VELUT ÆVO ARBOR

Graduate Studies in Mathematics

2011-2012

2011-12 GRADUATE STUDIES IN MATHEMATICS HANDBOOK

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1. INTRODUCTION

The purpose of this handbook is to provide information about the graduate programs of the Department of Mathematics, University of Toronto. It includes detailed information about the department, its faculty members and students, a listing of core courses offered in 2011-2012, a summary of research activities, admissions requirements, application procedures, fees and financial assistance, and information about similar matters of concern to graduate students and prospective graduate students in mathematics.

This handbook is intended to complement the calendar of the university's School of Graduate Studies, where full details on fees and general graduate studies regulations may be found.

For further information, please contact:

The Graduate Office
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Fax: (416) 978-4107
Email: grad-info@math.toronto.edu
Website: http://www.math.utoronto.ca/cms/graduate-program/

2. DEPARTMENT OF MATHEMATICS

Mathematics has been taught at the University of Toronto since 1827. Since the first Canadian Ph.D. degree in mathematics was conferred to Samuel Beatty (under the supervision of John Charles Fields) in 1915, more than 400 Ph.D. degrees and 1000 Master's degrees have been awarded in this University. Many of our recent graduates are engaged in university teaching and a significant number hold administrative positions in universities or in the professional communities. Others are pursuing careers in industry (technological or financial), or in government.

The Department of Mathematics, University of Toronto is a distinguished faculty of more than sixty mathematicians. We have a large selection of graduate courses and seminars, and a diverse student body of domestic and international students, yet classes are small and the ratio of graduate students to faculty is low. We are in a unique position to take maximum advantage of the presence of the Fields Institute, which features special programs in pure and applied mathematics. Currently the department has 127 graduate students, of whom 26 are enrolled in the Master's program, 98 in the Ph.D. program, and 3 in non-degree programs.

Opportunities for graduate study and research are available in most of the main fields of pure and applied mathematics. These fields include real and complex analysis, ordinary and partial differential equations, harmonic analysis, nonlinear analysis, several complex variables, functional analysis, operator theory, C*-algebras, ergodic theory, group theory, analytic and algebraic number theory, Lie groups and Lie algebras, automorphic forms, commutative algebra, algebraic geometry, singularity theory, differential geometry, symplectic geometry, classical synthetic geometry, algebraic topology, set theory, set theoretic topology, mathematical physics, fluid mechanics, probability (in cooperation with the Department of Statistics), combinatorics, optimization, control theory, dynamical systems, computer algebra, cryptography, and mathematical finance.

We offer a research-oriented Ph.D., and Master's program. Very strong students may be admitted directly to the Ph.D. program with a Bachelor's degree; otherwise; it is normal to do a 1-year Master's degree first. (Provisional admission to the Ph.D. program may be granted at the time of admission to the Master's program.) The Master's program may be extended to 16 months or 24 months for students who do not have a complete undergraduate preparation, or for industrial students engaged in a project.

There is a separate Master's of Mathematical Finance Program not directly under the Department's jurisdiction, but with which some of our faculty members are associated.

During their studies here, graduate students are encouraged to participate in the life of the close community of U of T mathematics. Almost all of them do some work in connection with undergraduate teaching, either as tutorial leaders, markers, or, especially in later years of their program, instructors. There is a Mathematics Graduate Student Association, which organizes social and academic events and makes students feel welcome.

GRADUATE FACULTY MEMBERS

AKCOGLU, M.A. (Professor Emeritus) Ph.D. 1963 (Brown)
- Ergodic theory, functional analysis, harmonic analysis

ALEXAKIS, Spyros (Assistant Professor) Ph.D. 2005 (Princeton)
- Geometric analysis and general relativity

ARKHIPOV, S. (Assistant Professor) Ph.D. 1998 (Moscow State)
- Geometric representation theory

ARTHUR, J. (University Professor, Mossman Chair) B.Sc. 1966 (Toronto), M.Sc. 1967 (Toronto), Ph.D. 1970 (Yale)
- Representations of Lie groups, automorphic forms

BARBEAU, E. (Professor Emeritus) B.Sc. 1960 (Toronto), M.A. 1961 (Toronto), Ph.D. 1964 (Newcastle)
- Functional analysis, optimization under constraint, history of analysis, number theory

BAR-NATAN, D. (Professor) Ph.D. 1991 (Princeton)
- Theory of quantum invariants of knots, links and three manifolds

BIERSTONE, E. (Professor) B.Sc. 1969 (Toronto), Ph.D. 1973 (Brandeis)
- Singularity theory, analytic geometry, differential analysis

BINDER, I. (Associate Professor) Ph.D. 1997 (Caltech)
- Harmonic and complex analysis, conformal dynamics

BLAND, J. (Professor) Ph.D. 1982 (UCLA)
- Several complex variables, differential geometry

BLOMER, V. (Professor) Ph.D. 2002 (Stuttgart)
- Analytic number theory

BLOOM, T. (Professor) Ph.D. 1965 (Princeton)
- Several complex variables

BRAVERMAN, M. (Assistant Professor) M.Sc. 2003 (Toronto), Ph.D. 2008 (Toronto)
- Complexity theory

BUCHWEITZ, R.-O. (Professor) Ph.D. (Dr.rer.nat.) 1976 (Hannover), Doctorat d'Etat 1981 (Paris VII)
- Commutative algebra, algebraic geometry, singularities

BURCHARD, A. (Professor) Ph.D. (Georgia Tech) 1994
- Functional analysis

CHOI, M.-D. (Professor) M.Sc. 1970 (Toronto), Ph.D. 1973 (Toronto)
- Operator theory, operator algebras, matrix theory

COLLIANDER, James (Professor) Ph.D. 1997 (Illinois, Urbana-Champaign)
- Partial differential equations, harmonic analysis

DAVIS, C. (Professor Emeritus) Ph.D. 1950 (Harvard)
- Operators on Hilbert spaces, matrix theory and applications (including numerical analysis)

DEL JUNCO, A. (Professor) B.Sc. 1970 (Toronto), M.Sc. 1971 (Toronto), Ph.D. 1974 (Toronto)
- Ergodic theory, functional analysis

DERZKO, N. (Associate Professor Emeritus) B.Sc. 1970 (Toronto), Ph.D. 1965 (Caltech)
- Functional analysis, structure of differential operators, optimization and control theory with applications to economics

ELLERS, E. (Professor Emeritus) Dr.rer.nat. 1959 (Hamburg)
- Classical groups

ELLIOTT, G. A. (Canada Research Chair and Professor) Ph.D. 1969 (Toronto)
- Operator algebras, K-theory, non-commutative geometry and topology

FRIEDLANDER, J. (University Professor) B.Sc. 1965 (Toronto), Ph.D. 1972 (Penn State)
- Analytic number theory

GOLDMAKHER, L. (Assistant Professor) Ph.D. 2009 (Michigan)
- Number theory

GOLDSTEIN, M. (Professor) Ph.D. 1977 (Tashkent), Doctorat d'Etat 1987 (Vilnius)
- Spectral theory of Schroedinger operators and localization

GRAHAM, I. (Professor) B.Sc. 1970 (Toronto), Ph.D. 1973 (Princeton)
- Several complex variables, one complex variable

GREINER, P.C. (Professor Emeritus) Ph.D. 1964 (Yale)
- Partial differential equations

GUALTIERI, M. (Assistant Professor) Ph.D. 2003 (Oxford)
- Differential geometry and mathematical physics

GUTH, Lawrence (Assistant Professor) Ph.D. 2005 (MIT)
- Geometry and Functional analysis

HALPERIN, S. (Professor Emeritus) B.Sc. 1965 (Toronto), M.Sc. 1966 (Toronto), Ph.D. 1970 (Cornell)
- Homotopy theory and loop space homology

HERZIG, F. (Assistant Professor) PhD 2006 (Harvard)
- Number theory, Galois representations, automorphic forms

IVRII, V. (Professor) Ph.D. 1973 (Novosibirsk)
- Partial differential equations

JEFFREY, L. (Professor) Ph.D. 1992 (Oxford)
- Symplectic geometry, geometric applications of quantum field theory

JERRARD, Robert (Professor) Ph.D. 1994 (Berkeley)
- Nonlinear partial differential equations, Ginzburg-Landau theory

JURDJEVIC, V. (Professor Emeritus) Ph.D. 1969 (Case Western)
- Systems of ordinary differential equations, control theory, global analysis

KAMNITZER, Joel (Assistant Professor) Ph.D. 2005 (Berkeley)
- Geometric and combinatorial representation theory

KAPOVITCH, V. (Associate Professor) Ph.D. 1997 (University of Maryland)
- Global riemannian geometry

KARSHON, Y. (Professor) Ph.D. 1993 (Harvard)
- Equivariant symplectic geometry

KHANIN, K. (Professor) Ph.D. 1983 (Landau Institute, Moscow)
- Dynamical systems and statistical mechanics

KHESIN, B. (Professor) Ph.D. 1989 (Moscow State)
- Poisson geometry, integrable systems, topological hydrodynamics

KHOVANSKII, A. (Professor) Ph.D. 1973, Doctorat d'Etat 1987 (Steklov Institute, Moscow)
- Algebra, geometry, theory of singularities

KIM, Henry (Professor) Ph.D. 1992 (Chicago)
- Automorphic L-functions, Langlands' program

KUDLA, S. (Canada Research Chair and Professor) Ph.D. 1971 (Harvard)
- Automorphic forms, Arithmetic geometry and Theta functions

LORIMER, J.W. (Professor) Ph.D. 1971 (McMaster)
- Rings and geometries, topological Klingenberg planes, topological chain rings

McCANN, R. (Professor) Ph.D. 1994 (Princeton)
- Mathematical physics, mathematical economics, inequalities, optimization, partial differential equations

McCOOL, J. (Professor Emeritus) Ph.D. 1966 (Glasgow)
- Infinite group theory

MEINRENKEN, E. (Professor) Ph.D. 1994 (Universität Freiburg)
- Symplectic geometry

MENDELSOHN, E. (Professor) Ph.D. 1968 (McGill)
- Block designs, combinatorial structures

MILMAN, P. (Professor) Ph.D. 1975 (Tel Aviv)
- Singularity theory, analytic geometry, differential analysis

