# 2009-2010 Graduate Calendar

The information published in this Graduate Calendar outlines the rules, regulations, curricula, programs and fees for the 2009-2010 academic years, including the Fall Semester 2009, the Winter Semester 2010 and the Summer Semester 2010.

For your convenience the Graduate Calendar is available in PDF format.

If you wish to link to the Graduate Calendar please refer to the Linking Guidelines.

The University is a full member of:

- The Association of Universities and Colleges of Canada

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# Disclaimer

The Office of Graduate Program Services has attempted to ensure the accuracy of this on-line Graduate Calendar. However, the publication of information in this document does not bind the university to the provision of courses, programs, schedules of studies, fees, or facilities as listed herein.

## Limitations

The University of Guelph reserves the right to change without notice any information contained in this calendar, including any rule or regulation pertaining to the standards for admission to, the requirements for the continuation of study in, and the requirements for the granting of degrees or diplomas in any or all of its programs.

The university will not be liable for any interruption in, or cancellation of, any academic activities as set forth in this calendar and related information where such interruption is caused by fire, strike, lock-out, inability to procure materials or trades, restrictive laws or governmental regulations, actions taken by the faculty, staff or students of the university or by others, civil unrest or disobedience, Public Health Emergencies, or any other cause of any kind beyond the reasonable control of the university.

The University of Guelph reaffirms section 1 of the Ontario Human Rights Code, 1981, which prohibits discrimination on the grounds of race, ancestry, place of origin, colour, ethnic origin, citizenship, creed, sex, sexual orientation, handicap, age, marital status or family status.

The university encourages applications from women, aboriginal peoples, visible minorities, persons with disabilities, and members of other under-represented groups.

# Introduction

## Collection, Use and Disclosure of Personal Information

Personal information is collected under the authority of the University of Guelph Act (1964), and in accordance with Ontario's Freedom of Information and Protection of Privacy Act (FIPPA) http://www.e-laws.gov.on.ca/DBLaws/Statutes/English/90f31_e.htm. This information is used by University officials in order to carry out their authorized academic and administrative responsibilities and also to establish a relationship for alumni and development purposes. Certain personal information is disclosed to external agencies, including the Ontario Universities Application Centre, the Ministry of Training, Colleges and Universities, and Statistics Canada, for statistical and planning purposes, and is disclosed to other individuals or organizations in accordance with the Office of Registrarial Services Departmental Policy on the Release of Student Information. For details on the use and disclosure of this information call the Office of Registrarial Services at the University at (519) 824-4120 or see http://www.uoguelph.ca/registrar/registrar/index.cfm?index.

## Statistics Canada - Notification of Disclosure

For further information, please see Statistics Canada's web site at http://www.statcan.gc.ca and Section XIV Statistics Canada.

## Address for University Communication

Depending on the nature and timing of the communication, the University may use one of these addresses to communicate with students. Students are, therefore, responsible for checking all of the following on a regular basis:

### Email Address

The University issued email address is considered an official means of communication with the student and will be used for correspondence from the University. Students are responsible for monitoring their University-issued email account regularly.

### Home Address

Students are responsible for maintaining a current mailing address with the University. Address changes can be made, in writing, through Graduate Program Services.

## Name Changes

The University of Guelph is committed to the integrity of its student records, therefore, each student is required to provide either on application for admission or on personal data forms required for registration, his/her complete, legal name. Any requests to change a name, by means of alteration, deletion, substitution or addition, must be accompanied by appropriate supporting documentation.

## Student Confidentiality and Release of Student Information Policy Excerpt

The University undertakes to protect the privacy of each student and the confidentiality of his or her record. To this end the University shall refuse to disclose personal information to any person other than the individual to whom the information relates where disclosure would constitute an unjustified invasion of the personal privacy of that person or of any other individual. All members of the University community must respect the confidential nature of the student information which they acquire in the course of their work.

Complete policy at http://www.uoguelph.ca/policies.

# Table of Contents

# Mathematics and Statistics

The objective of the graduate program is to offer opportunities for advanced studies and research in the fields of applied mathematics and applied statistics, including the interface between the two. Although the two fields within the program have different requirements in terms of specific courses and qualifying examination areas, there is a considerable degree of interaction and commonality between them, from both philosophical and practical viewpoints. Philosophically, this commonality relates to the methodology of constructing and validating models of specific real-world situations. The major areas of specialization in applied mathematics are dynamical systems, mathematical biology, numerical analysis and operations research. Applied statistics encompasses the study and application of statistical procedures to data arising from real-world problems. Much of the emphasis in this field concerns problems originally arising in a biological setting. The major areas of specialization include linear and nonlinear models; bioassay; and survival analysis, life testing and reliability.

