MATHEMATICS (MATH)

MATH 106b, The Shape of Space  Ian Adelstein
This course provides an introduction to mathematical thinking through ideas in geometry and graph theory. Traditional lecture, worksheets, discussion, group work, and classroom activities all contribute to a dynamic learning experience. The course follows a historical narrative, starting from antiquity, to understand the foundations of mathematical thought. An axiomatic approach to geometry affords students the opportunity to construct proofs of classical theorems. The basics of graph theory are introduced in order to explore real world problems such as map coloring and bridge crossing. The ancient Greek method of exhaustion previews a discussion of the integral, and from here we explore the beautiful relationship between the geometry and topology of graphs, polyhedra, and surfaces. Throughout the course students build their mathematical and geometric intuition through problem solving and exercises in geometric imagining. Permission of instructor required. Enrollment limited to 25 students who have not previously taken a high school or college calculus course.  QR

* MATH 107a, Mathematics in the Real World
The use of mathematics to address real-world problems. Applications of exponential functions to compound interest and population growth; geometric series in mortgage payments, amortization of loans, present value of money, and drug doses and blood levels; basic probability, Bayes’s rule, and false positives in drug testing; elements of logic. Permission of instructor required. Enrollment limited to 25 students who have not previously taken a high school or college calculus course.  QR

MATH 108b, Estimation and Error  James Barnes
A problem-based investigation of basic mathematical principles and techniques that help make sense of the world. Estimation, order of magnitude, approximation and error, counting, units, scaling, measurement, variation, simple modeling. Applications to demographics, geology, ecology, finance, and other fields. Emphasis on both the practical and the philosophical implications of the mathematics. Permission of instructor required. Enrollment limited to 25 students who have not previously taken a high school or college calculus course.  QR

* MATH 110a, Introduction to Functions and Calculus I  Robert McDonald
Comprehensive review of precalculus, limits, differentiation and the evaluation of definite integrals, with applications. Precalculus and calculus topics are integrated. Emphasis on conceptual understanding and problem solving. Successful completion of MATH 110 and 111 is equivalent to MATH 112. No prior acquaintance with calculus is assumed; some knowledge of algebra and precalculus mathematics is helpful. Placement into MATH 110 on the Mathematics placement exam is required.  QR

* MATH 111b, Introduction to Functions and Calculus II  Staff
Continuation of MATH 110. Comprehensive review of precalculus, limits, differentiation and evaluation of definite integrals, with applications. Precalculus and calculus topics are integrated. Emphasis on conceptual understanding and problem solving. Successful completion of both MATH 110 and 111 is equivalent to MATH 112. Prerequisite: MATH 110.  QR

* MATH 112a or b, Calculus of Functions of One Variable I  Staff
Limits and their properties. Definitions and some techniques of differentiation and the evaluation of definite integrals, with applications. Use of the software package Mathematica to illustrate concepts. Placement into MATH 112 on the Mathematics placement exam is required. No prior acquaintance with calculus or computing assumed. May not be taken after MATH 110 or 111.  QR

* MATH 112a or b, Calculus of Functions of One Variable II  Staff
A continuation of MATH 112. Applications of integration, with some formal techniques and numerical methods. Improper integrals, approximation of functions by polynomials, infinite series. Prerequisite: MATH 111 or MATH 112, or placement into MATH 115 on the Mathematics placement exam. May not be taken after MATH 116.  QR

* MATH 116b, Mathematical Models in the Biosciences I: Calculus Techniques  John Hall
Introduction to topics in mathematical modeling that are applicable to biological systems. Discrete and continuous models of population, neural, and cardiac dynamics. Stability of fixed points and limit cycles of differential equations. Applications include Norton’s chemotherapy scheduling and stochastic models of tumor suppressor gene networks. After MATH 112 or equivalent. May not be taken after MATH 115.  QR

* MATH 118a or b, Introduction to Functions of Several Variables  Staff
A combination of linear algebra and differential calculus of several variables. Matrix representation of linear equations, Gauss elimination, vector spaces, independence, basis and dimension, projections, least squares approximation, and orthogonality. Three-dimensional geometry, functions of two and three variables, level curves and surfaces, partial derivatives, maxima and minima, and optimization. Intended for students in the social sciences, especially Economics. May not be taken after MATH 120 or 222. Prerequisite: MATH 112.  QR

* MATH 120a or b, Calculus of Functions of Several Variables  Staff
Analytic geometry in three dimensions, using vectors. Real-valued functions of two and three variables, partial derivatives, gradient and directional derivatives, level curves and surfaces, maxima and minima. Parametrized curves in space, motion in space, line integrals; applications. Multiple integrals, with applications. Divergence and curl. The theorems of Green, Stokes, and Gauss. Prerequisite: MATH 115 or 116, or placement into MATH 120 on the Mathematics placement exam. May not be taken after MATH 121.  QR
MATH 160b / AMTH 160b / S&DS 160b, The Structure of Networks  Ronald Coifman
Network structures and network dynamics described through examples and applications ranging from marketing to epidemics and the world climate. Study of social and biological networks as well as networks in the humanities. Mathematical graphs provide a simple common language to describe the variety of networks and their properties.  QR