MURASUGI, K. (Professor Emeritus) D.Sc. 1960 (Tokyo)
- Knot theory

MURNAGHAN, F. (Professor) Ph.D. 1987 (Chicago)
- Harmonic analysis and representations of p-adic groups

MURTY, V.K. (Professor) Ph.D. 1982 (Harvard)
- Number theory

NABUTOVSKY, A. (Professor) Ph.D. 1992 (Weizmann Institute of Science)
- Geometry and logic

NACHMAN, A. (Professor) Ph.D. 1980 (Princeton)
- Inverse problems, partial differential equations, medical imaging

PETE, G. (Coxeter Assistant Professor) Ph.D. 2006 (UC, Berkeley)
- Probability

PUGH, M. (Associate Professor) Ph.D. 1993 (Chicago)
- Scientific computing, nonlinear PDEs, fluid dynamics, computational neuroscience

QUASTEL, J. (Professor) Ph.D. 1990 (Courant Institute)
- Probability, stochastic processes, partial differential equations

REPKA, J. (Professor) B.Sc. 1971 (Toronto), Ph.D. 1975 (Yale)
- Group representations, automorphic forms

ROONEY, P.G. (Professor Emeritus) Ph.D. 1952 (Caltech)
- Integral operators, functional analysis

ROSENTHAL, P. (Professor Emeritus) Ph.D. 1967 (Michigan)
- Operators on Hilbert spaces

ROTMAN, R. (Associate Professor) Ph.D. 1998 (SUNY, Stony Brook)
- Riemannian geometry

SCHERK, J. (Associate Professor) D.Phil. 1978 (Oxford)
- Algebraic geometry

SECO, L. (Professor) Ph.D. 1989 (Princeton)
- Harmonic analysis, mathematical physics, mathematical finance

SELICK, P. (Professor) B.Sc. 1972 (Toronto), M.Sc. 1973 (Toronto), Ph.D. 1977 (Princeton)
- Algebraic topology

SEN, D.K. (Professor Emeritus) Dr.es.Sc. 1958 (Paris)
- Relativity and gravitation, mathematical physics

SHARPE, R. (Professor Emeritus) B.Sc. 1965 (Toronto), M.Sc. 1966 (Toronto), Ph.D. 1970 (Yale)
- Differential geometry, topology of manifolds

SHERK, F.A. (Professor Emeritus) Ph.D. 1957 (Toronto)
- Finite and discrete geometry

SIGAL, I.M. (University Professor, Norman Stuart Robertson Chair in Applied Math) Ph.D. 1975 (Tel Aviv)
- Mathematical physics

SMITH, S.H. (Professor Emeritus) Ph.D. 1963 (London)
- Fluid mechanics, particularly boundary layer theory

SULEM, C. (Professor) Doctorat d'Etat 1983 (Paris-Nord)
- Partial differential equations, nonlinear analysis, numerical computations in fluid dynamics

SZEGEDY, B. (Assistant Professor) Ph.D. 2002 (Eötvös University, Budapest)
- Group theory, Combinatorics, Computer science

TALL, F.D. (Professor) Ph.D. 1969 (Wisconsin)
- Set theory and its applications, set-theoretic topology

TANNY, S.M. (Associate Professor) Ph.D. 1973 (M.I.T.)
- Combinatorics, mathematical modeling in the social sciences

TODORCEVIC, S. (Canada Research Chair and Professor) Ph.D. 1979 (Belgrade)
- Set theory and combinatorics

VIRAG, B. (Canada Research Chair and Associate Professor) Ph.D. 2000 (Berkeley)
- Probability

WEISS, W. (Professor) M.Sc. 1972 (Toronto), Ph.D. 1975 (Toronto)
- Set theory, set-theoretic topology

YAMPOLSKY, M. (Professor) Ph.D. 1997 (SUNY, Stony Brook)
- Holomorphic and low-dimensional dynamical systems

YOUNG, R. (Assistant Professor) PhD 2007 (Chicago)
- Geometric group theory, non-positive curvature, mathematical biology

3. THE GRADUATE PROGRAM

The Department of Mathematics offers graduate programs leading to Master of Science (M.Sc.) and Doctor of Philosophy (Ph.D.) degrees in mathematics, in the fields of pure mathematics and applied mathematics. Students admitted to our M.Sc. program are admitted either as "terminal master's" students or as "doctoral stream" students, the latter implying the intent of continuing on to our Ph.D. program. Students admitted to the doctoral-stream master's program are fully funded for one year at the master's level. Funding is limited to four years at the PhD level.

The M.Sc. Program

The M.Sc. program may be done on either a full- or part-time basis. Full-time students normally complete the program in one full year of study; part-time students may take up to three years to complete the program. The degree requirements are as follows:

1a. Completion of 6 half-courses (or the equivalent combination of half- and full-year courses). A current listing is available from the mathematics department website. The normal course load for full-time graduate students is 3 courses in the fall term and 3 in the spring term. Doctoral-stream students are required to take four half-course credits in core material.

1b. Completion of the Supervised Research Project (MAT 4000Y). This project is intended to give the student the experience of independent study in some area of advanced mathematics, under the supervision of a faculty member. The supervisor and the student, with the approval of the graduate coordinator decide the topic and program of study. The project is normally undertaken during the summer session, after the other course requirements have been completed, and has a workload roughly equivalent to that of a full-year course.

2. M.Sc. Thesis Option (less common than option 1). Students who take this option will be required to take and pass four half-courses and submit an acceptable thesis. A presentation of the thesis results, in the form of a seminar, is required.

The Ph.D. Program

The Ph.D. program normally takes three or four years of full-time study beyond the Master's level to complete. A Master's degree is normally a prerequisite; however, exceptionally strong B.Sc. students may apply for direct admission to the Ph.D. program. Expected progress in the program is outlined in the following table:

Year 1	Completion of course work; Pass at least 3 comprehensive exams; Select a thesis advisor.
Year 2	Supervisory committee selected by graduate coordinator; First annual supervisory committee progress report due.
Year 3	Presentation of preliminary thesis results to supervisory committee.
Year 4	Thesis Content Seminar; Departmental PhD Thesis Examination; Final PhD Thesis Examination at the School of Graduate Studies.
Year 4 – October	Students interested in academic employment after the PhD must have major thesis results ready.

1. Coursework**:** Completion of at least 6 half-courses (or the equivalent combination of half- and full-year courses) A current listing is available from the mathematics department website. Normally, 6 half-courses are taken in the first year of study (3 half-courses in the fall term and 3 in the spring term). It is strongly recommended that the student take some additional courses in other years.

2. Comprehensive Examination: The student is required to pass at least three comprehensive examinations in basic mathematics before beginning an area of specialization. The examinations in the four general areas (analysis (real and complex), algebra, topology and partial differential equations) take place during a one-week period in early September. The passing grade on these examinations is A-/80%. Exemptions from individual exams will be given if the student has obtained a grade of A- or better in the corresponding core course(s). Syllabi for the pure mathematics comprehensive exams appear in *Appendix A*. Copies of mock examination questions and/or past written examination papers are accessible to all candidates at http://www.math.toronto.edu/graduate/pce.

   Students with interests in applied mathematics should refer to Appendix B for possible alternate comprehensive exams.

   All exams are to be taken within 13 months of entering the Ph.D. program unless the Examination Committee grants permission in writing for a deferral.

3. Supervisory Committee: The purpose of the Supervisory Committee (SC) is to monitor the student's progress at least on an annual basis, keeping the following in mind.

   No supervisor is perfect! The SC may be able to offer further mathematical and further career advice beyond what the supervisor alone may offer. This is relevant both at the start of studies, when mathematical advice is most in need, and towards the end of studies, when career advice is needed.

   No student is perfect! The SC should note if a student is falling behind and should propose ways for the student to catch up, if necessary.

   While most student-supervisor relationships are cordial and productive, occasional misunderstandings, miscommunications and cases of false expectations do occur. The SC should note if a student-supervisor relationship is heading wrong and make sure that steps are taken to fix the problems.

   Ph.D. students must select a supervisor by the beginning of their second year in the Ph.D. program. In accordance with School of Graduate Studies regulations, a supervisory committee (SC) will be established for each Ph.D. student who has chosen a research area and a supervisor. This committee consists of three faculty members including the supervisor. The SC is expected to meet with the student at least annually, including on the last year of studies. Since some of the role of the SC is private and confidential, it is not appropriate to substitute these meetings with public lectures. The SC will file an annual written report with the graduate office.

Further information about general graduate supervision is available at
http://www.sgs.utoronto.ca/informationfor/students/track/superv.htm

4. Thesis: The main requirement of the degree is an acceptable thesis. This will embody an individual contribution to original research of a standard that warrants publication in the research literature. It must be written under the supervision of one or more members of the department. The student presents the thesis results in three stages.

   (i) *Thesis Content Seminar.* This is an opportunity for the student to present his/her thesis results to department members. The presentation frequently takes place within one of the regular departmental research seminars.
   (ii) *Departmental Oral Examination.* The student gives a 20-minute summary of the thesis and must defend it before a departmental examination committee. Copies of the thesis should be available two weeks before the departmental oral examination. The committee may approve the thesis without reservations, or approve the thesis on condition that revision be made, or require the student to take another departmental oral examination.
   (iii) *Final Oral Examination.* Eight weeks after the successful completion of the departmental oral, the student proceeds to the final oral examination conducted by the School of Graduate Studies. The thesis is sent to an external reader who submits a report two weeks prior to the examination; this report is circulated to members of the examination committee and to the student. The examination committee consists of four to six faculty members; it is recommended that the external reader attend the examination. The student gives a 20-minute summary of the thesis, which is followed by a question period.

5. Students are expected to become extensively involved in departmental life (seminars, colloquia and related activities).

Administration of the Graduate Program

A central administration authority called the School of Graduate Studies establishes the basic policies and procedures governing all graduate study at the University of Toronto. Detailed information about the School is obtained in its calendar, distributed to new graduate students during registration week.

