MATHEMATICS

The mission of the Mathematics Program at Fairfield University is two-fold:

We strive, as mentors and teachers, to graduate majors with broad knowledge of the principal content of Mathematics and its applications, who are aware of the historical and, when appropriate, cross-cultural development of Mathematics and the manifold connections among its subject areas, who have seen some of the connections of Mathematics to other disciplines, and who can think quantitatively and analytically. We want our majors to possess technical problem-solving skills, to have a deep appreciation for mathematical beauty and the power of abstraction, and to be able to understand and build complex logical arguments and communicate these arguments through written, visual, and oral means.

We strive to serve the mission of the Fairfield University Core by ensuring that the student body possesses the ability to reason quantitatively and analytically, and understands not only the power of Mathematics as the language of the sciences, but also the pervasive role of Mathematics in the arts, sciences, and other disciplines.

Mathematics in the Major: Learning Goals and Objectives

We would like mathematics majors to come away with the following:

1. Knowledge of:
   a. The fundamental concepts underlying the major areas of undergraduate Mathematics, including calculus, discrete mathematics, real analysis, linear algebra, and abstract algebra
   b. Applications of Mathematics to other disciplines
   c. Mathematical content and skills needed to support graduate study and/or professions that require mathematical proficiency
2. Awareness of:
   a. The beauty and power of Mathematics
   b. Connections between different fields of Mathematics
   c. The historical development of Mathematics across cultures
3. Ability to:
   a. Think quantitatively, analytically, and abstractly
   b. Understand and create logical arguments and proofs
   c. Read mathematics with comprehension
   d. Write and communicate mathematics clearly and effectively
   e. Demonstrate proficiency in symbolic representation and manipulation
   f. Use technology as a tool to solve problems

For the student of the humanities, the social sciences, or business, mathematics at Fairfield University offers training in basic mathematical skills and their application to real world problems. However, more importantly, it attempts to make the student aware of the relationships between mathematics and other branches of knowledge, while imparting a sense of its historical and cultural value.

The mathematics major offers students a strong and broad background in undergraduate mathematics, providing the foundation for further graduate studies in theoretical or applied fields of mathematics, for advanced study in fields where strong quantitative skills are needed, or for employment in mathematics-related fields in industry or in teaching.

The mathematics minor offers students an opportunity to strengthen their mathematical backgrounds.

Mathematics in the *Magis* Core Curriculum: Learning Objectives

All undergraduate students are required to complete the Magis Core Curriculum. Please refer to the Curricula section of this undergraduate catalog for a detailed explanation of the *Magis* Core. The mathematics component of the Magis Core will help students do the following:

1. Develop a Depth of Understanding of Mathematical Concepts, Context and Theories
   a. Understand sophisticated mathematical ideas when expressed abstractly and generally
   b. Critically analyze mathematical statements, arguments and solutions for correctness
   c. Be aware of the development and impact of mathematics in the context of human progress
2. Engage in Sophisticated Mathematical Problem Solving
   a. Solve multi-step problems by creatively combining a variety of mathematical techniques and reasoning, including graphical, symbolic, computational (including the use of technology), and algorithmic
   b. Solve problems arising from a broad array of disciplines and see the common mathematical threads that unite them
3. Effectively Model Situations Mathematically and Abstractly
   a. Translate word descriptions and real situations into mathematical language, recognizing unknown quantities and relationships, and identifying tools to help solve the problem
   b. Understand how mathematics describes problems in the real world and a wide variety of disciplines
4. Communicate in the Language of Mathematics
   a. Express ideas precisely, rigorously, abstractly and generally
   b. Communicate and demonstrate an understanding of mathematical concepts through projects, reports, problem sets and presentations

Programs

- Mathematics Major
- Actuarial Science Minor
- Applied Statistics Minor
- Mathematical Statistics Minor
- Mathematics Minor

Courses

MATH 1011 Precalculus **3 Credits**

Topics in this course include: algebra; linear, rational, exponential, logarithmic and trigonometric functions from a descriptive, algebraic, numerical and graphical point of view; limits and continuity. Primary emphasis is on techniques needed for calculus. This course does not count toward the mathematics core requirement, and is meant to be taken only by students who are required to take MATH 1121, MATH 1141, or MATH 1171 for their majors, but who do not have a strong enough mathematics background. Previously MA 0011.

