NP-complete problems and polynomial transformation techniques. This course is offered as both AMS 542 and CSE 548.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 544: Discrete and Nonlinear Optimization

Theoretical and computational properties of discrete and nonlinear optimization problems: integer programming, including cutting plane and branch and bound algorithms, necessary and sufficient conditions for optimality of nonlinear programs, and performance of selected nonlinear programming algorithms.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 545: Computational Geometry

Study of the fundamental algorithmic problems associated with geometric computations, including convex hulls, Voronoi diagrams, triangulation, intersection, range queries, visibility, arrangements, and motion planning for robotics. Algorithmic methods include plane sweep, incremental insertion, randomization, divide-and-conquer, etc. This course is offered as both AMS 545 and CSE 555.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 546: Network Flows

Theory of flows in capacity-constrained networks. Topics include maximum flow, feasibility criteria, scheduling problems, matching and covering problems, minimum-length paths, minimum-cost flows, and associated combinatorial problems.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 547: Discrete Mathematics

This course introduces such mathematical tools as summations, number theory, binomial coefficients, generating functions, recurrence relations, discrete probability, asymptotics, combinatorics, and graph theory for use in algorithmic and combinatorial analysis. This course is offered as both CSE 547 and AMS 547.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 548: Optimization techniques in biomolecular simulations

This practical hands-on course will teach basic techniques for building mathematical models, algorithms, and software for biomolecular simulations of macromolecular interactions. The topics of this course include, but are not limited to: the basics of statistical mechanics and its connection to the sampling algorithms; the origin of and approximations for the computation of molecular forces; geometry of the molecular configuration search space and multidimensional optimization; basics of software development and programming for high performance computing (HPC). During the course, the students will develop a multiscale approach for modeling protein-protein interactions from the ground up. No special background is required. Offered in the Spring Semester

0-3 credits, Letter graded (A, A-, B+, etc.)

AMS 549: Computational Biology

This course focuses on current problems in computational biology and bioinformatics. Our emphasis will be algorithmic, on discovering appropriate combinatorial algorithm problems and the techniques to solve them. Primary topics will include DNA sequence assembly, DNA/protein sequence comparison, hybridization array analysis, RNA and protein folding, and phylogenetic trees.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 550: Operations Research: Stochastic Models

Includes Poisson processes, renewal theory, discrete-time and continuous-time Markov processes, Brownian motion, applications to queues, statistics, and other problems of engineering and social sciences. Prerequisite: AMS 507 or equivalent

3 credits, Letter graded (A, A-, B+, etc.)

AMS 552: Game Theory I

Elements of cooperative and non-cooperative games. Matrix games, pure and mixed strategies, and equilibria. Solution concepts such as core, stable sets, and bargaining sets. Voting games, and the Shapley and Banzhaff power indices. This course is offered as both ECO 604 and AMS 552. Prerequisite for ECO 604: Graduate standing in the Economics Department or permission of the Graduate Director.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 553: Simulation and Modeling

A comprehensive course in formulation, implementation, and application of simulation models. Topics include data structures, simulation languages, statistical analysis, pseudo-random number generation, and design of simulation experiments. Students apply simulation modeling methods to problems of their own design. This course is offered as both ECO 605 and AMS 555.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 555: Game Theory II

Refinements of strategic equilibrium, games with incomplete information, repeated games with and without complete information, and stochastic games. The Shapley value of games with many players, and NTU-values. This course is offered as both ECO 605 and AMS 555.

Prerequisite for AMS 555: AMS 552/ECO 604. Spring, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 556: Dynamic Programming


3 credits, Letter graded (A, A-, B+, etc.)