The Department of Mathematics has its own graduate administrative body—the graduate committee—composed of 6-8 faculty members appointed by the chair of the department, and five graduate students elected by the Mathematics Graduate Students Association. One of the faculty members is the graduate coordinator, who is responsible for the day-to-day operation of the program. The graduate committee meets frequently throughout the year to consider matters such as admissions, scholarships, course offerings, and departmental policies pertaining to graduate students. Student members are not permitted to attend meetings at which the agenda concerns confidential matters relating to other students. Information regarding appeals of academic decisions is given in the Grading Procedures section of the Calendar of the School of Graduate Studies. Students may also consult the Graduate Coordinator (or the student member of the departmental Graduate Appeals Committee) regarding information about such appeals.

General Outline of the 2011-2012 Academic Year

Registration	August 8 – September 16, 2011
Fall Term	Monday, September 12 – Wednesday, December 7, 2011
Fall Break	Monday, November 7 and Tuesday, November 8, 2011
Spring Term	Monday, January 9 – Thursday, April 5, 2012
Reading Week	February 20 – 24, 2012

Official Holidays (University Closed):

Labour Day	Monday, September 5, 2011
Thanksgiving Day	Monday, October 10, 2011
Christmas/New Year	Wednesday, December 21, 2011 – Sunday, January 1, 2012 (inclusive)
Family Day	Monday, February 20, 2012
Good Friday	Friday, April 6, 2012
Victoria Day	Monday, May 21, 2012
Canada Day	Monday, July 2, 2012
Civic Holiday	Monday, August 6, 2012

4. GRADUATE COURSES

The following is a list and description of the core courses offered to graduate students in the 2011-2012 academic year. These are the basic beginning graduate courses. They are designed to help the student broaden and strengthen his/her general background in mathematics prior to specializing towards a thesis. A student with a strong background in the area of any of the core courses should not take that particular course. A complete listing of all graduate courses on offer in a given year is available from the mathematics department website. These include cross-listed graduate courses and topics courses. In addition, graduate students may take several intermediate (300-level) undergraduate courses (listed in the Faculty of Arts and Science Calendar) if their background is felt to be weak in some area; no graduate course credit is given for these courses.

There are three other means by which graduate students may obtain course credit, apart from completing the formal courses listed on the following pages. In each of these cases, prior approval of the graduate coordinator is required.

1. Students may take a suitable graduate course offered by another department. Normally at least two-thirds of the course requirements for each degree should be in the Mathematics Department.
2. It is sometimes possible to obtain course credit for appropriately extensive participation in a research seminar (see *Research Activities* section).
3. It is also possible to obtain a course credit by working on an individual reading course under the supervision of one of the faculty members, provided the material covered is not available in one of the formal courses or research seminars. (Note: this is distinct from the MAT 4000Y Supervised Research Project required of M.Sc. students.)

Most courses meet for three hours each week, either in three one-hour sessions or two longer sessions. For some courses, particularly those cross-listed with undergraduate courses, the times and locations of classes will be set in advance of the start of term. For other courses, the times and locations of classes will be established at organizational meetings during the first week of term, so that a time convenient for all participants may be arranged. During registration week, students should consult the math department website for class and organization meeting times and locations: http://www.math.toronto.edu/cms/tentative-2011-2012-graduate-course-timetable/

CORE COURSES

MAT 1000HF (MAT 457H1F)
REAL ANALYSIS I
A. Burchard

Measure Theory: Lebesque measure and integration, convergence theorems, Fubini's theorem, Lebesgue differentiation theorem, abstract measures, Caratheodory theorem, Radon-Nikodym theorem.

Functional Analysis: Hilbert spaces, orthonormal bases, Riesz representation theorem, compact operators, L-spaces, Holder and Minkowski inequalities.

Textbook:
Elias Stein and Rami Shakarchi, Measure Theory, Integration, and Hilbert Spaces,

References:
H.L. Royden: Real Analysis, Macmillan, 1988.
G. Folland, Real Analysis: Modern Techniques and their Applications, Wiley
A.N. Kolmogorov and S.V. Fomin: Introductory Real Analysis, 1975.
Elliott H. Lieb and Michael Loss, Analysis, AMS Graduate Texts in Mathematics, 14 (either edition)

MAT 1001HS (MAT 458H1S)
REAL ANALYSIS II
S. Alexakis

Fourier analysis: Fourier series and transform, convergence results, Fourier inversion theorem, L-theory, estimates, convolutions.

More functional analysis: Banach spaces, duals, weak topology, weak compactness, Hahn-Banach theorem, open mapping theorem, uniform boundedness theorem.

Textbook:
Elias Stein and Rami Shakarchi, Measure Theory, Integration, and Hilbert Spaces.
Elliott H. Lieb and Michael Loss, Analysis, AMS Graduate Texts in Mathematics, second edition

References:
G. Folland, Real Analysis: Modern Techniques and their Applications, Wiley.
Katznelson, Harmonic Analysis, Dover
S.D. Promislow, A First Course in Functional Analysis, Wiley, 2008.

MAT 1002HS (MAT 454H1S)
COMPLEX ANALYSIS
I. Graham

1. Review of elementary properties of holomorphic functions. Cauchy's integral formula, Taylor and Laurent series, residue calculus.
2. Harmonic functions. Poisson's integral formula and Dirichlet's problem
3. Conformal mapping, Riemann mapping theorem.
4. Analytic continuation, Monodromy Theorem, Riemann surfaces.
5. Modular functions and the Picard Theorems.
6. Other topics are possible, like product theorems, elliptic functions, and non-isolated removability theorems.

Main References:
Stein and Shakarchi: Complex Analysis
L. Ahlfors: Complex Analysis, 3rd Edition

T. Gamelin, Complex Analysis
W. Rudin, Real and Complex Analysis, 2^{nd} or 3^{rd} edition

Additional References:
Remmert: Theory of Complex Functions
Remmert: Classical Topics in Complex Function Theory
Needham: Visual Complex Analysis

MAT 1060HF
PARTIAL DIFFERENTIAL EQUATIONS I
M. Pugh

This is a basic introduction to partial differential equations as they arise in physics, geometry and optimization. It is meant to be accessible to beginners with little or no prior knowledge of the field. It is also meant to introduce beautiful ideas and techniques, which are part of most analysts' basic bag of tools. A key theme will be the development of techniques for studying non-smooth solutions to these equations.

Textbook:
L.C. Evans, "Partial Differential Equations"

MAT 1061HS
PARTIAL DIFFERENTIAL EQUATIONS II
V. Ivrii

This course will consider a range of mostly nonlinear partial differential equations, including elliptic and parabolic PDE, as well as hyperbolic and other nonlinear wave equations. In order to study these equations, we will develop a variety of methods, including variational techniques, and fixed point theorems. One important theme will be the relationship between variational questions, such as critical Sobolev exponents, and issues related to nonlinear evolution equations, such as finite-time blowup of solutions and/or long-time asymptotics.

The prerequisites for the course include familiarity with Sobolev and other function spaces, and in particular with fundamental embedding and compactness theorems.

Other topics in PDE will also be discussed.

Reference:
Lawrence Evans: Partial Differential Equations

MAT 1100HF
ALGEBRA I
D. Bar-Natan

Basic notions of linear algebra: brief recollection. The language of Hom spaces and the corresponding canonical isomorphisms. Tensor product of vector spaces.

Group Theory: Isomorphism theorems, group actions, Jordan-Hölder theorem, Sylow theorems, direct and semidirect products, finitely generated abelian groups, simple groups, symmetric groups, linear groups, nilpotent and solvable groups, generators and relations.

Ring Theory: Rings, ideals, Euclidean domains, principal ideal domains, and unique factorization domains.

Modules: Modules and algebras over a ring, tensor products, modules over a principal ideal domain.

Textbooks:
Lang: Algebra, 3rd Edition.
Dummit and Foote: Abstract Algebra, 2nd and 3rd Edition

Other References:
Jacobson: Basic Algebra, Volumes I and II.
Cohn: Basic Algebra
M. Artin: Algebra.

MAT 1101HS
ALGEBRA II
J. Kamnitzer

Fields: Algebraic and transcendental extensions, normal and separable extensions, fundamental theorem of Galois theory, solution of equations by radicals.

Commutative Rings: Noetherian rings, Hilbert basis theorem, invariant theory, Hilbert Nullstellensatz, primary decomposition, affine algebraic varieties. structure of semisimple algebras, application to representation theory of finite groups.

Textbooks:
Dummit and Foote: Abstract Algebra, 3rd Edition

Other References:
Lang: Algebra, 3rd Edition.
M. Artin: Algebra.

MAT 1300HF
TOPOLOGY I
Y. Karshon

Local differential geometry: the differential, the inverse function theorem, smooth manifolds, the tangent space, immersions and submersions, regular points, transversality, Sard's theorem, the Whitney embedding theorem, smooth approximation, tubular neighborhoods, the Brouwer fixed point theorem.

Differential forms: exterior algebra, forms, pullbacks, integration, Stokes' theorem, div grad curl and all, Lagrange's equation and Maxwell's equations, homotopies and Poincare's lemma, linking numbers.

Prerequisites**:** linear algebra; vector calculus; point set topology

Textbook:
John M. Lee: Introduction to Smooth Manifolds

MAT 1301HS
TOPOLOGY II
R. Rotman

Fundamental groups: paths and homotopies, the fundamental group, coverings and the fundamental group of the circle, Van-Kampen's theorem, the general theory of covering spaces.

Homology: simplices and boundaries, prisms and homotopies, abstract nonsense and diagram chasing, axiomatics, degrees, CW and cellular homology, subdivision and excision, the generalized Jordan curve theorem, salad bowls and Borsuk-Ulam, cohomology and de-Rham's theorem, products.

Textbook:
Allen Hatcher, Algebraic Topology

Recommended Textbooks:
Munkres, Topology
Munkres, Algebraic Topology

2011-12 TOPICS COURSES AND CROSS-LISTED UNDERGRADUATE/GRADUATE COURSES

A listing is available from the graduate website: http://www.math.utoronto.ca/cms/tentative-2011-2012-graduate-course-descriptions/

INDIVIDUAL READING COURSES

Students requiring individual course numbers:

MAT 1900Y/1901H/1902H
READING IN PURE MATHEMATICS
Numbers assigned for students wishing individual instruction in an area of pure mathematics.

MAT 1950Y/1951H/1952H
READING IN APPLIED MATHEMATICS
Numbers assigned for students wishing individual instruction in an area of applied mathematics.