MATH 1015 Mathematics: An Exploration **3 Credits**
This course introduces various ideas in mathematics at an elementary level. It is meant for the student who would like to fulfill a core mathematics requirement, but who does not need to take mathematics for their major. Topics will vary, depending upon the instructor, but in general will include topics of both historical and current interest. Previously MA 0015.

MATH 1016 Concepts of Calculus **3 Credits**
This course introduces differentiation and integration, and shows how these ideas are related. The course illustrates how important and interesting applied questions, when expressed in the language of mathematical functions, turn out to be questions about derivatives and integrals and, thus, can be solved using calculus. The basic concepts of calculus are numerically, algebraically, and geometrically investigated, using graphing technology to illustrate many of the underlying geometrical ideas. This is a terminal core course and is not a prerequisite for any other course. Please note that MATH 1011 is not an appropriate course to take before taking this course. Previously MA 0016.

MATH 1017 Elementary Probability and Statistics **3 Credits**
This introduction to the theory of statistics includes measures of central tendency, variance, Chebyshev's theorem, probability theory, binomial distribution, normal distribution, the central limit theorem, and estimating population means for large samples. Students who have received credit for any higher-level mathematics course may not take this course for credit without the permission of the department chair. Previously MA 0017.

MATH 1121 Applied Calculus I **3 Credits**
Prerequisite: Precalculus.
Topics in this course include: foundations of the calculus, differentiation of algebraic, exponential and logarithmic functions, extrema and curve sketching, applications of derivatives, antiderivatives, the Fundamental Theorem of Calculus, and integration of algebraic functions. A graphing calculator and Wolfram Alpha are among the technologies that may be used. Students who received credit for MATH 1141 or MATH 1171 may not take this course for credit. Previously MA 0119.

MATH 1122 Applied Calculus II **3 Credits**
Prerequisite: MATH 1121.
Topics in this course include: applications of the derivative, including implicit differentiation, related rates and linear approximation; integration of algebraic, transcendental and trigonometric functions; differentiation of trigonometric functions; techniques of integration; applications of the definite integral; infinite series. A graphing calculator and Wolfram Alpha are among the technologies that may be used. Students who receive credit for MATH 1142 or MATH 1172 may not receive credit for this course. Previously MA 0120.

MATH 1123 Intermediate Calculus **3 Credits**
This course is designed for students majoring in Physics, Engineering, Chemistry and Biochemistry and/or Mathematics, who have taken the Applied Calculus sequence (MATH 1121/1122), to prepare them for MATH 2243. This course will revisit the typical calculus 1 and 2 concepts from a more formal point of view and will offer applications to Physics and Engineering. The course will cover study of continuity, differentiation and integration of real functions. In this course students will learn the theory of sequences and series.

MATH 1141 Calculus I for Chemistry, Engineering, and Physics Majors **4 Credits**
Prerequisite: Precalculus.
This course covers analytic geometry, continuous functions, derivatives of algebraic and trigonometric functions, product and chain rules, implicit functions, extrema and curve sketching, indefinite and definite integrals, applications of derivatives and integrals, exponential, logarithmic and inverse trig functions, hyperbolic trig functions, and their derivatives and integrals. It is recommended that students not enroll in this course unless they have a solid background in high school algebra and precalculus. Previously MA 0145.

