Mathematical Sciences

NJIT's nationally recognized Department of Mathematical Sciences offers a B.S. degree in mathematical sciences with concentrations in applied mathematics, applied statistics, computational mathematics, mathematical biology, and mathematics of finance and actuarial science; a B.S. in data science (statistics concentration); an M.S. in applied mathematics; an M.S. in applied statistics; an M.S. in data science – statistics option; a Ph.D. in mathematical sciences with tracks in applied mathematics and applied probability and statistics; and a PhD in data science – statistics option. A seven-year accelerated B.S./M.D. program in mathematical sciences is also offered as well as several double major B.S. programs. In addition to its own degree programs, the department serves the university by providing courses in mathematics required for programs in various technological and scientific disciplines. The diverse research interests of department faculty include mathematical biology, mathematical fluid dynamics, linear and nonlinear waves, electromagnetics, optics, acoustics, data science, applied statistics, biostatistics, and numerical analysis. This work is supported by substantial funding from sources such as the NSF, ONR, AFOSR, NASA, DOE, Simons Foundation, and the Council for International Exchange of Scholars (Fulbright Foundation).

NJIT Faculty

A

Afkhami, Shahriar, Professor

Ahluwalia, Daljit Singh, Professor Emeritus

Andrushkiw, Roman, Professor Emeritus

Askham, Travis, Assistant Professor

B

Bechtold, John K., Professor

Booty, Michael R., Professor

Bose, Amitabha K., Professor

Boubendir, Yassine, Professor

Bui, Trang, Senior University Lecturer

Bukiet, Bruce G., Professor

C

Carfora, Kristin, University Lecturer

Choi, Wooyoung, Professor

Cirillo, Michelle, Professor

Cummings, Linda J., Professor

D

Dhar, Sunil K., Professor

Diekman, Casey O., Professor

F

Frederick, Christina, Associate Professor

G

Garfield, Ralph, Associate Professor Emeritus

Goodman, Roy H., Professor

Guo, Wenge, Associate Professor

H

Horntrop, David J., Associate Professor

Horwitz, Kenneth A., Senior University Lecturer

J

Jaquette, Jonathan, Assistant Professor

John, Pelesko, Professor

K

Kim, Chulmin, Senior University Lecturer

Kondic, Lou, Distinguished Professor

L

Loh, Ji Meng, Professor

Luke, Jonathan H. C., Professor

Lushi, Enkeleida, Assistant Professor

M

MacLaurin, James, Assistant Professor

Mahmood, Sirag, University Lecturer

Matveev, Victor V., Professor

Michalopoulou, Zoi-Heleni, Professor

Milojevic, Petronije, Professor

N

Natarajan, Padma, Senior University Lecturer

Nguyen, Thi-Phong, Assistant Professor

O

Oza, Anand, Associate Professor

P

Petropoulos, Peter G., Associate Professor

Plastock, Roy A., Associate Professor Emeritus

Pole, Andrew, Senior University Lecturer

Porus, Jonathan J., Math Tutoring Center Director

Potocki-Dul, Magdallena M., University Lecturer

R

Rana Concepcion, Priyanka, University Lecturer

Ro, Je Hyun, Senior University Lecturer

S

Sagiv, Amir, Assistant Professor

Schmidt, Donivyn, Senior University Lecturer

Shang, Zuofeng, Associate Professor

Shi, Chenlu, Assistant Professor

Shirokoff, David, Associate Professor

Siegel, Michael S., Professor

Stickler, David, Professor Emeritus

Subramanian, Sundarraman, Associate Professor

T

Tavantzis, John, Professor Emeritus

Turc, Catalin C., Associate Professor

W

Wang, Antai, Associate Professor

Ward, Peter, Senior University Lecturer

Y

Young, Yuan-Nan, Professor

Z

Zaleski, Joseph, University Lecturer

Zhao, Xinyu, Assistant Professor

Programs

Data Science (Statistics Option) - B.S. (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/data-science-bs/)

Mathematical Sciences - B.S.

