

DEPARTMENT OF MATHEMATICS

Mathematics is the symbolic language of nature. More than numbers and symbols, it encompasses the logic and methodology of reasoning and provides the tools for making decisions, interpreting observations, explaining natural phenomena and solving problems. It is both a subject with widespread applications to the sciences and social sciences and a subject of intrinsic intellectual interest.

Students majoring in Mathematics acquire the mathematical skills necessary to be successful in their chosen field and become an informed and responsible citizen, and learn to appreciate the relevance of mathematics in society.

Students completing a major in Mathematics should:

- be prepared for employment in mathematics-related careers in fields such as business, science, government and education
 - be prepared to pursue graduate studies in mathematics
 - be able to work collaboratively on mathematical problems and effectively communicate these results
 - be exposed to technological innovations used in mathematics
 - be able to read and use the current mathematical literature to further their own education
- Bachelor of Arts in Mathematics (<http://catalog.qu.edu/arts-sciences/mathematics/mathematics-ba>)
 - Minor in Applied Statistics and Data Science (<http://catalog.qu.edu/arts-sciences//mathematics/applied-statistics-and-data-science-minor>)
 - Minor in Mathematics (<http://catalog.qu.edu/arts-sciences/mathematics/mathematics-minor>)

Mathematics (MA)

MA 100. Basic Algebra. 3 Credits.

This course reviews basic arithmetic and algebraic skills and introduces mathematical methods to the entering student with little or no mathematics background, with the goal of providing sufficient skill to take course work requiring two years of college preparatory mathematics. Students are expected to participate in four hours of course work per week. MA 100 is for institutional credit and does not apply to graduation requirements. Note: Students may not withdraw from MA 100. Students who fail MA 100 the first time receive a grade of Unsatisfactory. If the student does not pass the second time, then a failure is recorded on the student's record.

Offered: Every year, Fall and Spring

MA 107. College Algebra. 3 Credits.

This course reviews the fundamentals of algebra. Students learn about the following topics: the real number system, factoring and expanding polynomials, properties of logarithms and exponentials, linear equations and inequalities, quadratic equations and inequalities, absolute value equations and inequalities, systems of equations and inequalities, functions and their graphs, and algebra of functions, including composition, and inverse functions. This course is designed for students who need to improve their algebraic skills to prepare for future mathematics courses such as Applied Calculus, Pre-Calculus, or Statistics. MA 107 does not fulfill the Quantitative Literacy requirement. Prerequisite: A math placement level of 2 or above, or successful completion of MA 100.

Offered: Every year, All

MA 110. Contemporary Mathematics. 3 Credits.

This course introduces students to the study of mathematics as a discipline and also presents topics that are applicable to students' everyday lives. Topics include logic, probability and statistics and financial mathematics. The course also covers two topics from the following list: geometry, set theory, number theory, measurement, problem solving, mathematical systems, scientific applications, history of mathematics. Topics are chosen by the instructor. Students should check the mathematics requirements for their major before selecting their first course in mathematics. MA 110 is not designed to be a prerequisite for any calculus course. Prerequisite: A math placement level of 2 or above, or successful completion of MA 100.

Offered: Every year, All

MA 110H. Honors Contemporary Mathematics. 3 Credits.

This course introduces students to the study of mathematics as a discipline and also presents topics that are applicable to students' everyday lives. Topics include logic, probability and statistics and financial mathematics. The course also covers two topics from the following list: geometry, set theory, number theory, measurement, problem solving, mathematical systems, scientific applications, history of mathematics. Topics are chosen by the instructor. Students should check the mathematics requirements for their major before selecting their first course in mathematics. MA 110 is not designed to be a prerequisite for any calculus course.

Offered: As needed

MA 140. Pre-Calculus. 3 Credits.

This course concentrates on topics that students need to understand profoundly to succeed in calculus. Students learn about the following topics: functions and their graphs, exponents and logarithms and trigonometry. There is a focus on basic concepts and visualization of problems. The material has many real-life applications. Use of a TI-83 or TI-84 calculator is required. Primary emphasis is on developing the following New Synthesis proficiencies: quantitative reasoning and critical thinking and reasoning.

Prerequisites: Take MA 107; Minimum grade C- or placement level of 3.

