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 506: Finite Structures
Problem solving in combinatorial analysis and graph theory using generating functions, recurrence relations, Polya's enumeration formula, graph coloring, and network flows.
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: Stochastic Processes
A brief introduction to the theory of stochastic processes, with applications to the solution of applied problems. An appropriate selection of topics is based on the concepts of Markov chains, martingales, and Brownian motion. Strong emphasis on proofs.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

AMS 509: Financial Mathematics
An introduction to the mathematics of finance, including 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 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.

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 PDEs 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 distributions. Variance reduction techniques such as control variates, antithetic variates, stratified and Latin hypercube 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. Whenever 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 Computational Finance**

Actual applications of Quantitative Finance to problems of risk assessment, product design, portfolio management and securities pricing will be covered. Particular attention will be paid to data collection and analysis, the design and implementation of software, and, most importantly, to differences the occur between "theory and practice" in model application, and to the development of practical strategies for handling cases in which "model failure" makes the naive use of quantitative techniques dangerous. Extensive use of guest lecturers drawn from the industry will be made.

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

**AMS 516: Statistical Methods in Finance**

The course introduces statistical methods 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 volatilities.

Prerequisite: AMS 586 or permission of the instructor
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 517: Quantitative Risk Management**

Quantitative Methods for risk management problems including market risk, credit risk, operational risk and Basel II accord. Multivariable models; extreme value theory; structure and reduced-form models of default; and copula-based models.

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.

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

**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.

3-6 credits.
May be repeated 2 times FOR credit.

**AMS 520: Fundamentals of Financial Risk Management**

This course covers the fundamentals of financial risk management. It focuses on, among other topics, the use of financial instruments for hedging and risk management, including derivatives such as options, futures, and swaps. The course also covers the principles of asset liability management, the use of financial statements, and the role of financial market instruments in risk management.

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

**AMS 521: Portfolio Optimization**

This course provides a thorough treatment of 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.

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

**AMS 522: Bayesian Methods in Finance**

The course explores in depth the fundamentals of the Bayesian methodology and the use of the Bayesian theory in portfolio and risk management. It focuses on, among other topics, incorporating the prior views of analysts and investors into the asset allocation process, estimating and predicting volatility, improving risk forecasts, and combining the conclusions of different models. Numerical exercises and projects in a high-level programming environment will be assigned.

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.

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

**AMS 524: Stochastic Calculus in Finance**

This course covers the basics of stochastic calculus and its application in finance. It focuses on, among other topics, Brownian motion, stochastic differential equations, and the Black-Scholes model. The course also covers the principles of option pricing and hedging strategies.

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

**AMS 525: Computational Finance**

This course covers the fundamentals of computational finance, including numerical methods for solving problems in finance. It focuses on, among other topics, the use of finite difference methods, Monte Carlo methods, and optimization techniques in financial applications. The course also covers the principles of risk management and portfolio optimization.

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

**AMS 526: Numerical Analysis I**


Corequisite: AMS 510 and AMS 595
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

**AMS 527: Numerical Analysis II**

Numerical methods based upon functional approximation: polynomial interpolation and approximation; and numerical differentiation and integration. Solution methods for ordinary differential equations. AMS 527 may be taken whether or not the student has completed AMS 526.

Spring, 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, such as FORTRAN and C. 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 students 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
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.

Prerequisite for CSE 548: CSE 373 recommended
Spring, 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. 

Prerequisite for CSE 555: CSE 373 or CSE 548
Spring, 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.

Prerequisite for CSE 547: AMS 301
Spring, 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 CSE 529, AMS 553 and MBA 553.

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

AMS 554: Queuing Theory

Prerequisite: AMS 507
Fall, even years, 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


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.

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; consistency; Neyman-Pearson Lemma; UMP tests; UMPU tests; Likelihood ratio tests; large sample theory. Offered as HPH 697 or AMS 571.

Prerequisite: AMS 560

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.

Prerequisite: AMS 312 or permission of instructor

Fall, 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
AMS 582: Statistical Inference

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

Fall, 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, of analyzing longitudinal data will be covered in this course. Offered in the Spring Semester

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

AMS 584: Theory of Probability

This course covers the fundamentals of probability theory. Topics include: basic set theory, measure theory, Lebesgue measure and integration, random variables, independence, convergence, moments, characteristic functions, law of large numbers, central limit theorem, conditional probability, martingales, Markov chains, and Brownian motion. Prerequisites: AMS 572

Spring, 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


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. The course will cover Kaplan-Meier estimator for characterizing the distribution of the failure and survival data, non-parametric log-rank test for comparing multiple groups, and accelerated failure time model and Cox regression model uncovering various predictor/explanatory variables to survival/failure. Applications to finance, economics, 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 accelerated failure time model and Cox regression model uncovering various predictor/explanatory variables to survival/failure. Applications to finance, economics, and biostatistics. Different censoring mechanisms will be discussed.

Prerequisites: AMS 572

Spring, 1 credit, Letter graded (A, A-, B+, etc.)

AMS 592: Mathematical Methods of Finance and Investments II

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, and risk management.

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, mortgages), Credit value adjustment (CVA, XVA).

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.

Prerequisites: 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 project 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 are anticipated. Participation via conferencing software will be available as an option to class attendance.
*3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.*

AMS 605: Probability Theory II
*3 credits, Letter graded (A, A-, B+, etc.)*

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

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 graduate 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.
0-3 credits, S/U grading
May be repeated for credit.

AMS 698: Practicum in Teaching
Undergraduate teaching to be supervised by a faculty member of the Applied Mathematics and Statistics program. Course to be identified by the student and Graduate Program Director. May be repeated for credit
3 credits, 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 receive 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.