MATH (MATH-UA)

MATH-UA 9 Algebra, Trigonometry, and Functions (4 Credits)
Typically offered Fall, Spring, and Summer terms
Serves as preparation for students who do not otherwise place into Discrete Mathematics (MATH-UA 120), Calculus I (MATH-UA 121), Mathematics for Economics I (MATH-UA 131; formerly MATH-UA 211), Linear Algebra (MATH-UA 140), Honors Linear Algebra (MATH-UA 148; an A- in MATH-UA 9 is required to enter MATH-UA 148), and some courses in other departments (such as chemistry and economics). Intermediate algebra and trigonometry; algebraic, exponential, logarithmic, and trigonometric functions and their graphs. <https://mail.google.com/mail/u/0/#_msocom_1>
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 120 Discrete Mathematics (4 Credits)
Typically offered Fall, Spring, and Summer terms
A first course in discrete mathematics. Sets, algorithms, and induction. Combinatorics. Graphs and trees. Combinatorial circuits. Logic and Boolean algebra.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 121 Calculus I (4 Credits)
Typically offered Fall, Spring, and Summer terms
Any one of the following: a score of 670 or higher on the mathematics portion of the SAT, a score of 650 or higher on the SAT Subject Test in Mathematics 1, a score of 650 or higher on the SAT Subject Test in Mathematics 2, an ACT mathematics score of 30 or higher, a score of 3 or higher on the AP Calculus AB exam, an AB subscore of 3 or higher on the AP Calculus BC exam, a score of 3 or higher on the AP Calculus BC exam, a grade of C or higher in Algebra and Calculus (MATH-UA 9), or a passing score on a departmental placement exam. Derivatives, antiderivatives, and integrals of functions of one variable. Applications include graphing, maximizing, and minimizing functions. Definite integrals and the fundamental theorem of calculus. Areas and volumes.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 122 Calculus II (4 Credits)
Typically offered Fall, Spring, and Summer terms
Techniques of integration. Further applications. Plane analytic geometry. Polar coordinates and parametric equations. Infinite series, including power series.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 123 Calculus III (4 Credits)
Typically offered Fall, Spring, and Summer terms
Prerequisite: MATH-UA.0122 with a grade of C or better, departmental placement exam, or permission of the department. Functions of several variables. Vectors in the plane and space. Partial derivatives with applications. Double and triple integrals. Spherical and cylindrical coordinates. Surface and line integrals. Divergence, gradient, and curl. Theorem of Gauss and Stokes.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 129 Honors Calculus III (4 Credits)
The scope of this honors class will include the usual MATH-UA 123 syllabus; however this class will move faster, covering additional topics and going deeper. Functions of several variables. Vectors in the plane and space. Partial derivatives with applications, especially Lagrange multipliers. Double and triple integrals. Spherical and cylindrical coordinates. Surface and line integrals. Divergence, gradient, and curl. Theorem of Gauss and Stokes.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 131 Mathematics for Economics I (4 Credits)
Typically offered Fall, Spring, and Summer terms
Formerly numbered MATH-UA 211; the content has not changed. Will only count toward the major in mathematics for: economics majors with a double or joint major in math. Elements of calculus and linear algebra are important to the study of economics. This class is designed to provide the appropriate tools for study in the policy concentration. Examples and motivation are drawn from important topics in economics. Topics covered include derivatives of functions of one and several variables; interpretations of the derivatives; convexity; constrained and unconstrained optimization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 132 Mathematics for Economics II (4 Credits)
Typically offered Fall and Spring
Formerly numbered MATH-UA 212; the content has not changed. Not open to students who already have credit for Calculus (from an NYU or transfer course, or from AP or another accepted exam), unless they have declared or will declare a major in economics. A continuation of Mathematics for Economics I. Matrix algebra; eigenvalues; Ordinary differential equations and stability analysis, multivariable integration and (possibly) dynamic optimization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 133 Mathematics for Economics III (4 Credits)
Typically offered Fall and Spring
Formerly numbered MATH-UA 213; the content has not changed. Further topics in vector calculus. Vector spaces, matrix analysis. Linear and nonlinear programming with applications to game theory. This course will provide economics students who have taken MATH-UA 131 Mathematics for Economics I (formerly MATH-UA 211) and MATH-UA 132 Mathematics for Economics II (formerly MATH-UA 212) with the tools to take higher-level mathematics courses.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 140 Linear Algebra (4 Credits)
Typically offered Fall, Spring, and Summer terms
Systems of linear equations. Gaussian elimination, matrices, determinants, and Cramer?s rule. Vectors, vector spaces, basis and dimension, linear transformations. Eigenvalues, eigenvectors, quadratic forms.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 144 Introduction to Computer Simulation (4 Credits)
Typically offered Spring
Prerequisite: A grade of C or higher in Calculus I (MATH-UA 121) or Math for Economics II (MATH-UA 212) (for economics majors), and General Physics (PHYS-UA 11). Simulations of such phenomena as orbits (Kepler problem and N-body problem), epidemic and endemic disease (including evolution in response to the selective pressure of malaria), musical stringed instruments (piano, guitar, and violin), and traffic flow in a city (with lights, breakdowns, and gridlock). Simulations are based on mathematical models, numerical methods, and Matlab programming techniques taught in class. Emphasizes use of animation (and sound where appropriate) to present the results of simulations.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 148 Honors Linear Algebra (4 Credits)
This honors section of Linear Algebra is a proof-based course intended for well-prepared students who have already developed some mathematical maturity and ease with abstraction. Its scope will include the usual Linear Algebra (MATH-UA 140) syllabus; however this class will be faster, more abstract and proof-based, covering additional topics. Topics covered are: Vector spaces, linear dependence, basis and dimension, matrices, determinants, solving linear equations, linear transformations, eigenvalues and eigenvectors, diagonalization, inner products, applications.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 228 Fundamental Dynamics of Earth's Atmosphere and Climate (4 Credits)
Typically offered Spring
An introduction to the dynamical processes that drive the circulation of the atmosphere and ocean, and their interaction. This is the core of climate science. Lectures will be guided by consideration of observations and experiments, but the goal is to develop an understanding of the unifying principles of planetary fluid dynamics. Topics include the global energy balance, convection and radiation (the greenhouse effect), effects of planetary rotation (the Coriolis force), structure of the atmospheric circulation (the Hadley cell and wind patterns), structure of the oceanic circulation (wind-driven currents and the thermohaline circulation), climate and climate variability (including El Nino and anthropogenic warming).
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 230 Introduction to Fluid Dynamics (4 Credits)
Typically offered Spring
Prerequisite: A grade of C or higher in Calculus III (MATH-UA 123) or Math for Economics III (MATH-UA 213) (for economics majors). Recommended: Mathematical Physics (PHYS-UA 106). Fluid dynamics is the branch of physics that can describe the flow of blood in the human body, the flight of an insect, or the motions of weather systems. Key concepts include: the formalism of continuum mechanics; the conservation of mass, energy, and momentum in a fluid; the Euler and Navier-Stokes equations; and viscosity and vorticity. These concepts are applied to such classic problems in fluid dynamics as potential flow around a cylinder, the propagation of sound and gravity waves, and the onset of instability in shear flow.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 233 Theory of Probability (4 Credits)
Typically offered Fall, Spring, and Summer terms
Introduction to the mathematical techniques of random phenomena occurring in the natural, physical, and social sciences. Axioms of mathematical probability, combinatorial analysis, binomial distribution, Poisson and normal approximation, random variables and probability distributions, generating functions, Markov chains, applications.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 234 Mathematical Statistics (4 Credits)
Typically offered Spring
Prerequisite: a grade of C or better in Theory of Probability (MATH-UA 233) or equivalent. Not open to students who have taken Probability and Statistics (MATH-UA 235). Introduction to the mathematical foundations and techniques of modern statistical analysis used in the interpretation of data in quantitative sciences. Mathematical theory of sampling; normal populations and distributions; chi-square, t, and F distributions; hypothesis testing; estimation; confidence intervals; sequential analysis; correlation, regression, and analysis of variance. Applications to the sciences.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 233 with a Minimum Grade of C OR MATH-UA 238 with a Minimum Grade of C OR MATH-SHU 238 OR MA-UY 2233 OR (MA-UY 3012 and MA-UY 3022)) AND Restriction: Academic Program UY-Tandon Schl of Engineering.