## Administrative Staff

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## Graduate Faculty

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**Chris Bauch**
BSc Texas, PhD Warwick - Associate Professor

**Edward M. Carter**
BSc, MSc, PhD Toronto - Professor

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## MSc Program

The department offers an MSc degree with several options. Students choose between either mathematics or statistics fields and complete their program either by thesis or project. The two main program types are regular and interdisciplinary.

Interdisciplinary programs involve faculty members of this and other university departments and focus on problems of common interest to both departments. Examples include joint studies in quantitative genetics involving faculty in the Department of Animal and Poultry Science; studies of economic management of renewable resources involving faculty from the economics departments; modeling of physiological processes involving faculty from the Ontario Veterinary College or the College of Biological Science; toxicological modeling or risk assessment in collaboration with faculty involved in the Toxicology Research Centre.

### Admission Requirements

For the MSc Degree Program, an honours degree with an equivalent to a major in the intended area of specialization is preferred. Applicants with an honours degree with the equivalent of a minor in mathematics or in statistics as defined in the University of Guelph Undergraduate Calendar will be considered.

An applicant who does not meet the requirements must register as a nondegree undergraduate student and take courses to achieve an equivalent to the above. Such students are encouraged to consult the departmental graduate officers or the chair of the department. The department's undergraduate diploma in applied statistics fulfils the requirement of a minor equivalent in statistics.

### Degree Requirements

For both regular and interdisciplinary programs, the degree requirements may be met by taking either:

- an MSc by thesis which requires at least 2.0 credits (four courses) plus a thesis; or
- an MSc without thesis (by project) which requires at least six courses; i.e., 3.0 credits, 2.0 of which must be for graduate-level courses plus successful completion within two semesters:

  One of:

| | | |
|---|---|---|
| MATH*6998 | [1.00] | MSc Project in Mathematics |
| STAT*6998 | [1.00] | MSc Project in Statistics |

All programs of study must include the appropriate core courses (see below). Students who have obtained prior credit for a core course or its equivalent will normally substitute a departmental graduate course at the same or higher level, with the approval of the graduate co-ordinator. The remaining prescribed courses are to be selected from either graduate courses or 400-level undergraduate courses. Courses taken outside of this department must have the prior approval of the graduate program committee.

### Mathematical Area of Emphasis

All candidates for the MSc by thesis with a mathematical area of emphasis are required to include in their program of study at least two of the core courses. All candidates for the MSc without thesis (by project) with a statistical area of emphasis are required to include in their program of study at least three of the core courses.

The core courses are:

| | | |
|---|---|---|
| MATH*6011 | [0.50] | Dynamical Systems I |
| MATH*6021 | [0.50] | Optimization I |
| MATH*6400 | [0.50] | Numerical Analysis I |
| MATH*6041 | [0.50] | Partial Differential Equations I |

### Statistical Area of Emphasis

All candidates for the MSc by thesis with a statistical area of emphasis are required to include in their program of study at least two of the core courses. All candidates for the MSc without thesis (by project) with a statistical area of emphasis are required to include in their program of study at least three of the core courses.

The core courses are:

| | | |
|---|---|---|
| STAT*6801 | [0.50] | Advanced Data Analysis I |
| STAT*6802 | [0.50] | Advanced Data Analysis II |
| STAT*6841 | [0.50] | Statistical Inference |
| STAT*6860 | [0.50] | Linear Statistical Models |

It is required that students take the undergraduate course Statistical Inference, STAT*4340, if this course or its equivalent has not previously been taken.

### Interdisciplinary Programs

1. The general course requirements, above, must be met.
2. The project or thesis of an interdisciplinary program must directly integrate the study of mathematics or statistics with another discipline.

## PhD Program

### Admission Requirements

A candidate for the PhD degree program must possess a recognized master's degree obtained with high academic standing. Also, a member of the department's graduate faculty must agree to act as an advisor to the student.

### Degree Requirements

The PhD degree is primarily a research degree. For that reason, course work commonly comprises a smaller proportion of the student's effort than in the master's program. Course requirements are as follows:

#### Applied Mathematics

Students must successfully complete 2.0 graduate-course credits. Depending upon the student's academic background, further courses may be prescribed. The required four courses must include at least two core courses selected from:

| | | |
|---|---|---|
| MATH*6012 | [0.50] | Dynamical Systems II |
| MATH*6022 | [0.50] | Optimization II |
| MATH*6410 | [0.50] | Numerical Analysis II |
| MATH*6042 | [0.50] | Partial Differential Equations II |

All courses are chosen in consultation with the advisory committee. Additional courses may be required at the discretion of the advisory committee and/or the departmental graduate committee. With departmental approval, some courses given by other universities may be taken for credit.