- with Applied Mathematics Concentration (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-mathematics/)
- with Applied Statistics Concentration (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-statistics/)
- with Computational Mathematics Concentration (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/computational-mathematics/)
- with Mathematical Biology Concentration (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematical-biology/)
- with Mathematics of Finance and Actuarial Science Concentration (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematics-finance-actuarial-science/)

Accelerated Programs **(**http://catalog.njit.edu/undergraduate/academic-policies-procedures/special-degree-options/**)**

- Mathematical Sciences - B.S./M.D., D.M.D., D.D.S., O.D. (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/accelerated-bs-md-dmd-dds-od/)

Double Majors **(**http://catalog.njit.edu/undergraduate/academic-policies-procedures/special-degree-options/**)**

- Applied Physics & Mathematical Sciences with Applied Mathematics Concentration - B.S. (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-mathematics-applied-physics-bs/)
- Biology and Mathematical Sciences - B.S.
- Computer Science & Mathematical Sciences with Computational Mathematics Concentration - B.S. (http://catalog.njit.edu/undergraduate/computing-sciences/computer-science/cs-math-bs-comp/)
- Computer Science and Applied Mathematics - B.S. (http://catalog.njit.edu/undergraduate/computing-sciences/computer-science/cs-math-bs/)

- Applied Mathematics Minor (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-mathematics-minor/)
- Applied Statistics Minor (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-statistics-minor/)

- Computational Mathematics Minor (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/computational-mathematics-minor/)
- Mathematical Biology Minor (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematical-biology-minor/)
- Mathematics of Finance and Actuarial Science Minor (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematics-finance-actuarial-science-minor/)

- Applied Mathematics (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-mathematics/)
- Applied Statistics and Data Analysis (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-statistics/)
- Computational Mathematics (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/computational-mathematics/)
- Mathematical Biology (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematical-biology/)
- Mathematics of Finance and Actuarial Science (http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/mathematics-finance-actuarial-science/)

Mathematical Sciences Courses

MATH 101. Foundations of Mathematics for the Liberal Arts. 3 credits, 3 contact hours (3;0;0).
Intended for students in degree programs offered by HSS and History. This course reviews principles of algebra and the foundations of mathematics. Degree credit awarded for degrees offered by HUM and HIST.

MATH 102. Modern Pre-calculus. 6 credits, 6 contact hours (6;0;0).
This course is an intensive non-traditional approach to pre-calculus employing curriculum innovations for the preparation of students for college calculus. The course infuses calculus techniques into the pre-calculus curriculum. The format includes both regular class and workshop environments with a focus on student problem solving. Course meets on Saturdays in the fall and spring terms and M, T, W, R in the summer, second session. This course is only available to high school students.

MATH 105. Elementary Probability and Statistics. 3 credits, 3 contact hours (3;0;0).
Consider notions of probability. Topics include the binomial and normal distributions, expected value, and variance. The notions of sampling, hypothesis testing, and confidence intervals are applied to elementary situations.

MATH 107. University Mathematics A. 3 credits, 3 contact hours (3;0;0).
Linear functions, equations, inequalities, systems of linear equations, quadratic equations elementary functions, graphing functions.

MATH 108. University Mathematics B. 4 credits, 5 contact hours (4;0;1).
Intended for students whose major requires MATH 111. Linear functions, equations, inequalities, systems of linear equations, quadratic equations, polynomials, rational expressions, expressions involving radicals, partial fraction decomposition, conic sections, graphing functions.

MATH 110. University Mathematics B II - Trigonometry. 4 credits, 5 contact hours (4;0;1).
Intended for students whose major requires MATH 111. Prerequisite: MATH 108 or placement by performance on standardized entrance examinations. Trigonometric functions and identities, laws of sines and cosines, logarithmic equations, systems of nonlinear equations, polar coordinates.

MATH 111. Calculus I. 4 credits, 5 contact hours (4;0;1).
Prerequisites: MATH 110 with a grade of C or better or placement by performance on standardized entrance examinations. Topics include limits, differentiation, applications of differentiation, and integration.

