Mathematics

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Courses

MATH 1010 Foundations for Calculus
A limited enrollment class for students planning to take calculus but who need additional precalculus preparation. The course aims to build both the technical skills and the conceptual understanding needed to succeed in calculus. Course emphasizes links between the graphical, numeric, and algebraic viewpoints. A variety of approaches are used to present the material. Prerequisites: 2 years of high school algebra and a course in geometry (or the equivalent).
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Summer

MATH 1510 Calculus I
Derivatives of algebraic, trigonometric, and transcendental functions, techniques of differentiation, Mean Value Theorem, applications of the derivative. The definite integral and Fundamental Theorem of Calculus. Areas. Simpler integration techniques. Prerequisites: high school algebra and precalculus, including trigonometry.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring, Summer

MATH 1513 Peer-Led Team Learning: Calculus I
In this course, student groups meet weekly and work together on a problem set that builds on topics covered in MATH 1510 - Calculus I. The purpose of the course is to encourage students to work in small groups, supervised by a trained peer leader, on problems that require a collaborative effort and are designed to enhance understanding. PLTL sessions guide students to become conscious of the problem-solving process and to rigorously evaluate and revise those processes by considering the reasonableness of their results, rather than by consulting an answer key. Sign-ups for PLTL begin in the first week of the semester, with meetings starting on the weekend following the second week of classes. Grading is Pass/No Pass based on participation. Students must attend at least eight sessions during the semester to earn credit; those who do not meet the attendance threshold will be dropped from the course, and the course will be removed from their transcript. Please note the following exceptions to the enrollment and drop policy: (1) Students will not be able to enroll in PLTL if doing so would bring them above 21 credit units, but they will still be able to participate. (2) Students who wish to participate in PLTL but want to opt out of receiving credit should contact their course's PLTL program manager. (3) If dropping PLTL would bring a student below 12 credit units, the drop will instead be entered as a withdrawal.
Credit 1 unit.
Typical periods offered: Fall, Spring

MATH 1515 Calculus I With Foundations
MATH 1515 covers the same content as MATH 1510 but includes the additional review of precalculus concepts integrated throughout the semester. It is aimed at students whose precalculus skills are not yet fully developed. By the end of this course, students should be ready to enroll in MATH 1520.
Credit 4 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall

MATH 1517 Real Mathematical Applications: Solving Problems With Calculus I
The purpose of this course is to show how mathematics can solve real-world problems and how calculus dramatically expands the range of problems that can be tackled. Each class will be devoted to the analysis of some problems, which may include dimensional analysis, the mathematics of convoys, Fibonacci numbers, fractals, linear regression, Euclid's algorithm, Stein's algorithm, network capacities, Braess's paradox, Galton's approach to surnames, how genes spread through populations, and the SIR model of infectious diseases. The first few classes will not use differentiation. Course enrollment preference is given to first-year students. Corequisite: MATH 1510.
Credit 1 unit. SamFox: FANATSCI
Typical periods offered: Fall

MATH 1520 Calculus II
Continuation of MATH 1510. A brief review of the definite integral and Fundamental Theorem of Calculus. Techniques of integration, applications of the integral, sequences and series, Taylor polynomials and series, and some material on differential equations.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring, Summer

MATH 1523 Peer-Led Team Learning: Calculus II
In this course, student groups meet weekly and work together on a problem set that builds on topics covered in MATH 1520 - Calculus II. The purpose of the course is to encourage students to work in small groups, supervised by a trained peer leader, on problems that require a collaborative effort and are designed to enhance understanding. PLTL sessions guide students to become conscious of the problem-solving process and to rigorously evaluate and revise those processes by considering the reasonableness of their results, rather than by consulting an answer key. Sign-ups for PLTL begin in the first week of the semester, with meetings starting on the weekend following the second week of classes. Grading is Pass/No Pass based on participation. Students must attend at least eight sessions during the semester to earn credit; those who do not meet the attendance threshold will be dropped from the course, and the course will be removed from their transcript. Please note the following exceptions to the enrollment and drop policy: (1) Students will not be able to enroll in PLTL if doing so would bring them above 21 credit units, but they will still be able to participate. (2) Students who wish to participate in PLTL but want to opt out of receiving credit should contact their course's PLTL program manager. (3) If dropping PLTL would bring a student below 12 credit units, the drop will instead be entered as a withdrawal.
Credit 1 unit.
Typical periods offered: Fall, Spring