AMS 559: Smart Energy in the Information Age

Energy and sustainability have become critical issues of our generation. While the abundant potential of renewable energy sources, such
as solar and wind, provides a real opportunity for sustainability, their intermittency and uncertainty present a daunting operational challenge. This course studies how to use Information Technology (IT) to improve sustainability in our energy-hungry society. In particular, topics include the applications of mathematical modeling, algorithm design, optimization, game theory, and control theory in real systems. The goal of the course is to provide rigorous foundations for the study of smart energy management for sustainability. Offered in the Spring Semester

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 560: Big Data Systems, Algorithms and Networks**

Recent progress on big data systems, algorithms and networks. Topics include the web graph, search engines, targeted advertisements, online algorithms and competitive analysis, and analytics, storage, resource allocation, and security in big data systems. Offered in the Spring Semester

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 561: Introduction to Computational Science**

This course provides a foundation of knowledge and basic skills for the successful application in graduate research of modern techniques in computational and data science relevant to engineering, the humanities, and the physical, life and social sciences. It is consciously crafted to provide a rich, project-oriented, multidisciplinary experience that establishes a common vocabulary and skill set. Centered around the popular programming language Python, the course will serve as an introduction to programming including data structures, algorithms, numerical methods, basic concepts in computer architecture, and elements of object-oriented design. Also introduced will be important concepts and tools associated with the analysis and management of data, both big and small, including basic statistical modeling in R, aspects of machine learning and data mining, data management, and visualization. No previous computing experience is assumed. Students are assumed to have taken some introductory courses in two of these three math subjects: linear algebra, calculus, and probability.

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 562: Introduction to Scientific Programming in C++**

This course provides students with foundational skills and knowledge in practical scientific programming relevant for scientists and engineers. The primary language is C++ + since it is a widely-used, object-oriented language, includes C as a subset, and is a powerful tool for writing robust, complex, high-performance software. Elements of Python, Bash, and other languages will be introduced to complement the capabilities of C++, and essential tools for software development and engineering will be employed throughout the course (e.g., makefiles, version control, online code repositories, debugging, etc.).

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 565: Wave Propagation**


3 credits, Letter graded (A, A-, B+, etc.)

**AMS 566: Compressible Fluid Dynamics**

Physical, mathematical, and computational description in compressible fluid flows. Integral and differential forms of the conservation equations, one-dimensional flow, shocks and expansion waves in two and three dimensions, quasi-one-dimensional flow, transient flow, numerical methods for steady supersonic flow, numerical methods for transient flow.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 569: Probability Theory I**


Prerequisite: AMS 510 3 credits, ABCF grading

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 570: Introduction to Mathematical Statistics**

Probability and distributions; multivariate distributions; distributions of functions of random variables; sampling distributions; limiting distributions; point estimation; confidence intervals; sufficient statistics; Bayesian estimation; maximum likelihood estimation; statistical tests. Prerequisite: AMS 507

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 571: Mathematical Statistics**

Sampling distribution; convergence concepts; classes of statistical models; sufficient statistics; likelihood principle; point estimation; Bayes estimators; consistence; Neyman-Pearson Lemma; UMP tests; UMPU tests; Likelihood ratio tests; large sample theory. Offered as HPH 697 or AMS 571.

Prerequisite: AMS 570

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 572: Data Analysis I**

Introduction to basic statistical procedures. Survey of elementary statistical procedures such as the t-test and chi-square test. Procedures to verify that assumptions are satisfied. Extensions of simple procedures to more complex situations and introduction to one-way analysis of variance. Basic exploratory data analysis procedures (stem and leaf plots, straightening regression lines, and techniques to establish equal variance).

Offered as AMS 572 or HPH 698.

3 credits, Letter graded (A, A-, B+, etc.)

**AMS 573: Categorical Data Analysis**

Measuring the strength of association between pairs of categorical variables. Methods for evaluating classification procedures and inter-rater agreement. Analysis of the associations among three or more categorical variables using log linear models. Logistic regression.

Prerequisite: AMS 572

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 575: Internship in Statistical Consulting**

Directed quantitative research problem in conjunction with currently existing research programs outside the department. Students specializing in a particular area work on a problem from that area; others work on problems related to their interests, if possible. Efficient and effective use of computers. Each student gives at least one informal lecture to his or her colleagues on a research problem and its statistical aspects.

1-9 credits, Letter graded (A, A-, B+, etc.)

May be repeated for credit.

**AMS 577: Multivariate Analysis**


3 credits, Letter graded (A, A-, B+, etc.)