MATH 112. Calculus II. 4 credits, 5 contact hours (4;0;1).
Prerequisite: MATH 111 with a grade of C or better. Topics include integration, applications of integration, series, exponential and logarithmic functions, transcendental functions, polar coordinates, and conic sections.

MATH 113. Finite Mathematics and Calculus I. 3 credits, 3 contact hours (3;0;0).
Prerequisite: (Intended for Architecture students.) MATH 107 with a grade of C or better, or MATH 110 with a grade of C or better, or NJIT placement. An introduction to differential and integral calculus. Applications include area, volumes, curve lengths, surface area, centroids, and moments. Focus is on application throughout the course.

MATH 120. Basic Concepts in Statistics. 1 credit, 1 contact hour (1;0;0).
The course offers an introduction to the basic concepts in statistics. Topics include the role of statistics, data summary, normal distribution, elements of probability, and computation of mean and variance. This course will also include an introduction to statistical estimation and inference.

MATH 135. Calculus for Business. 3 credits, 3 contact hours (3;0;0).
Intended for students with major offered by SOM. Prerequisite: MATH 107 with a grade of C or better or MATH 110 with a grade of C or better or NJIT placement. An introduction to mathematics of business, principles of differential and integral calculus, and optimization.

MATH 138. General Calculus I. 3 credits, 3 contact hours (3;0;0).
Intended for students who are not in Science or in Engineering. Prerequisite: MATH 107 with a grade of C or better, or MATH 110 with a grade of C or better or NJIT placement. An introduction to differential and integral calculus of a single variable.

MATH 161. Calculus I for Computing. 4 credits, 5 contact hours (4;0;1).
Prerequisites: MATH 110 with a grade of C or placement by performance on standardized entrance examinations. Corequisite: CS 100. A calculus course with the same core content as MATH 111 but with an emphasis on building foundations for computing rather than differential equations. The course is characterized by an emphasis on symbolic computing over numerical computing. Topics include limits, differentiation, applications of differentiation, and integration. Student can not receive credit for both MATH 161 and MATH 111.

MATH 211. Calculus III A. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. Topics include vectors, curvature, partial derivatives, multiple integrals, line integrals, and Green's theorem. Students who are considering a major in Mathematical Sciences or who are undecided about their major should take MATH 213.

MATH 213. Calculus III B. 4 credits, 4 contact hours (4;0;0).
Prerequisite: MATH 112 with a grade of C or better. Topics include vectors, curvature, partial derivatives, multiple integrals, line integrals, and Green's, divergence, and Stokes' theorems.

MATH 222. Differential Equations. 4 credits, 4 contact hours (4;0;0).
Prerequisite: MATH 112 with a grade of C or better. Methods for solving ordinary differential equations are studied together with physical applications, Laplace transforms, numerical solutions, and series solutions.

MATH 225. Survey of Probability and Statistics. 1 credit, 1 contact hour (1;0;0).
Prerequisite: MATH 112 with a grade of C or better. Topics include descriptive statistics, elements of probability, random variables and distributions; mean and variance; introduction to estimation and inference. This course satisfies the Mathematics GUR in probability and statistics. However, degree credit will not be granted for both MATH 225 and any other upper level course in probability and/or statistics.

MATH 225A. Survey of Probability and Statistics. 1 credit, 1 contact hour (1;0;0).
Prerequisite: MATH 112 with a grade of C or better. Restriction: For Chemical Engineering students only. Topics include descriptive statistics, elements of probability, random variables and distributions; mean and variance; introduction to estimation and inference. This course satisfies the Mathematics GUR in probability and statistics. However, degree credit will not be granted for both MATH 225 and any other upper level course in probability and/or statistics.

MATH 226. Discrete Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. An introduction to discrete mathematics. An introduction to discrete mathematics. Topics include elementary set theory, logic, combinatorics, relations, and selections from graphs and trees and algebraic systems.