MATH 1710 Mathematics And Music
An elementary introduction to the connections between mathematics and musical sound. Review of integers, ratios, prime numbers, functions, rationality, exponents, logarithms, trigonometry. Review of scales, clefs, key signatures, intervals, time signatures. Frequency and pitch. The connection between intervals and logarithms. Tuning and temperament, just intonation. Scales and modular arithmetic. The mathematics of harmony; the sound of the low prime numbers and their roles in harmony. Harmonics, partials and overtones. Numerical integration and basic Fourier analysis. The nature of complex tones. Analysis of instrument sounds. Human vowels and formants. Prerequisites: 2 years of high school algebra, and trigonometry.
Credit 3 units. ArtSci IQ: AN, NSM SamFox: FANATSCI

Typical periods offered: Fall, Spring

MATH 1996 Mathematics Elective: 1000-Level
This course is for 1000 level transfer credit.
Credit 3 units.
Typical periods offered: Fall, Spring

MATH 2050 Finite Mathematics
Topics from discrete mathematics will be explored with an emphasis on problem-solving and methods of proofs. Modules on counting; combinatorial tools; binomial coefficients and Pascal's triangle; Fibonacci numbers; combinatorial probability; integers, divisors and primes; and graphs will be covered as well as additional topics as time permits. Addressed mainly to college freshmen and sophomores; it would also be suitable to advanced high school students with an interest in mathematics. Prerequisites: A good understanding of high school mathematics.
Credit 3 units. ArtSci IQ: AN, NSM SamFox: FANATSCI
Typical periods offered: Summer

MATH 2130 Calculus III
Multivariable calculus. Topics include differential and integral calculus of functions of two or three variables: vectors and curves in space, partial derivatives, multiple integrals, line integrals, vector calculus at least through Green's Theorem.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring, Summer

MATH 2133 Peer-Led Team Learning: Calculus III
In this course, student groups meet weekly and work together on a problem set that builds on topics covered in MATH 2130 - Calculus III. The purpose of the course is to encourage students to work in small groups, supervised by a trained peer leader, on problems that require a collaborative effort and are designed to enhance understanding. PLTL sessions guide students to become conscious of the problem-solving process and to rigorously evaluate and revise those processes by considering the reasonableness of their results, rather than by consulting an answer key. Sign-ups for PLTL begin in the first week of the semester, with meetings starting on the weekend following the second week of classes. Grading is Pass/No Pass based on participation. Students must attend at least eight sessions during the semester to earn credit; those who do not meet the attendance threshold will be dropped from the course, and the course will be removed from their transcript. Please note the following exceptions to the enrollment and drop policy: (1) Students will not be able to enroll in PLTL if doing so would bring them above 21 credit units, but they will still be able to participate. (2) Students who wish to participate in PLTL but want to opt out of receiving credit should contact their course's PLTL program manager. (3) If dropping PLTL would bring a student below 12 credit units, the drop will instead be entered as a withdrawal.
Credit 1 unit.
Typical periods offered: Fall, Spring

MATH 2135 Calculus III Enhanced
An enriched treatment of the topics of MATH 2130, designed for students with a strong background in differential and integral calculus and serious interest in mathematics. Students cannot receive credit for both MATH 2130 and MATH 2135.
Credit 4 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Spring

MATH 2197 Practical Applications
Credit for internships in Mathematics.
Credit 3 units.
Typical periods offered: Fall, Spring