#### Applied Statistics

Students must successfully complete 2.0 graduate-course credits. Depending upon the student's academic background, further courses may be prescribed. Students must take the following courses as part of the four required courses (providing that these courses were not taken as part of the student's master's-degree program):

| | | |
|---|---|---|
| STAT*6802 | [0.50] | Advanced Data Analysis II |
| STAT*6841 | [0.50] | Statistical Inference |
| STAT*6860 | [0.50] | Linear Statistical Models |

All courses are chosen in consultation with the student's advisory committee. Additional courses may be required at the discretion of the advisory committee and/or the departmental graduate committee. With departmental approval, some courses given by other universities may be taken for credit.

## Graduate Diploma Applied Statistics

This program is aimed at providing advanced training in applied statistics equivalent to that obtained in a MSc, in selected areas of statistics judged to be most useful. It is ideal for individuals who are already employed in positions requiring statistical analysis and study design but who have had limited undergraduate training in statistics. Two core hybrid courses combine distance education with intensive on-campus training at the beginning and end of each course. A substantive research project typically revolves around an important problem from the student's work environment. Modern statistical software is integrated into all aspects of the courses.

The program will also appeal to students who have recently completed an undergraduate degree with concentration in statistics and who wish to advance their employment prospects by further study in applied statistics.

### Admission Requirements

The minimum requirement for admission to the program is a baccalaureate, in an honours program or the equivalent, from a recognized university or college.

The applicant must have achieved an average standing of at least second-class honours ('B-' standing) in the work of the last four semesters or the last two undergraduate years (full-time equivalent). The honours program must have included 1.0 credit in mathematics and 1.5 credits in statistics. 0.5 credits in matrix or linear algebra is recommended. The program directors may waive some requirements for students with substantive work experience.

### Diploma Requirements

#### Course Requirements:

Students must successfully complete 2.0 credits, including:

- STAT*6010
- STAT*6020
- STAT*6098
- 0.50 credits selected from 4th year or graduate STAT courses, excluding STAT*6950 and STAT*6960. With departmental approval, this requirement may also be met by taking a course at another university.

#### Project supervision:

Upon admission, students will select or be assigned a faculty supervisor or a pair of co-supervisors. The supervisors will be responsible to provide project guidance to the student for the project research and to grade the project.

#### Graduation Requirements:

Students must achieve a weighted (by credits) average of 70% in order to graduate.

## Interdepartmental Program

### Biophysics MSc/PhD Program

The Department of Mathematics and Statistics participates in the MSc/PhD programs in biophysics. Professors Bauch, Eberl, Langford, Lawniczak, and Willms are members of the Biophysics Interdepartmental Group (BIG). These faculty members' research and teaching expertise includes aspects of biophysics. Professors Bauch, Eberl, Lawniczak, and Willms may serve as advisors for MSc and PhD students in biophysics. Professor Langford may serve as co-advisor. Please consult the Biophysics listing for a detailed description of the graduate programs offered by the Biophysics Interdepartmental Group.

## Courses

### Mathematics

**MATH*6011 Dynamical Systems I U [0.50]**

Basic theorems on existence, uniqueness and differentiability; phase space, flows, dynamical systems; review of linear systems, Floquet theory; Hopf bifurcation; perturbation theory and structural stability; differential equations on manifolds. Applications drawn from the biological, physical, and social sciences.

**MATH*6012 Dynamical Systems II U [0.50]**

The quantitative theory of dynamical systems defined by differential equations and discrete maps, including: generic properties; bifurcation theory; the center manifold theorem; nonlinear oscillations, phase locking and period doubling; the Birkhoff-Smale homoclinic theorem; strange attractors and deterministic chaos.

**MATH*6021 Optimization I U [0.50]**

A study of the basic concepts in: linear programming, convex programming, non-convex programming, geometric programming and related numerical methods.

**MATH*6022 Optimization II U [0.50]**

A study of the basic concepts in: calculus of variations, optimal control theory, dynamic programming and related numerical methods.