MATH 1142 Calculus II for Chemistry, Engineering, and Physics Majors **4 Credits**
Prerequisite: MATH 1141 or MATH 1171.
This course covers applications of the integral to area, arc length, and volumes of revolution; integration by substitution and by parts; indeterminate forms and improper integrals: Infinite sequences and infinite series, tests for convergence, power series, and Taylor series; geometry in three-space. Previously MA 0146.

MATH 1171 Calculus I **4 Credits**
Prerequisite: Precalculus.
This is our most rigorous first-year calculus sequence. However, students are not expected to have had calculus before taking this course. Topics include functions; limits (including the epsilon-delta definition), continuity, and derivatives; trigonometric functions and their derivatives; applications; relative and absolute extrema, and curve sketching; related rates; Rolle's Theorem and the mean value theorem; antiderivatives, definite integrals and area, and the fundamental theorem of calculus. It is recommended that students not enroll in this course unless they have a solid background in high school algebra and precalculus. Students who have received credit for MATH 1121 or MATH 1141 may not take this course for credit. Previously MA 0171.

MATH 1172 Calculus II **4 Credits**
Prerequisite: MATH 1141 or MATH 1171.
Topics include integration by substitution and by parts; areas between curves; volumes of revolution; inverse functions; logarithms and exponential functions; inverse trigonometric functions; indeterminate forms and l'Hospital's rule; improper integrals; and infinite sequences and series, including convergence tests, absolute and conditional convergence, power series, and Taylor series. Students who have received credit for MATH 1122 or MATH 1142 may not take this course for credit. Previously MA 0172.

MATH 2211 Applied Matrix Theory **3 Credits**
Students majoring in the sciences, economics, and business learn the basic techniques and applications of linear algebra, including solving linear systems of equations, determinants, linear geometry, eigenvalues, and eigenvectors. Closed to mathematics majors. Students may not receive credit for both MATH 2211 and MATH 2235. Previously MA 0211.

MATH 2217 Statistics I **3 Credits**
Attributes: EVAP Environmental Studies: Applied Professional Skills
Prerequisite: MATH 1121 or MATH 1122 or MATH 1141 or MATH 1142 or MATH 1171 or MATH 1172.
This introductory, calculus-based statistics course focuses on applications in business, statistics, and everyday events. Topics include descriptive statistics including mean, median, mode, standard deviation, histograms, distributions, box plots, and scatter plots; probability theory including counting rules, random variables, probability distributions, expected values, binomial and normal distributions, and the central limit theorem; inferential statistics including point estimates, confidence intervals, and hypothesis testing; and regression theory. Students learn to analyze data with the aid of common software packages. Mathematics majors may not take this course as a mathematics elective. Students who have received credit for MATH 3317 or MATH 3352 may not take this course for credit. Previously MA 0217.

MATH 2223 Applied Calculus III **3 Credits**
Prerequisite: MATH 1122 or MATH 1142 or MATH 1172.
This course covers first order differential equations, vectors in 2-D and 3-D, partial differentiation and multiple integrals. This is the third course in the three-course sequence MATH 1121, MATH 1122, MATH 2223. Previously MA 0221.

MATH 2231 Discrete Mathematics **3 Credits**
Topics in this course include logic, sets, functions, equivalence relations and partitions, mathematical induction, and countability. Previously MA 0231.

MATH 2235 Linear Algebra **3 Credits**
Prerequisite: MATH 2231.
Students examine linear spaces and subspaces, linear independence and dependence, bases and dimension, linear operators, matrix theory, determinants and systems of linear equations, eigenvalues and eigenvectors. Students may not receive credit for both MATH 2211 and MATH 2235. Previously MA 0235.

MATH 2243 Calculus III for Chemistry, Engineering, and Physics Majors **4 Credits**
Prerequisite: MATH 1142 or MATH 1172.
Topics include partial differentiation; chain rule, exact differentials, maxima and minima; multiple integration; application to volumes, center of gravity; and polar, cylindrical, and spherical coordinates; vector arithmetic and algebra, dot and cross products, parametric equations, lines and planes; gradient, directional derivative, curl, divergence; line integrals, work, Green's theorem, surface integrals; Stokes's and divergence theorems. Previously MA 0245.