**AMS 578: Regression Theory**

Classical least-squares theory for regression including the Gauss-Markov theorem
and classical normal statistical theory. An introduction to stepwise regression, procedures, and exploratory data analysis techniques. Analysis of variance problems as a subject of regression. Brief discussions of robustness of estimation and robustness of design. Prerequisite: AMS 572
3 credits, Letter graded (A, A-, B+, etc.)

AMS 580: Statistical Learning
This course will first review classical linear and generalized linear models such as Linear Regression, and Linear Discriminant Analysis. We shall then study modern Resampling Methods such as Bootstrapping, and modern variable selection methods such as the Shrinkage Method. Finally, we shall introduce modern non-linear statistical learning methods such as the Generalized Additive Models, Decision Trees, Random Forest, Boosting, Bagging, and, Support Vector Machines.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 581: Analysis of Variance
Analysis of models with fixed effects. The Gauss-Markov theorem; construction of confidence ellipsoids and tests with Gaussian observations. Problems of multiple tests of hypotheses. One-way, two-way, and higher-way layouts. Analysis of incomplete designs such as Latin squares and incomplete blocks. Analysis of covariance problems.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 582: Design of Experiments
Discussion of the accuracy of experiments, partitioning sums of squares, randomized designs, factorial experiments, Latin squares, confounding and fractional replication, response surface experiments, and incomplete block designs. Offered as AMS 582 or HPH 699. Prerequisite: AMS 572
3 credits, Letter graded (A, A-, B+, etc.)

AMS 583: Applied Longitudinal Data Analysis
Longitudinal data takes the form of repeated measurements of the same subject (humans, animals, plants, samples, etc) over time (or other conditions). This type of data has a broad range of applications, including public health, medical research, pharmaceutical studies, life sciences, agriculture, engineering and physical sciences. Longitudinal data analysis allows one to study the changes in mean response over time and answer other scientific questions pertaining to the relationship between the response and time. This course aims to introduce statistical models and methods for the analysis of longitudinal data. Both the classical (univariate and multivariate repeated analysis of variance) and more recent approaches (1) general linear models for correlation, random coefficient models, linear mixed effect models for normal repeated measurements; (2) generalized linear models for non-normal response and population-averaged models (generalized estimating equations) for non-normal repeated measurements, analyzing longitudinal data will be covered in this course. Offered in the Spring Semester
3 credits, Letter graded (A, A-, B+, etc.)

AMS 585: Internship in Data Science
Directed data science problem in conjunction with currently existing research programs outside the department. Students specializing in a particular area work on a problem from that area; others work on problems related to their interests, if possible. Efficient and effective use of computers. Each student gives at least one informal lecture to his or her colleagues on a research problem and its statistical aspects.
1-9 credits, Letter graded (A, A-, B+, etc.) May be repeated for credit.

AMS 586: Time Series
Analysis in the frequency domain. Periodograms, approximate tests, relation to regression theory. Pre-whitening and digital filters. Common data windows. Fast Fourier transforms. Complex demodulation, Gibbs' phenomenon issues. Time-domain analysis. Prerequisites: AMS 570 or AMS 572 3 credits, ABCF grading
3 credits, Letter graded (A, A-, B+, etc.)