**MATH*6031 Functional Analysis U [0.50]**

Review of metric, normed, and inner product spaces; Banach contraction principle; brief introduction to measure and integration; elementary Fourier analysis; adjoint and compact operators; nonlinear operators and the Frechet derivative; Baire category theorem; principle of uniform boundedness; open mapping theorem; principle ot uniform boundedness; closed graph theorem.

**MATH*6041 Partial Differential Equations I U [0.50]**

Classification of partial differential equations. The Hyperbolic type, the Cauchy problem, range of influence, well- and ill-posed problems, successive approximation, the Riemann function. The elliptic type: fundamental solutions, Dirichlet and Neumann problems. The parabolic type: boundary conditions, Green's functions and separation of variables. Introduction to certain non-linear equations and transformations methods.

**MATH*6042 Partial Differential Equations II U [0.50]**

A continuation of some of the topics of Partial Differential Equations I. Also, systems of partial differential equations, equations of mixed type and non-linear equations.

**MATH*6051 Mathematical Modelling U [0.50]**

Selected advanced topics in mathematical modelling, possibly in conjunction with the departmental Mathematics and Statistics Clinic.

**MATH*6071 Biomathematics U [0.50]**

The application of mathematics to model and analyze biological systems. Specific models to illustrate the different mathematical approaches employed when considering different levels of biological function.

**MATH*6091 Topics in Analysis U [0.50]**

Selected topics from topology, real analysis, complex analysis, and functional analysis.

**MATH*6181 Topics in Applied Mathematics I U [0.50]**

This course provides graduate students, either individually or in groups, with the opportunity to pursue topics in applied mathematics under the guidance of graduate faculty. Course topics will normally be advertised by faculty in the semester prior to their offering. Courses may be offered in any of lecture, reading/seminar, or individual project formats.

**MATH*6182 Topics in Applied Mathematics II U [0.50]**

This course provides graduate students, either individually or in groups, with the opportunity to pursue topics in applied mathematics under the guidance of graduate faculty. Course topics will normally be advertised by faculty in the semester prior to their offering. Courses may be offered in any of lecture, reading/seminar, or individual project formats.

**MATH*6400 Numerical Analysis I U [0.50]**

Topics selected from numerical problems in: matrix operations, interpolation, approximation theory, quadrature, ordinary differential equations, partial differential equations, integral equations, nonlinear algebraic and transcendental equations.

**MATH*6410 Numerical Analysis II U [0.50]**

One or more topics selected from those discussed in Numerical Analysis I, but in greater depth.

**MATH*6990 Mathematics Seminar U [0.00]**

Students will review mathematical literature and present a published paper.

**MATH*6998 MSc Project in Mathematics U [1.00]**

## Statistics

**STAT*6010 Strategies for Study Design and Regression Analysis U [0.50]**

Exploratory data analysis and review of elementary statistical methods. Design and analysis strategies for both randomized and observational studies. Sample size and power computations. Mixed models. Missing data techniques. Linear, logistic and Poisson regression. The focus is on problem formulation and associated study designs and analyses for real-world problems. Statistical software (R and SAS) is used throughout.

*Prerequisite(s):* Honours degree with 1.5 stat credits, 1 math credit, or relevant work experience

*Restriction(s):* Students registered in the Graduate Diploma in Applied Statistics. Cannot be used to satisfy departmental MSc/PhD requirements.

**STAT*6020 Data Analysis and Statistical Inference U [0.50]**

Generalized linear and additive models, likelihood theory, Bayesian inference. Multilevel, longitudinal, and event history models. Methods for temporally and spatially correlated data. Although secure statistical foundations are laid down, the emphasis is on applications and experimental planning. Statistical software (R, SAS, BUGS) is used throughout.

*Restriction(s):* Students registered in the Graduate Diploma in Applied Statistics. Cannot be used to satisfy departmental MSc/PhD requirements.

**STAT*6098 Graduate Diploma Project in Applied Statistics U [0.50]**

A project leading to a technical report, which utilizes statistical principles and procedures in the solution of a substantive research problem. Completion of this course requires a formal presentation of the project to faculty and students.

*Restriction(s):* Students registered in the Graduate Diploma in Applied Statistics. Cannot be used to satisfy departmental MSc/PhD requirements.

**STAT*6550 Computational Statistics U [0.50]**

This course covers the implementation of a variety of computational statistics techniques. These include random number generation, Monte Carlo methods, non-parametric techniques, Markov chain Monte Carlo methods, and the EM algorithm. A significant component of this course is the implementation of techniques.

**STAT*6700 Stochastic Processes U [0.50]**

The content of this course is to introduce Brownian motion leading to the development of stochastic integrals thus providing a stochastic calculus. The content of this course will be delivered using concepts from measure theory and so familiarity with measures, measurable spaces, etc., will be assumed.