MATH 2251 Ordinary Differential Equations **3 Credits**
Prerequisite: MATH 2223 or MATH 2243 or MATH 2273.
This course presents the solution of first order differential equations and of higher order linear differential equations, power series solutions, Laplace transforms, and a multitude of applications. Mathematics majors may not take this course as a mathematics elective. Students who have received credit for MATH 3331 may not take this course for credit. Previously MA 0251.

MATH 2253 Applied Probability Theory **3 Credits**
Prerequisites: A calculus II course (MATH 1172 or MATH 1142 or MATH 1122).
This is an applied, calculus-based probability theory course. The emphasis of the course will be on understanding and applying the theories and main tools of probability. Students will learn about and use common discrete and continuous probability models. There will be heavy emphasis on applications and computer simulations. Differential and integral calculus will be used throughout the course. [Does not count towards the Math Major or Mathematical Statistics minor. This course can count towards either the Mathematics Minor or the Applied Statistics minor, not both.]

MATH 2273 Multivariable Calculus **4 Credits**
Prerequisite: MATH 1142 or MATH 1172.
Topics in this course include vectors in the plane and in three-space; equations of lines and planes; vector functions; arc length; functions of several variables, limits, continuity, differentiability and partial derivatives, the gradient, directional derivatives; tangent planes; relative and absolute extrema; multiple integration in cartesian, cylindrical, and spherical coordinates; vector fields; line integrals; Green's theorem. Previously MA 0273.

MATH 3301 Topics in Discrete Mathematics **3 Credits**
Prerequisite: MATH 2231.
Topics include basic combinatorics (permutations, combinations, counting complicated sets, binomial coefficients), elementary number theory (divisors, Euclid's algorithm, modular arithmetic), and elementary graph theory (connectivity, circuits, cycles, planar graphs, graph isomorphisms). Previously MA 0300.

MATH 3317 Applied Statistics I **3 Credits**
Prerequisite: MATH 2243 or MATH 2273.
This course introduces students to applied statistical methods used in the physical sciences, social sciences and business. Topics include probability, descriptive and exploratory statistics using analytic and graphical tools, basic statistical testing (sampling techniques, theory of estimation and standard hypothesis tests), regression analysis (simple linear regression, multivariate regression, and model building, as time permits), correlation techniques, and analysis of variance and factorial designs, if time permits. Students will be required to bring a laptop to class, and a statistical software package such as R, SPSS, or Minitab, will be used extensively, though no prior experience will be assumed. Students who have received credit for MATH 2217 may not receive credit for this course. Previously MA 0317.

MATH 3331 Applied Mathematics **3 Credits**
Prerequisites: MATH 2235, MATH 2273.
This course covers the theory and solution of ordinary differential equations: first-order equations, linear equations of arbitrary order, and linear systems; power series solutions; Laplace transforms; and existence and uniqueness of solutions. Students who have received credit for MATH 2251 may not take this course for credit. Previously MA 0331.

MATH 3332 Partial Differential Equations **3 Credits**
Prerequisites: MATH 2243 or MATH 2273; MATH 2251 or MATH 3331.
Topics in this course include first order PDEs and the method of characteristics; separation of variables for linear homogeneous PDEs; eigenvalue problems; Fourier series; solution of the 1-D heat equation, the 1-D wave equation, and the 2-D Laplace equation, both homogeneous and non-homogeneous; and Fourier transforms. Previously MA 0332.

MATH 3336 Abstract Algebra **3 Credits**
Prerequisites: MATH 2231, MATH 2235.
Students will study group theory, rings and ideals, integral domains, and fields. Previously MA 0334.

