MATHEMATICS (MATH)

MATH 7240 Advanced Group Theory 3 cr
Representation theory of finite groups, presentations of finite and infinite groups, or other topics. May not be held with MATH 4240.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: permission of department.
Equiv To: MATH 4240

MATH 7260 Abstract Measure Theory 3 cr
Lebesgue and abstract measures, measurable functions, convergence theorems, absolutely continuous functions, measure spaces, the Radon-Nikodym theorem, Fubini's and Tonnelli's theorems. May not be held with MATH 4260 and the former MATH 4750.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4260, MATH 4750

MATH 7270 Algebraic Topology 3 cr
This course will serve as an introduction to elements of homotopy or homology theory. May not be held with MATH 4270 and the former MATH 4230.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4230, MATH 4270

MATH 7280 Basic Functional Analysis 3 cr
Banach spaces, Hahn-Banach, open mapping and closed graph theorems, linear operators and functionals, dual space, Hilbert spaces and compact operators. May not be held with MATH 4280 and the former MATH 4750.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4280, MATH 4750

MATH 7290 Complex Analysis 2 3 cr
Conformal mappings, normal families, harmonic and subharmonic functions, Perron's family, Dirichlet problem and Green's function. May not be held with MATH 4290 and the former MATH 4710.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4290, MATH 4710

MATH 7300 Combinatorial Geometry 3 cr
Topics in combinatorial geometry, including arrangements of convex bodies, introduction to polytopes, problems in discrete geometry, repeated distances, and geometric graphs. May not be held with MATH 4300.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4300

MATH 7320 Dynamical Systems 3 cr
Techniques for the qualitative analysis of nonlinear systems of ordinary differential equations and discrete-time systems. May not be held with MATH 4320 and the former MATH 4800.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4320, MATH 4800

MATH 7330 Fundamentals of Approximation Theory 3 cr
Theoretical aspects of approximation theory: density, existence, uniqueness; direct and inverse theorems for polynomial approximation. May not be held with MATH 4330.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4330

MATH 7340 Introduction to Algebraic Geometry 3 cr
This course will introduce students to the basics of affine and projective varieties through a combination of basic theoretical tools and elementary examples. May not be held with MATH 4340.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4340

MATH 7360 Introduction to Differential Geometry 3 cr
Manifolds and submanifolds. One of: exterior calculus and Stokes' theorem, Riemannian or symplectic geometry, and Hamiltonian mechanics. May not be held with MATH 4360 and the former MATH 4730.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4360, MATH 4730

MATH 7370 Linear Algebra and Matrix Analysis 3 cr
Norms, matrix factorizations, eigenvalues/eigenvectors, theory of non-negative matrices. Applications to differential equations, math biology, numerical analysis, graph theory, etc. May not be held with MATH 4370 and the former MATH 4310.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4310, MATH 4370

MATH 7380 Mathematical Biology 3 cr
Formulation, analysis and simulation of models in math biology. Applications will be chosen from population dynamics, epidemiology, ecology, immunology and cellular dynamics. May not be held with MATH 4380 and the former MATH 3530.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 3530, MATH 4380

MATH 7390 Numerical Approximation Theory 3 cr
Computational aspects of approximation by interpolatory polynomials, convolutions, artificial neural networks, splines and wavelets. May not be held with MATH 4390.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of the department.
Equiv To: MATH 4390

MATH 7440 Numerical Analysis of Partial Differential Equations 3 cr
Finite difference method, theory of Elliptic PDEs, finite element method, iterative solution of linear systems. Emphasis will be on the error analysis. May not be held with MATH 4440 and the former MATH 8150.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4440, MATH 8150

MATH 7450 Number Theory 2 3 cr
Algebraic number theory, arithmetic geometry and analytic number theory, Diophantine equations, examples such as arithmetic of elliptic curves and Dirichlet L- functions. May not be held with MATH 4450 and the former MATH 3450.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 3450, MATH 4450

MATH 7460 Partial Differential Equations 2 3 cr
Green's function, Poisson, heat, Schrodinger and wave equations, Fourier and Laplace transforms, introduction to functional analytic techniques. May not be held with MATH 4460 and the former MATH 4810.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4460, MATH 4810

MATH 7470 Rings and Modules 3 cr
The general theory of (non-commutative) rings, modules and algebras. May not be held with MATH 4470.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of department.
Equiv To: MATH 4470

MATH 7490 Optimization 3 cr
This course, cross-listed with MATH 4490, introduces the theory and practice of optimization. Topics include unconstrained optimization (quasi-Newton's, BFGS, nonlinear conjugate gradient methods), linear programming (Simplex method, duality), nonlinear constrained optimization (optimality conditions, duality, saddle point theory, barrier and penalty methods, Slater's condition) and integer programming (branch- and-bound, cutting plane and branch-and-cut methods). Applications to calculus of variations, statistics, data science, optimal control, signal processing and neural networks are given. Some computer programming will be required. This course is especially useful for students studying Data Science. Students cannot obtain credit for both MATH 4490 and MATH 7490.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: permission of instructor.