MATH-UA 235 Probability & Statistics (4 Credits)
Typically offered Spring
Prerequisite: a grade of C or better in Calculus II (MATH-UA 122) or Math for Economics II (MATH-UA 212) (for economics majors) or equivalent. Not open to students who have taken Theory of Probability (MATH-UA 233) or Mathematical Statistics (MATH-UA 234). Combination of MATH-UA 233 and 234 at a more elementary level to acquaint students with both probability and statistics in a single term. In probability: mathematical treatment of chance; combinatorics; binomial, Poisson, and Gaussian distributions; law of large numbers and the normal distribution; application to coin-tossing; radioactive decay. In statistics: sampling; normal and other useful distributions; testing of hypotheses; confidence intervals; correlation and regression; applications to scientific, industrial, and financial data.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 238 Honors Theory of Probability (4 Credits)
The aim of this class is to introduce students to probability theory, with a greater emphasis on rigor, more material, and a faster pace than the Theory of Probability class. The material will include discrete and continuous probability, and the most fundamental limit theorems (law of large numbers and Central Limit Theorem).
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 240 Combinatorics (4 Credits)
Typically offered Spring
Techniques for counting and enumeration, including generating functions, the principle of inclusion and exclusion, and Polya counting. Graph theory. Modern algorithms and data structures for graph theoretic problems.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 248 Theory of Numbers (4 Credits)
Typically offered Fall
Divisibility and prime numbers. Linear and quadratic congruences. The classical number-theoretic functions. Continued fractions. Diophantine equations.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 250 Mathematics of Finance (4 Credits)
Typically offered Fall
Introduction to the mathematics of finance. Topics: linear programming with application to pricing. Interest rates and present value. Basic probability, random walks, central limit theorem, Brownian motion, log-normal model of stock prices. Black-Scholes theory of options. Dynamic programming with application to portfolio optimization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 251 Intro to Math Modeling (4 Credits)
Typically offered Spring
Formulation and analysis of mathematical models. Mathematical tools include dimensional analysis, optimization, simulation, probability, and elementary differential equations. Applications to biology, economics, other areas of science. The necessary mathematical and scientific background is developed as needed. Students participate in formulating models as well as in analyzing them.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 252 Numerical Analysis (4 Credits)
Typically offered Spring
In numerical analysis one explores how mathematical problems can be analyzed and solved with a computer. As such, numerical analysis has very broad applications in mathematics, physics, engineering, finance, and the life sciences. This course introduces the subject for mathematics majors. Theory and practical examples using Matlab are combined in the studying of topics ranging from simple root-finding procedures to differential equations and the finite element method.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 253 Linear and Nonlinear Optimization (4 Credits)
Optimization is a major part of the toolbox of the applied mathematician, and more broadly of researchers in quantitative sciences including economics, data science, machine learning, and quantitative social sciences. This course provides an application-oriented introduction to linear programming and convex optimization, with a balanced combination of theory, algorithms, and numerical implementation. While no prior experience in programming is expected, the required coursework will include numerical implementations, including some programming; students will be introduced to appropriate computational tools, with which they will gain experience as they do the numerical assignments. Theoretical topics will include linear programming, convexity, duality, minimax theorems, and dynamic programming. Algorithmic topics will include the simplex method for linear programming, selected techniques for smooth multidimensional optimization (eg Newton's method and the conjugate gradient method), techniques for solving for L1-type optimizations, and stochastic gradient descent. Applications will be drawn from many areas, but will emphasize economics (eg two-person zero-sum games, matching and assignment problems, optimal resource allocation), data science (eg regression, convex-relaxation-based approaches to sparse inverse problems, tuning of neural networks, prediction with expert advice) and operations research (eg shortest paths in networks and optimization of network flows).
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 255 Mathematics and Biology (4 Credits)
Typically offered Fall
Intended primarily for premedical students with interest and ability in mathematics. Topics of medical importance using mathematics as a tool, including control of the heart, optimal principles in the lung, cell membranes, electrophysiology, countercurrent exchange in the kidney, acid-base balance, muscle, cardiac catheterization, and computer diagnosis. Material from the physical sciences is introduced as needed and developed within the course.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 256 Computers in Medicine & Biology (4 Credits)
Typically offered Spring
Introduces the student of biology or mathematics to the use of computers as tools for modeling physiological phenomena. The student constructs two computer models selected from the following list: circulation, gas exchange in the lung, control of cell volume, and the renal countercurrent mechanism. The student then uses the model to conduct simulated physiological experiments.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: MATH-UA 255 with a Minimum Grade of C AND Restriction: Academic Program UY-Tandon Schl of Engineering.

