MATHEMATICS & STATISTICS

The Graduate Program in Mathematics & Statistics offers instruction leading to Master of Arts, Master of Science in Applied & Industrial Mathematics and Doctor of Philosophy degrees. Research interests of faculty members cover diverse areas of mathematics including algebraic geometry, applied mathematics, category theory, complexity theory, differential equations, dynamical systems, discrete mathematics, functional analysis, geometry, group theory, history of mathematics, logic and set theory, mathematics education, numerical analysis, optimization, probability, stochastic processes and topology. They also cover various areas of statistics including foundations of statistics, generalized linear models, interactive statistical graphics, statistical inference and survey sampling techniques.

Master's candidates may specialize in pure mathematics, applied mathematics, probability, or theoretical and applied statistics. Areas of special emphasis for doctoral studies are foundations of mathematics, algebra and geometry, probability and statistical theory, analysis, and applied mathematics.

LIBRARY AND RESEARCH FACILITIES

The York University Library has a large number of books in mathematics and statistics and subscribes to over 250 periodicals in those fields. There is a wide variety of computer facilities, including some with sophisticated interactive graphic capabilities. Shared office space is available for full-time students.

ENQUIRIES AND APPLICATIONS

Further information can be obtained by writing to the Graduate Program in Mathematics & Statistics, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3; or by sending an email to gradir@mathstat.yorku.ca .

MASTER OF ARTS PROGRAM

ADMISSION REQUIREMENTS

An honours degree in Mathematics or Statistics (or equivalent background) normally with a B standing may qualify the student for admission as a candidate to a program leading to the MA degree. Applicants without the appropriate breadth in Mathematics or Statistics, but who have good standing, may be admitted on condition they take additional graduate and/or undergraduate courses. Faculty of Graduate Studies regulations regarding standing (see Grading System under Faculty Regulations) apply to these additional courses. Students whose first language is not English must demonstrate an acceptable command of English: at least 213 in the Test of English as a Foreign Language or 85 in the Michigan English Language Assessment Battery.

DEGREE REQUIREMENTS

Master of Arts Degree—Regular Program

Students in the regular program must choose one of three options.

MA by Coursework

Four 6000 level full courses (or equivalent), plus a seminar*: (**Mathematics & Statistics 6004 0.0**).

MA by Survey Paper

Three 6000-level full courses (or equivalent), a supervised survey paper (**Mathematics & Statistics 6001 0.0**; students give one talk in a student Colloquium outlining the results of their papers), plus a seminar† (**Mathematics & Statistics 6004 0.0**).

MA by Thesis

Two 6000-level full courses (or equivalent), a thesis (students give two talks in a student Colloquium outlining the results of their theses), plus a seminar† (**Mathematics & Statistics 6004 0.0**). The thesis must be defended before an examining committee in accordance with the regulations of the Faculty of Graduate Studies.

Whatever option is chosen, no more than one-third of courses can be integrated, and **all** students must include among their courses one of the following sets:

i) *Pure Mathematics*:
Mathematics & Statistics 6121 3.0: Applied Algebra,
Mathematics & Statistics 6122 3.0: Algebra II,
Mathematics & Statistics 6461 3.0: Functional Analysis I , and either
Mathematics & Statistics 6280 3.0: Measure Theory,
Mathematics & Statistics 6300 3.0: Complex Analysis,
Mathematics & Statistics 6420 3.0: Introduction to Harmonic Analysis,
Mathematics & Statistics 6462 3.0: Functional Analysis II,
Mathematics & Statistics 6540 3.0: Topology I,
Mathematics & Statistics 6550 3.0: Algebraic Topology I or
Mathematics & Statistics 6605 3.0: Probability Theory; or

ii) *Applied Mathematics*:
Four courses chosen from
Mathematics & Statistics 6121 3.0: Applied Algebra,
Mathematics & Statistics 6340 3.0: Ordinary Differential Equations,
Mathematics & Statistics 6350 3.0: Partial Differential Equations,
Mathematics & Statistics 6602 3.0: Stochastic Processes,
Mathematics & Statistics 6604 3.0: Probability Models,
Mathematics & Statistics 6651 3.0: Advanced Numerical Methods,
Mathematics & Statistics 6652 3.0: Numerical Solutions to Differential Equations,
Mathematics & Statistics 6904 3.0: Modern Optimization,
Mathematics & Statistics 6910 3.0: Stochastic Calculus in Finance,
Mathematics & Statistics 6911 3.0: Numerical Methods in Finance,
Mathematics & Statistics 6920 3.0: Harmonic Analysis and Image Processing,
Mathematics & Statistics 6931 3.0: Mathematical Modeling,
Mathematics & Statistics 6936 3.0: Mathematical Epidemiology; or