Offered: Every year, All

UC: Breadth Elective, University Curriculum Ele

- MA 141. Calculus of a Single Variable.** **3 Credits.**
 This course covers functions, graphs, limits, continuity, derivatives, applications of derivatives, antiderivatives and definite integrals, as well as the Fundamental Theorem of Calculus. This course significantly advances the following Essential Learning Outcomes: quantitative reasoning, critical thinking and reasoning. Many sections require a TI-83/84 calculator (or the equivalent); check with the instructor. Students cannot receive credit for both MA 141 and MA 151.
Prerequisites: Take MA 140; Minimum grade C; or placement level of 5.
Offered: Every year, All
UC: Breadth Elective, University Curriculum Ele
- MA 141H. Honors Calculus of a Single Variable.** **3 Credits.**
 This course covers functions, graphs, limits, continuity, derivatives, applications of derivatives, antiderivatives and definite integrals, as well as the Fundamental Theorem of Calculus. This course significantly advances the following Essential Learning Outcomes: quantitative reasoning, critical thinking and reasoning. Many sections require a TI-83/84 calculator (or the equivalent); check with the instructor. Students cannot receive credit for both MA 141 and MA 151.
Prerequisites: Take MA 140; Minimum grade C; or placement level of 5.
Offered: As needed
UC: University Curriculum Ele
- MA 150. Integral Calculus With Applications.** **1 Credit.**
 This course provides a bridge from MA 141 to MA 152. Students review basic integration rules, integration by substitution, Fundamental Theorem of Calculus, numerical integration and applications of integration, including area between curves, volumes, arc length and applications from physics. A graphing calculator is required; the TI-83 or TI-84 is recommended.
Prerequisites: Take MA 141 or MA 141H; Minimum grade C-.
Offered: Every year, Fall and Spring
- MA 151. Calculus I.** **4 Credits.**
 This course covers functions and graphs, limits and continuity, derivatives, applications of derivatives, antiderivatives and definite integrals, the Fundamental Theorem of Calculus, numerical integration and applications of definite integrals. A graphing calculator is required; the TI-83 or TI-84 is recommended. Students cannot receive credit for both MA 151 and MA 141.
Prerequisites: Take MA 140; Minimum grade C; or placement level of 5.
Offered: Every year, Fall and Spring
UC: Breadth Elective, University Curriculum Ele
- MA 152. Calculus II.** **4 Credits.**
 This course covers techniques of integration, improper integrals, differential equations, infinite series, parametric equations, polar coordinates, vectors, operations on vectors, and three-dimensional coordinate systems.
Prerequisites: Take MA 151 or MA 141; Minimum grade C-.
Corequisites: Take MA 150.
Offered: As needed
- MA 153. Calculus II: Part A.** **2 Credits.**
 Students in this course study techniques of integration and infinite sequences and series. Techniques studied include u-substitution, integrals involving logarithms and inverse trigonometric functions, trigonometric integrals, trigonometric substitution, integration by parts, and partial fractions. For infinite series, the course includes a study of convergence, tests of convergence, power series, and Taylor and Maclaurin series. Additional topics include indeterminate forms, L'Hopital's Rule, and improper integrals. Offered the first half of each semester.
Prerequisites: Take MA 141 or MA 151. Minimum Grade C-.
Offered: Every year, Fall and Spring
- MA 154. Calculus II: Part B.** **2 Credits.**
 In this course students study differential equations, conic sections, parametric equations, polar coordinates, vectors, operations on vectors, lines and planes in space, three-dimensional coordinate systems (cylindrical and spherical coordinates) and quadric surfaces. Offered the second half of each semester.
Corequisites: MA 151; or MA 141 and MA 150; Minimum grade C-. Take MA 153;
Offered: Every year, Fall and Spring
- MA 170. Probability and Data Analysis.** **3 Credits.**
 This course teaches students the fundamentals of probability and solves real-life probability problems. Students learn to use graphical techniques and descriptive statistics to analyze data. Topics include: ratios, proportions, percentages, empirical and theoretical probability calculations, conditional probability and independence, Bayes' Theorem, expected value, discrete probability distributions, continuous probability distributions, descriptive statistics for central tendency and variability, graphical techniques including histograms and scatter diagrams, and analyzing data sets. The course also includes an introduction to Excel and prepares students for future courses in statistics and analytics.
Prerequisites: Take MA 100; Minimum grade C-; or placement level of 2.
Offered: Every year, Fall and Spring
UC: Breadth Elective
- MA 176. Baseball and Statistics (SPS 226).** **3 Credits.**
 This course covers Sabermetrics: the use of standard statistical topics to analyze data derived from baseball records. The book, Moneyball, is read to understand how statistics was used by Billy Beane to bring success to the Oakland Athletics. The standard statistical topics covered include exploratory data analysis, elementary probability, discrete probability distributions, normal probability distributions, sampling distributions, regression, and correlation. Learning to use Excel to do statistical analysis is an integral part of the course. Students must possess a basic knowledge of baseball.
Prerequisites: Take MA 100; or placement level of 2.
Offered: Every year, Fall and Spring
- MA 190. Mathematics Freshman Seminar.** **1 Credit.**
 This course presents excursions into a variety of areas in advanced mathematics, as well as its applications, history and philosophy. Students also explore career options related to the study of mathematics.
Prerequisites: Take MA 140 MA 141 MA 141H or MA 151; Grade of C- or better.
Offered: Every year, Spring