AMS 587: Nonparametric Statistics
This course covers the applied nonparametric statistical procedures: one-sample Wilcoxon tests, two-sample Wilcoxon tests, runs test, Kruskal-Wallis test, Kendall's tau, Spearman's rho, Hodges-Lehman estimation, Friedman analysis of variance on ranks. The course gives the theoretical underpinnings to these procedures, showing how existing techniques may be extended and new techniques developed. An excursion into the new problems of multivariate nonparametric inference is made.
Prerequisites: AMS 312 and AMS 572 or equivalents Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 588: Failure and Survival Data Analysis
This course introduces both parametric and non-parametric statistical models for analysis of the failure and survival data is a critical topic in quantitative finance, econometrics, and biostatistics. Different censoring mechanisms will be discussed. The course will mainly cover Kaplan-Meier estimator for characterizing the distribution of the failure and survival data, non-parametric log-rank test for comparing multiple groups, and the accelerated failure time model and Cox regression model uncovering various predictor/explanatory variables to survival/failure. Applications to finance, economics and biomedicine will be illustrated. We have revised the course title and content to better suit our current graduate programs in Applied Mathematics and Statistics that have evolved substantially from our old forms. In our current program, students from many tracks, especially in statistics and in quantitative finance, need this updated course as a highly relevant and important elective. This same subject is generally referred to as 'Survival data analysis'; in biostatistics, but 'Failure data analysis' in finance. This updated title will reflect the content of the course clearly for students from all tracks.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 589: Quantitative Genetics
A broad-based course in mathematical Finance and Investments I
AMS 592: Mathematical Methods of
AMS 591: Topics for M.S. Students
Various topics of current interest in applied mathematics will be offered if sufficient interest is shown. Several topics may be taught concurrently in different sections.
3 credits, Letter graded (A, A-, B+, etc.) May be repeated for credit.

AMS 592: Mathematical Methods of Finance and Investments I
A broad-based course in mathematical modeling and quantitative analysis of financial transactions and investment management issues such as debt and equity, measures of risk and returns, efficient markets and efficient set mathematics, asset pricing, one-factor and multiple-factor models, portfolio selection, futures and options.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 593: Interest Rate and Credit Modeling
Introduction to most commonly used interest rate models: Heath-Jarrow-Morton, Brace-Gatarek-Musiela, etc. Cap, Floor, European
and Bermudian option pricing. Credit
Modeling: Merton structural approach vs.
Intensity approach. Corporate bonds, CDS,
securitized products (CDO, CLO, mortages),
Credit value adjustment (CVA, XVA).
3 credits, Letter graded (A, A-, B+, etc.)

AMS 594: Mathematical Methods of
Finance and Investments II
This course employs the techniques of
mathematical statistics and empirical finance,
e.g., estimation theory, linear and nonlinear
regression, time series analysis, modeling
and simulation to examine critically various
models of prediction for asset-pricing, pricing
of derivative products and term-structure of
interest rates assuming stochastic volatility.
Statistics necessary for analysis is incorporated
in the course.
Prequisite: AMS 592
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 595: Fundamentals of Computing
Introduction to UNIX operating system,
C language, graphics, and parallel
supercomputing.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 596: Fundamentals of Large-
Scale Computing
Overview of the design and maintenance
of large scale computer projects in
applied mathematics, including basic
programming techniques for massively parallel
supercomputers.
Prequisite: AMS 595 or permission of
instructor
Spring, 1 credit, Letter graded (A, A-, B+, etc.)

AMS 597: Statistical Computing
Introduction to statistical computing using
SAS and S plus.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 598: Big Data Analysis
The rapid advancement of modern
technologies in all walks of research and
business has introduced tremendous amount
of data and the related big data mining tasks
such as real-time credit card processing and
fraud detection, high dimensional RNA
sequencing analysis, and risk management
of high frequency trading data measured in
milliseconds. Traditional data processing and
analysis techniques are no longer adequate--
they have to be revised and customized to
parallel computing paradigms, at the same
time, modern data mining tools are being
created and evolved, at their own fast pace,
to accommodate the analysis of various big
data problems. This course is subsequently
created to enable the timely education of a
new generation of competent data analysts.
This course introduces the application of the
supercomputing to statistical data analyses,
particularly on big data. Implementations
of various statistical methodologies
within parallel computing framework are
demonstrated through all lectures. The course
will cover (1) parallel computing basics,
including architecture on interconnection
networks, communications methodologies,
algorithm and performance measurements,
and (2) their applications to modern data
mining techniques, including modern variable
selection/Dimension reduction, linear/logistical
regression, tree-based classification methods,
Kernel-based methods, non-linear statistical
models, and model inference/Resampling
methods. Prerequisites: AMS 572, AMS 573
and AMS 578
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 599: Research
Thesis research for Doctoral students who
have not yet advanced to candidacy. Master's
students may also enroll, but must have
approval from a faculty advisor before
registering. Pre-requisite: Student must obtain
consent from individual faculty advisor in
order to register for AMS 599 under his/her
section. 1-12 credits, S/U grading, may be
repeated for credit.
1-12 credits, S/U grading
May be repeated for credit.