MATH-UA 258 Honors Numerical Analysis (4 Credits)
Covers the analysis of numerical algorithms which are ubiquitously used to solve problems throughout mathematics, physics, engineering, finance, and the life sciences. Topics include: algorithms for solving nonlinear equations; optimization; finding eigenvalues/eigenvectors of matrices; computing matrix factorizations and performing linear regressions; function interpolation, approximation, and integration; basic signal processing using the Fast Fourier Transform; Monte Carlo simulation. An introduction to programming will be provided as it is an integral part of numerical analysis, but students should feel quite comfortable programming on their own (or be exceptionally willing to learn along the way).
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 262 Ordinary Diff Equations (4 Credits)
Typically offered Fall and Spring
First- and second-order equations. Series solutions. Laplace transforms. Introduction to partial differential equations and Fourier series.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 263 Partial Diff Equations (4 Credits)
Typically offered Spring
Many laws of physics are formulated as partial differential equations. This course discusses the simplest examples of such laws as embodied in the wave equation, the diffusion equation, and Laplace?s equation. Nonlinear conservation laws and the theory of shock waves. Applications to physics, chemistry, biology, and population dynamics.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 262 with a Minimum Grade of C OR MATH-UA 268 with a Minimum Grade of C OR MATH-SHU 262 OR MATH-UH 2010 OR MATH-SHU 362 OR MA-UY 2034 OR (MA-UY 2132 and MA-UY 2012)) AND Restriction: Acad Prog UY-Tandon Schl of Engineering.