MATH 227. Mathematical Modeling. 3 credits, 4 contact hours (3;1;0).
Prerequisites: MATH 112 with a grade of C or better and CS 115 with a grade of C or better or CS 113 with a grade of C or better or CS 100 with a grade of C or better or CS 101 with a grade of C or better. An introduction to the theory and practice of mathematical modeling. Techniques include scaling and dimension, fitting of data, linear and exponential models, elementary dynamical systems, probability, optimization, Markov chain modeling. Models are drawn from applications including biology, physics, economics, finance, and chemistry.

MATH 238. General Calculus II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 138 with a grade of C or better or MATH 111 with a grade of C or better. A continuation of MATH 138. Topics include applications of integral calculus and an introduction to ordinary differential equations.

MATH 244. Introduction to Probability Theory. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. Topics include basic probability theory in discrete and continuous sample space, conditional probability and independence, Bayes' theorem and event trees, random variables and their distributions, joint distribution and notion of dependence, expected values and variance, moment generating functions, useful parametric families of distributions including binomial, geometric, hypergeometric, negative binomial, exponential, gamma, normal and their applications, simple case of central limit theorem and its uses.

MATH 279. Statistics and Probability for Engineers. 2 credits, 2 contact hours (2;0;0).
Prerequisite: MATH 112 with a grade of C or better. This course introduces methods of summarizing and analyzing engineering data and the importance of observing processes over time such as control charts. Descriptive statistics, plots and diagrams are then used to summarize the data. Elements of probability and random variables with their distributions along with mean and variance are taught. All this knowledge is then used as a platform towards covering how to do basic estimation and inference, including confidence intervals and hypothesis testing based on a single sample. Students taking this course cannot receive degree credit for MATH 225, MATH 244, or MATH 333.

MATH 305. Statistics for Technology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 111 with a grade of C or better or MATH 138 with a grade of C or better. (Intended for students in Engineering Technology) An introduction to the modern concepts of statistics needed by engineering technologists. Topics include organization of data, descriptive statistics, discrete and continuous probability distributions, sampling distribution and designs, estimation -- one and two populations, tests of hypotheses.

MATH 309. Mathematical Analysis for Technology. 4 credits, 4 contact hours (4;0;0).
Prerequisite: MATH 112 with a grade of C or better or MATH 238 with a grade of C or better. Emphasis on partial derivatives; vector calculus, and multiple integrals.

MATH 310. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Completion of the sophomore year, departmental approval, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.

MATH 322. Differential Equations for Applications. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better or MATH 238 with a grade C or better. An applied science study using differential equations as the vehicle for comprehension of the unknown. Introduction to first-order differential equations and their applications to motion, cooling and electromechanical systems followed by higher order differential equations and their solutions. Study of methods of undetermined coefficients, variation of parameters, and many series and numerical methods. Includes Laplace transforms, matrix methods, and eigenvalue problems.

MATH 326. Discrete Analysis for Computer Engineers. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. An introduction to mathematical logic, Boolean algebra, and Karnaugh maps. Other topics include functions, equivalence relations and partially ordered sets, counting, graph theory and finite state machines. The emphasis is on computation but proofs will be addressed. Students cannot receive credit for both MATH 226 and MATH 326.

MATH 328. Mathematical Methods for Scientists and Engineers. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211 with a grade of C or better, or MATH 213 with a grade of C or better. Corequisite: MATH 222. The course exposes students to concepts of mathematics encountered throughout the physical science and engineering disciplines. Topics include matrix algebra, vector analysis, complex numbers, and boundary value problems in partial differential equations.

MATH 331. Introduction to Partial Differential Equations. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211 or MATH 213 and MATH 222 all with a grade of C or better. Partial differential equations in science and engineering. Topics include initial- and boundary-value problems for parabolic, hyperbolic, and elliptic second-order equations. Emphasis is placed on separation of variables, special functions, transform methods, and numerical techniques.