COURSE IN TEACHING TECHNIQUES

The following course is offered to help train students to become effective lecturers. It is not for degree credit and is not to be offered every year.

MAT 1499HS
TEACHING LARGE MATHEMATICS CLASSES
J. Repka

The goals of the course include techniques for teaching large classes, sensitivity to possible problems, and developing an ability to criticize one's own teaching and correct problems.

Assignments will include such things as preparing sample classes, tests, assignments, course outlines, designs for new courses, instructions for teaching assistants, identifying and dealing with various types of problems, dealing with administrative requirements, etc.

The course will also include teaching a few classes in a large course under the supervision of the instructor. A video camera will be available to enable students to tape their teaching for later (private) assessment.

COURSES FOR GRADUATE STUDENTS FROM OTHER DEPARTMENTS

(Math graduate students cannot take the following courses for graduate credit.)

MAT 2000Y READINGS IN THEORETICAL MATHEMATICS
MAT 2001H READINGS IN THEORETICAL MATHEMATICS I
MAT 2002H READINGS IN THEORETICAL MATHEMATICS II

(These courses are used as reading courses for engineering and science students in need of instruction in special topics in theoretical mathematics. These course numbers can also be used as dual numbers for some third and fourth year undergraduate mathematics courses if the instructor agrees to adapt the courses to the special needs of graduate students. A listing of such courses is available in the 2011-2012 Faculty of Arts and Science Calendar. Students taking these courses should get an enrolment form from the graduate studies office of the Mathematics Department. Permission from the instructor is required.)

PROFESSIONAL DEVELOPMENT PROGRAMS OFFERED BY SGS

English Language and Writing Support (ELWS)
The English Language and Writing Support program, at the School of Graduate Studies, offers individual consultations, single-session workshops, and free non-credit courses for both native and non-native speakers of English. Information and registration:
http://www.sgs.utoronto.ca/informationfor/students/english.htm

Graduate Professional Skills Program (GPS)
The Graduate Professional Skills program (GPS) is a new initiative from the School of Graduate Studies to help doctoral-stream graduate students become fully prepared for their future. It focuses on skills beyond those conventionally learned within a disciplinary program, skills that may be critical to success in the wide range of careers that graduates enter, both within and outside academe. GPS can help you to communicate effectively, plan and manage your time, be entrepreneurial, understand and apply ethical practices, and work effectively in teams and as leaders. The GPS consists of a range of optional "offerings" with a time commitment roughly equivalent to 60 hours of work. Its successful completion will be recognized by a transcript notation. For more information: http://www.sgs.utoronto.ca/informationfor/students/profdev/gps.htm.

5. RESEARCH ACTIVITIES

The Department of Mathematics offers numerous research activities, in which graduate students are encouraged to participate. Research seminars are organized informally at the beginning of each year by one or more faculty members and/or students, and are offered to faculty and graduate students on a weekly basis throughout the year. The level and specific content of these seminars varies from year to year, depending upon current faculty and student interest, and upon the availability and interests of invited guest lecturers. The following research seminars were offered in the past year:

Algebra and Geometry Seminar
Analysis and Applied Math Seminar
Category O Learning Seminar
CoolStuff Seminar
DG Categories Learning Seminar
Dynamics Seminar
Fields Analysis Working Group Seminar
Fields Colloquium/Seminar in Applied Math
Ganita Seminar
Geometric Representation Theory Seminar
Geometry and Topology Seminar
Graduate Student Seminar

Homological Methods Seminar
Math Union
Number Theory/Representation Theory Seminar
Operator Theory Seminar
Physics/Fields Colloquium
Probability Study Group
Symplectic Seminar
Toronto Probability Seminar
Toronto Set Theory Seminar
Working Group in Hamiltonian Systems
Women in Mathematics

In addition to the weekly seminars, there are numerous special seminars throughout the year, a series of colloquia, and an active program of visiting lecturers:

Departmental Colloquium
Blyth Lecture Series

Graduate students are also encouraged to attend lectures and seminars offered by other departments.

6. ADMISSION REQUIREMENTS AND APPLICATION PROCEDURES

Due to the large numbers of applications received in the Department of Mathematics each year, serious consideration will only be given to applicants with strong backgrounds in theoretical mathematics and with first class academic standing.

Application materials and admission requirements are available from the Department of Mathematics website: http://www.math.utoronto.ca/cms/potential-students-grad/

Please read all instructions carefully and note the deadlines. In addition, the Department of Mathematics requires three letters of reference. The letters must be from *three* people familiar with your mathematical work, giving their assessment of your potential for graduate study and research in mathematics.

It is essential that all incoming graduate students have a good command of English. Facility in the English language must be demonstrated by all applicants educated outside Canada whose primary language is not English. This requirement is a condition of admission and should be met before application. Here are three ways to satisfy this requirement: (1) Test of English as a Foreign Language (TOEFL): (a) internet-based test (iBT), minimum score of 22/30 for both the Writing and Speaking sections, with an overall minimum TOEFL score of 93/120, or (b) paper-based test, minimum score 580, with TWE (Test of Written English), minimum score 5.0; (2) a score of at least 85 on the Michigan English Language Assessment Batter (MELAB); (3) a score of at least 7.0 on the International English Language Testing Service (IELTS). Applicants are required to satisfy this requirement by January 22, so that scores are available at the time applications are considered.

Suggested prerequisites*:*

We recognize that our students come from many different places and with a significant range of differing backgrounds. Hence there is no fixed and rigid list of prerequisites, and applicants are considered and often admitted even if their formal previous mathematical education is very different from the informal list of prerequisites below. **In general, we'd like to see some sort of overall mathematical maturity and experience, and we appreciate (though we do not require) evidence of in-depth concentration in one mathematical discipline or another.**

Yet here's a non-binding list of courses that are recommended to applicants from within the University of Toronto in order to be seriously considered for the doctoral stream master's program. Students coming from other institutions will have to make the appropriate substitutions:

2^{nd} year Advanced ODE's, e.g. MAT 267H

Approximate syllabus: First-order equations. Linear equations and first-order systems. Non-linear first-order systems. Existence and uniqueness theorems for the Cauchy problem. Method of power series. Elementary qualitative theory; stability, phase plane, stationary points. Examples of applications in mechanics, physics, chemistry, biology and economics.

3^{rd} year Real Analysis, e.g. MAT 357H

Approximate syllabus: Function spaces; Arzelà-Ascoli theorem, Weierstrass approximation theorem, Fourier series. Introduction to Banach and Hilbert spaces; contraction mapping principle, fundamental existence and uniqueness theorem for ordinary differential equations. Lebesgue integral; convergence theorems, comparison with Riemann integral, L^p spaces. Applications to probability.

3^{rd} year Complex Analysis, e.g. MAT 354H

Approximate syllabus: Complex numbers, the complex plane and Riemann sphere, Möbius transformations, elementary functions and their mapping properties, conformal mapping, holomorphic functions, Cauchy's theorem and integral formula. Taylor and Laurent series, maximum modulus principle, Schwarz's lemma, residue theorem and residue calculus.

3^{rd} year Algebra, e.g. MAT 347Y

Approximate syllabus: Groups, subgroups, quotient groups, Sylow theorems, Jordan-Hölder theorem, finitely generated abelian groups, solvable groups. Rings, ideals, Chinese remainder theorem; Euclidean domains and principal ideal domains: unique factorization. Noetherian rings, Hilbert basis theorem. Finitely generated modules. Field extensions, algebraic closure, straight-edge and compass constructions. Galois theory, including insolvability of the quintic.

3^{rd} year Topology, e.g. MAT 327H

Approximate syllabus: Metric spaces, topological spaces and continuous mappings; separation, compactness, connectedness. Topology of function spaces. Fundamental group and covering spaces. Cell complexes, topological and smooth manifolds, Brouwer fixed-point theorem.

In addition to that we also value some ability in computer programming and some background in physics (though neither is required).

Likewise here's a non-binding list of courses that are recommended to applicants from within the University of Toronto in order to be seriously considered for the terminal master's program. Students coming from other institutions will have to make the appropriate substitutions:

Linear Algebra, e.g. MAT 224

Approximate syllabus: Abstract vector spaces: subspaces, dimension theory. Linear mappings: kernel, image, dimension theorem, isomorphisms, matrix of linear transformation. Changes of basis, invariant spaces, direct sums, cyclic subspaces, Cayley-Hamilton theorem. Inner product spaces, orthogonal transformations, orthogonal diagonalization, quadratic forms, positive definite matrices. Complex operators: Hermitian, unitary and normal. Spectral theorem. Isometries of R^2 and R^3 .

Groups and Symmetries, e.g. MAT 301

Approximate syllabus: Congruences and fields. Permutations and permutation groups. Linear groups. Abstract groups, homomorphisms, subgroups. Symmetry groups of regular polygons and Platonic solids, wallpaper groups. Group actions, class formula. Cosets, Lagrange's theorem. Normal subgroups, quotient groups. Classification of finitely generated abelian groups. Emphasis on examples and calculations.

Complex Variables, e.g. MAT 334

Approximate syllabus: Theory of functions of one complex variable, analytic and meromorphic functions. Cauchy's theorem, residue calculus, conformal mappings, introduction to analytic continuation and harmonic functions.

Real Analysis, e.g. MAT 337

Approximate syllabus: Metric spaces; compactness and connectedness. Sequences and series of functions, power series; modes of convergence. Interchange of limiting processes; differentiation of integrals. Function spaces; Weierstrass approximation; Fourier series. Contraction mappings; existence and uniqueness of solutions of ordinary differential equations. Countability; Cantor set; Hausdorff dimension.