- MA 205. Introduction to Discrete Mathematics (CSC 205). 3 Credits.**
This course introduces students to basic concepts and structures of discrete mathematics. Topics can include propositional and predicate logic, sets and set operations, functions, proof techniques, counting problems, probability and basic number theory. Applications include computer science, biology, social sciences, law and the physical sciences.
Prerequisites: Take CSC 110 or MA 110 or higher; Grade of C- or better.
Offered: Every year, Spring
- MA 206. Statistics for the Behavioral Sciences. 3 Credits.**
This course presents a study of statistical procedures pertinent to the work of the social and behavioral scientist. Students are introduced to descriptive procedures, confidence intervals, hypothesis testing, regression and correlation, analysis of variance and non-parametric techniques. Students are not allowed to receive credit for more than one of the following courses: MA 206, MA 275 and MA 285.
Prerequisites: Take MA 107 or MA 170; Minimum grade C-; or placement level of 3.
Offered: Every year, All
- MA 229. Linear Algebra. 3 Credits.**
This course covers the basic concepts of linear algebra, along with an introduction to the language and techniques of formal mathematics. Topics include systems of linear equations, vector spaces, linear transformations, matrices, determinants and eigenvalues.
Offered: Every year, Spring
- MA 251. Calculus III. 4 Credits.**
This course covers vector functions, derivatives and integrals of vector functions, arc length and curvature, motion in space, functions of several variables, limits and continuity, partial derivatives, tangent planes and linear approximations, directional derivatives and the gradient vector, maximum and minimum values, Lagrange multipliers, multiple integration in Cartesian, cylindrical and spherical coordinates, surface area, vector fields, line integrals, Green's theorem, curl and divergence, surface integrals, Stoke's theorem and divergence theorem.
Prerequisites: Take MA 152 or MA 154; Minimum grade C-.
Offered: Every year, Fall
- MA 265. Linear Algebra and Differential Equations. 4 Credits.**
This course covers the basic concepts of both linear algebra and ordinary differential equations with an emphasis on applications in science and engineering. Linear algebra topics include systems of linear equations, vector spaces and subspaces, linear transformations, matrix algebra, determinants and eigenvalues. Differential equation topics include solutions to first, second and higher order homogeneous and nonhomogeneous differential equations. Solution methods include use of eigenvalues and eigenvectors, Laplace transforms, infinite series and numerical approximations. Special differential equations including Legendre, Bessel, Hermite and Chebyshev equations also are discussed as well as transformations for autonomous equations. A graphing calculator is recommended (TI-83 or TI-84) as well as knowledge of Excel.
Prerequisites: Take MA 152 or MA 154 or MA 241; Minimum grade C-.
Offered: Every year, Spring
- MA 275. Biostatistics. 3 Credits.**
Students are introduced to the application of statistical techniques to the biological and health sciences with emphasis on probability laws, sampling and parameter estimation, central limit theorem, test of hypothesis, correlation, regression and analysis of variance. Students are not allowed to receive credit for more than one of the following courses: MA 206, MA 275 and MA 285.
Prerequisites: Take MA 107 MA 170 MA 176 or MA 140; Minimum grade C- or placement level of 4
Offered: Every year, All
- MA 275H. Honors Biostatistics. 3 Credits.**
Students are introduced to the application of statistical techniques to the biological and health sciences with emphasis on probability laws, sampling and parameter estimation, central limit theorem, test of hypothesis, correlation, regression and analysis of variance.
Prerequisites: Take MA 107; Minimum grade C- or placement level of 4.
Offered: As needed
- MA 285. Applied Statistics. 3 Credits.**
This introductory statistics course is intended primarily for students majoring in engineering, mathematics or the sciences. Emphasis is on using statistics to answer questions in the physical and social sciences. Topics include descriptive statistics, probability, point and interval estimation, hypothesis testing, correlation and regression, analysis of variance, chi-square tests and nonparametric methods. Students are required to analyze real data sets using Excel, SAS, SPSS or similar computer programs. Students are not allowed to receive credit for more than one of the following courses: MA 206, MA 275 and MA 285.
Prerequisites: Take MA 141 MA 141H or MA 151; Minimum grade C-.
Offered: Every year, Spring
- MA 299. Independent Study in Mathematics. 1-6 Credits.**
This individual study in a specialized area is open to juniors and seniors by special arrangement with the department chairman. This is a structured program of reading, problem solving and experiments established through conferences with a member of the mathematics faculty. Graded by examination or term project.
Offered: Every year, All
- MA 300. Special Topics. 3 Credits.**
Offered: As needed, All
- MA 301. Foundations of Advanced Mathematics. 3 Credits.**
This course is an exploration of the language and nature of mathematics. Emphasis is placed on developing the students' ability to construct and write mathematical proofs and helping students read and understand mathematical reasoning. Various techniques of proof are discussed, including direct, contrapositive, induction, contradiction and counterexample. Mathematical content includes elementary logic, quantifiers, set theory, relations, functions and number systems. Other topics are at the instructor's discretion, and may include number theory, graph theory, point-set topology or counting problems.
Prerequisites: Take MA 229; Minimum grade C-.
Offered: Every year, Fall
- MA 305. Discrete Mathematics. 3 Credits.**
Students study various topics in discrete mathematics, such as proof by induction, recurrence relations, cardinality of a set, the pigeonhole principle, counting techniques, probability and graph theory.
Prerequisites: Take MA 301 or CSC 205; Minimum grade C-;
Offered: Every other year, Spring