MATH-UA 264 Chaos & Dynamical Systems (4 Credits)
Typically offered Spring
Topics include fixed points of one-dimensional maps; linear operators and linear approximations; stability and bifurcation; logistic maps. Cantor set, fractal sets, symbolic dynamics, conjugacy of maps. Dynamics in two dimensions. Introduction for students with little preparation to the recent discovery that, in certain regimes, fully deterministic mechanics can produce chaotic behavior.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 268 Honors Ordinary Differential Equations (4 Credits)
This class will develop rigorously the basic theory of Ordinary Differential Equations (ODEs). Existence and uniqueness of solutions to ODEs are first investigated, for linear and nonlinear problems, set on the real line or the complex plane. More qualitative questions are then considered, about the behavior of the solutions, with possible prolongations to various topics in Dynamical Systems theory. Applications to Physics and Biology will appear naturally when discussing examples.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 328 with a Minimum Grade of B+ OR MATH-UA 325 with a Minimum Grade of A-).

MATH-UA 282 Functions of a Complex Variable (4 Credits)
Typically offered Spring
Complex numbers and complex functions. Differentiation and the Cauchy-Riemann equations. Cauchy?s theorem and the Cauchy integral formula. Singularities, residues, Taylor and Laurent series. Fractional linear transformations and conformal mapping. Analytic continuation.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 325 Analysis (4 Credits)
Typically offered Fall and Spring
This course is an introduction to rigorous analysis on the real line. Topics include: the real number system, sequences and series of numbers, functions of a real variable (continuity and differentiability), the Riemann integral, basic topological notions in a metric space, sequences and series of functions including Taylor and Fourier series.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 328 Honors Analysis I (4 Credits)
Typically offered occasionally
This is an introduction to the rigorous treatment of the foundations of real analysis in one variable. It is based entirely on proofs. Students are expected to know what a mathematical proof is and are also expected to be able to read a proof before taking this class. Topics include: properties of the real number system, sequences, continuous functions, topology of the real line, compactness, derivatives, the Riemann integral, sequences of functions, uniform convergence, infinite series and Fourier series. Additional topics may include: Lebesgue measure and integral on the real line, metric spaces, and analysis on metric spaces.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 329 Honors Analysis II (4 Credits)
Typically offered Spring
Prerequisites: a grade of C or better in Honors Analysis I (MATH-UA 328), or a grade of A in Analysis (MATH-UA 325) and permission of instructor. Continuation of Honors Analysis I (MATH-UA 328). Topics include: metric spaces, differentiation of functions of several real variables, the implicit and inverse function theorems, Riemann integral on R^n, Lebesgue measure on R^n, the Lebesgue integral.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 328 OR MATH-SHU 328) AND Restriction: Academic Program UY-Tandon Schl of Engineering.

