

# MATHEMATICS

## Courses

### Our Courses

#### MATH 1000. Precalculus. (3 Credits)

This course does not fulfill the Mathematics reasoning portion of the Curriculum. The course is designed to allow students entry into calculus courses.

#### MATH 1001. Math for Business: Precalculus. (3 Credits)

A preparatory course to assist students at GSB to take Math for Business: Calculus. Topics include inequalities; linear, polynomial, rational, exponential, logarithm and inverse functions and their graphs; distance, lengths and area of simple regions. This course does not satisfy the mathematical reasoning core area requirement.

#### MATH 1002. Mathematics in Music. (3 Credits)

In this course, students focus on relationships between mathematics and music. Topics include integers, rational and real numbers, equivalence, relations, geometric transformations, logarithms, sequences and series, groups, rings, modular arithmetic, periodic functions, and elementary trigonometric series. The mathematical topics describe diatonic and chromatic scales, intervals, rhythm, meter, form, melody, chords, progressions, temperament, just intonation, and timbre from music. The course assumes familiarity with algebra and functions, as well as basic staff notation; Previous coursework in Calculus and Music Theory are not required.

**Attributes:** MANR, MCR.

#### MATH 1100. Finite Mathematics. (3 Credits)

Solutions to systems of linear equations, counting techniques including Venn diagrams, permutations, combinations, probability, Bayes theorem, Markov chains. This course is designed to introduce general liberal arts students to the use of mathematics as a tool in the solution of problems that arise in the "real world". Applications will be chosen from areas such as business, economics, and other social and natural sciences. These applications will be based upon mathematical topics chosen from a field called Finite Mathematics. Specific topics to be covered may include Linear Programming, Probability, Statistics, and Finance. The only prior knowledge expected is arithmetic, elementary algebra, and graphing, which students should already be familiar with from previous high school or college courses and/or the Mathematics Workshop. It will be presumed that students possess basic skills in these areas.

**Attribute:** MCR.

#### MATH 1108. Math for Business: Finite. (3 Credits)

Open only to CBA students. Solutions to systems of linear equations, elementary matrix theory, linear programming, elementary counting techniques, probability, mathematics of finance.

#### MATH 1109. Math for Business: Calculus. (3 Credits)

Open only to CBA students. Calculus for business majors. Topics include derivatives of polynomial, rational, exponential and logarithm functions. Curve sketching and optimization problems. The definite integral. Applications are drawn from business and economics.

#### MATH 1198. Honors Business Math. (4 Credits)

Review of Calculus. Solutions of systems of linear equations using matrix algebra. Discrete and continuous probability. Applications to business. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

#### MATH 1200. Topics in Finite Mathematics. (1 Credit)

This course covers basic concepts of finite mathematics: counting techniques including Venn diagrams, permutations, combinations, probability, and Bayes' theorem.

#### MATH 1203. Applied Calculus I. (3 Credits)

This course is designed for students who do not intend to take Calculus 2 or other upper-level math courses. Topics include derivatives of polynomial, rational, exponential, and logarithmic functions; curve sketching; and optimization problems.

**Attributes:** ENVS, MCR, NEUR.

#### MATH 1204. Applied Calculus II. (3 Credits)

A continuation of MATH 1203. Topics include derivatives of trigonometric functions, methods of integration and applications, calculus of functions of several variables, Lagrange multipliers.

**Prerequisite:** MATH 1203.

#### MATH 1205. Applied Statistics. (3 Credits)

Course designed for students in fields that emphasize quantitative methods. It includes calculus based preliminary probability material followed by introduction to the basic statistical methods such as estimation, hypothesis testing, correlation and regression analysis. Illustrations are taken from a variety of fields. Practical experience with statistical software.

**Attribute:** ENVS.

**Prerequisites:** MATH 1203 or MATH 12AB or MATH 12BC.

#### MATH 1206. Calculus I. (4 Credits)

Calculus for science and math majors. Functions, limits, continuity, Intermediate Value Theorem. The derivative and applications, antiderivatives, Riemann sums, definite integrals, the Fundamental Theorem of Calculus. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Attributes:** ENVS, MCR, NEUR.