MA 315. Theory of Computation (CSC 315).**3 Credits.**

This course provides an introduction to the classical theory of computer science with the aim of developing a mathematical understanding of the nature of computing by trying to answer one overarching question: "What are the fundamental capabilities and limitations of computers?" Specific topics include finite automata and formal languages (How do we define a model of computation?), computability (What can be computed?) and complexity (What do we prove something cannot be computed?) and complexity (What makes some problems so much harder than others to solve? and What is the P versus NP question and why is it important?).

Prerequisites: Take MA 301 or CSC 215; Minimum grade C-.**Offered:** Every other year, Fall**MA 318. Cryptography (CSC 318).****3 Credits.**

Students study methods of transmitting information securely in the face of a malicious adversary deliberately trying to read or alter it. Participants also discuss various possible attacks on these communications.

Students learn about classical private-key systems, the Data Encryption Standard (DES), the RSA public-key algorithm, discrete logarithms, hash functions and digital signatures. Additional topics may include the Advanced Encryption Standard (AES), digital cash, games, zero-knowledge techniques and information theory, as well as topics chosen by the students together with the instructor for presentations.

Prerequisites: Take MA 229 or CSC 215 or ISM 301; Minimum grade C-.**Offered:** Every other year, Spring**MA 321. Abstract Algebra.****3 Credits.**

This course presents a study of topics selected from groups, normal groups, rings, ideals, integral domains, fields, polynomial rings and isomorphism theorems.

Prerequisites: Take MA 229 MA 301; Minimum grade C-.**Offered:** Every year, Spring**MA 341. Advanced Calculus.****3 Credits.**

The concepts of limit, continuity, differentiation and Riemann integration are studied in depth. Also considered are sequences and series, improper integrals, and Riemann-Stieltjes Integral.