MATH 332. Introduction to Functions of a Complex Variable. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211 or MATH 213 and MATH 222 all with a grade of C or better. Functions of a complex variable: Cauchy-Riemann equations, Cauchy-Goursat theorem, integration, series, residues, poles, geometrical aspects. Emphasis on techniques.

MATH 333. Probability and Statistics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. Descriptive statistics and statistical inference. Topics include discrete and continuous distributions of random variables, statistical inference for the mean and variance of populations, and graphical analysis of data.

MATH 334. Operations Research. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 244 with a grade of C or better or MATH 333 with a grade of C or better. Considers mathematical methods found especially in contemporary fields such as operations research and reliability engineering. Topics include linear programming, graph theory, finite mathematics, differential equations, matrices, and determinants.

MATH 335. Vector Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better. Algebra and calculus of vectors. Topics include the theorems of Gauss, Green, and Stokes, and curvilinear coordinates.

MATH 336. Applied Abstract Algebra. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. Classical algebra from a modern and constructive viewpoint. Emphasis is on the development of algorithmic and computational skills. Topics include rings, fields, and groups and their applications to science and engineering.

MATH 337. Linear Algebra. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. Matrices, determinants, systems of linear equations, vector spaces, linear transformations, eigenvalues, eigenvectors, and related topics.

MATH 340. Applied Numerical Methods. 3 credits, 4 contact hours (3;1;0).
Prerequisites: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better, and CS 100 with a grade of C or better or CS 101 with a grade of C or better or CS 113 with a grade of C or better or CS 115 with a grade of C or better. Introduction to numerical methods with emphasis on mathematical models. Implements and investigates numerical techniques for the solution of linear and nonlinear systems of equations, eigenvalue problems, interpolation and approximation, techniques of optimization, Monte Carlo methods, and applications to ordinary differential equations and integration.

MATH 341. Statistical Methods II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 244 with a grade of C or better or MATH 333 with a grade of C or better. Covers applications of classical statistical inference. Topics include transformation of variables, moment generating technique for distribution of variables, introduction to sampling distributions, point and interval estimation, maximum likelihood estimators, basic statistical hypotheses and tests of parametric hypotheses about means of normal populations, chi-square tests of homogeneity, independence, goodness-of-fit.

MATH 344. Regression Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 333 with a grade of C or better or MATH 341 with a grade of C or better. An introduction to statistical data analysis using regression techniques. Topics include least squares estimation, hypothesis testing, prediction, regression diagnostics, residual analysis, variance stabilizing transformations, regression using indicator variables, variable selection, and model building.

MATH 345. Multivariate Distributions. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 244 with a grade of C or better or MATH 333 with a grade of C or better. Topics include discrete and continuous multivariate distributions and their moments, multivariate distributions including multivariate normal and multinominal distributions, order statistics, conditional probability and the use of conditioning, discrete time Markov chains and their examples, discrete time branching processes, homogeneous and nonhomogeneous Poisson processes.

MATH 346. Mathematics of Finance I. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 112 with a grade of C or better. The main topics include basic problems in interest, annuities, certain amortization and sinking funds, bonds and related securities.

MATH 347. Mathematics of Finance II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 346 and MATH 244 or MATH 333 all with a grade of C or better. This course introduces mathematical models of bond and stock prices, which lead to arbitrage pricing of options and other derivative securities, and portfolio management. These areas of mathematical finance have a great impact on the way financial markets function. Topics include risk-free, and risky assets, portfolio management, futures, and options.

MATH 356. Loss Models. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 341 with a grade of C or better. This course will introduce a variety of frequency, severity, and aggregate models that are useful for actuarial applications. This will include analyzing data from applications, determining a suitable model, providing measures of confidence for decisions based on the model, and estimating losses.

MATH 371. Physiology And Medicine. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 222 with a grade of C or better. Mathematical models of organs and organ systems: the heart and circulation, gas exchange in the lungs, electrical properties of excitable membranes, neuro-biological clocks, the renal countercurrent mechanism, muscle mechanics. The biology is introduced with each topic. Emphasis is on quantitative problem solving, model building, and numerical simulation.