**STAT*6721 Stochastic Modelling U [0.50]**

Topics include the Poisson process, renewal theory, Markov chains, Martingales, random walks, Brownian motion and other Markov processes. Methods will be applied to a variety of subject matter areas.

**STAT*6741 Statistical Analysis for Reliability and Life Testing U [0.50]**

Statistical failure models, order statistics, point and interval estimation procedures for life time distributions, testing reliability hypotheses, Bayes methods in reliability, system reliability.

**STAT*6761 Survival Analysis U [0.50]**

Kaplan-Meier estimation, life-table methods, the analysis of censored data, survival and hazard functions, a comparison of parametric and semi-parametric methods, longitudinal data analysis.

**STAT*6801 Advanced Data Analysis I U [0.50]**

Residual analysis, deletion residuals, influential points,added variable plots, constructed variables, families of transformations, jackknife and bootstrap methods, local linear regression, regression splines and cubic smoothing splines.

**STAT*6802 Advanced Data Analysis II U [0.50]**

Generalized linear and generalized additive models, linear and nonlinear mixed effects models, parameteric and semiparametric analysis of longitudinal and clustered data, generalized estimating equations, applications to categorical and spatial data.

**STAT*6821 Multivariate Analysis U [0.50]**

This is an advanced course in multivariate analysis and one of the primary emphases will be on the derivation of some of the fundamental classical results of multivariate analysis. In addition, topics that are more current to the field will also be discussed such as: multivariate adaptive regression splines; projection pursuit regression; and wavelets.

**STAT*6841 Statistical Inference U [0.50]**

Bayesian and likelihood methods, large sample theory, nuisance parameters, profile, conditional and marginal likelihoods, EM algorithms and other optimization methods, estimating functions, MonteCarlo methods for exploring posterior distributions and likelihoods, data augmentation, importance sampling and MCMC methods.

**STAT*6850 Advanced Biometry U [0.50]**

Topics on advanced techniques for analyzing data from biological systems. In particular, univariate discrete models, stochastic processes as it relates to population dynamics and growth models with time dependencies, generalized discrete models for spatial patterns in wildlife, the theoretical foundation and recent results in aquatic bioassays, and other topics relating to the student's research interest.

**STAT*6860 Linear Statistical Models U [0.50]**

Generalized inverses of matrices; distribution of quadratic and linear forms; regression or full rank model; models not of full rank; hypothesis testing and estimation for full and non-full rank cases; estimability and testability; reduction sums of squares; balanced and unbalanced data; mixed models; components of variance.

**STAT*6870 Experimental Design U [0.50]**

This is an advanced course in experimental design which emphasizes proofs of some of the fundamental results in the topic. The topics will include: design principles; design linear models; designs with several factors; confounding in symmetrical factorials; fractional factorials.

**STAT*6880 Sampling Theory U [0.50]**

Theory of equal and unequal probability sampling. Topics in: simple random, systematic, and stratified sampling; ratio and regression estimates; cluster sampling and subsampling; double sampling procedure and repetitive surveys; nonsampling errors.

**STAT*6920 Topics in Statistics U [0.50]**

**STAT*6950 Statistical Methods for the Life Sciences F [0.50]**

Analysis of variance, completely randomized, randomized complete block and latin square designs; planned and unplanned treatment comparisons; random and fixed effects; factorial treatment arrangements; simple and multiple linear regression; analysis of covariance with emphasis on the life sciences. STAT*6950 and STAT*6960 are intended for graduate students of other departments and may not normally be taken for credit by mathematics and statistics graduate students.

**STAT*6960 Design of Experiments and Data Analysis for the Life Sciences W [0.50]**

Principles of design; randomized complete block; latin square and extensions the split plot and extension; incomplete block designs; confounding and fractional replication of factorial arrangements; response surfaces the analysis of series of experiments; the general linear model; multiple regression and data analytic techniques. STAT*6950 and STAT*6960 are intended for graduate students of other departments and may not normally be taken for credit by mathematics and statistics graduate students.

**STAT*6970 Statistical Consulting Internship U [0.25]**

This course provides experience in statistical consulting in a laboratory and seminar environment. The student will participate in providing statistical advice and/or statistical analyses and participate in seminar discussions of problems arising from research projects in various disciplines.

**STAT*6990 Statistics Seminars by Graduate Students U [0.00]**

**STAT*6998 MSc Project in Statistics U [1.00]**