MATH 8010 Advanced Matrix Computations 3 cr
Matrix computation, decomposition of matrices, iterative methods, sparse matrices, eigenvalue problems.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisites: linear algebra, computing, numerical analysis, and consent of instructor.

MATH 8110 Applied Finite Element Analysis 3 cr
Theory and practice of the finite element method of the solution of partial differential equations and its application to engineering and scientific problems. It includes the h, p and h-p versions, a priori and a posteriori error estimates, adaptability and the structure of finite element software.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: numerical analysis and partial differential equations or consent of the instructor.

MATH 8140 Advanced Numerical Analysis of Differential & Integral Equations 3 cr
Continuation of MATH 4440/7440. Topics include spectral methods, time dependent equations, multigrid, domain decomposition methods, problems on infinite domains, methods for boundary integral equations, Riemann-Hilbert problems and integrable systems.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: Permission of the department.

MATH 8210 Topics in Combinatorics 1 3 cr
Topics will be chosen from the areas of algebraic combinatorics, coding theory, design theory, enumerative combinatorics, graph theory,
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8310 Partial Differential Equations 3 3 cr
Continuation of MATH 4460/7460. Topics include functional analytic techniques for linear and nonlinear partial differential equations, conservation laws, KdV equation, singular perturbation, viscosity solutions.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisites: Permission of the department.

MATH 8410 Seminar in Applied and Computational Mathematics 1 3 cr
Designed to accommodate special topics in applied or computational areas of mathematics not included in other course offerings. Students are advised to consult the department as to availability.

MATH 8420 Seminar in Applied and Computational Mathematics 2 6 cr
Designed to accommodate special topics in applied or computational areas of mathematics not included in other course offerings. Students are advised to consult the department as to availability.

MATH 8430 Seminar in Mathematics 1 3 cr
Designed to accommodate special topics not included in topics courses.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8440 Seminar in Mathematics 2 6 cr
Designed to accommodate special topics not included in topics courses.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8510 Topics in Algebra 1 3 cr
Designed to accommodate special topics not included in topics courses.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8520 Topics in Algebra 2 6 cr
Topics will be chosen from the areas of associative and non-associative algebras, Boolean algebra and lattice theory, category theory, group theory, ring theory and universal algebra.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8610 Topics in Analysis 1 3 cr
Topics will be chosen from the areas of asymptotics, functional analysis, operator theory, real and complex variables, summability theory, topological vector spaces.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8620 Topics in Analysis 2 6 cr
Topics will be chosen from the areas of asymptotics, functional analysis, operator theory, real and complex variables, summability theory, topological vector spaces.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8720 Topics in Foundations 2 6 cr
Topics will be chosen from the areas of logic, model theory, recursive functions, set theory.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval by department

MATH 8810 Topics in Geometry 1 3 cr
Topics will be chosen from the areas of algebraic curves, combinatorial geometry, Euclidean geometry, fractal geometry, groups and geometrics, projective geometry.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8910 Topics in Topology 1 3 cr
Topics will be chosen from the areas of compactifications and related extensions, covering properties, rings of continuous functions, set-theoretic topology, topological groups, uniformities and related structures.
PR/CR: A minimum grade of C is required unless otherwise indicated.
Prerequisite: approval of department.

MATH 8996 MSc project 1 6 cr
This is a project course exclusively for students enrolled in the Course-based MSc program. Students must submit a written report, on the order of 40 to 60 pages, which can be a survey of a topic in mathematics, for instance. This course is taken under the supervision of a faculty member. Course graded pass/fail.

MATH 8998 MSc project 2 6 cr
This is a project course exclusively for students enrolled in the teaching track of the Course-based MSc program. Students must submit a written report, on the order of 20-30 pages, which can be a survey of a topic in mathematics, for instance. In addition, students are required to teach one undergraduate course. This course is taken under the supervision of a faculty member. Course graded pass/fail.