MATH-UA 343 Algebra (4 Credits)
Typically offered Fall and Spring
Introduction to abstract algebraic structures, including groups, rings, and fields. Sets and relations. Congruences and unique factorization of integers. Groups, permutation groups, homomorphisms and quotient groups. Rings and quotient rings, Euclidean rings, polynomial rings. Fields, finite extensions.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 348 Honors Algebra I (4 Credits)
Typically offered occasionally
Introduction to abstract algebraic structures, including groups, rings, and fields. Sets and relations. Congruences and unique factorization of integers. Groups, permutation groups, group actions, homomorphisms and quotient groups, direct products, classification of finitely generated abelian groups, Sylow theorems. Rings, ideals and quotient rings, Euclidean rings, polynomial rings, unique factorization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 349 Honors Algebra II (4 Credits)
Typically offered Spring
Prerequisites: a grade of C or better in Honors Algebra I (MATH-UA 348), or a grade of A in Algebra (MATH-UA 343) and permission of instructor. Principal ideal domains, polynomial rings in several variables, unique factorization domains. Fields, finite extensions, constructions with ruler and compass, Galois theory, solvability by radicals.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 348 with a Minimum Grade of C OR MATH-SHU 348) AND Restriction: Academic Program UY-Tandon Schl of Engineering.

MATH-UA 375 Topology (4 Credits)
Typically offered Spring
Metric spaces, topological spaces, compactness, connectedness. Covering spaces and homotopy groups.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 325 with a Minimum Grade of C OR MATH-UA 328 OR MATH-SHU 201 OR MA-UY 4614) AND Restriction: Academic Program UY-Tandon Schl of Engineering.

MATH-UA 377 Differential Geometry (4 Credits)
Typically offered Spring
The differential properties of curves and surfaces. Introduction to manifolds and Riemannian geometry.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 395 Special Topics (4 Credits)
Typically offered occasionally
Lecture-seminar course on advanced topics selected by the instructor. Topics vary yearly. Detailed course descriptions are available during preregistration.Covers topics not offered regularly: experimental courses and courses offered on student demand.
Grading: CAS Graded
Repeatable for additional credit: Yes

MATH-UA 897 Internship in Mathematics (2-4 Credits)
An internship in mathematics is an excellent complement to formal course work. Practical training along with their classroom experience can help students to explore different career options and gain hands-on experience. An internship is for majors only.
Grading: CAS Pass/Fail
Repeatable for additional credit: No

MATH-UA 898 Internship in Mathematics (2-4 Credits)
Prerequisite: Restricted to declared math majors. Math major or Math joint major with Computer Science or Economics, a 3.0 Cumulative GPA and 3.5 Math Major GPA required. Students have to have completed 50% of their major. MATH-UA 897 is offered in the fall and summer session I terms. MATH-UA 898 is offered in the spring and summer session II terms. 2 or 4 points per term. An internship in mathematics is an excellent complement to formal course work. Practical training along with their classroom experience can help students to explore different career options and gain hands-on experience. An internship is for majors only. The internship will be pass/fail.
Grading: CAS Pass/Fail
Repeatable for additional credit: No

MATH-UA 997 Independent Study (2-4 Credits)
Typically offered Fall and Summer terms
Prerequisite: permission of the department. 2 or 4 points per term. To register for this course, a student must complete an application form for independent study and have it approved by a faculty sponsor and the director of undergraduate studies.
Grading: CAS Graded
Repeatable for additional credit: Yes

MATH-UA 9009 Algebra, Trigonometry, and Functions (4 Credits)
Prerequisite: Three years of high school math or permission of the department. An intensive course in intermediate algebra and trigonometry. Topics include algebraic, exponential, logarithmic, and trigonometric functions and their graphs.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9121 Calculus I (4 Credits)
Typically offered Fall and Spring
Any one of the following: a score of 670 or higher on the mathematics portion of the SAT, a score of 650 or higher on the SAT Subject Test in Mathematics 1, a score of 650 or higher on the SAT Subject Test in Mathematics 2, an ACT mathematics score of 30 or higher, a score of 3 or higher on the AP Calculus AB exam, an AB subscore of 3 or higher on the AP Calculus BC exam, a score of 3 or higher on the AP Calculus BC exam, a grade of C or higher in Algebra and Calculus (MATH-UA 9), or a passing score on a departmental placement exam. Derivatives, antiderivatives, and integrals of functions of one variable. Applications include graphing,maximizing, and minimizing functions. Definite integrals and the fundamental theorem of calculus. Areas and volumes.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: MATH-UA 9).