*Students may substitute another half course for the seminar if they are pursuing their MA by Survey Paper or by Thesis. Students completing their MA by Coursework can replace the seminar requirement with another half course only if one of their four courses toward the degree is the practicum in statistical consulting (**Mathematics & Statistics 6627 3.0**).

iii) *Probability*:
Mathematics & Statistics 6910 3.0: Stochastic Calculus in Finance;
either
Mathematics & Statistics 6605 3.0: Probability Theory or
Mathematics & Statistics 6280 3.0: Measure Theory;
either
Mathematics & Statistics 6602 3.0: Stochastic Processes or
Mathematics & Statistics 6604 3.0: Probability Models;
and one of
Mathematics & Statistics 6620 3.0: Mathematical Statistics,
Mathematics & Statistics 6630 3.0: Applied Statistics I or
Mathematics & Statistics 6911 3.0: Numerical Methods in Finance; or

iv) *Theoretical Statistics*:
Mathematics & Statistics 6620 3.0: **Mathematical Statistics**,
Mathematics & Statistics 66213.0: **Advanced Mathematical Statistics** or
Mathematics & Statistics 6605 3.0: Probability Theory,
Mathematics & Statistics 6622 3.0: Generalized Linear Models,
Mathematics & Statistics 6630 3.0: Applied Statistics I; or

v) *Applied Statistics*:
Mathematics & Statistics 6620 3.0: Mathematical Statistics,
Mathematics & Statistics 6622 3.0: Generalized Linear Models,
Mathematics & Statistics 6630 3.0: Applied Statistics I,
either,
Mathematics & Statistics 6631 3.0: Applied Statistics II or
Mathematics & Statistics 6635 3.0: Introduction to Bayesian Statistics or
Mathematics & Statistics 6641 3.0: Survival Analysis or
Mathematics & Statistics 6642 3.0: Applied Longitudinal Data Analysis, and
Mathematics & Statistics 6627 3.0: Practicum in Statistical Consulting; or

vi) *Data Science*
Mathematics & Statistics 6620 3.0: Mathematical Statistics,
Mathematics & Statistics 6622 3.0: Generalized Linear Models,
Mathematics & Statistics 6630 3.0: Applied Statistics I,
Mathematics & Statistics 6650 3.0: Data Science, and
either **Mathematics & Statistics 6636 3.0: Data Mining** or
Mathematics & Statistics 6644 3.0: Statistical Learning.

Students may, with permission, use courses from other graduate programs such as Electrical Engineering & Computer Science, Economics or Physics & Astronomy to meet the requirements.

PROGRAM LENGTH

The expected degree completion time for full-time master's students is 3 terms. A part-time student normally takes one or two full courses in a 12-month period. For those students who complete degree requirements earlier than 3 terms, they must register and pay fees for a minimum of the equivalent of 3 terms of full- time study. All requirements for a master's degree must be fulfilled within 12 terms (4 years) of registration as a full-time or part-time master's student in accordance with Faculty of Graduate Studies' registration policies.

MASTER OF SCIENCE IN APPLIED & INDUSTRIAL MATHEMATICS

ADMISSION REQUIREMENTS

An honours degree in mathematics (or equivalent background) normally with a B standing may qualify the student for admission as a candidate to the program leading to the MSc degree in Industrial & Applied Mathematics. Applicants without the appropriate breadth in mathematics, but who have good standing, may be admitted on condition they take additional graduate and/or undergraduate courses. Faculty of Graduate Studies regulations regarding standing (see Grading System under Faculty Regulations) apply to these additional courses. Students whose first language is not English must demonstrate an acceptable command of English (at least 213 in the Test of English as a Foreign Language or 85 in the Michigan English Language Assessment Battery).

DEGREE REQUIREMENTS

Students must complete **Mathematics & Statistics 6651 3.0: Advanced Numerical Methods**, **Mathematics & Statistics 6931 3.0: Mathematical Modeling**, **Mathematics & Statistics 6937 3.0: Practicum in Industrial & Applied Mathematics**, another three credit non-integrated course appropriate to the student's program of study approved by the student's supervisory committee, and a thesis which must be defended before an examining committee in accordance with the regulations of the Faculty of Graduate Studies.

PROGRAM LENGTH

The expected degree completion time for full-time master's students is 4 terms. For those students who complete degree requirements earlier than 4 terms, they must register and pay fees for a minimum of the equivalent of 4 terms of full- time study. All requirements for a master's degree must be fulfilled within 12 terms (4 years) of registration as a full-time or part-time master's student in accordance with Faculty of Graduate Studies' registration policies.