7. FEES AND FINANCIAL ASSISTANCE

Fees

Listed below are the fees for the 2010-11 academic session, including incidental fees and the health insurance premium for visa students. The university has not yet published a listing of fees for 2011-12. For detailed information, visit http://www.fees.utoronto.ca/

Domestic Degree Students	**Academic Fees**	**Incidental Fees**	**Total Fees**
Full-time	$6,621	$1,118	$7,739
Full-time, one-session only	$3,311	$582	$3,892
Part-time	$1,987	$350	$2,336
Part-time, one-session only	$994	$198	$1,191

Domestic Non-Degree Special Students	**Academic Fees**	**Incidental Fees**	**Total Fees**
0.5 course-load	$994	$350	$1,343
1.0 course-load	$1,987	$350	$2,336

International Degree Students	**Academic Fees**	**Incidental Fees**	**Total Fees***
Full-time	$15,316	$1,128	$17,154
Full-time, one-session only	$7,658	$582	$8,960
Part-time	$4,595	$350	$5,664
Part-time, one-session only	$2,298	$198	$3,215

Intl Non-Degree Special Students	**Academic Fees**	**Incidental Fees**	**Total Fees***
0.5 course-load	$2,298	$350	$3,367
1.0 course-load	$4,595	$350	$5,664

- includes University Health Insurance Premium (UHIP)

Financial Assistance

Below is a list of those types of financial assistance most commonly awarded to mathematics graduate students in 2010-11. This information should also be applicable for students who wish to apply for the 2011-12 academic year; the deadlines for applications will be altered slightly in accordance with the 2011-12 calendar. Some awards are available from external funding agencies; others come from within the University.

Less common scholarships, offered by smaller or foreign funding agencies, are also available; information about these may be found at http://www.sgs.utoronto.ca/informationfor/students/money.htm .

Vanier Canada Graduate Scholarships (Vanier CGS) Program
Value: $50,000 per annum for a maximum of 3 years

Eligibility: a student must be nominated by a Canadian university. Vanier Scholarships must be held by the student at the university that nominated them. The scholarships are not transferable: they may not be taken to another university Applicants do not have to be registered as doctoral students at the time of application, but must be registered as doctoral students at a Canadian university when they take up the Vanier Scholarship. Canadian citizens, landed immigrants (permanent residents), and international students are all eligible for Vanier Scholarships Students who have held or are currently holding Tri-Agency scholarship funding for their doctoral program are not eligible to apply.
Application:* *http://www.vanier.gc.ca/
Deadline: early September. Consult department for deadline.

Natural Sciences and Engineering Research Council (NSERC) Postgraduate Scholarships and Canada Graduate Scholarships
Value: approx. $17,300-$35,000 for a twelve month period
Eligibility: Canadian citizens, permanent residents; first class academic standing; full-time attendance
Application: apply through the university you are currently attending; application available at www.nserc.ca
Deadline: early October. Consult department for deadline.

Ontario Graduate Scholarships (OGS)
Value: approx. $5,000 per term for two or three terms
Eligibility: no citizenship restrictions; first class academic standing; full-time attendance at an Ontario university
Application: apply through the university you are currently attending or contact the OGS office in Thunder Bay, Ontario directly at 1-800-465-3957 (https://osap.gov.on.ca/OSAPPortal/en/A-ZListofAid/TCONT003465.html).
Deadline: mid October. Consult department for deadline.

Queen Elizabeth II Graduate Scholarship in Science and Technology (QEII-GSST)
Value: approx. $15,000 for a twelve month period
Eligibility: Canadian citizens, permanent residents; first class academic standing; full-time attendance
Application: OGS application (see above).
Deadline: mid October. Consult department for deadline.

University of Toronto Fellowships
Value: minimum $1,000
Eligibility: no citizenship restrictions; at least an A- average; full-time attendance at the University of Toronto
Application: graduate school applicants will be considered automatically
Deadline: January 15

Connaught Scholarship (entrance scholarship for doctoral students)
Value: $35,000 plus full fees for each of 4 years
Eligibility: international students only
Application: international graduate school applicants will be considered automatically
Deadline: January 15

Research Assistantships
Value: a limited amount of funds is available for academically worthy students
Eligibility: no citizenship restrictions; full-time attendance; high academic standing
Application: graduate school applicants will be considered automatically
Deadline: January 15

Teaching Assistantships
Value: $38.76 per hour; number of hours per week will not exceed a maximum average of 8
Eligibility: full-time students who are accepted by the Mathematics Department (subject to satisfactory performance); may be held in conjunction with other awards
Application: forms available in May from the Graduate Office, Department of Mathematics
Deadline: early June

Doctoral Thesis Completion Award (DCA)
Value: $10,000 plus a full tuition fee waiver for one year only
Eligibility: The DCA is run as a competition and is available for doctoral students in the first and second year beyond the funded cohort; no citizenship restrictions
Application and information:
http://www.sgs.utoronto.ca/Assets/SGS+Digital+Assets/2011-2012+DCA+Information+Sheet_FINAL_Updated+April+7.pdf
Deadline: Spring; consult department for deadline

Conference Travel Grant
An important part of the research process is the presentation of one's work at scholarly conferences. The purpose of this program is to provide additional funds to enable graduate students in the Faculty of Arts and Science to travel to conferences where they will present their work.
Value: varies to a maximum of $1,000
Eligibility: no citizenship restrictions; award holders must be doctoral students in the funded cohort. Graduate students may hold only one Travel Grant during their time in the department.
Eligible Expenses: Conference registration and abstract submission costs, travel and living expenses.
Application: Applications available from the Math Graduate Office; deadline October 1.
Selection Criteria: Past academic performance, need to attend conference for professional development, quality of abstract. Preference will be given to students near the end of their degrees.

Department of Mathematics Policy on Financial Support of Graduate Students

Ph.D. Students: At the time of admission to the Ph.D. program, students will normally be guaranteed support for a period of four years (five years in the case of students admitted directly from a Bachelor's program), except that students who complete their degree requirements earlier will not be supported past the end of the academic year in which they finish. This guarantee will be made up of a mix of fellowships (including external awards such as NSERC, OGS), teaching assistantships and other sources of funding, at the discretion of the Department; and is subject to satisfactory academic progress, the maintenance of good standing, and in the case of teaching assistantships, satisfactory performance in that role, as judged by the Department. Absent this, support may be reduced, suspended, or discontinued.

In exceptional circumstances some funding may be provided to students in a subsequent year, but the Department expects that students will normally have completed their degree requirements within the four year period.

M.Sc. Students: Students who are granted provisional admission to the Ph.D. program at the time of admission will receive financial support, for one year only.
All full-time students in the first or second year of a Master's program are eligible for teaching assistant work (subject to availability and satisfactory performance).

8. OTHER INFORMATION

The Department of Mathematics is located in the heart of the University of Toronto, which in turn is located in the heart of downtown Toronto. Students therefore have access to a wide range of facilities and services. A list of these appear below.

Facilities and Services

Library Facilities

The University of Toronto Library system is the 4th largest academic research library in North America. It contains over 4 million print volumes as well as a vast assortment of electronic resources. The Mathematical Sciences Library (MSL) is in the same building as the Mathematics Department. The majority of mathematics journals held by the University of Toronto are housed in the MSL, with some being held in the Gerstein Science Information Centre. The MSL's collection also contains over 20,000 books. The MSL website includes an interface with the

UofT catalogue that includes the collections of all the libraries on the St. George, Mississauga, and Scarborough campuses and includes links to online books, journals and abstract and indexing databases including MathSciNet. The MSL offers a wireless environment with study spaces for research. Each graduate student in mathematics receives a photocopying allowance. The Gerstein Science Information Centre also has a comprehensive collection of mathematics books up to 1998.

St. George T-Card Office
North lobby, Room 2054A, 2nd floor
Robarts Library, 130 St. George Street
tcard.office@utoronto.ca
416-946-8047
http://www.utoronto.ca/tcard/

- University of Toronto TCard is a photo ID smartcard which provides identification for academic purposes, student activities and services, facility access and a Library Card.

Mathematics Library
40 St. George Street, Room 6141
Toronto, Ontario M5S 3G3
416-978-8624
416-978-4107 (Fax)
mathlib@math.toronto.edu
http://www.library.utoronto.ca/math/

- Hours: M-F, 9 – 5; Summer hours: M-F, 9 – 4:30

Gerstein Science Information Centre
7 - 9 King's College Circle
Toronto, Ontario M5S 1A5
Phone: 416-978-2280
Fax: 416-971-2848
ask.gerstein@utoronto.ca
http://www.library.utoronto.ca/gerstein

Computer Facilities

All faculty and graduate students can request accounts on the main departmental server and the departmental compute server (these servers are quad-processor IBM x3550 M3 servers with 16GB of RAM running Red Hat Enterprise Linux 5). These accounts give access to electronic mail facilities, which are also remotely accessible via IMAPS or webmail, to the internet including the ability to put a webpage on the departmental webserver, many mathematical software packages (for example, Maple, Matlab, Mathematica, pari/gp, octave), scientific and other graphics programs (most of the symbolic manipulators, gimp), software compilers (supporting, for example, fortran77, fortran95, C, C++, java), a rich mathematical software library, mathematical typesetting programs (TeX, LaTeX), etc. There are wiki and blog servers available to users. There is a public Computer Room (BA6200) in addition to machines in individual offices. University managed wireless connectivity is available for most people in the department.

Applications for math department computer accounts are available from the Mathematics Graduate Office.

Housing

The university operates five graduate student residences-apartment complexes on or near the campus, ranging from unfurnished family apartments to the more conventional bed-and-board residences. In addition, the University Housing Service provides a listing of privately owned rooms, apartments and houses available for students to rent.
Students should keep in mind that accommodation could be expensive and limited, particularly in downtown Toronto. It is therefore advisable to make inquiries well in advance and to arrive in Toronto a few days prior to the start of term. Students can expect to pay anywhere between $500 to $900 per month on accommodation and from $300 to $500 per month on food, travel and household necessities.

University Housing Service
214 College Street, 1st Floor
Toronto, Ontario M5T 2Z9
416-978-8045
416-978-1616 (Fax)
housing.services@utoronto.ca
http://www.housing.utoronto.ca

Health Services

The University of Toronto Health Service offers medical services and referrals to private physicians for University of Toronto students. Most of these services are free of charge if you are covered under Ontario Health Coverage (OHIP), or the University Health Insurance Plan (UHIP) for visa students. OHIP application forms and information are available from the University Health Services.
UHIP coverage for visa students is compulsory and is arranged during registration at the Centre for International Experience

University Health Service
214 College Street, 2nd Floor
Toronto, Ontario M5T 2Z9
416-978-8030
416-978-2089 (Fax)
http://www.healthservice.utoronto.ca/

- Medical assistance for University of Toronto students
- Application forms for Ontario Health Coverage

Centre for International Experience (formerly known as the International Student Centre)
Cumberland House, 33 St. George Street
416-978-2564
416-978-4090 (Fax)
http://cie.utoronto.ca/

- University Health Insurance Plan (UHIP) registration at Cumberland House

Students with Disabilities

Services and facilities for students with disabilities are available at the University of Toronto. The University of Toronto's Accessibility Services facilitates the inclusion of students with hidden or obvious disabilities and health conditions into university life Services are provided to students with a documented disability, be it physical, sensory, a learning disability or a mental health condition, temporary or long-term.