AMS 600: Socially Responsible
Investing
Introduction to a scope of investments
which are socially responsible because of
the nature of the business the company
conducts, including but not limited to:
avoiding investment in companies that
produce or sell addictive substances (like
alcohol, gambling, and tobacco) and seeking
out companies engaged in environmental
sustainability. The course includes analysis
of investments strategies maximizing
financial return as well as social goods,
such as: (i) Negative Screening: excluding
securities with potentially social and/or
environmental harmful characteristics; (ii)
Shareholder activism: activities steering the
management towards enhancing the well being
of the stockholders, customers, employees,
vendors, and communities. (iii) Positive
investing: making investments in activities
and companies believed to have a positive
impact on issues such as social justice and
the environment through stock selection, that
guarantees sustainability, in environmental and
humanitarian sense, and providing a company's
long term potential to compete and succeed.
Offered in Fall.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 601: Risk Management and
Business Risk Control in BRIC
Countries
Introduction to the challenges and
opportunities in investing in the BRIC
countries Brazil, Russia, India, and China,
with emphasis in the risk assessment, control
and management. Opportunities in investing
in BRIC: growth in infrastructure, middle
class demand, educated cheap workforce,
potential for outsourcing work, high risk/
high reward. Risks facing investors in BRIC:
strategic, operational, political, market risk,
credit risks. Cultural barriers: family owned
businesses, lack of business professionalism,
poor transparency and disclosures of business
practices, shallow and volatile markets,
unstable macro-economics policies, tardy
legal system. Responsibilities of investors
in the BRIC countries: helping the BRIC
governments and corporations in smooth
transition to global markets and to developed
status, providing co-ordination and transfer
of business knowledge and technology from
risk professionals in developed countries to
emerging markets. Offered in Fall.
3 credits, Letter graded (A, A-, B+, etc.)

AMS 603: Risk Measures For Finance
& Data Analysis
Risk analysis is important to quantitative
finance, insurance, commercial credit and
many areas of data analysis. We emphasize
risk analysis methods that capture observed
features of risk, such as heavy tails, and
validation of risk models against observed
data. Students will be graded on the basis of
projects drawn from multiple asset classes
considered in the course work, including fixed
income, options, portfolio optimization and
foreign exchange. Professional standards for
software development will be followed. Guest
lectures by industry leaders will be included.
Participation via conferencing software will
be available. The course is open to all AMS
graduate students and, with the instructor's
permission, to CEAS graduate students.
3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

AMS 621: Finite Element Methods for
Partial Differential Equations
Variational form of the problem, Ritz
Galerkins, collocation, and mixed methods;
triangular, rectangular (2-D), and tetrahedral
(3-D) elements; accuracy, convergence, and
stability; solutions of linear, nonlinear steady-
state, and dynamic problems; implicit and

explicit time integration; equivalence of finite-element and finite-difference methods.

3 credits, Letter graded (A, A-, B+, etc.)

AMS 641: Special Topics in Mathematical Programming

The course is designed for second- and third-year graduate students with a strong foundation in linear algebra and analysis who wish to pursue research in applied mathematics. Varying topics from nonlinear programming and optimization to applied graph theory and applied combinatorics may be offered concurrently.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 644: Special Topics in Applied Probability

The course is designed for second- and third-year graduate students with a background in probability and stochastic modeling who wish to pursue research in applications of the probability theory. Several topics may be taught concurrently in different sections.

Prerequisites: AMS 550 and permission of instructor
Fall, 3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 651: Nonlinear Analysis and Optimization


3 credits, Letter graded (A, A-, B+, etc.)