GRADUATE DIPLOMA IN FINANCIAL ENGINEERING

ADMISSION REQUIREMENTS

The Graduate Diploma in Financial Engineering is completed either in conjunction with the regular master's or doctoral program in Mathematics & Statistics, or as a standalone graduate diploma. For the concurrent offering, students must first apply and be accepted to the regular master's or doctoral program in Mathematics & Statistics. Applicants may indicate their interest in pursuing the concurrent Graduate Diploma in Financial Engineering at the same time they apply to the regular master's or doctoral program in Mathematics & Statistics, or they may submit a separate application for the diploma during the first term in which they are registered in the regular master's or doctoral program.

For the stand-alone diploma offering, see the Business Administration section of this *Calendar*.

DIPLOMA REQUIREMENTS

The requirements for the concurrent Graduate Diploma in Financial Engineering may be completed in conjunction with the MA by Coursework or MA by Survey Paper program requirements.

The requirements for the diploma are as follows:

a) Successful completion of the following **courses**:
Mathematics & Statistics 6910 3.0: Stochastic Calculus in Finance
Mathematics & Statistics 6911 3.0: Numerical Methods in Finance
Finance 6200 3.0: Investments
Finance 6800 3.0: Options, Futures and Other Derivative Securities
Financial Engineering 6820 3.0: Advanced Derivative Securities
Financial Engineering 6850 3.0: Fixed Income Securities
Operations Management & Information Systems 6000 3.0: Models and Applications in Operational Research

❖ *Note 1:* **Mathematics 6910 3.0**, **Mathematics 6911 3.0**, and **Operations Management & Information Systems 6000 3.0**, may be used to satisfy the MA by Coursework or MA by Survey Paper program requirements.

❖ *Note 2:* Students with little or no background in finance may find it beneficial to take **Economics 5030 3.0: Econometrics of Financial Markets**, as background for the finance courses listed above.

b) In addition to the course requirements, diploma students must complete one of the following: (i) subject to availability, an **internship** of at least 10 weeks duration in a financial institution, or (ii) a **research project**.

Note: Students in the MA by Survey Paper program option who decide to fulfill the above requirement through completion of a research project may request that the diploma research project also be used toward the fulfillment of the MA survey paper requirement. Such requests must be made in writing to the Financial Engineering Coordination Committee, accompanied by confirmation from the student's faculty advisor that the diploma research project is of acceptable quality to meet the MA by Survey Paper program requirements. Such requests will be considered by the Financial Engineering Coordination Committee only if the diploma research project contains substantial mathematics content, equivalent to that expected of students in the MA by Survey Paper program option.

c) Diploma seminar requirement: Students who did not complete **Mathematics 6627 3.0: Practicum in Statistical Consulting**, as part of their Mathematics & Statistics degree program requirements are required to give a talk on their internship or research paper to fulfill the diploma seminar requirement. Such students should enrol in **Mathematics 6004 0.0: Mathematics Seminar** in order to receive a grade.

Diploma Length
Students typically require four consecutive terms to complete coursework for the Mathematics & Statistics degree program and Type 2 Graduate Diploma in Financial Engineering, and then go on to complete the internship or research project, normally in one term.

Doctor of Philosophy Program

ADMISSION REQUIREMENTS
For admission to the PhD program, applicants must have completed an acceptable master's degree in mathematics or statistics with a B+ average (high second class) or better.

DEGREE REQUIREMENTS
Candidates for the PhD degree must fulfil the following requirements:

Five major components make up the degree requirements for the PhD in Mathematics and Statistics. These are 1) coursework 2) comprehensive exams 3) dissertation subject oral 4) dissertation proposal 5) dissertation oral examination (preceded by the dissertation colloquium).

Students can complete these degree requirements in four years and the following is the projected timeline and checklist for completion:

Course Requirements
Students must successfully complete 12 credits at the graduate level. The courses must be chosen with the approval of the program director. Up to 12 additional credits may be required, at the discretion of the Graduate Program Director, the PhD committee and the supervisor.

Comprehensive Examinations
Students must declare a specialization in pure mathematics or applied mathematics or statistics, and must write comprehensive examinations in subjects which are appropriate to the chosen specialization. In addition, statistics students must complete a statistical consulting requirement.

Specialization Requirement
Students in the PhD program must demonstrate depth of knowledge in their field of specialization. The candidate must pass an oral examination, which is given within one year after the comprehensive examinations have been passed.