Accessibility Services
Location 1: 1st Floor, Robarts Library, 130 St. George Street, Toronto, ON M5S 3H1
Voice: 416-978-8060
Fax: 416-978-8246
TTY: 416-978-1902
Email: accessibility.services@utoronto.ca
Location 2: 215 Huron Street, 9th Floor, Room 939 Toronto, ON M5S 1A2
Voice: 416 978-7677
Fax: 416 978-5729
TTY: 416 978-1902
Email: as.huronstreet@utoronto.ca
http://www.accessibility.utoronto.ca

International Students

The Centre for International Experience (CIE) offers many services to international students, including an orientation program in late August – early September, individual counselling whenever appropriate, and an English language program. In addition, the CIE contacts all foreign students once they have been accepted into the graduate program, to provide information and advice concerning immigration procedures (visa and student authorization forms), employment restrictions and authorization while in Canada, and other relevant matters.
Centre for International Experience (formerly known as the International Student Centre)
Cumberland House, 33 St. George Street, and Koffler Student Centre, Room 201, 214 College Street
416-978-2564
416-978-4090 (Fax)
http://cie.utoronto.ca/

- Serves international students coming to U of T and domestic students looking to go abroad
- University Health Insurance Plan (UHIP) registration at Cumberland House

Athletics & Recreation

A wide range of athletic facilities are available within the university, including an arena and stadium, playing fields, swimming pools, squash, tennis, badminton, volleyball and basketball courts, running tracks, archery and golf ranges, fencing salons, exercise and wrestling rooms, dance studios, saunas, lockers and a sports store. Instruction courses, exercise classes and fitness testing are regularly offered, and there is an extensive intramural program with several levels of competition in more than 30 sports.
Other recreational activities and facilities are also available within the university, such as theatre, music, pubs, dances, art exhibitions, a wide range of clubs, debates lectures and seminars, reading rooms, cafeterias and chapels.
University of Toronto students also enjoy easy access (walking distance or only a few minutes by subway) to symphony concerts, theatres, ballet, operas, movies, restaurants and shopping.

The Athletic Centre
55 Harbord Street
Toronto, Ontario M5S 2W6
416-978-3437
416-978-6978 (Fax)
www.athletics.utoronto.ca

- Multi-use health and fitness facility
- Members of the Athletic Centre also enjoy access to the state-of-the-art facilities at the new Varsity Centre, located at 299 Bloor Street West.
- All U of T students are automatically members of the Athletic Centre and Varsity Centre.

Hart House
7 Hart House Circle
Toronto, Ontario M5S 3H3
416-978-2452
inquiries@harthouse.ca
http://www.harthouse.ca

- University of Toronto centre for arts, culture and recreation

Graduate Student Associations

Every graduate student at the University of Toronto is automatically a member of the Graduate Student Union (GSU). Graduate students in the Department of Mathematics are also members of the Mathematical Graduate Students Association (MGSA). Between them, these associations sponsor many events every year, including parties, pubs, dances, outings and more serious endeavours such as seminars and lectures.

Mathematics Graduate Student Union
Department of Mathematics
40 St. George Street, Room 6290
mgsa@math.utoronto.ca
http://www.math.toronto.edu/mgsa/

Graduate Students' Union
16 Bancroft Avenue
Toronto, Ontario M5S 1C1
416-978-2391, 416-946-8699
info@utgsu.ca
http://www.utgsu.ca
Health and Dental Insurance Office***: 416-978-8465 / health@utgsu.ca***

- The Graduate Students' Union at the University of Toronto represents over 17,000 students studying in over 80 departments. It advocates for increased student representation, funding, and provided services such as health insurance, confidential advice, and a voice for the graduate student body on the various committees of the University.

Other Contacts and Sources of Information

Mathematics Graduate Office
Department of Mathematics
University of Toronto
40 St. George St., Room 6166
Toronto, Ontario M5S 2E4
416-978-7894
416-978-4107 (Fax)
grad-info@math.toronto.edu
http://www.math.utoronto.ca/cms/graduate-program/

- all matters relating to graduate studies in mathematics at the University of Toronto
- Office Hours: M-F, 9-5

School of Graduate Studies
University of Toronto
63 St. George Street
Toronto, Ontario
Canada M5S 2Z9
416-978-5369
416-978-4367 (Fax)
graduate.information@utoronto.ca
http://www.sgs.utoronto.ca

- general information concerning graduate studies at the University of Toronto
- services include confirmation of registration letters, confirmation of degree letters, legal status changes, legal name changes
- Office Hours: M-F, 10-4

Fees Department
Office of the Comptroller
University of Toronto
215 Huron Street, 3rd Floor
Toronto, Ontario M5S 1A1
416-978-2142
416-978-2610 (Fax)
fees@finance.utoronto.ca
www.**fees**.**utoronto**.ca

- enquiries concerning fees
- payment of fees

Sexual Harassment Office
University of Toronto
3rd Floor, 40 Sussex Avenue
416-978-3908
http://www.utoronto.ca/sho/

- Students are covered by the Sexual Harassment Policy while on university premises or carrying on a university-related activity. Complaints and requests for information are confidential.

Human Resources Development Canada (HRDC)
25 St. Clair Avenue East, 1st Floor
1-800-206-7218

- To obtain a Social Insurance Number (in person only). Office hours: Monday-Friday, 08:30-16:00
- Application form available from http://www.servicecanada.gc.ca/cgi-bin/search/eforms/index.cgi?app=prfl&frm=nas2120&ln=eng Supporting documentation must be original, e.g. student authorization and an offer of employment letter
- Takes an average of 4 weeks to process

APPENDIX A: COMPREHENSIVE EXAMINATION SYLLABI

Algebra
1. Linear algebra. Students will be expected to have a good grounding in linear algebra, vector spaces, dual spaces, direct sum, linear transformations and matrices, determinants, eigenvectors, minimal polynomials, Jordan canonical form, Cayley-Hamilton theorem, symmetric, alternating and Hermitian forms, polar decompositon.
2. Group Theory. Isomorphism theorems, group actions, Jordan-Hölder theorem, Sylow theorems, direct and semidirect products, finitely generated abelian groups, simple groups, symmetric groups, linear groups, nilpotent and solvable groups, generators and relations.
3. Ring Theory. Rings, ideals, rings of fractions and localization, factorization theory, Noetherian rings, Hilbert basis theorem, invariant theory, Hilbert Nullstellensatz, primary decompositon, affine algebraic varieties.
4. Modules. Modules and algebras over a ring, tensor products, modules over a principal ideal domain, applications to linear algebra, structure of semisimple algebras, application to representation theory of finite groups.
5. Fields. Algebraic and transcendental extensions, normal and separable extensions, fundamental theorem of Galois theory, solution of equations by radicals.

No reference is provided for the linear algebra material.
References for the other material:
Dummit & Foote: *Abstract Algebra,* Chapters 1-14 (pp. 17-568).
Alperin & Bell: *Groups and Representations,* Chapter 2 (pp. 39-62), 5, 6 (pp. 107-178).

Complex Analysis
1. Review of elementary properties of holomorphic functions. Cauchy's integral formula, Taylor and Laurent series, residue calculus.
2. Harmonic functions. Poisson integral formula and Dirichlet's problem.
3. Conformal mapping, Riemann mapping theorem.
4. Analytic continuation, monodromy theorem, little Picard theorem.

L. Ahlfors, *Complex Analysis,* Third Edition, McGraw-Hill, Chapters 1-4, 5.1, 5.5, 6.1, 6.2, 6.3.
W. Rudin, *Real and Complex Analysis,* Second Edition, Chapter 16 (except 16.4-16.7).
Note: The material in Ahlfors can largely be replaced by Chapters 10, 11, 12.1-12.6, and 14 of Rudin. But Ahlfors is the official syllabus for this material. The second edition of Ahlfors can be used if it is noted that Section 5.5 in the third edition is Section 5.4 in the second edition.)

Real Analysis
References:
H.L. Royden, *Real Analysis,* Third Edition, Prentice Hall, 1988.
Gerald B. Folland, Real Analysis, Modern Techniques and Their Applications, John Wiley & Sons, 1984.
Yitzhak Katznelson, An Introduction to Harmonic Analysis, Dover, 1976.
1. Background: Royden, Chapters 1 and 2; Folland (Prologue).
2. Basic Measure Theory: Royden, Chapters 3 and 4, for the classical case on the real line (which contains all the basic ideas and essential difficulties), then Chapter 11, Sections 1-4, for the general abstract case; Folland, Chapters 1 and 2.
3. Differentiation: Royden, Chapter 5, for the classical case, then Chapter 11, Sections 5 and 6 for the general case; Folland, Chapter 3 (For differentiation on $|^n$ one can restrict the attention to the one dimensional case, which contains all the basic ideas and essential difficulties.)
4. Basic Functional Analysis: Royden, Chapter 10, Sections 1,2,3,4,8; Folland, Chapter 5, Sections 1,2,3,5.
5. L^p -Spaces: Royden, Chapter 6 for the classical case, and Chapter 11, Section 7 for the general case, Chapter 13, Section 5 for the Riesz Representation Theorem; Folland, Chapter 6, Sections 1 and 2, Chapter 7, Section 1.
6. Harmonic Analysis: Katznelson, Chapter 1, Chapter 2, Sections 1 and 2, and Chapter 6, Sections 1 to 4; Folland, Chapter 8, Sections 1,2,3,4,5, and 8. One can restrict the attention to the one dimensional case, as done in Katznelson.

