MATHEMATICS AND STATISTICS

Courses

The department offers a selection of courses from the following list each academic year. Course offerings for the current academic year can be found on the Department of Mathematics and Statistics website (http://www.queensu.ca/mathstat/graduate/current-graduate/).

All courses are 3.0 credit units, except MATH 898, 899 and 999, and STAT 888, 898, 899 and 999, which are 6.0 credit units.

Courses in Mathematics

MATH 800 Seminar
Students are expected to participate in a weekly seminar in which they are required to present material on a topic that relates to their research.

MATH 801 Graph Theory
An introduction to graph theory, one of the central disciplines of discrete mathematics. Topics include: graphs, subgraphs, trees, connectivity, Euler tours, Hamiltonian cycles, matchings, independent sets, cliques, colourings, and planarity. (Offered jointly with MATH 401.) Three term-hours; lectures.
EXCLUSION: MATH 401

MATH 802 Enumerative Combinatorics
Enumerative combinatorics is concerned with counting the number of elements of finite sets with prescribed conditions. The techniques covered include inclusion-exclusion, bijective proofs, double-counting arguments, recurrence relations, and generating functions. (Offered jointly with MATH 402.) Three term hours; lectures.
EXCLUSION: MATH 402

MATH 806 Introduction to Coding Theory
Construction and properties of finite fields. Polynomials, vector spaces, block codes over finite fields. Hamming distance and other code parameters. Bounds relating code parameters. Cyclic codes and their structure as ideals. Weight distribution. Special codes and their relation to designs and projective planes. Decoding algorithms. (Offered jointly with MATH/MTHE 406.) Three term-hours; lectures.
EXCLUSIONS: MATH 406, MTHE 406

MATH 807 Discrete Mathematics
Asymptotic methods for discrete structures, including singularity analysis and saddle point methods for generating series; applications to number theory, including Dirichlet series, exponential sums, and the circle method; additive combinatorics, including probabilistic and Fourier methods. Three term hours; lectures.

MATH 812 Topics in Number Theory
Subject matter may vary from year to year. Three term-hours; lectures.

MATH 813 Introduction to Algebraic Geometry
An introduction to the study of systems of polynomial equations in one or many variables. Topics covered include the Hilbert basis theorem, the Nullstellenstaz, the dictionary between ideals and affine varieties, and projective geometry (Offered jointly with MATH 413). Three term-hours; lectures.
EXCLUSION: MATH 413

MATH 817 Lie Groups and Lie Algebras
Elementary properties of Lie groups and Lie algebras: topological properties, exponential map, lifting of Lie algebra homomorphisms. Compact Lie groups: maximal tori, Weyl group, simply connected compact Lie groups. Root systems. Irreducible representations: weights and characters. Peter-Weyl theorem. Borel-Weil theorem. Three term hours; lectures.

MATH 818 Number Theory and Cryptography
Time estimates for arithmetic and elementary number theory algorithms (division algorithm, Euclidean algorithm, congruences), modular arithmetic, finite fields, quadratic residues. Design of simple cryptographic systems; public key, RSA systems. Primality and factoring: pseudoprimes, Pollard's rho-method, index calculus. Elliptic curve cryptography. (Offered jointly with MATH/MTHE 418.) Three term hours; lectures.
EXCLUSIONS: MATH 418, MTHE 418

MATH 819 Algebraic Geometry
Affine varieties, sheaves of functions, the Nullstellensatz, plane curves and singularities, dimension, projective varieties, morphisms of varieties, properness, theorems on upper-semicontinuity, Grassmannians, tangent spaces, blowups, vector and line bundles. Three term hours; lectures.

MATH 823 Ordinary Differential Equations
Existence, uniqueness, continuous-dependence, and differentiable dependence of solutions. Fixed points, periodic orbits, and their stability. Phase plane analysis, the Poincaré-Bendixson Theorem, homoclinic and heteroclinic orbits. Stable manifold theorem, Hartman-Grobman

Theorem. Centre manifold Theorem and codimension-one bifurcations. Three term hours; lectures.

MATH 824 Partial Differential Equations
Distributions and Sobolev spaces. Theory of linear PDEs including variational formulation of elliptic problems, weak formulation and regularity of solutions for evolution problems (parabolic and hyperbolic equations). System of conservation laws / Semigroup theory and non-variational techniques (fixed point methods) for nonlinear evolution equations. Applications. Three term hours; lectures.