MATH 222a or b / AMTH 222a or b, Linear Algebra with Applications  Staff

MATH 225a or b, Linear Algebra and Matrix Theory  Staff
An introduction to the theory of vector spaces, matrix theory and linear transformations, determinants, eigenvalues, and quadratic forms. Some relations to calculus and geometry are included. After or concurrently with MATH 120. May not be taken after MATH 222.  QB

* MATH 230a, Vector Calculus and Linear Algebra I  Patrick Devlin
A careful study of the calculus of functions of several variables, combined with linear algebra.  QR

* MATH 231b, Vector Calculus and Linear Algebra II  Patrick Devlin
Continuation of MATH 230. Application of linear algebra to differential calculus. Inverse and implicit function theorems; the idea of a manifold; integration of differential forms; general Stokes’ theorem.  QR

* MATH 235b, Reflection Groups  Igor Frenkel
Concepts of linear algebra are used to explore the algebraic and geometric properties of groups generated by reflections. Examples from reflection groups introduce elements of group theory, Lie algebras, and representation theory. Reflections in a real Euclidean space, groups generated by reflections, crystallographic groups, and Coxeter groups. Preference to sophomores majoring in mathematics or the sciences. Prerequisite: MATH 222 or 225.  QR

MATH 240b, Advanced Linear Algebra  Gurbir Dhillon
The course continues the study of linear algebra from MATH 225 or MATH 230/231. It discusses several aspects of linear algebra that are of crucial importance for the subject and its applications to abstract algebra, geometry and number theory. Topics include generalized eigenspaces and Jordan normal form theorem, dual vector spaces, bilinear and hermitian forms, symmetric and hermitian operators, Hom spaces and tensor products. After MATH 225 or MATH 230/231.

MATH 241a / S&DS 241a, Probability Theory  Yihong Wu and Winston Lin
Introduction to probability theory. Topics include probability spaces, random variables, expectations and probabilities, conditional probability, independence, discrete and continuous distributions, central limit theorem, Markov chains, and probabilistic modeling. After or concurrently with MATH 120 or equivalent.  QR

MATH 242b / S&DS 242b, Theory of Statistics  William Brinda and Andrew Barron
Study of the principles of statistical analysis. Topics include maximum likelihood, sampling distributions, estimation, confidence intervals, tests of significance, regression, analysis of variance, and the method of least squares. Some statistical computing. After S&DS 241 and concurrently with or after MATH 222 or 225, or equivalents.  QB

MATH 244a or b / AMTH 244a or b, Discrete Mathematics
Basic concepts and results in discrete mathematics: graphs, trees, connectivity, Ramsey theorem, enumeration, binomial coefficients, Stirling numbers. Properties of finite set systems. Recommended preparation: MATH 115 or equivalent.  QR

MATH 246a or b, Ordinary Differential Equations  Staff
First-order equations, second-order equations, linear systems with constant coefficients. Numerical solution methods. Geometric and algebraic properties of differential equations. After MATH 120 or equivalent; after or concurrently with MATH 222 or 225 or equivalent.  QR

MATH 250a or b, Vector Analysis  Staff
Calculus of functions of several variables, using vector and matrix methods. The derivative as a linear mapping. Inverse and implicit function theorems. Transformation of multiple integrals. Line and surface integrals of vector fields. Curl and divergence. Differential forms. Theorems of Green and Gauss; general Stokes’ theorem. Prerequisites: After MATH 120, and 222 or 225 or equivalent. May not be taken after MATH 231.  QR

MATH 251b / EENG 434b / S&DS 351b, Stochastic Processes  Joseph Chang
Introduction to the study of random processes including linear prediction and Kalman filtering, Poison counting process and renewal processes, Markov chains, branching processes, birth-death processes, Markov random fields, martingales, and random walks. Applications chosen from communications, networking, image reconstruction, Bayesian statistics, finance, probabilistic analysis of algorithms, and genetics and evolution. Prerequisite: S&DS 241 or equivalent.  QR

MATH 270a, Set Theory  Yifeng Liu
Algebra of sets; finite, countable, and uncountable sets. Cardinal numbers and cardinal arithmetic. Order types and ordinal numbers. The axiom of choice and the well-ordering theorem. After MATH 120 or equivalent.  QR
MATH 300b, Topics in Analysis  Anibal Velozo
An introduction to analysis, with topics chosen from infinite series, the theory of metric spaces, and fixed-point theorems with applications. Students who have taken MATH 230, 231 should take MATH 301 instead of this course. After MATH 250 or with permission of instructor.  QR