MATH 372. Population Biology. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 222 with a grade of C or better. Introduction to the mathematics of populations: Malthus' model of geometric population growth, Euler's renewal equations, age structure in human populations, predator satiation, chaos, mathematical models of inheritance, and the theory of epidemics. The ability to weave back and forth between physical concepts and mathematical notation is emphasized as well as the relationships between random and non-random models of similar phenomena.

MATH 373. Introduction to Mathematical Biology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better and MATH 222 with a grade of C or better. This course provides an introduction to the use of mathematical techniques applied to problems in biology. Discrete and continuous models of biological phenomena will be discussed. Biological topics discussed range from the subcellular molecular systems and cellular behavior to physiological problems, population biology and developmental biology. Techniques of phase plane analysis for differential equations are introduced in the course. No prior background in biology is necessary.

MATH 374. Stochastic and Discrete Models in Biology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 244 or MATH 333 with a grade of C or better. This course provides an introduction to stochastic and discrete models in biology with a focus on applications in structured populations, molecular evolution, phylogenetics, genetics, and infectious disease modeling. No prior background in biology is needed; the emphasis of this course is on the underlying mathematical models and theory, quantitative problem solving, and computer explorations.

MATH 388. Introduction to Chaos Theory. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better. An elementary treatment of chaos theory and its applications concentrating on discrete dynamical systems. Uses theory and applications illustrated by computer experiments to develop such topics as bifurcation, attractors, the logistic map, period-doubling routes to chaos, symbolic dynamics, Sarkovskii's theorem, fractals, and Julia and Mandelbrot sets for complex dynamics.

MATH 391. Numerical Linear Algebra. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 337 with a grade of C or better and CS 113 with a grade of C or better or CS 115 with a grade of C or better or CS 101 with a grade of C or better or CS 100 with a grade of C or better. This course provides an introduction to computational linear algebra. Topics include direct solution of linear systems, iterative methods for linear systems, fast Fourier transforms, least squares problems, singular value decomposition and eigenvalue/eigenvector problems.

MATH 401. Undergraduate Research Seminar. 1 credit, 1 contact hour (0;0;1).
Research seminar intended for students who participate in year-long research projects. Methodologies and techniques needed for summer research projects are discussed. Presentations of current research topics are made by various faculty.

MATH 410. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: MATH 310 with a grade of C or better, departmental approval, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience. Mandatory participation in seminars and completion of requirements that include a report and/or project. Note: Normal grading applies to this COOP Experience.

MATH 430. Analytical and Computational Neuroscience. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better, and MATH 222 with a grade of C or better, and CS 100 with a grade of C or better or CS 113 with a grade of C or better or CS 115 with a grade of C or better or MATH 340 with a grade of C or better. A mathematical and computational introduction to the biophysical mechanisms that underlie physiological functions of single neurons and synapses. Topics include voltage-dependent channel gating mechanisms, the Hodgkin-Huxley model for membrane excitability, repetitive and burst firing, nerve impulse propagation in axons and dendrites, single- and multi-compartmental modeling, synaptic transmission, calcium handling dynamics and calcium dependent currents and processes.

MATH 431. Systems Computational Neuroscience. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 430 with a grade of C or better or departmental approval. This course provides a mathematical and computational introduction to operations of neuronal systems and networks. Topics covered include central pattern generators, neuroethology of sensory systems, sensory-motor transformations, models of various brain regions, models of visual processes, large networks modeling, models of learning and memory, neural coding and mathematics of neural networks.

MATH 432. Mathematics of Financial Derivatives I (Capstone I). 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222 with a grade of C or better and MATH 346 with a grade of C or better. Mathematical analysis of models encountered in the area of financial derivatives. Topics include modeling and analysis of futures markets, determination of future prices, hedging strategies, swaps, option markets, stock options and their trading strategies.

MATH 433. Mathematics of Financial Derivatives II (Capstone II). 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 340 with a grade of C or better; MATH 432 with a grade of C or better. Mathematical analysis of models encountered in the area of financial derivatives with emphasis on numerical methods. Topics include: Binomial Trees, Black Scholes Models, Finite Difference Methods.