MATH 827 Introduction to Deterministic Dynamical Systems
Topics include: global properties of flows and diffeomorphisms; invariant sets and dynamics; bifurcations of fixed and periodic points; stability and chaos. (Offered jointly with MATH 427.) Three term-hours; lectures.
EXCLUSION: MATH 427

MATH 829 Functional Analysis
A generalization of linear algebra and calculus to infinite dimensional spaces. Now questions about continuity and completeness become crucial, and algebraic, topological, and analytical arguments need to be combined. We focus mainly on Hilbert spaces and the need for Functional Analysis will be motivated by its application to Quantum Mechanics. (Offered jointly with MATH 429.) Three term hours; lectures.
EXCLUSION: MATH 429

MATH 830 Control Theory
This course covers core topics in both classical and modern control theory. Review of classical control theory using frequency methods. Linearization, existence and uniqueness of trajectories for nonlinear and linear systems. Feedback and stability. Lyapunov stability criteria. Controllability, observability, minimal realizations, feedback stabilization, observer design. Optimal control theory, the linear quadratic regulator, dynamic programming. (Offered jointly with MTHE 430.) Three term-hours; lectures.
EXCLUSION: MTHE 430

MATH 833 Continuum Mechanics
Continuum mechanics lays the foundations for the study of the mechanical behavior of solids and fluids. Topics include vector and tensor analysis, stress, strain and deformation, and balance laws with constitutive models for applications in fluid mechanics and elasticity. (Offered jointly with MTHE 433.) Three term hours; lectures.
EXCLUSION: MATH 433

MATH 834 Optimization Theory with Applications to Machine Learning
Theory of convex sets and functions; separation theorems; primal-dual properties; geometric treatment of optimization problems; algorithmic procedures for solving constrained optimization programs; applications of optimization theory to machine learning. (Offered jointly with MATH/MTHE 434.)
EXCLUSIONS: MTHE 434, MATH 434

MATH 835 Mathematical Biology
This is a course in advanced mathematical methods used to construct models of biological phenomena in ecology, epidemiology, and evolutionary biology. The course will focus on population models, starting with individual-based models based on assumptions on the distribution of individual traits, then scaling up to stochastic models for small populations and deterministic models for large populations. Three term-hours; lectures.

MATH 836 Lagrangian Mechanics, Dynamics, and Control
Geometric modelling, including configuration space, tangent bundle, kinetic energy, inertia, and force. Euler-Lagrange equations using affine connections. The last part of the course develops one of the following three applications: mechanical systems with nonholonomic constraints; control theory for mechanical systems; equilibria and stability. (Offered jointly with MATH/MTHE 439) Three term-hours; lectures.
EXCLUSIONS: MATH 439, MTHE 439

MATH 837 Topics in Applied Mathematics
Subject matter may vary from year to year. Three term-hours; lectures.

MATH 838 Topics in Mathematical Biology
Subject matter may vary from year to year. Three term-hours; lectures.

MATH 839 Evolutionary Dynamics
This course covers mathematical models of evolution. Both stochastic and deterministic models will be discussed. Topics will include evolutionary game theory, structured populations and adaptive dynamics. Applications include the origin of cooperation and the evolution of virulence. Three term hours; lectures.

MATH 844 Differentiable Manifolds
Differentiable structures, smooth manifolds and submanifolds, immersions and submersions, vector fields and differential forms, orientation and integration, de Rham cohomology. Three term-hours; lectures.

MATH 845 Algebraic Topology of Manifolds
De Rham cohomology; Mayer-Vietoris sequence; Poincaré lemmas, smooth homotopy invariance; Poincaré duality;

Simplicial and Singular homology; homotopy invariance; de Rham Theorem; Examples and applications. Three term hours; lectures.

MATH 859 Stochastic Calculus and Analysis
Discrete and continuous time martingales, Brownian motion, stopping times, martingale convergence theorems, local martingales and semimartingales, predictable and optional processes, the Itô stochastic integral, quadratic and mutual variation, the Itô formula, representations of martingales, local times, Girsanov theorem, stochastic differential equations and applications, Stratonovich integration. Three term hours; lectures.

MATH 872 Optimization and Control of Stochastic Systems
This course concerns the optimization, control, and stabilization of dynamical systems under probabilistic uncertainty with applications in engineering systems and applied mathematics. Topics include: controlled and control-free Markov chains and stochastic stability; martingale methods for stability and stochastic learning; dynamic programming and optimal control for finite horizons, infinite horizons, and average cost problems; partially observed models, non-linear filtering and Kalman Filtering; linear programming and numerical methods; reinforcement learning and stochastic approximation methods; decentralized stochastic control, and continuous-time stochastic control. (Offered jointly with MTHE 472.) Three term -hours, fall or winter; lectures.
EXCLUSION: MTHE 472