MATH 3337 Number Theory **3 Credits**
Attributes: EDCG Educational Studies Cognate
Prerequisite: MATH 2231.
This study of the integers includes but is not limited to: primes and their distribution, divisibility and congruences, quadratic reciprocity, special numerical functions such as Euler's one-function, and Diophantine equations. Students consider the influence number theory has had on the development of algebra and the interplay between the two. Previously MA 0337.

MATH 3342 Theory of Computation **3 Credits**
Prerequisite: MATH 2231.
This course explores what computers can and can't do, although it does not require any background in computer science or programming. Topics include finite state machines, push-down automata, Turing machines and recursive functions; mechanisms for formal languages, such as regular grammars, context-free grammars, context-sensitive grammars; and decidable versus undecidable problems. Previously MA 0342.

MATH 3345 Functional Programming **3 Credits**
Prerequisites: CPSC 1101, MATH 2231.
This course provides an introduction to the theory and practice of programming in the functional paradigm. Functional programming is based on a view of computing as calculation. This approach facilitates the development of programs that are concise, elegant, and free of broad classes of errors. Topics covered will include basic calculation in the functional style, recursion, data types, higher-order functions, and user interactions. This course is intended for students with some imperative programming experience who wish to expand their knowledge.

MATH 3351 Probability Theory **3 Credits**
Attributes: EDCG Educational Studies Cognate
Prerequisites: MATH 2231 or CPEG 2245; MATH 2243 or MATH 2273.
Topics in this course include counting techniques; axiomatic probability theory; discrete and continuous sample spaces; random variables, cumulative distribution functions, probability density and mass functions; joint distributions; expected value and moments; common distributions like the normal, binomial, and Poisson distributions; and limit laws. Previously MA 0351.

MATH 3352 Mathematical Statistics **3 Credits**
Attributes: EDCG Educational Studies Cognate
Prerequisite: MATH 3351.
This course covers transformations of random variables; statistical application of probability; theory of sampling and the Central Limit Theorem; variances of sums and averages; estimation and hypothesis testing; and least squares, curve-fitting, and regression. Previously MA 0352.

MATH 3354 Actuarial Problem Solving **1 Credit**
Prerequisite: MATH 3352 (may be taken concurrently).
This course explores the methods and techniques of solving problems in actuarial mathematics for students interested in the actuary field. This course covers, via student led problem sessions and lectures, the tools for quantitatively assessing risk as presented on Society of Actuaries Exam P. Previously MA 0354.

MATH 3361 Topics in Algebra **3 Credits**
Prerequisite: MATH 3336.
This course investigates three topics in greater depth than can be done in the first linear or abstract algebra course. Topics may include canonical forms for matrices, metric linear algebra, ideal theory, finite non-abelian groups, and Galois Theory. The course typically includes one linear and one abstract algebra topic. Previously MA 0361.

MATH 3371 Real Analysis **3 Credits**
Prerequisites: MATH 2231, MATH 2273.
This course examines the set of real numbers as a complete, ordered, archimedean field; R as a linear vector space equipped with inner product and norm; metrics, particularly Euclidean, on R, topological concepts: continuity, connectedness, and compactness; the intermediate value, extreme value, monotone convergence, Bolzano/Weierstrass and Heine/Borel theorems; convergence and uniform convergence of sequences of continuous functions; differentiation. Previously MA 0371.

MATH 3373 Complex Analysis **3 Credits**
Prerequisites: MATH 2231, MATH 2273.
Topics in this course include algebra of complex numbers, Cauchy-Riemann equations and analytic functions, complex differentiation, integration in the complex plane, Cauchy's Theorem and integral formula, conformal mapping, Laurent series and residue theory, and applications. Previously MA 0373.

MATH 3377 Numerical Analysis **3 Credits**
Prerequisites: MATH 1172, MATH 2235, proficiency in a computer language.
This course investigates computer arithmetic, round-off errors, the solution of nonlinear equations, polynomial approximation, numerical differentiation and integration, and the solution of systems of linear equations via student-written code to implement the algorithms and/or the use of available software. Previously MA 0377.