#### MATH 1207. Calculus II. (4 Credits)

A continuation of MATH 1206. The definite integral, area, volumes, work. Logarithm, inverse functions, techniques of integration, Taylor polynomials. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 1206 or MATH 12AB or MATH 12BC.

#### MATH 1700. Mathematical Modelling. (4 Credits)

This course shows how discrete and continuous mathematical models can be built and used to solve problems in many fields. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Attributes:** ENVS, MCR, NEUR.

**Prerequisites:** MATH 1206 or MATH 1207 or MATH 12AB or MATH 12BC.

#### MATH 1800. Internship. (1 Credit)

#### MATH 1999. Service Learning-1000 Level. (1 Credit)

In this student-initiated program, the student may earn one additional credit by connecting a service experience to a course with the approval of the professor and the service-learning director.

**MATH 2001. Discrete Mathematics. (4 Credits)**

This course introduces students to higher order mathematical thinking in the context of writing proofs using discrete structures. Topics include elementary logic; basic proof techniques such as direct proof, proof by contradiction, case division, contraposition, induction; division, Euclid's algorithm, modular arithmetic; set theory, relations and functions; and equivalence. Additional topics may include cardinality of sets, combinatorics, and graphs. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 1206 or MATH 1207 or MATH 12AB or MATH 12BC.

**MATH 2004. Multivariable Calculus I. (4 Credits)**

The calculus of sequences and series, power series, uniform convergence, vector methods of solid geometry, vector valued functions, functions of several variables, partial derivatives, gradients, Lagrange multipliers. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 1207.

**MATH 2005. Multivariable Calculus II. (4 Credits)**

This is a continuation of MATH 2004. Topics include vector fields and their derivatives, multiple integrals, line and surface integrals, and the theorems of Gauss, Green and Stokes. Additional topics, as time permits, may cover one or more of the following: differential forms, functions of a complex variable, equations of fluid mechanics, or mean and Gauss curvature.

**Prerequisite:** MATH 2004.

**MATH 2006. Linear Algebra I. (4 Credits)**

Topics include systems of linear equations, Real and complex vector spaces, linear independence, dimension, linear transformations, matrix representations, kernel and range, determinants and eigenvalues. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 1206 or MATH 1207 or MATH 12AB or MATH 12BC.

**MATH 2011. Programming for Math and Science. (4 Credits)**

Basic Python programming and scripting and basic algorithms of linear algebra. Students will develop their own Python implementations of these algorithms, which form the basis of many computational methods in the sciences. The course is accessible to students in the physical and social sciences, computer science and math. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** CISC 1600.

**MATH 3001. Linear Algebra II. (4 Credits)**

Topics include vector spaces over arbitrary fields, triangular form, Jordan canonical form, inner product spaces, coding theory. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 2001 and MATH 2006.

**MATH 3002. Differential Equations. (4 Credits)**

Topics covered in this course include existence and uniqueness theorems for ordinary differential equations, linear differential equations, power series solutions, Laplace transform and numerical methods. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 2004.

**MATH 3003. Real Analysis. (4 Credits)**

This course focuses on analysis on Euclidean spaces. Topics include limits, continuity, uniform continuity, sequences of numbers and functions, modes of convergence, differentiability, Riemann integrability, and associated theorems. Students who have not taken MATH 2004 prior to taking Real Analysis may request permission from the instructor. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 2001 and MATH 2004.

**MATH 3004. Complex Analysis. (4 Credits)**

Topics include complex numbers and mappings, analytic functions, Cauchy-Riemann equations, Cauchy integral theorem, Taylor and Laurent series expansions, residue theory. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 2004.

**MATH 3005. Abstract Algebra I. (4 Credits)**

Topics include well ordering and induction, unique factorization, modular arithmetic, groups, subgroups, Lagrange's theorem, normality, homomorphisms of groups, permutation groups, simple groups. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 2001 and MATH 2006.

**MATH 3006. Probability. (4 Credits)**

Topics include discrete and continuous probability models in one and several variables, expectation and variance, limit theorems, applications. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 2004.