MATH 874 Information Theory
An introduction to the fundamental principles of the theory of communication. Topics include: information measures, entropy, mutual information, divergence; modeling of information sources, discrete memoryless sources, Markov sources, entropy rate, source redundancy, fundamentals of lossless data compression, block encoding, variable-length encoding, Kraft inequality, design of Shannon-Fano and Huffman codes; fundamentals of channel coding, channel capacity, noisy channel coding theorem, channels with memory, lossless information transmission theorem; continuous-alphabet sources and channels, differential entropy, capacity of discrete-time and band-limited continuous-time Gaussian channels; rate-distortion theory, lossy data compression, rate-distortion theorem, lossy information transmission theorem. (Offered jointly with MATH/MTHE 474). Three term hours; lectures.
EXCLUSIONS: MATH 474, MTHE 474

MATH 877 Data Compression and Source Coding: Theory and Algorithms
Topics include: arithmetic coding, universal lossless coding, Lempel-Ziv and related dictionary based methods, rate distortion theory, scalar and vector quantization, predictive and transform coding, applications to speech and image coding. (Offered jointly with MATH/MTHE 477.) Three term hours; lectures.
EXCLUSIONS: MATH 477, MTHE 477

MATH 884 Data Networks
This course covers performance models for data networking, delay models and loss models; analysis of multiple access systems, routing, and flow control; multiplexing; priority systems; satellite multiple access, wireless networking, wireless sensor networks. Knowledge of networking protocols is not required. (Offered jointly with MATH/MTHE 484.) Three term hours; lectures.
EXCLUSIONS: MATH 484, MTHE 484

MATH 891 Core Course in Analysis I
This course provides basic knowledge in real and complex analysis at the graduate level on the following topics: Lebesgue measure and integration theory; elementary Hilbert space theory; examples of Banach space techniques. Three term-hours, fall; lectures.

MATH 892 Core Course in Analysis II
This course provides basic knowledge in real and complex analysis at the graduate level on the following topics: basic theory of Fourier transforms; basic elements of spectral theory and Banach algebras; complex analysis. Three term-hours, winter; lectures.

MATH 893 Core Course in Algebra I
This course provides basic knowledge in algebra at the graduate level on the following topics: elementary theory of groups; elementary theory of rings and modules; Galois theory. Three term-hours, fall; lectures.

MATH 894 Core Course in Algebra II
This course provides basic knowledge in algebra at the graduate level on the following topics: representation theory of finite groups through characters; advanced theory of modules; advanced theory of rings. Three term-hours, winter; lectures.

MATH 895 Core Course in Probability Theory
This course provides basic knowledge in probability at the graduate level. Topics will include: basic notions and concepts of Probability Theory; characteristic functions; law of large numbers and central limit theorem; martingales; stochastic processes. Three term-hours, winter; lectures.

MATH 896 Core Mathematical Statistics I

This course provides basic knowledge in mathematical statistics at the graduate level. Topics will include: Classical and Bayesian inference, Multivariate Gaussian distribution and its applications in Statistics; decision theory; basic techniques of non-parametric estimation. Three term-hours, fall; lectures.

MATH 897 Core Mathematical Statistics II
This course provides basic knowledge in mathematical statistics at the graduate level. Topics will include: Weak convergence in metric spaces; Delta method; Method of moments; M-estimation; Asymptotic normality and efficiency; Likelihood ratio test; U statistics; Bootstrap; Applications in statistics. Three term-hours, winter; lectures.

MATH 898 Master's Project

MATH 899 Master's Thesis Research

MATH 901 Research Institute Course
Advanced topics course, normally offered in the summer term, by a research institute in Canada or abroad can be taken for credit with the permission of the Supervisor and Coordinator of Graduate Studies and in cooperation with Institute organizers. Grades are assigned on a PASS - FAIL basis.

MATH 902 Topics in Algebra
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 903 Topics in Algebra
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 905 Topics in Algebra
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 912 Topics in Number Theory
Subject matter will vary from year to year. Three term-hours; seminar or reading course.

MATH 913 Topics in Number Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 915 Topics in Number Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 922 Topics in Analysis
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 923 Topics in Analysis
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 925 Topics in Analysis
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 932 Topics in Applied Mathematics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 933 Topics in Applied Mathematics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 935 Topics in Applied Mathematics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 936 Topics in Control Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 937 Topics in Control Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 939 Topics in Control Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 942 Topics in Topology and Geometry
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 943 Topics in Topology and Geometry
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 945 Topics in Topology and Geometry
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 972 Topics in Communication Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 973 Topics in Communication Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 975 Topics in Communication Theory
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

MATH 999 Ph.D. Thesis Research

COURSES IN PROBABILITY AND STATISTICS

STAT 853 Statistical Inference
Decision theory and Bayesian inference; principles of optimal statistical procedures; maximum likelihood principle; large sample theory for maximum likelihood estimates; principles of hypotheses testing and the Neyman-Pearson theory; generalized likelihood ratio tests; the chi-square, t, F and other distributions. (Offered jointly with STAT 463.) Three term hours; lectures.
EXCLUSION: STAT 463