* MATH 301a, Introduction to Analysis  Peter Jones
Foundations of real analysis, including metric spaces and point set topology, infinite series, and function spaces. After MATH 230, 231 or equivalent.  QR

MATH 305b, Real Analysis  Yair Minsky
The Lebesgue integral, Fourier series, applications to differential equations. After MATH 301 or with permission of instructor.  QR

MATH 310a, Introduction to Complex Analysis  An introduction to the theory and applications of functions of a complex variable. Differentiability of complex functions. Complex integration and Cauchy’s theorem. Series expansions. Calculus of residues. Conformal mapping. After MATH 231 or 250 or equivalent. QR

* MATH 315b, Intermediate Complex Analysis  Alexander Goncharov
Continuation of MATH 310. Topics may include argument principle, Rouché’s theorem, Hurwitz theorem, Runge’s theorem, analytic continuation, Schwarz reflection principle, Jensen’s formula, infinite products, Weierstrass theorem. Functions of finite order, Hadamard’s theorem, meromorphic functions. Mittag-Leffler’s theorem, subharmonic functions. After MATH 310.  QR RP

* MATH 320a, Measure Theory and Integration  Tom VandenBoom
Construction and limit theorems for measures and integrals on general spaces; product measures; L_p spaces; integral representation of linear functionals. After MATH 305 or equivalent.  QR RP

* MATH 325b, Introduction to Functional Analysis  Tom VandenBoom
Hilbert, normed, and Banach spaces; geometry of Hilbert space, Riesz-Fischer theorem; dual space; Hahn-Banach theorem; Riesz representation theorems; linear operators; Baire category theorem; uniform boundedness, open mapping, and closed graph theorems. After MATH 320.  QR RP

MATH 330a / S&D 400a, Advanced Probability  Sekhar Tatikonda
Measure theoretic probability, conditioning, laws of large numbers, convergence in distribution, characteristic functions, central limit theorems, martingales. Some knowledge of real analysis assumed.  QR

* MATH 345a, Modern Combinatorics  Richard Kenyon
Recent developments and important questions in combinatorics. Relations to other areas of mathematics such as analysis, probability, and number theory. Topics include probabilistic method, random graphs, random matrices, pseudorandomness in graph theory and number theory, Szemerédi’s theorem and lemma, and Green-Tao’s theorem. Prerequisite: MATH 244.  QR

MATH 350a or b, Introduction to Abstract Algebra  Staff
Group theory, structure of Abelian groups, and applications to number theory. Symmetric groups and linear groups including orthogonal and unitary groups; properties of Euclidean and Hermitian spaces. Some examples of group representations. Modules over Euclidean rings, Jordan and rational canonical forms of a linear transformation. After MATH 231 or 250.  QR

MATH 370b, Fields and Galois Theory  Alexander Goncharov
Structure of fields of algebraic numbers (solutions of polynomial equations with integer coefficients) and their rings of integers; prime decomposition of ideals and finiteness of the ideal class group; completions and ramification; adeles and ideles; zeta functions. Prerequisites: MATH 310 and 370.  QR

MATH 373a, Algebraic Number Theory  Alexander Goncharov
Structure of fields of algebraic numbers (solutions of polynomial equations with integer coefficients) and their rings of integers; prime decomposition of ideals and finiteness of the ideal class group; completions and ramification; adeles and ideles; zeta functions. Prerequisites: MATH 310 and 370.  QR

MATH 380a, Modern Algebra I  Ivan Loseu
The course serves as an introduction to commutative algebra and category theory. Topics include commutative rings, their ideals and modules, Noetherian rings and modules, constructions with rings, such as localization and integral extension, connections to algebraic geometry, categories, functors and functor morphisms, tensor product and Hom functors, projective modules. Other topics may be discussed at instructor’s discretion. After MATH 350 and 370.  QR

MATH 435b, Differential Geometry  Andrew Neitzke
Applications of calculus to the study of the geometry of curves and surfaces in Euclidean space, intrinsic differential geometric properties of manifolds, and connections with non-Euclidean geometries and topology. After MATH 231 or 250 or equivalent.  QR
Mathematics (MATH)

MATH 470a or b, Individual Studies  Staff
Individual investigation of an area of mathematics outside of those covered in regular courses, involving directed reading, discussion, and either papers or an examination. A written plan of study approved by the student’s adviser and the director of undergraduate studies is required. The course may normally be elected for only one term.

MATH 475a or b, Senior Essay  Staff
Highly qualified students may write a senior essay under the guidance of a faculty member, and give an oral report to the department. Students wishing to write a senior essay should consult the director of undergraduate studies early in the fall term.

* MATH 480a or b, Senior Seminar: Mathematical Topics  Staff
A number of mathematical topics are chosen each term — e.g., differential topology, Lie algebras, mathematical methods in physics — and explored in one section of the seminar. Students present several talks on the chosen topic. One section each year is devoted to topics of interest to Economics and Mathematics majors, and is co-taught by a member of the Economics department.