AMS 652: Special Topics in Game Theory

The course is designed for second- and third-year graduate students who wish to specialize in the mathematical theory of games.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 670: Special Topics in Probability and Mathematical Statistics

The course is designed for second- and third-year graduate students with a strong foundation in analysis and statistics who wish to pursue research in mathematical statistics. Several topics may be taught concurrently in different sections.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 675: Special Topics in Applied Statistics

The course is designed for second- and third-year students with a strong foundation in statistical analysis who wish to pursue research in applied statistics.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 676: Internship in Applied Mathematics

Directed research and/or practical experience in industry, financial and consulting firms, and research institutions. Students are required to have a department faculty adviser who coordinates and supervises the internship. Submission of the final report is required.

1-9 credits, S/U grading
May be repeated for credit.

AMS 683: Biological Physics & Biophysical Chemistry: Theoretical Perspectives

This course will survey a selected number of topics in biological physics and biophysical chemistry. The emphasis is on the understanding of physical organization principles and fundamental mechanisms involved in the biological process. The potential topics include: Protein Folding, Protein Dynamics, Biomolecular Interactions and Recognition, Electron and Proton Transfer, Motors, Membranes, Single Molecules and Single Cells, Cellular Networks, Development and Differentiation, Brains and Neural Systems, Evolution. There will be no homework or exams. The grades will be based on the performance of the term projects. Crosslisted with PHY 680 and CHE 683.

0-3 credits, Letter graded (A, A-, B+, etc.)

AMS 690: Special Topics in Differential Equations and Applied Analysis

The course is designed for second- and third-year graduate students with a strong foundation in analysis who wish to pursue research in applied mathematics. Several topics may be taught concurrently in different sections.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 691: Topics in Applied Mathematics

Varying topics selected from the list below if sufficient interest is shown. Several topics may be taught concurrently in different sections: Advanced Operational Methods in Applied Mathematics Approximate Methods in Boundary Value Problems in Applied Mathematics Control Theory and Optimization Foundations of Passive Systems Theory Game Theory Mixed Boundary Value Problems in Elasticity Partial Differential Equations Quantitative Genetics Stochastic Modeling

0-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 695: Special Topics in Numerical Analysis and Scientific Computing

Analysis and Scientific Computing

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

AMS 696: Applied Mathematics Seminar

0-3 Credits, S/U Grading, May be repeated for credit.

AMS 698: Practicum in Teaching

A practicum on teaching courses in applied mathematics and statistics. Topics may include designing a syllabus, planning lectures, developing assignments and assessments, coordinating and utilizing teaching assistants, monitoring for academic dishonesty, and using instructional technologies. Students will work with AMS instructors to both observe and practice teaching techniques.

S/U grading
May be repeated for credit.

AMS 699: Dissertation Research on Campus

Prerequisite: Must be advanced to candidacy (G5). Major portion of research must take place on SBU campus, at Cold Spring Harbor, or at the Brookhaven National Lab.

Fall, Spring, and Summer, 0-9 credits, S/U grading
May be repeated for credit.

AMS 700: Dissertation Research off Campus - Domestic

Prerequisite: Must be advanced to candidacy (G5). Major portion of research will take place off-campus, but in the United States and/or U.S. provinces. Please note, Brookhaven National Labs and the Cold Spring Harbor Lab are considered on-campus. All international students must enroll in one of the graduate student insurance plans and should be advised by an International Advisor.

Fall, Spring, 1-9 credits, S/U grading
May be repeated for credit.

AMS 701: Dissertation Research off Campus - International

Prerequisite: Must be advanced to candidacy (G5). Major portion of research will take
place outside of the United States and/or
U.S. provinces. Domestic students have the
option of the health plan and may also enroll
in MEDEX. International students who are
in their home country are not covered by
mandatory health plan and must contact the
Insurance Office for the insurance charge to
be removed. International students who are
not in their home country are charged for the
mandatory health insurance. If they are to be
covered by another insurance plan they must
file a waiver be second week of classes. The
charge will only be removed if other plan is
deemed comparable.

All international students must received
clearance from an International Advisor.
Fall, Spring, 1-9 credits, S/U grading
May be repeated for credit.

AMS 800: SUMMER RESEARCH

May be repeated for credit.