MATH 440. Advanced Applied Numerical Methods. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 331 with a grade of C or better and MATH 340 with a grade of C or better. A survey of numerical methods for solving ordinary and partial differential equations. Includes initial-value and boundary-value problems for ordinary differential equations and for elliptic, hyperbolic, and parabolic partial differential equations.

MATH 441. Actuarial Mathematics I. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 346 with a grade of C or better. Topics include the economics of insurance, individual risk models for a short term, survival distributions and life tables, life insurance per year, life annuities, and net premiums.

MATH 442. Actuarial Mathematics II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 441 with a grade of C or better. Topics include net premium reserves, insurance models including expenses, nonforfeiture benefits, and dividends.

MATH 444. Applied Sampling Methods and Quality Control. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 333 with a grade of C or better, or MATH 244 with a grade of C or better and MATH 341 with a grade of C or better. An introduction to sample survey and statistical quality control. Topics include sampling from a finite population and different sampling techniques, more detailed study of random sampling and stratification, control charts and acceptance sampling plans in statistical quality control.

MATH 445. Introduction to Experimental Design. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 333 with a grade of C or better, or MATH 244 with a grade of C or better and MATH 341 with a grade of C or better. Basic concepts and principles of designs are covered. Topics include randomized blocks, Latin squares, factorial designs.

MATH 446. Topics in Applied Statistics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 341 with a grade of C or better or MATH 333 with a grade of C or better. Topics may include biostatistics, environmental statistics, statistical consulting.

MATH 447. Applied Time Series Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 341 with a grade of C or better or MATH 333 with a grade of C or better. An introduction to applied univariate time series analysis. Topics include regression techniques for modeling trends, smoothing techniques (moving average smoothing, exponential smoothing), autocorrelation, partial auto-correlation, moving average, and autoregressive representation of series, Box-Jenkins models, forecasting, model selection, estimation, and diagnostic checking, Fourier analysis, and spectral theory for stationary processes.

MATH 448. Stochastic Simulation. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 340 and either MATH 244 or MATH 333 with a grade of C or better. An introduction in the use of computer simulation to study stochastic models. Topics include the generation of samples of continuous and discrete random variables and processes with applications to stochastic models, statistical analysis of the results, and variance reduction techniques.

MATH 450. Methods Of Applied Math. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 331 with a grade of C or better, MATH 337 with a grade of C or better, and MATH 340 with a grade of C or better. Combines mathematical modeling with physical and computational experiments conducted in the Undergraduate Mathematics Computing Laboratory.

MATH 451. Methods Appl Math II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 450 with a grade of C or better. Small teams of students conduct research projects under the guidance of faculty members who perform applied research.

MATH 453. High-Performance Numerical Computing. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 340 with a grade of C or better and MATH 391 with a grade of C or better. The course covers state-of-the-art numerical algorithms for solving large-scale problems accurately and efficiently. Topics include iterative methods for linear systems and eigenvalue computations, introduction to parallel program and parallel numerical algorithms and spectral methods. An instructor-selected advanced topic will be included in the course.

MATH 461. Introduction to Statistical Computing with SAS and R. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 341 with a grade of C or better or MATH 344 with a grade of C or better or MATH 447 with a grade of C or better. In this course, SAS and R statistical software will be studied from a programming language perspective. It will emphasize SAS and R data steps including getting data into SAS and R environments, working and combining data using control flows, merge and subsets. SAS and R mathematical, statistical, and data functions are discussed, as well as learning to write SAS Macro and generate high resolution graphics using SAS/Graph. The concentration is on SAS and R programming issues rather than on statistical procedures or functions; however, several SAS and R statistical procedures or functions are discussed and illustrated. Finally, interactive statistical software JMP and Minitab are briefly introduced.