MATH-UA 9131 Mathematics for Economics I (4 Credits)
Typically offered Fall
This course is only open to Economics Majors and prospective majors. If an Economics Major decides to double or joint major in Math these courses will replace Calculus I - III. Elements of calculus and linear algebra are important to the study of economics. This class is designed to provide the appropriate tools for study in the policy concentration. Examples and motivation are drawn from important topics in economics. Topics covered include derivatives of functions of one and several variables; interpretations of the derivatives; convexity; constrained and unconstrained optimization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9132 Mathematics for Economics II (4 Credits)
Typically offered Spring
A continuation of Mathematics for Economics I. Matrix algebra; eigenvalues; Ordinary differential equations and stability analysis, multivariable integration and (possibly) dynamic optimization.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9140 Linear Algebra (4 Credits)
This is an introductory course on linear algebra, one of the most important and basic areas of mathematics, with many real-life applications. The course introduces students to both the theory of vector spaces and linear transformations and the techniques such as row-reduction of matrices and diagonalisation, which can be applied to problems in areas such as engineering, economics, and mathematical biology. As well as mastering techniques, it is important that the students get to grips with the more abstract ideas of linear algebra, and learn to understand and write correct mathematical arguments. Taking an active approach to problem-solving is also important.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: MATH-UA 121 with a Minimum Grade of C.

MATH-UA 9233 Theory of Probability (4 Credits)
An introduction to the mathematical treatment of random phenomena occurring in the natural, physical, and social sciences. Axioms of mathematical probability, combinatorial analysis, binomial distribution, Poisson and normal approximation, random variables and probability distributions, generating functions, Markov chains applications.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9235 Probability & Statistics (4 Credits)
Typically offered Fall
Combination of MATH-UA 233 and 234 at a more elementary level to acquaint students with both probability and statistics in a single term. In probability: mathematical treatment of chance; combinatorics; binomial, Poisson, and Gaussian distributions; law of large numbers and the normal distribution; application to coin-tossing; radioactive decay. In statistics: sampling; normal and other useful distributions; testing of hypotheses; confidence intervals; correlation and regression; applications to scientific, industrial, and financial data.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9253 Linear and Nonlinear Optimization (4 Credits)
Optimization is a major part of the toolbox of the applied mathematician, and more broadly of researchers in quantitative sciences including economics, data science, machine learning, and quantitative social sciences. This course provides an application-oriented introduction to linear programming and convex optimization, with a balanced combination of theory, algorithms, and numerical implementation. While no prior experience in programming is expected, the required coursework will include numerical implementations, including some programming; students will be introduced to appropriate computational tools, with which they will gain experience as they do the numerical assignments. Theoretical topics will include linear programming, convexity, duality, minimax theorems, and dynamic programming. Algorithmic topics will include the simplex method for linear programming, selected techniques for smooth multidimensional optimization (eg Newton's method and the conjugate gradient method), techniques for solving for L1-type optimizations, and stochastic gradient descent. Applications will be drawn from many areas, but will emphasize economics (eg two-person zero-sum games, matching and assignment problems, optimal resource allocation), data science (eg regression, convex-relaxation-based approaches to sparse inverse problems, tuning of neural networks, prediction with expert advice) and operations research (eg shortest paths in networks and optimization of network flows).
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9262 Ordinary Differential Equations (4 Credits)
This course is a first course in ordinary differential equations, including analytical solution methods, elementary numerical methods and modeling. Topics to be covered include first-order equations including integrating factors, second-order equations including variation of parameters, series solutions, elementary numerical methods including Euler's methods, Laplace transforms, systems of linear equations and boundary-value problems.
Grading: CAS Graded
Repeatable for additional credit: No

MATH-UA 9263 Partial Differential Equations (4 Credits)
Many laws of physics are formulated as partial differential equations. This course discusses the simplest examples of such laws as embodied in the wave equation, the diffusion equation, and Laplace?s equation. Nonlinear conservation laws and the theory of shock waves. Applications to physics, chemistry, biology, and population dynamics. Prerequisite: prerequisite for MATH-UA 263
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: (MATH-UA 262 OR MATH-SHU 262 OR MATH-UH 2010 OR MATH-SHU 362 OR MA-UY 2034 OR (MA-UY 2132 and MA-UY 2012)).

MATH-UA 9282 Functions of a Complex Variable (4 Credits)
Complex numbers and complex functions. Differentiation and the Cauchy-Riemann equations. Cauchy?s theorem and the Cauchy integral formula. Singularities, residues, Taylor and Laurent series. Fractional linear transformations and conformal mapping. Analytic continuation.
Grading: CAS Graded
Repeatable for additional credit: No
Prerequisites: MATH-UA 282.

MATH-UA 9325 Analysis (4 Credits)
Typically offered Spring
This course is an introduction to rigorous analysis on the real line. Topics include: the real number system, sequences and series of numbers, functions of a real variable (continuity and differentiability), the Riemann integral, basic topological notions in a metric space, sequences and series of functions including Taylor and Fourier series.
Grading: CAS Graded
Repeatable for additional credit: No