MATH 2500 Differential Equations
Introduction to ordinary differential equations: first-order equations, linear equations, systems of equations, series solutions, Laplace transform methods, numerical solutions.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring, Summer

MATH 2801 Honors Mathematics I
This is the first half of a one-year calculus sequence for first year student with a strong interest in mathematics with an emphasis on rigor and proofs. The course begins at the beginning but assumes the students have already studied the material from a more mechanical view. Students who complete both semesters will have complete the material Calc III and other topics that may let them move through the upper level math curriculum more quickly. Sets, functions, real numbers, and methods of proof. The Riemann-Darboux integral, limits and continuity, differentiation, and the fundamental theorems of calculus. Sequences and series of real numbers and of functions. Vector spaces and linear maps. Score of 5 on the AP Calculus Exam, BC version, or the equivalent required.
Credit 4 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall

MATH 2802 Honors Mathematics II
Matrices, linear systems, and determinants. Eigenvalues and eigenvectors, diagonalization, and the spectral theorem. Scalar and vector fields, differential and integral calculus of several variables, and the fundamental theorems of Green, Gauss, and Stokes. Restricted to first year students who have completed MATH 2801 in the fall semester. MATH 2802 can replace MATH 2130 in major/minor requirements.
Credit 4 units. ArtSci IQ: AN, NSM
Typical periods offered: Spring

MATH 2996 Mathematics Elective: 2000-Level
This course is for 2000 level transfer credit.
Credit 3 units.
Typical periods offered: Fall, Spring, Summer

MATH 3010 Foundations for Higher Mathematics
Introduction to the rigorous techniques used in more advanced mathematics. Topics include propositional logic, use of quantifiers, set theory, methods of proof and disproof (counterexamples), foundations of mathematics. Use of these tools in the construction of number systems, and in other areas such as elementary number theory, combinatorial arguments, and elementary proofs in analysis.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 3015 Foundations for Higher Mathematics With Writing
Introduction to the rigorous techniques used in more advanced mathematics. Topics include basic logic, set theory, methods of proof and counterexamples, foundations of mathematics, construction of number systems, counting methods, combinatorial arguments, and elementary analysis. At least 3 papers will be required with revisions. This course satisfies the writing intensive requirement.
Credit 3 units. ArtSci IQ: NSM, WI

Typical periods offered: Fall, Spring

MATH 3180 Introduction to Calculus of Several Variables
Selected topics for functions of several variables involving some matrix algebra and presented at a level of rigor intermediate between that of Calculus III and higher level analysis courses. Students may not receive credit toward a mathematics major or minor for both MATH 3180 and 3550.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Fall, Spring

MATH 3280 Elementary Geometry From an Advanced Point of View
A rigorous modern treatment of Euclidean geometry, and an introduction to non-Euclidean geometry.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Fall

MATH 3300 Matrix Algebra
An introductory course in linear algebra that focuses on Euclidean n-space, matrices and related computations. Topics include: systems of linear equations, row reduction, matrix operations, determinants, linear independence, dimension, rank, change of basis, diagonalization, eigenvalues, eigenvectors, orthogonality, symmetric matrices, least square approximation, quadratic forms. Introduction to abstract vector spaces.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring, Summer

MATH 3310 Algebraic Systems
Polynomials, binomial expansions, factoring, rings (integers and polynomials), unique factorization, and other topics relevant to the high school curriculum. Designed for future secondary school teachers and other students looking for a course in algebra at a less abstract level than MATH 4302.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Fall

MATH 3410 Introduction to Combinatorics
Basics of enumeration (combinations, permutations and enumeration of functions between finite sets), generating functions; the inclusion-exclusion principle, partition theory and introductory graph theory. As time permits, additional topics may include Ramsey's Theorem, probabilistic methods in combinatorics and algebraic methods in combinatorics.
Credit 3 units. ArtSci IQ: AN, NSM
Typical periods offered: Fall, Spring