MATH 462. Statistics and Statistical Learning (Capstone I). 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 461, MATH 478 with a grade of C or better. This is the first semester of a two-semester undergraduate-level statistical learning capstone course. The course provides an opportunity for students to synthesize knowledge gained during their undergraduate study by applying modern statistical tools to solve real-world projects. In this first semester course, the following basic statistical learning objects will be reviewed: statistical decision theory, linear/logistic regression, discriminant analysis, principle component analysis, high-dimensional data analysis, nearest neighbor methods, multiclass classification. The course will also select important papers on the above topics for students to read and present. Capstone research topics will be selected approaching the end of the semester.

MATH 463. Statistics and Statistical Learning (Capstone II). 3 credits, 3 contact hours (1;2;0).
Prerequisites: MATH 462 with a grade of C or better. This course is the continuation of MATH 462. In this course, the following basic statistical learning objects will be reviewed: variable/model selection, support vector machine, tree-based methods, cluster analysis. Students will work in teams on real-world projects which will require extensive use of statistical software. Each group will produce a written report and give an oral presentation of their findings. present their work in a research talk. Successful completion of this course will equip students with the modern statistical learning, teamwork, and presentation skills necessary to conduct advanced research or enter the professional world.

MATH 473. Intermediate Differential Equations. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222 with a grade of C or better and MATH 337 with a grade of C or better. Topics in the qualitative behavior of solutions of ordinary differential equations with applications to engineering problems. Includes phase plane analysis, stability, dynamical systems, and chaos.

MATH 477. Stochastic Processes. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 244 with a grade of C or better or MATH 333 with a grade of C or better and MATH 337 with a grade of C or better. This course introduces the theory and applications of random processes needed in various disciplines such as mathematical biology, finance, and engineering. Topics include discrete and continuous Markov chains, Poisson processes, as well as topics selected from Brownian motion, renewal theory, and simulation.

MATH 478. Stat Methods in Data Sci. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 333 with a grade of C or better or MATH 341 with a grade of C or better. This course introduces to students concepts in statistical methods used in data science, including data collection, data visualization and data analysis. Emphasis is on model building and statistical concepts related to data analysis methods. The course provides the basic foundational tools on which to pursue statistics, data analysis and data science in greater depth. Topics include sampling and experimental design, understanding the aims of a study, principles of data analysis, linear and logistic regression, resampling methods, and statistical learning methods. Students will use the R statistical software.

MATH 480. Introductory Mathematical Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 211 with a grade of C or better or MATH 213 with a grade of C or better. Builds on principles taught in basic calculus courses. Topics discussed include continuity, differentiation, integration, and the limit process of sequences and series.

MATH 481. Advanced Calculus. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 480 with a grade of C or better. Systematic development of partial differentiation, multiple and improper integrals, transformations, inverse and implicit function theorems, and integrals over curves and surfaces.

MATH 491. Independent Study in Mathematics. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Senior standing and departmental approval. Each student works under the direct supervision of a member of the Department of Mathematical Sciences. The work consists primarily of a project applying the student's mathematical skills to an engineering- or science-oriented project.

MATH 492. Independent Study II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Senior standing and departmental approval. Each student works under the direct supervision of a member of the Department of Mathematical Sciences. The work consists primarily of a project applying the student's mathematical skills to an engineering- or science-oriented project.

MATH 495. Topics in Applied Mathematics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 331 with a grade of C or better, MATH 332 with a grade of C or better, and MATH 340 with a grade of C or better, or departmental approval. A survey of selected areas of applied mathematics. Case histories of problems in applied mathematics from an industrial background.

MATH E. Math Stack Engineers. 3 credits, 3 contact hours (3;0;0).

MATH NE. Math Stack For Non-Engineers. 3 credits, 3 contact hours (3;0;0).

Rutgers-Newark Courses

R960 211. Statistics I. 3 credits, 3 contact hours (3;0;0).

R960 212. Statistics II. 3 credits, 3 contact hours (3;0;0).

R960 238. Found Modern Math. 3 credits, 3 contact hours (3;0;0).

R960 463. Regression Methods. 3 credits, 3 contact hours (3;0;0).