Topology

1. local differential geometry: the differential, the inverse function theorem, smooth manifolds, the tangent space, immersions and submersions, regular points, transversality, Sard's theorem, the Whitney embedding theorem, smooth approximation, tubular neighborhoods, the Brouwer fixed point theorem.
2. differential forms: exterior algebra, forms, pullbacks, d, integration, Stokes' theorem, div grad curl and all, Lagrange's equation and Maxwell's equations, homotopies and Poincare's lemma, linking numbers.
3. fundamental groups: paths and homotopies, the fundamental group, coverings and the fundamental group of the circle, Van-Kampen's theorem, the general theory of covering spaces.
4. homology: simplices and boundaries, prisms and homotopies, abstract nonsense and diagram chasing, axiomatics, degrees, CW and cellular homology, subdivision and excision, the generalized Jordan curve theorem, salad bowls and Borsuk-Ulam, cohomology and de-Rham's theorem, products.

Partial Differential Equations

Note: This is meant to be an exam syllabus not a course outline.
As such, topics are not necessarily ordered as in a logical development.

1) ***Basic Notions in Ordinary Differential Equations:*** Fundamental theorem on existence and uniqueness of solutions of y' = f(x,y) when f is Lipschitz w.r.t. y. Fixed point theorem, Picard iterates. (Various topics in PDE will also assume familiarity with undergraduate ODE material.)
2) Basic Notions in Linear Partial Differential Equations
   a) ***Elliptic PDEs:*** *Laplacian*: fundamental solution, properties of harmonic functions, Dirichlet and Neumann problems, Green's function, Poisson kernel representation for solution of Dirichlet problem on the unit disk in $\R^2$, Fourier series, Poisson's equation. *Weak solutions of second order elliptic PDE*: Lax-Milgram Theorem, ellipticity, energy estimates. *Regularity of weak solutions*: interior and at the boundary. *Maximum principle*: weak, strong, Harnack inequality *Eigenvalues for second order linear elliptic operators*.
   b) ***Parabolic PDEs:*** Heat Equation, fundamental solution of the heat equation, mean value property, maximum principle, regularity properties, initial value problem for the heat equation, semigroups, gradient flows
   c) ***Hyperbolic PDEs***: Wave equation, fundamental solution of the wave equation, spherical means, Huygen's principle, conservation of energy, finite speed of propagation, initial value problem for the wave equation, other hyperbolic PDEs.
3) Distributions; Fourier Transform
4) ***Sobolev spaces; Weak Solutions:*** Weak derivatives, Sobolev spaces $W^{k,p}$, L^2 based fractional Sobolev spaces H^s, Approximation properties, Extensions, Traces, Sobolev inequalities, Poincaré lemma *Weak solutions and regularity theory is enmeshed with the topics on the exam.*
5) ***Nonlinear PDEs*****:** *First-Order***:** Method of characteristics, Hamilton-Jacobi equations, Conservation laws, weak solutions, shocks and rarefactions, uniqueness and entropy solutions, *Second-Order:* gradient flows, linearization around special solutions, vanishing viscosity limit of Burger's equation.
6) ***Calculus of variations*****:** direct methods, convexity, weak-* continuity and compactness, first and second variations, Euler-Lagrange equation, Lagrange multipliers, constraints

<u>*References:*</u>

V. I. Arnold: Ordinary differential equations 1992
L.C. Evans: Partial differential equations 1998
G.B. Folland: Introduction to partial differential equations 1995
W. Hurewicz: Lectures on ordinary differential equations 1990

APPENDIX B: APPLIED MATH COMPREHENSIVE EXAMINATION SYLLABI

A student planning to specialize in applied mathematics must pass three comprehensive exams, at least two of which are a general written exam (algebra, analysis (real and complex), topology, or partial differential equations (PDE I and PDE II)). The following are samples of other exam topics.

Combinatorics

1) ***Enumeration****:* Ordinary and exponential generating functions. Difference equations and recursions. Partition and permutations. Polya counting, Fruchts Theorem, systems of distinct representatives.
2) ***Graph Theory***: Trees, connectivity, bipartite graphs, minimal spanning trees, Eulerian and Hamiltonian graphs, travelling salesman and chinese postman problems, matchings, chromatic number, perfect graphs.
3) ***Design Theory***: Definitions, examples, finite fields, finite affine and projective spaces, Fisher's inequality, symmetric designs, statement of Wilson's Theorem and Wilson's Fundamental Construction.
4) ***Coding Theory***: Linear codes, sphere packing, Hamming and Plotkin bounds, perfect codes, polynomial over finite fields.
5) ***Algorithms and Complexity****:* Algorithms for listing permutations, combinations, subsets. Analysis of algorithms, basic concepts such as NP, and #P, and NPC.

References:

P.J. Cameron: *Combinatorics: Topics, Techniques Algorithms,* Cambridge Univ. Press, ISBN 0521457610.

Control Theory and Optimization

1) ***Control Theory***: Qualitative properties of the reachable sets, Lie bracket and Lie determined systems, linear theory, stability and feedback. (*Reference*: V. Jurdjevic: *Geometric Control Theory,* Cambridge University Press, Chapters 1,2 and 3)
2) ***Optimal Control***: Linear-quadratic problems, symplectic form, Lagrangians, the Riccati equation, the Maximum Principle and its relation to the calculus of variations. (*Reference*: V. Jurdjevic: *Geometric Control Theory,* Cambridge University Press, Chapters 7, 8 ,11)
3) ***Linear Programming***: Convex analysis, simplex algorithm, duality, computational complexity and Karmarkar's Algorithm. (*Reference*: Bazaraa, Jarvis & Sherali: *Linear Programming and Network Flows,* Wiley, 1990, Chapters 2,3,4,6,8)
4) ***Nonlinear Programming***: Unconstrained and constrained nonlinear problems. Introduction to computational methods. (*Reference*: Luenberger: *Linear and Nonlinear Programming,* Addison-Wesley, 1984, Chapters 6,7,10)

Fluid Mechanics

It is expected that a student has a basic knowledge of real and complex analysis including ordinary differential equations. The extra mathematics required includes:

1) ***Partial differential equations***: Laplace's equation, properties of harmonic functions, potential theory, heat equation, wave equation. Solutions through series and transform techniques. Bessel functions and Legendre functions. Distributions. (e.g. Duff and Naylor)
2) ***Asymptotic and perturbation techniques***: Asumptotic series solutions of ordinary differential equations, asymptotic expansion of integrals. Singular perturbation problems, boundary layer methods, WKB theory, multiple time-scale analysis. (e.g. Bender and Orszag)

Basic physical properties of fluids. Derivation of the Navier-Stokes equations for a viscous compressible fluid; vorticity; energy balance. Simple exact solutions of the Navier-Stokes equations. Slow viscous motions; Stokes flows; Oseen flow. Irrotational flow; sources and sinks; complex variable methods. Boundary layer approximation. Blasius flow; separation; jets and wakes. Rotating flows; geostrophic behaviour. Free surface flows; wave propagation. Simple unsteady boundary layer flows; Stokes layers. Shock waves in a tube; supersonic flow.

General Relativity and Classical Mechanics

1) Space-times as Lorentz manifolds. Differential geometry (curvature, etc.) and local and global properties of Lorentz manifolds.
2) Field equations of general relativity, stationary and static space-times. Exact solutions. Schwarzschild, Kruskal, Kerr solutions. Cosmological models: Robertson-Walker and Friedman models and their

properties.
3) Cauchy problem for the field equations. Classification of space-times.
4) Symplectic geometry, symplectic structure of cotangent bundles, Poisson brackets.
5) Hamiltonian equations, canonical transformations, Legendre transformations, Lagrangian systems, Hamilton-Jacobi theory.

<u>*References:*</u>

Hawking & Ellis: Large Scale Structure of Space-Time, Chapters 2,3,4,5.
O'Neill: Semi-Riemannian Geometry with Applications to Relativity.
Abraham & Marsden: *Foundations of Mechanics,* Chapters 3,4,5.
Wald: *General Relativity*, Chapters 1-6 and Appendices A-C and E

<u>Mathematical Finance</u>

1) ***Stochastic calculus***: Martingales, Ito's lemma, Girsanov's theorem, stochastic differential equations, stopping times. *(<u>Reference</u>*: Baxter & Rennie, *Financial Calculus)*
2) ***Finance***: Equity derivatives, interest rate derivatives, market risk, credit risk, portfolio theory, numerical methods. (*<u>References</u>*: D. Duffie: *Dynamic Asset Pricing Theory.* P. Wilmott et al.: *Mathematics of Financial Derivatives.* RiskMetrics and CreditMetrics documents.)

<u>Probability</u>

The Probability Exam is a written exam and is administered by the Department of Statistics. It is based on material covered in STA 2111F and STA 2211S. It is normally scheduled in May.
Topics covered include:

1) ***Elementary probability theory:*** Bernoulli trails, combinatorics, properties of standard probability distributions, Poisson processes, Markov chains
2) ***Probability spaces:*** measure theory and Lebesgue integration, extension theorems, Borel-Cantellis lemmas, product measures and independence, Fubini's Theorem
3) ***Random variables and expectations:*** probability distributions, Radon-Nikodym derivatives and densities, convergence theorems such as dominated convergence, monotone convergence, etc
4) ***Limit theorems:*** inequalities, weak and strong laws of large numbers for sums of i.i.d. random variables, Glivenko-Cantelli Theorem, weak convergence (convergence in distribution), continuity theorem for characteristic functions, Central Limit theorems
5) ***Conditional probability and expectation:*** definitions and properties, statistical applications, martingales
6) Basics of Brownian motion and diffusions

<u>*References*</u>

Most of the above material is covered in any one of the following texts:
P. Billingsley: Probability and Measure 1995
L. Breiman: *Probability* 1992
K.L. Chung: A Course in Probability Theory 1974
R.M. Dudley: Real Analysis and Probability 1989
R. Durrett: Probability: Theory and Examples 1996
B. Fristedt and L. Gray: A Modern Approach to Probability Theory 1997
J.S. Rosenthal: A First Look at Rigorous Probability Theory 2000

<u>Quantum Field Theory</u>

Nonrelativistic quantum mechanics: Quantum observables are self-adjoint operators. The spectral theorem for self-adjoint operators in terms of spectral measures, and the physical interpretation of the quantum formalism. Complete sets of observables. The essential self-adjointness of the Schrödinger operator: the Kato and Rellich theorems. Eigenvalue problems and the energy spectrum: the harmonic oscillator; the hydrogen atom. The Schrödinger, Heisenberg and interaction pictures. Regular and singular perturbation theory. Canonical commutation relations and von Neumann's theorem. *Statistical operators and the trace class. *The Hilbert-Schmidt class as Liouville space and von Neumann's equation.