MATH 3420 Graph Theory
Introduction to graph theory including the basic definitions andtheorems and some more advanced topics which drive much currentresearch in graph theory: Ramsey's Theorem, random graph theoryand, if time permits, Szemeredi's regularity lemma. Graphs will bestudied as abstract objects; however graph theory is also of interestto applied mathematicians because graphs are natural models fornetworks (social, electric, ...). Students should know what a proof isand how to produce one. Some informal understanding of probabilitywill be helpful, but students need not have taken a probability course.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Fall, Spring

MATH 3520 Differential Equations and Dynamical Systems
Linear systems of differential equations. Dynamical systems and flows. Bifurcations. Limit Cycles. Chaos.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 3550 Mathematics for the Physical Sciences
Continuation of MATH 2130 emphasizing topics of interest in the physical sciences. Topics in multivariable and vector calculus (div, grad, curl); line, surface integrals and connections to electromagnetism; Fourier series and integrals; boundary value problems (diffusion and wave equations); additional topics if time permits. Students may not receive credit toward a math major or minor for both MATH 3180 and MATH 3550.
Credit 3 units. ArtSci IQ: NSM Bus: PLS SamFox: FANATSCI
Typical periods offered: Spring

MATH 3590 Topics in Applied Mathematics
Topics change with each offering of the course. Past topics have included Mathematics and Multimedia, The Mathematics and Chemistry of Reaction-Diffusion Systems, Mathematical Biology, Simulation Analysis of Random Processes, and Introduction to Monte Carlo Methods.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Spring

MATH 3996 Mathematics Elective: 3000-Level
This course is for 3000 level transfer credit.
Credit 3 units.
Typical periods offered: Fall, Spring, Summer

MATH 4000 Undergraduate Independent Study
Credit for independent research. Approval of instructor required.
Credit 3 units. WashU: IS
Typical periods offered: Fall, Spring

MATH 4001 Honors Seminar in Math
Topic may vary with each offering of the course. Approval of instructor required.
Credit 3 units.
Typical periods offered: Spring

MATH 4101 Real Analysis I
The real number system, metric spaces, sequences and series, functional limits and continuity; differentiation and Riemann integration on the real line; sequences and series of functions, pointwise and uniform convergence, power series.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4102 Real Analysis II
Further topics on spaces of continuous functions (equicontinuity, Arzelà–Ascoli, Stone–Weierstrass); differentiation in Euclidean space, the inverse and implicit function theorems; Lebesgue measure and integration on the real line and in Euclidean space, L^p spaces, and modes of convergence.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4150 Introduction to Fourier Series and Integrals
The basic theory of Fourier series and Fourier integrals including different types of convergence. Applications to certain differential equations.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall

MATH 4160 Complex Variables
Analytic functions, elementary functions and their properties, line integrals, the Cauchy integral formula, power series, residues, poles, conformal mapping and applications.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4193 Topics in Analysis
Topic may vary with each offering of the course.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4201 Topology I
An introduction to the most important ideas of topology. Course includes necessary ideas from set theory, topological spaces, subspaces, products and quotients, compactness and connectedness. Some time is also devoted to the particular case of metric spaces (including topics such as separability, completeness, completions, the Baire Caregory Theorem, and equivalents of compactness in metric spaces).
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall

