# MATHEMATICS (MAT) COURSES

**MAT-100 Math Modeling and Precalculus**
This course develops problem solving skills fundamental to further study in higher mathematics through mathematical modeling and applications. Students will study algebraic and graphical properties of polynomial, rational, exponential, logarithmic, and trigonometric functions, with a focus on using these to build and understand mathematical models. With a dual emphasis on sharpening core skills and understanding applications, this course provides a review of material relevant for continuing to a full course in calculus. This course is limited to students who intend to continue to MAT-111 as a requirement for his major, but whose placement indicates that a precalculus course is advisable. While it satisfies the Quantitative Literacy (QL) distribution requirement, enrollment in MAT 100 is only available through instructor permission. For students who need distribution credit in QL but do not require a subsequent course in calculus, MAT-103, MAT-104, MAT-106, and MAT-108 are recommended. MAT-100 does not count toward a major or minor in mathematics.
**Prerequisites:** none
**Corequisites:** Prerequisite: MAT-100 placement
**Credit:** 1
**Distribution:** Quantitative Literacy

**MAT-103 Probability**
The course introduces students to key measures of uncertainty (probability) and long-run average (expected value). Probabilistic reasoning is applied to a wide variety of interesting in the areas of medical testing, gambling, game theory, sports, asset-price modelling, financial derivatives, insurance, and retirement annuities. MAT-103 does not count toward the mathematics major or minor. Credit cannot be given for both MAT-103 and MAT-253. The course is offered most semesters.
**Prerequisites:** none
**Credits:** 0.5
**Distribution:** Quantitative Literacy

**MAT-104 Statistics**
The course looks briefly at some standard statistics: averages, variances, standard deviations, medians, and proportions. Correlation coefficients are introduced and used for prediction. The classical p-value approach to claim testing is presented and applied to a wide variety of testing situations. In addition, the classical confidence interval approach to estimation is examined. MAT-104 does not count toward the mathematics major or minor. (MAT-103 is not a prerequisite for MAT-104). Credit cannot be given for both MAT-104 and MAT-254. The course is offered most semesters.
**Prerequisites:** none
**Credits:** 0.5
**Distribution:** Quantitative Literacy

**MAT-106 Topics in Contemporary Math**
A study of selected topics dealing with the nature of mathematical ideas. This course focuses on mathematics as a creative endeavor. Through participation and discovery, students will consider an articulation of mathematics that focuses on patterns, abstraction, and inquiry. Topics will vary, but could include logic, Euclidean geometry, algorithms, etc. This course does not count toward the major or minor in mathematics.Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** none
**Credit:** 1
**Distribution:** Quantitative Literacy

**MAT-108 Intro to Discrete Structures**
An introduction to discrete mathematics for students not planning to major in mathematics. Topics include sets and logic, proof methods, counting arguments, recurrence relations, graphs, and trees. This course may be used to meet the mathematics requirement for the computer science minor. However, it does not count toward the mathematics major or minor. Students may not present both MAT 108 and 219 for credit toward graduation.
**Prerequisites:** none
**Credit:** 1
**Distribution:** Quantitative Literacy

**MAT-111 Calculus I**
This course studies the fundamentals of single-variable calculus, developing analytical and computational skills appropriate for students in quantitatively rigorous disciplines. Topics include limits, continuity, techniques of differentiation, applications of derivatives, the Mean Value Theorem, the Intermediate Value Theorem, the Fundamental Theorem of Calculus, and the method of substitution for integration.
**Prerequisites:** MAT-100 with a minimum grade of C-, or MAT-111 placement, or permission of the instructor
**Credit:** 1
**Distribution:** Quantitative Literacy
**Equated Courses:** MAT-110

**MAT-112 Calculus II**
This course continues the study of calculus from MAT-111, developing analytical and computational skills appropriate for students in quantitatively rigorous disciplines. Topics include techniques and applications of integration, numerical integration, improper integrals, infinite sequences and series, Taylor series, and an introduction to multivariable calculus including partial derivatives and multiple integrals.
**Prerequisites:** MAT-110 or MAT-111 with a minimum grade of C-, or MAT-112 placement
**Credit:** 1
**Distribution:** Quantitative Literacy
**Equated Courses:** APCR