**MATH 3007. Statistics. (4 Credits)**

Topics include sampling distributions, estimation, testing hypotheses, analysis of variance, regression and correlation, nonparametric methods, time series. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 3006 and MATH 2004.

**MATH 3008. Number Theory. (4 Credits)**

Topics include divisibility and related concepts, congruencies, quadratic residues, number theoretic functions, additive number theory, some Diophantine equations. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 2001.

**MATH 3009. Mathematics of Finance. (4 Credits)**

The market for options, a type of contract in finance, has grown quickly in the past fifty years. In this course we will explore the Nobel Prize-winning Black-Scholes-Merton model for valuing these contracts. We will introduce basic notions of probability (such as Brownian motion) as well as basic notions from finance (such as the No Arbitrage Principle) and use these to derive and solve the Black-Scholes equation. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 3006.

**MATH 3010. Scientific Communication. (4 Credits)**

In this course, students develop skills in written and oral communication needed to produce scientific articles, monographs, and presentations that are accomplished in both form and content. The course covers both the use of LaTeX to produce work that meets the highest standards of design and typography, and the techniques of writing, organization, and scholarly citation needed to ensure that this work accurately embodies, effectively communicates, and professionally documents the author's scientific thought. Students will learn the ins and outs of generating and using copyright material, and how to present data in forms of pictures, tables, graphs, or schematics. Permission of the Instructor needed to register for the course. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**MATH 3012. Math of Infinity. (4 Credits)**

Elementary set and function theory. Notion of counting infinite sets, including Hilbert's infinite hotel. Cardinality and infinite cardinals. Cantor's work on infinite sets. Additional topics may include: well-ordered sets and math induction; prime number generators; the Riemann zeta function; logic and meta-mathematics. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**MATH 3800. Internship. (3 Credits)****MATH 4001. Mathematical Ethics Practicum. (4 Credits)**

In this class, which fulfills the Senior Values seminar requirement of the Core Curriculum and serves as a capstone to both the pure and applied tracks of the Mathematics major, students will learn the ethical responsibilities of mathematicians, both as interpreters and as creators of mathematics. The course will combine historical and contemporary case studies with practical training in the skills and disciplines students must master to assume full ownership of their mathematics. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Attributes:** EP4, VAL.

**MATH 4004. Topology. (4 Credits)**

Topics include open sets and continuity in metric spaces and topological spaces, subspaces and quotient topologies, compact sets, connected sets. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**MATH 4006. Numerical Analysis. (4 Credits)**

Topics include approximation of functions, interpolation, solution of systems of equations, numerical integration, and solutions to differential equations, error analysis. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 2004 and MATH 2006.

**MATH 4009. Topics in Geometry. (4 Credits)**

This course focuses on the study of Euclidean and Non-Euclidean geometries using both axiomatic and discovery based approaches. We review some of the basics in logic and study some of the proofs presented in Euclid's Elements before focusing on more advanced topics. We may use Geometer's Sketchpad in making discoveries and conjectures. We will study the history of the parallel postulate, the discovery of Non-Euclidean Geometry and the attendant philosophical implications. We will build models and focus on some interesting properties in hyperbolic geometry. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisite:** MATH 2004.

**MATH 4020. Differential Geometry. (4 Credits)**

This course introduces the geometry of curved spaces in many dimensions, which are the basis of subjects such as Einstein's theory of gravitation. Topics include manifolds, tangent spaces, the Gauss map, the shape operator, curvature, and geodesics. Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** (MATH 2004 and MATH 2006).

**MATH 4022. Partial Differential Equations. (4 Credits)**

This course is an introduction to partial differential equations. Topics include first-order, diffusion, wave, and Laplace equations; Fourier series; Green's functions; and finite difference methods. Partial differential equations are a fundamental tool in physics, and they find broad application in geometry, acoustics, image processing, and finance. Note: Four-credit courses that meet for 150 minutes per week require three additional hours of class preparation per week on the part of the student in lieu of an additional hour of formal instruction.

**Prerequisites:** MATH 2005 or (MATH 2006 and MATH 3002).

**MATH 4999. Independent Study. (1 to 4 Credits)**