MATH 4202 Topology II
A continuation of MATH 4201 featuring more advanced topics intopology. The content may vary with each offering.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4220 An Introduction to Differential Geometry
A study of properties of curves and surfaces in 3-dimensional Euclidean space. The course is essentially a modern recounting of a seminal paper of Gauss.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4301 Linear Algebra
This course is an introduction to the linear algebra of finite-dimensional vector spaces. It includes systems of equations, matrices, determinants, inner product spaces, and spectral theory. MATH 3300 is not an explicit prerequisite, but students should already be familiar with such basic topics from matrix theory as matrix operations, linear systems, row reduction, and Gaussian elimination. (Material on these topics in early chapters of the text will be covered very quickly.)
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4302 Modern Algebra
Introduction to groups, rings, and fields. Includes permutation groups, group and ring homomorphisms, field extensions, connections with linear algebra.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4350 Number Theory and Cryptography
The course will cover many of the basics of elementary number theory, providing a base from which to approach modern algebra, algebraic number theory and analytic number theory. It will also introduce one of the most important real-world applications of mathematics, namely the use of number theory and algebraic geometry in public key cryptography. Topics from number theory involve divisibility (Euclidean algorithm, primes, Fundamental Theorem of Arithmetic), congruences (modular arithmetic, Chinese Remainder Theorem, primality testing and factorization). Topics from cryptography will include RSA encryption, Diffie-Hellman key exchange and elliptic curve cryptography. Topics about algebraic numbers may be include if time permits.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4360 Algebraic Geometry
Introduction to affine and projective algebraic varieties, the Zariski topology, regular and rational mappings, simple and singular points, divisors and differential forms, genus, the Riemann-Roch theorem.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Spring

MATH 4393 Topics in Algebra
Topics vary each semester.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4490 Topics in Combinatorics
Topic may vary with each offering of the course.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4493 Topics in Graph Theory
Analytic combinatorics is the study of counting sequemces associated to combinatorial configurations and breaks up into two complementary components. First, we systematically encode and study counting problems through the use of power series (generating functions). Second, the analytic properties of these power series are used to understand the growth of counting sequences. Some examples are counting structured strings, functions, permutations, trees, and lattice paths. The principal analytic technique will be complex analysis and the course will include a user's self-contained introduction to complex analysis. Time permitting, we may study counting problems with parameters which naturally leads to multivariable generating functions and allows us to investigate statistical properties of counting sequences.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4501 Numerical Applied Mathematics
Computer arithmetic, error propagation, condition number and stability; mathematical modeling, approximation and convergence; roots of functions; calculus of finite differences; implicit and explicit methods for initial value and boundary value problems; numerical integration; numerical solution of linear systems, matrix equations, and eigensystems; Fourier transforms; optimization. Various software packages may be introduced and used.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall

MATH 4502 Topics in Applied Mathematics
Topic may vary with each offering of the course.

Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Spring

MATH 4540 Partial Differential Equations
Introduction to the theory of PDEs with applications to selectedclassical problems in physics and engineering. Linear and quasilinearfirst order equations, derivation of some of the classical PDEs ofphysics, and standard solution techniques for boundary and initialvalue problems. Preliminary topics such as orthogonal functions,Fourier series, and variational methods introduced as needed.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall

MATH 4560 Topics in Financial Mathematics
An introduction to the principles and methods of financial mathematics, with a focus on discrete-time stochastic models. Topics include no-arbitrage pricing of financial derivatives, risk-neutral probability measures, the Cox-Ross-Rubenstein and Black-Scholes-Merton options pricing models, and implied volatility.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall

MATH 4570 The Mathematics of Quantum Theory
An introduction to the mathematical foundations of quantum theory aimed at advanced undergraduate/beginning graduate students in Mathematics and Engineering, although students from other disciplines are equally welcome to attend. Topics include: the mathematical postulates of quantum theory and simple physical systems, spectral theory of self-adjoint operators, rudiments of Lie groups, Lie algebras and unitary group representations, elements of quantum probability and quantum information theory.
Credit 3 units. ArtSci IQ: NSM SamFox: FANATSCI
Typical periods offered: Fall

MATH 4590 Topics in Applied Mathematics:
Topic may vary with each offering of the course.
Credit 3 units. ArtSci IQ: NSM
Typical periods offered: Fall, Spring

MATH 4595 Topics in Applied Mathematics
Topics vary each semester.
Credit 3 units.
Typical periods offered: Fall

MATH 4996 Mathematics Elective: 4000-Level
This course is for 4000 level transfer credit.
Credit 3 units.
Typical periods offered: Fall, Spring, Summer