**MAT-178 Special Topics**
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** none
**Credits:** 0.5-1
**Distribution:** Quantitative Literacy

**MAT-219 Combinatorics**
This course is an introduction to combinatorial reasoning and discrete mathematics. Topics include enumeration, combinatorial identities, graph theory, generating functions, and recurrence relations. Additional topics may include graph algorithms, partitions, and partially ordered sets. Students may not present both MAT 108 and 219 for credit towards graduation. This course is offered in the spring semester.
**Prerequisites:** MAT-223
**Credit:** 1

**MAT-221 Geometry**
This course studies aspects of the development of Euclidean and non-Euclidean geometries from a modern and/or historical viewpoint.
**Prerequisites:** MAT-112
**Credit:** 1

**MAT-222 Number Theory**
A study of elementary number theory. Topics include divisibility, congruences, properties of prime numbers, linear Diophantine equations, the Euler phi function, primitive roots, and additional topics. Such topics may include public key cryptography, quadratic reciprocity, and Pythagorean triples. This course is offered in the spring semester.
**Prerequisites:** MAT-112
**Credit:** 1

**MAT-223 Linear Algebra**
An introduction to linear equations and vector spaces. Topics include solving linear equations, matrix algebra, row operations, determinants, vector spaces, bases and dimension, linear transformations, eigenvalues and eigenvectors, and orthogonality. Optional topics include least squares problems, matrix factorization, and other applications. An important aspect of the course is to introduce the student to abstract thinking and proofs.
**Prerequisites:** MAT-112 with a minimum grade of C-, or MAT-223 placement
**Credit:** 1
**Distribution:** Quantitative Literacy
**Equated Courses:** CR

**MAT-224 Differential Equations**
An introduction to ordinary differential equations. Special solution techniques and some theory for first-order and linear equations including integrating factors, constant coefficients, undetermined coefficients, variation of parameters, power series solutions, Laplace transforms, and systems of differential equations with applications. This course is offered in the spring semester.
**Prerequisites:** MAT-112 with a minimum grade of C-, and MAT-223.
**Credit:** 1
**Equated Courses:** CR

**MAT-225 Multivariable Calculus**
This course builds on the introduction to calculus in higher dimensions in MAT-112. Topics covered include limits, continuity, differentiability, directional derivatives, constrained and unconstrained optimization, geometry of curves, multiple integrals, general coordinate systems, path and surface integrals, vector calculus, theorems of Green and Stokes, and applications. This course is offered in the fall semester.
**Prerequisites:** MAT-112 with a minimum grade of C-, and MAT-223
**Credit:** 1
**Distribution:** Quantitative Literacy

**MAT-226 Operations Research**
Linear and nonlinear optimization, linear programming, integer programming, duality, combinatorics, the simplex method and related algorithms, game theory, Markov chains, queuing theory.
**Prerequisites:** MAT-223
**Credit:** 1

**MAT-235 Stochastic Simulation**
Interesting real world phenomena often involve randomness at some level, and this course develops mathematical and computational tools for studying these systems. In particular, students will study and implement computer simulation models of continuous and discrete stochastic processes with potential applications in physics, economics, epidemiology, networks, sports, elections, and industrial engineering. Specific topics for study include: basic probability models, pseudo-random number generation, queueing models, discrete event simulations, Poisson processes, random walks, Markov chains, Monte Carlo methods, and statistical analysis of simulated data.
**Prerequisites:** MAT-112 and CSC-111
**Credit:** 1

**MAT-251 Mathematical Finance**
This course gives an overview of the mathematical reasoning behind the pricing of financial derivatives. Special emphasis is given to replication arguments and using risk-neutral distributions in the binomial pricing model and using risk neutral distributions in the geometric Brownian motion model. A probabilistic derivation of the Black-Scholes pricing formula for gap call options is given. Other topics covered include put-call parity, delta hedging, value at risk, and compound options. The course is typically offered every fall semester.
**Prerequisites:** MAT-112
**Credits:** 0.5