Projected Timeline/Checklist for Completion

Progress requirements	Completed by
Advising appointment	Annual
Progress report	Annual
Comprehensive exams	End of 3rd term
Supervisor confirmed	End of 5th term
Course requirements	End of 6th term
Supervisory committee approved	End of 6th term
Dissertation subject oral	End of 6th term
Statistics practicum/ comprehensive exam	(Statistics stream only) End of 6th term
Dissertation proposal	No less than 6 months before oral examination
Dissertation colloquium	Normally 12th term
Oral examination	Normally 12th term

The details of these requirements are listed below:

A doctoral candidate must satisfy their comprehensive examination requirement by completing the examinations in the first year of study. Students need not enrol in the course nor attend lectures in order to write the examination for comprehensive credit. The comprehensive exams are as follows:

1. **Mathematics & Statistics 6300 3.0: Complex Analysis**
2. **Mathematics & Statistics 6280 3.0: Measure Theory**
3. **Mathematics & Statistics 6461 3.0: Functional Analysis**
4. **Mathematics & Statistics 6121 3.0: Applied Algebra**
5. **Mathematics & Statistics 6122 3.0: Algebra II**
6. **Mathematics & Statistics 6130 3.0: Commutative Algebra**
7. **Mathematics & Statistics 6540 3.0: Topology**
8. **Mathematics & Statistics 6550 3.0: Algebraic Topology**
9. **Mathematics & Statistics 6340 3.0: Ordinary Differential Equations**

10. **Mathematics & Statistics 6350 3.0: Partial Differential Equations**
11. **Mathematics & Statistics 6110 3.0: Number Theory**
12. **Mathematics & Statistics 6605 3.0: Probability Theory**
13. **Mathematics & Statistics 6180 3.0: Category Theory**
14. **Mathematics & Statistics 6530 3.0: Differential Geometry**
15. **Mathematics & Statistics 6040 3.0: Set Theory**
16. **Mathematics & Statistics 6651 3.0: Advanced Numerical Methods**
17. **Mathematics & Statistics 6652 3.0: Numerical Solutions to Differential Equations**
18. **Mathematics & Statistics 6931 3.0: Mathematical Modeling**
19. **Mathematics & Statistics 6620 3.0: Mathematical Statistics**
20. **Mathematics & Statistics 6621 3.0: Advanced Mathematical Statistics**
21. **Mathematics & Statistics 6622 3.0: Generalized Linear Models**
22. **Mathematics & Statistics 6630 3.0: Applied Statistics I**

❖ *Note: While not all courses are offered annually, course offerings are responsive to student need. Examinations may be taken in a year in which the course is not offered.*

Candidates must declare themselves to be in one of these three streams: applied mathematics, pure mathematics, or statistics streams. Candidates decide which comprehensive exams to complete with the approval of their supervisor and the Graduate Program Director.

Pure mathematics students must complete at least one examination from 1-3, one examination from 4-6, one examination from 7-11, plus one additional examination.

Applied mathematics students must complete examination 18, at least one examination from 9 or 10, at least one examination from 16 or 17, plus one additional examination.

Statistics students must complete exams 19, 20, 21 and 22. In addition, statistics students must fulfill a practicum requirement. This requirement is usually completed in the second year of study.

Practicum requirement for statistics stream
The purpose of the practicum is to prepare students for the transition from statistics theory to the application of statistics through consulting and collaboration. The requirement for statistics students consists of two parts. The first part is the completion of **Mathematics & Statistics 6627 3.0** or an equivalent consulting course from another university, approved by the Graduate Program Director. Further details regarding the requirements for the course can be found in the course description for **Mathematics & Statistics 6627 3.0**. The second part is the comprehensive examination in consulting.

Students in the doctoral program must demonstrate depth of knowledge in their field of specialization. The candidate must pass an oral examination (the dissertation subject oral), which occurs within the second year of study.

Progress Report
All students enrolled in a PhD program are required to complete an annual research progress report detailing the achievements of the previous year and the objectives for the next year. Permission to continue to register in the program depends on a satisfactory report. Progress report forms are distributed by email at the end of the Winter term.

Deadlines for Meeting Requirements
Students are expected to finish the comprehensive examination requirement in the first year of their PhD studies. The dissertation subject oral should be taken within the second year of study. Students who are in the statistics stream should also finish the practicum requirement in the second year of study. The dissertation itself should be completed within two years of the dissertation subject oral, although one additional year may be allowed by permission.

PROGRAM LENGTH
Doctor of Philosophy students must register and pay fees for a minimum of the equivalent of six terms of full-time registration. All requirements for a doctoral degree must be fulfilled within 18 terms (6 years) of registration as a full-time or part-time doctoral student in accordance with Faculty of Graduate Studies' registration policies.