Prerequisites: Take MA 142 or MA 152 and MA 301; Minimum grade C-.**Offered:** Every year, Fall**MA 351. Real Analysis.****3 Credits.**

This course examines the theoretic foundations of continuity, differentiation and integration at a more abstract level than MA 341. The class reinforces and further expands on proof techniques covered in MA 301. Topics include: convergence of sequences and series, construction of the real number system, metric spaces, dense sets, continuity, compactness, connectedness, differentiation, Riemann-Stieltjes Integral and sequences of functions. Students who wish to pursue graduate studies in mathematics are strongly encouraged to take this class. It is recommended that students take MA 341 before attempting this class.

Prerequisites: Take MA 142 or MA 152 and MA 301; Minimum grade C-.**Offered:** Every other year, Spring**MA 361. Numerical Analysis (CSC 361).****3 Credits.**

This course covers selected techniques for obtaining numerical values of functions, solving linear and nonlinear equations, interpolation, numerical differentiation and integration, error analysis and numerical stability.

Prerequisites: Take MA 142 or MA 152 and MA 229; Minimum grade C-.**Offered:** As needed**MA 365. Ordinary Differential Equations.****3 Credits.**

Students are introduced to standard methods for solving ordinary differential equations, including Laplace transforms as well as singular solutions, series solutions and the system of linear differential equations. Existence and uniqueness theorems also are introduced, as are geometrical interpretation and applications.

Prerequisites: Take MA 142 or MA 152; Minimum grade C-.**Offered:** Every other year, Fall**MA 370. Number Theory.****3 Credits.**

Topics include representation of integers, primes, the Fundamental Theorem of Arithmetic, divisibility, modular arithmetic, Fermat's Little Theorem and Euler's Theorem, perfect numbers, and Diophantine equations. Additional topics may include quadratic residues, sums of squares, and Fermat's Last Theorem.

Prerequisites: take 1 course; from subject MA; from level 300; Minimum grade C-.**Offered:** Every other year, Spring**MA 371. Mathematical Statistics and Probability I.****3 Credits.**

This course covers foundations of probability, random variables and select probability distributions with applications. Topics include sample spaces and events; conditional probability; independence; expected value, variance and other moments; joint densities; and probability distributions including the normal, Poisson, Binomial and other distributions.

Prerequisites: Take MA 242 or MA 251 and MA 301; Minimum grade C-.**Offered:** Every other year, Fall**MA 372. Mathematical Statistics and Probability II.****3 Credits.**

Students are introduced to general principles of estimation and testing hypotheses; small sample distributions; regression and correlation; design of experiments and analysis of variance; nonparametric techniques; and other methods.

Prerequisites: Take MA 371; Minimum grade C-.**Offered:** Every other year, Spring**MA 378. Mathematical Modeling.****3 Credits.**

Students develop mathematical models for problems in biology, environment, health sciences and politics.

Prerequisites: Take MA 141 MA 141H or MA 151 and MA 229; Minimum grade C-.**Offered:** Every other year, Fall**MA 380. Data Mining.****3 Credits.**

This course introduces students to data mining concepts and techniques, and data mining software. Topics include data preprocessing and cleaning, concept hierarchy generation, attribute relevance analysis, association rule mining and decision tree induction.

Corequisites: Take EC 365.**Offered:** Every year, Fall**MA 385. Machine Learning.****3 Credits.**

This course introduces students to the theory of machine learning and practical applications. Topics include supervised learning, unsupervised learning, learning theory, regularization models, validation and models.

Prerequisites: Take MA 380.**Offered:** Every year, Spring**MA 399. Independent Study in Mathematics.****1-6 Credits.**

This individual study in a specialized area is open to juniors and seniors by special arrangement with the department chairman. This is a structured program of reading, problem solving and experiments established through conferences with a member of the mathematics faculty. Graded by examination or term project.