**MAT-252 Mathematical Interest Theory**
This course gives a thorough treatment of the mathematical theory of interest, with special attention paid to calculating present and accumulation values for annuities (series of payments made at regular time intervals). Some topics include nominal and effective rates of interest and discount, force of interest, amortization schedules, sinking funds, bonds, duration, and the use of modified duration to measure bonds' sensitivity to changes in the yield rate. This course is typically offered every fall semester.
**Prerequisites:** MAT-112
**Credits:** 0.5

**MAT-253 Probability Models**
This course is a standard calculus-based introduction to discrete and continuous random variables. Discrete distributions considered include the hypergeometric, binomial, geometric, Poisson, and discrete uniform. Continuous distributions considered include the gamma, chi-square, normal, beta, t and F. The Central Limit Theorem is covered, as well as multivariate distributions (including the bivariate normal and multinomial distributions), and transformations of random variables. Credit cannot be given for both MAT-103 and MAT-253. This course is typically offered in the fall semester.
**Prerequisites:** MAT-112
**Credits:** 0.5

### MAT-254 Statistical Models
This course gives an overview of confidence intervals and classical hypothesis testing procedures: z-tests, t-tests, F-tests, Chi-square tests, and regression. An intuitive but mathematical treatment is given for all the distributions and procedures involved. Credit cannot be given for both MAT-104 and MAT-254. This course is typically offered in the spring semester.
**Prerequisites:** MAT-112
**Credits:** 0.5

### MAT-277 Special Topics
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** none
**Credit:** 1

### MAT-287 Independent Study
Individual research projects. The manner of study will be determined by the student in consultation with the instructor. Students must receive written approval of their project proposal from a department Chair before registering for the course.
**Prerequisites:** none
**Credits:** 0.5-1

### MAT-314 Modeling With Differential Equations
A course to develop the basic skills of formulation, simplification, and analysis of mathematical models for describing and predicting phenomena in the natural and social sciences, with special emphasis in modeling with differential equations. Topics may be taken from fields such as physics, chemistry, biology, psychology, economics, and political science. This course is offered in the fall semester of even-numbred years.
**Prerequisites:** MAT-224
**Credit:** 1

### MAT-323 Topics in Linear Algebra
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** MAT-223
**Credit:** 1

### MAT-324 Topics in Differential Equations
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** MAT-224
**Credit:** 1

### MAT-331 Abstract Algebra I
This course is a first course in algebraic structures and higher abstract mathematics. The algebraic structures studied are groups and rings, which generalize symmetry and familiar number systems like the integers or real numbers. Topics include modular arithmetic, subgroups, quotient groups, isomorphism theorems, and permutation groups. This course has a strong emphasis placed on writing and reading mathematical proofs. This course is offered in the spring semester.
**Prerequisites:** MAT-223 with a minimum grade of C-
**Credit:** 1

### MAT-332 Abstract Algebra II
This course is a continuation of MAT-331. Topics will depend on the instructor but may include fields, modules, Galois theory, algebraic geometry, Gröbner bases, or advanced topics in groups and rings. This course has a strong emphasis placed on writing and reading mathematical proofs.
**Prerequisites:** MAT-331
**Credit:** 1

### MAT-333 Funct Real Variable I
A first course in the foundations of modern analysis. Topics include set theory, topology of the real numbers, sequences, series, differentiation, integration, and rigorous proofs of the major theorems of single-variable calculus. This course is offered in the fall semester.
**Prerequisites:** MAT-223
**Credit:** 1

### MAT-334 Funct Real Variable II
A continuation of MAT 333. Topics will depend on the instructor but may include sequences and series of functions, Fourier analysis, elementary functional analysis, advanced multivariable calculus or metric spaces.
**Prerequisites:** MAT-333
**Credit:** 1