STAT 854 Statistical Spectrum Estimation
Many systems evolve with an inherent amount of randomness in time and/or space. The focus of this course is on developing and analyzing methods for analyzing time series. Because most of the common time--domain methods are unreliable, the emphasis is on frequency--domain methods, i.e. methods that work and expose the bias that plagues most time--domain techniques. Slepian sequences (discrete prolate spheroidal sequences) and multi--taper methods of spectrum estimation are covered in detail. (Offered jointly with MTHE 454.) Three term-hours; lectures.
EXCLUSION: MTHE 454

STAT 855 Stochastic Processes and Applications
Markov chains, birth and death processes, random walk problems, elementary renewal theory, Markov processes, Brownian motion and Poisson processes, queuing theory, branching processes. (Offered jointly with MTHE/STAT 455.) Three term hours; lectures.
EXCLUSIONS: MTHE 455, STAT 455

STAT 856 Bayesian Analysis
This course is an introduction to Bayesian analysis and decision theory. Topics covered will include: elements of decision theory; Bayesian point estimation, set estimation, and hypothesis testing; special priors; computations for Bayesian analysis. (Offered jointly with STAT 456.)
EXCLUSION: STAT 456

STAT 857 Statistical Learning II
Introduction to the theory and application of statistical algorithms. Topics may include classification, smoothing, model selection, optimization, sampling, supervised and unsupervised learning. (Offered jointly with STAT 457).
EXCLUSION: STAT 457

STAT 862 Statistical Learning I
A working knowledge of the statistical software R is assumed. Classification; spline and smoothing spline; regularization, ridge regression, and Lasso; model selection; treedbased methods; resampling methods; importance sampling; Markov chain Monte Carlo; Metropolis-Hasting algorithm; Gibbs sampling; optimization. (Offered jointly with STAT 462.)
EXCLUSION: STAT 462

STAT 864 Discrete Time Series Analysis
Autocorrelation and autocovariance, stationarity; ARIMA models; model identification and forecasting; spectral analysis. Applications to biological, physical and economic data. (Offered jointly with STAT 464.) Three term-hours; lectures.
EXCLUSION: STAT 464.

STAT 865 Quality Management
An overview of the statistical and lean manufacturing tools and techniques used in the measurement and improvement of quality in business, government and industry today. Topics include management and planning tools, Six Sigma approach, statistical process charting, process capability analysis, measurement system analysis. (Offered jointly with STAT 465.) Three term-hours; lectures.
EXCLUSION: STAT 465

STAT 866 Statistical SAS Programming
Introduction to the basic knowledge in programming, data management, and exploratory data analysis using SAS software: data manipulation and management; output delivery system; advanced text file generation, statistical procedures and data analysis, macro language, structure query language, and SAS applications in clinical trial, administrative financial data. (Offered jointly with STAT 466). Three term-hours; lectures.
EXCLUSION: STAT 466

STAT 871 Sampling and Experimental Design
Simple random sampling; Unequal probability sampling; Stratified sampling; Cluster sampling; Multi#stage sampling; Analysis of variance and covariance; Block designs; Fractional factorial designs; Split#plot designs; Response surface methodology; Robust parameter designs for products and process improvement. (Offered jointly with STAT 471.) Three term hours; lectures.
EXCLUSION: STAT 471.

STAT 873 Generalized Linear Models
An introduction to advanced regression methods for binary, categorical, and count data. Major topics include maximum-likelihood method, binomial and Poisson regression, contingency tables, log linear models, and random effect models. The generalized linear models will be discussed both in theory and in applications to real data from a variety of sources. (Offered jointly with STAT 473.)
EXCLUSION: STAT 473

STAT 886 Survival Analysis
Introduces the theory and application of survival analysis: survival distributions and their applications, parametric and nonparametric methods, proportional hazards models, counting process and proportional hazards regression, planning and designing clinical trials. (Offered jointly with STAT 486.) Three term-hours; lectures.
EXCLUSION: STAT 486

STAT 888 Master's Practicum
Under the guidance of the supervisor, students will carry out a practicum project in a health research group/site and practise biostatistical methods and data analysis, or conduct methodology research in a biostatistical project. Students will summarize the results of the project in a written report that will be reviewed and orally defended.

STAT 898 Master's Project

STAT 899 Master's Thesis Research

STAT 952 Topics in Probability
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 953 Topics in Probability
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 955 Topics in Probability
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 962 Topics in Statistics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 963 Topics in Statistics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 965 Topics in Statistics
Subject matter will vary from year to year. Three term-hours; Seminar or reading course.

STAT 999 Ph.D. Thesis Research