Offered: As needed, Spring

- MA 400. Special Topics in Math.** 3 Credits.
Special topics are selected from the areas of differential equations, complex variables, and topology and application of the theory to scientific and business problems is explored.
Offered: As needed, Spring
- MA 421. Advanced Algebra.** 3 Credits.
Advanced topics in algebra include Sylow theorems (groups), field extensions, and Galois theory. If time permits, Jordan form of matrices, modules, and introduction to category theory are included.
Prerequisites: Take MA 321; Minimum grade C-.
Offered: As needed, Spring
- MA 441. Complex Variables.** 3 Credits.
This course extends the concepts of calculus to deal with functions whose variables and values are complex numbers. Topics include the geometry of complex numbers, differentiation and integration, representation of functions by integrals and power series, and the calculus of residues.
Prerequisites: Take MA 242 or MA 251 and MA 301; Minimum grade C-.
Offered: As needed
- MA 451. Elements of Point-Set Topology.** 3 Credits.
Open sets, closed sets, and topological spaces are considered. Also covered are connectedness and compactness, functions, limit points, and continuity. Metric spaces are introduced as well as completeness and the Heine-Borel property. Construction of real numbers is introduced.
Prerequisites: Take MA 341; Minimum grade C-.
Offered: As needed
- MA 480. ASDS Capstone.** 3 Credits.
This course serves as a culminating experience for the ASDS minor. Students will work on an independent project that will allow them to integrate knowledge from their previous courses in the minor. Students will learn best practices of data visualization and use appropriate visualization software to help craft a narrative about their project.
Prerequisites: Take MA 385;
Offered: Every year, Fall
- MA 490. Mathematics Senior Seminar.** 3 Credits.
Students work on a senior-level project, culminating in a written and oral report. For senior mathematics majors.
Offered: Every year, Spring
- MA 499. Independent Study in Mathematics.** 3 Credits.
This individual study in a specialized area is open to juniors and seniors by special arrangement with the department chairman. This is a structured program of reading, problem solving and experiments established through conferences with a member of the mathematics faculty. Graded by examination or term project.
Offered: As needed, Spring
- MA 521. Algebraic Reasoning.** 2 Credits.
Students apply proof-based reasoning in the context of different algebraic systems, including groups, rings and fields. Specific examples include finite fields and matrix rings, as well as the real and complex numbers. Emphasis is placed on the interplay between axiomatic algebra and the existence and solution of algebraic equations.
Offered: Every year, Summer
- MA 522. Analytic Reasoning.** 2 Credits.
Students explore properties of the real numbers and functions of real numbers based on the completeness axiom, including continuity in the context of powers and roots, exponentials and logarithms, and the trigonometric functions. Definitions and properties of these functions are developed and proved, with an emphasis on their reliance on continuity.
Offered: Every year, Fall
- MA 541. Complex Variables.** 2 Credits.
This course extends the concepts of calculus to deal with functions whose variables and values are complex numbers. Topics include the geometry of complex numbers, differentiation and integration, representation of functions by integrals and power series, and the calculus of residues.
Prerequisites: Take MA 242 or MA 251 and MA 301; Minimum grade C- or better.
Offered: Every year, Fall
- MA 565. Famous Mathematical Constants.** 3 Credits.
This course is a tour of mathematics from the viewpoint of the well known constants e , π and i . Topics are chosen from geometry, number theory, calculus and algebra.
Offered: Every Third Year
- MA 580. Euclidean and Non-Euclidean Geometry.** 4 Credits.
Students study concepts in Absolute, Euclidean and non-Euclidean geometries, including planar geometry, hyperbolic geometry, and spherical geometry. In particular, students explore topics which may include finite geometries, axiom systems, transformations and symmetries, analytic geometry, circles, triangles, quadrilaterals, the parallel postulate, Pythagorean Theorem, area and similarity.
Offered: Every year, Spring
- MA 583. Mathematics: Historical Insights.** 2 Credits.
Students explore mathematics from historical perspectives. In particular, students investigate contributions of ancient Babylonian, Egyptian, and Persian cultures, historical methods of solving quadratic and cubic equations, development of the calculus.
Offered: Every year, Summer
- MA 585. Mathematical Problem Solving.** 3 Credits.
This course presents an introduction to the spirit of mathematical inquiry through a problem-based approach; heuristics; problem-solving techniques; Polyá's stages of problem solving; specific strategies.
Offered: As needed, All
- MA 586. Discrete Structures.** 3 Credits.
This course considers induction, set theory, relations, functions, graphs, trees, logic and boolean algebra, counting techniques, applications to probability, computer science and algorithm development.
Offered: As needed, All