### MAT-337 Numerical Analysis
This course provides a broad introduction to the field of numerical analysis. Topics of study include rootfinding, numerical linear algebra, function approximation, numerical differentiation and integration, and numerical methods for differential equations. The primary focus involves the derivation, analysis and implementation of numerical methods, but the course also includes discussion of uses and implications of these methods in applications. This course is offered in the fall semester of even-numbered years.
**Prerequisites:** CSC-111 and MAT-223
**Credit:** 1

### MAT-338 Topics Computational Math
This course develops mathematical and computational techniques in areas of mathematics or interdisciplinary study in which computation plays a central and essential role. Topics vary by semester but they may include computational geometry, computer algebra, scientific computing, and symbolic computation. This course is offered in the fall. Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** CSC-111 and MAT-112
**Credit:** 1

### MAT-341 Topology
An introduction to point-set topology. Topics include topological spaces, continuous functions, product and quotient spaces, metric spaces, connectedness, and compactness.
**Prerequisites:** MAT-223
**Credit:** 1

### MAT-344 Complex Analysis
This course develops the core analytical framework for complex functions of one variable. Topics include basic operations and properties of the complex plane, transformations of elementary functions, analytic functions, contour integrals, theory of residues, and conformal mapping. This course is offered in the spring semester of odd-numbered years.
**Prerequisites:** MAT-223
**Credit:** 1

**MAT-353 Probability Models II**
This course is a continuation of MAT-253 (Probability Models) with a focus on applications to financial problems. Brownian motion and Ito integrals are introduced and used for ruin theory calculations and applied to some simple investment models with continuous trading. The compound Poisson, mixed, and mixture distributions are used for some insurance settings. Expected present value and variance of present value are calculated for a wide variety of life insurance and annuity problems. The course is typically offered in the fall semester.
**Prerequisites:** MAT-253
**Credits:** 0.5

**MAT-354 Mathematical Statistics**
This course takes a more theoretical look at estimation and hypothesis testing than MAT-254 (Statistical Models). Classical estimation topics include method of moment estimators, maximum likelihood estimators (MLE's), the information inequality, and the asymptotic theory of MLE's. Classical hypothesis testing topics include using the Neyman-Pearson Lemma to find most powerful tests and uniformly most powerful tests, Likelihood ratio tests (LRT's), and the asymptotic theory of LRT's. The course also looks at the Bayesian approach to statistical inference, in particular, the situation with binomial data and beta priors. This course is typically offered in the spring semester, loosely alternating with MAT-355 Regression Models.
**Prerequisites:** MAT-253 and MAT-254
**Credits:** 0.5

**MAT-355 Regression Models**
This course takes a mathematical, matrix-based look at regression (introduced in MAT-254, Statistical Models). The probabilistic machinery needed when working with linear combinations of normal random variables is developed, including orthant probability calculation and several results involving the chi-square distribution. A general method for hypothesis testing is presented and used in a variety of testing situations. Time series models are also looked at and maximum likelihood estimation in both regression and time series settings is considered. This course is typically offered in the spring semester, loosely alternating with MAT-354 Mathematical Statistics.
**Prerequisites:** MAT-223, MAT-253, and MAT-254
**Credits:** 0.5

**MAT-377 Special Topics**
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** none
**Credits:** 0.5-1

**MAT-378 Special Topics**
Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.
**Prerequisites:** none
**Credits:** 0.5-1

**MAT-387 Independent Study**
Individual research projects. The manner of study will be determined by the student in consultation with the instructor. Students must receive written approval of their project proposal from a department Chair before registering for the course.
**Prerequisites:** none
**Credits:** 0.5-1

**MAT-388 Independent Study**
Individual research projects. The manner of study will be determined by the student in consultation with the instructor. Students must receive written approval of their project proposal from a department Chair before registering for the course.
**Prerequisites:** none
**Credits:** 0.5-1

**MAT-400 Senior Seminar**
Topics in the history and foundations of mathematics, the special emphasis varying from year to year. Every student will be expected to write a term paper. Please refer to the Registrar's page for course description.
**Prerequisites:** none
**Credits:** 0.5