MATH 3383 Modern Geometry **3 Credits**
Attributes: EDCG Educational Studies Cognate
Prerequisites: MATH 2231, MATH 2235.
Topics in this course include: foundation for plane geometries; theorems of Menelaus, Ceva, Desargues, Pascal, Brianchon, and Feuerbach; inversion and reciprocation transformations; projective, Riemannian and Lobachevskian geometries; and Poincaré models. Previously MA 0383.

MATH 3385 Point Set Topology **3 Credits**
Prerequisite: MATH 3371.
This course considers topological spaces, continuous functions; product, metric, and quotient spaces; countability and separation axioms; existence and extension of continuous functions; compactification; metrization theorems and complete metric spaces. Previously MA 0385.

MATH 4391 Honors Seminar I **3 Credits**
This course is open to senior mathematics majors with a mathematics GPA of 3.5 or higher and invited junior and senior mathematics majors with demonstrated ability who have been recommended by the mathematics faculty. This seminar provides talented students with an opportunity to undertake individualized study under faculty direction. Participants present several lectures before a group of peers. The seminar's subject matter varies each semester. Previously MA 0390.

MATH 4392 Honors Seminar II **3 Credits**
This course is open to senior mathematics majors with a mathematics GPA of 3.5 or higher and invited junior and senior mathematics majors with demonstrated ability who have been recommended by the mathematics faculty. This seminar provides talented students with an opportunity to undertake individualized study under faculty direction. Participants present several lectures before a group of peers. The seminar's subject matter varies each semester. Previously MA 0391.

MATH 4900 Special Topics (Shell) **3 Credits**
Prerequisites: MATH 2231, additional mathematics courses depending on the topic.
Mathematical topics not currently among the department's offerings can be offered one-time or to allow a professor the opportunity to "test drive" a course for the first time. Previously MA 0395.

MATH 4980 Internship **1-3 Credits**
Prerequisite: Senior standing.
The internship program provides senior mathematics majors with opportunities to gain practical, career-related experience in a variety of supervised field settings. Student interns select from a variety of placements, especially those requiring applications of mathematics, numerical methods, and statistics. Interns spend a minimum of 10 hours per week working at the placement site and complete the required academic component specified by their faculty advisor. Internship credits vary; interns may register for a summer session and/or one or two semesters for an overall maximum of six credits. In addition, an internship must satisfy the requirements outlined in the University Internship Policy, which is available from the Career Center. An internship may not take the place of a mathematics elective. Enrollment by permission only. Previously MA 0397-0398.

MATH 4990 Independent Study **1-3 Credits**
Independent study provides students with the opportunity to examine areas not covered in the undergraduate curriculum. Under the guidance of a faculty member, advanced students learn about an area in mathematics through reading and research. Independent study includes written work in the form of exercises or papers. Students apply to a professor under whose direction they wish to study and obtain the approval of the department chair. This course may not replace a mathematics elective to fulfill the requirements for the major unless special permission is given by the department chair. Previously MA 0399.

Faculty

Professors

Demers, *Chair*
Sawin
Staecker
Striuli

Associate Professors

Baginski
Berikkyzy
Casement
McSweeney
Rafalski

Assistant Professors

Aherns (visiting)
Barba
Cunningham (visiting)
Dumitrescu
Naples
Trolle (visiting)
van Wyk
Venkatesan

Assistant Professors of the Practice

Hooda

Instructors of the Practice

Kapoor

Instructors

Madera (Visiting)

Lecturers

Blum
Bohan, M.
Brown, C.
Brown, J.
Carbone
Cerruti
Chludzinski
David
Dykty
Farley
Fitzsimmons
Gjemnica
Gu
Mittag
Olaniyan
Puhl
Whiteman
Wynn

Faculty Emeriti

Bernhardt
Coleman
Dennin
Mulvey
Weiss