1) ***Group theory and quantum mechanics***: Representations of space and time translations. Stone's theorem for one-parameter. Abelian groups of unitary operators. $SU(2)$ and the concept of spin. The Heisenberg-Weyl group and canonical commutation relations. Ray representations of the Galilei group. Relativistic invariance and representations of the Poincaré group. The Lie algebras of the Galilei and Poincaré groups, and of their main kinematical subgroups. *Systems of imprimitivity and particle localization.

2) ***Quantum scattering theory****:* Time-dependent scattering theory, wave operators and their intertwining properties. The *S*-operator and scattering cross-sections. Stations. The Coulomb potential and scattering for long-range interactions. Eigenfunction expansions and Green functions. The *T*-matrix, the scattering amplitude and the Born series. *Asymptotic completeness. *Channel wave operators and asymptotic states.
3) ***Relativistic quantum field theory****:* The Klein-Gordon and Dirac equations. Fock space for spin 0 and spin ½ particles. Creation and annihilation operators. Quantum fields as operator-valued distributions. The Gupta-Bleuler formalism for photons and gauge freedom.

<u>*References:*</u>

Intermediate:

J.M. Jauch: Foundations of Quantum Mechanics, 1968.
W. Miller, Jr.: Symmetry Groups and their Applications, 1972.
E. Prugovecki: Quantum Mechanics in Hilbert Space, 2nd Edition, 1981.
S.S. Schweber: An Introduction to Quantum Field Theory, 1961.

Advanced:

A.O. Barut & R. Raczka: Theory of Group Representations and Applications, 1978.
N.N. Bogulubov, A.A. Logunov & I.T. Todorov: *Introduction to Axiomatic Quantum Field Theory,* 1975.
T. Kato: Perturbation Theory for Linear Operators, 2nd Edition, 1976.
M. Reed & B. Simon: Methods of Modern Mathematical Physics, vols. 1-4, 1972-78.

APPENDIX C: PH.D. DEGREES CONFERRED FROM 2000-2011

2000

CALIN, Ovidiu (Differential Geometry) The Missing Direction and Differential Geometry on Heisenberg Manifolds
DERANGO, Alessandro (C*-Algebras) On C*-Algebras Associated with Homeomorphisms of the Unit Circle
HIRSCHORN, James (Set Theory) Cohen and Random Reals
MADORE, Blair (Ergodic Theory) Rank One Group Actions with Simple Mixing **Z** Subactions
MARTINEZ-AVENDAÑO, Rubén (Operator Theory*)* Hankel Operators and Generalizations
MERKLI, Marco (Mathematical Physics) Positive Commutator Method in Non-Equilibrium Statistical Mechanics
MIGHTON, John (Knot Theory) Topics in Ramsey Theory of Sets of Real Numbers
MOORE, Justin (Set Theory) Topics in Ramsey Theory of Sets of Real Numbers
RAZAK, Shaloub (C*-Algebras) Classification of Simple Stably Projectionless C*-Algebras
SCOTT, Jonathan (Algebraic Topology) Algebraic Structure in Loop Space Homology
ZHAN, Yi (PDE) Viscosity Solution Theory of Nonlinear Degenerate

2001

COLEMAN, James (Nonlinear PDE's) Blowup Phenomena for the Vector Nonlinear Schrödinger Equation
IZADI, Farz-Ali (Differential Geometry) Rectification of Circles, Spheres, and Classical Geometries
KERR, David (C*-Algebras) Pressure for Automorphisms of Exact C*-Algebras and a Non-Commutative Variational Principle
OLIWA, Chris (Mathematical Physics) Some Mathematical Problems in Inhomogeneous Cosmology
PIVATO, Marcus (Mathematical Finance) Analytical Methods for Multivariate Stable Probability Distributions
POON, Edward (Operator Theory) Frames of Orthogonal Projections
SAUNDERS, David (Mathematical Finance) Mathematical Problems in the Theory of Incomplete Markets
SOLTYS-KULINICZ, Michael (Complexity) The Complexity of Derivations of Matrix Identities
VASILIJEVIC, Branislav (Mathematical Physics) Mathematical Theory of Tunneling at Positive Temperatures
YUEN, Waikong (Probability) Application of Geometric Bounds to Convergence Rates of Markov Chains and Markov Processes on $\mathbf{R}^n$

2002

HERNANDEZ-PEREZ, Nicholas (Math. Finance) Applications of Descriptive Measures in Risk Management
KAVEH, Kiumars (Algebraic Geometry) Morse Theory and Euler Characteristic of Sections of Spherical Varieties
MOHAMMADALIKANI, Ramin (Symplectic Geometry) Cohomology Ring of Symplectic Reductions
SOPROUNOV, Ivan (Algebraic Geometry) Parshin's Symbols and Residues, and Newton Polyhedra
SOPROUNOVA, Eugenia (Algebraic Geometry) Zeros of Systems of Exponential Sums and Trigonometric Polynomials
TOMS, Andrew (Operator Algebras) On Strongly Performated K_0 Groups of Simple C*-Algebras
VUKSANOVIC, Vojkan (Set Theory) Canonical Equivalence Relations
ZIMMERMAN, Jason (Control Theory) The Rolling Stone Problem

2003

ADAMUS, Janus (Analytic Geometry) Vertical components in fibre powers of analytic mappings
BUBENIK, Peter (Algebraic Topology) Cell attachments and the homology of loop spaces and differential graded algebras
HO, Nan-Kuo (Symplectic Geometry) The moduli space of gauge equivalence classese of flat connections over a compact nonorientable surface
JONG, Peter (Ergodic Theory) On the Isomorphism Problem of p-Endomorphisms
PEREIRA, Rajesh (Operator Theory) Trace Vectors in Matrix Analysis
STAUBACH, Wolfgang (PDE) Path Integrals, Microlocal Analysis and the Fundamental Solution for Hörmander Laplacians
THERIAULT, Nicolas (Algebraic Number Theory) The discrete logarithm problem in the Jacobian of algebraic curves
TING, Fridolin (Mathematical Physics) Pinning of magnetic vortices by external potential
TSANG, Kin Wai (Operator Algebras) A Classification of Certain Simple Stably Projectionless C*-Algebras

2004

AHMAD, Najma (Applied Math) The geometry of shape recognition via the Monge-Kantorovich optimal t ransportation problem (in conjunction with Brown University)

BRANKER, Maritza (Several Complex Variables) Weighted approximation in $\mathbf{R}^n$

CHEN, Oliver (Mathematical Finance) Credit barrier models

ESCOBAR AÑEL, Marcos (Mathematical Finance) Mathematical treatment of commodity markets

HUNG, Ching-Nam (Operator Algebras) The numerical range and the core of Hilbert-space operators

IVANESCU, Cristian (Operator Algebras) On the classification of simple C*-algebras which are inductive limits of continuous-trace C*-algebras with spectrum the closed interval [0,1]

KIRITCHENKO, Valentina (Analytic Geometry) A Gauss-Bonnet Theorem, Chern Classes and an Adjunction Formula for Reductive Groups

KUZNETSOV, Alexey (Mathematical Finance) Solvable Markov processes

LAWI, Stephan (Mathematical Finance) Exactly solvable stochastic integrals and q-deformed processes

SAVU, Anamaria (Probability) Hydrodynamic scaling limit of the continuum solid on solid model

SHAHBAZI, Zohreh (Differential Geometry) Differential Geometry of Relative Gerbes

SONG, Joon-Hyeok (Symplectic Geometry) Intersection Numbers in q-Hamiltonian Spaces

TIMORIN, Vladlen (Analytic Geometry) Rectifiable Pencils of Conics

2005

DE LOS SANTOS, Alejandro (Mathematical Finance) Liquidity risk estimation: non-gaussian AR models and quantile expansions

HAMILTON, Mark (Symplectic Geometry) Singular Bohr-Sommerfeld Leaves and Geomertic Quantization

NIU, Zhuang (Operator Algebras) A classification of the tracially approximately sub-homogeneous C*-algebras

PATANKAR, Vijay (Number Theory) Splitting of Abellian Varieties

POLLANEN, Marco (Probability) Low discrepancy sequences in probability spaces

2006

CHAN, Jackson (Harmonic Analysis) Methods of variations of potential of quasi-periodic Schroedinger equation

DEJAK, Steven (Nonlinear PDE) Long-time dynamics of KdV solitary waves over a variable bottom

DOUGLAS, Andrew (Representation Theory) A classification of the finite dimensional indecomposable representations of the Euclidean algebra $e(2)$

FU, Guangyu (Probability) Random walks and random polynomials

HERNANDEZ CORTES, Janko (Mathematical Finance) Ergodic properties of some hidden Markov models with applications to mathematical finance

HO, Toan Minh (Operator Algebras) On the inductive limits of homogeneous algebras with diagonal morphisms between building blocks

KNAFO, Emmanuel (Number Theory) Variance of distribution of almost primes in arithmetic progressions

ROBERT GONZALEZ, Leonel (Operator Algebras) Classification of nonsimple approximate interval C*-algebras: the triangular case

2007

CALLAGHAN, Joe (Several Complex Variables) A Green's function for θ -incomplete polynomials

COWARD, Kristofer (Operator Algebras) The Cuntz semigroup as a classification functor for C*-algebras

LANGRIDGE, Allan (Number Theory) Values of Artin L-functions at s=1

NAOT, Gad (Knot Theory) The Universal sl_2 link homology theory

ZHOU, Gang (Mathematical Physics) Asymptotic dynamics of trapped solitons of nonlinear Schroedinger equations with external potentials

2008

BAIRD, Thomas (Symplectic Geometry and Algebraic Topology) Moduli spaces of flat G-bundles over nonorientable surfaces

BROOKE, David (Representation Theory) Resolving Multiplicities in the Tensor Product of Irreducible Representations of Semisimple Lie Algebras

CIUPERCA, Alin (Operator Algebras) Some Properties of the Cuntz Semigroup and an Isomorphism Theorem for a Certain Class of Non-simple C*-algebras
DONIN, Dmitry (Representation Theory and Differential Geometry) Lie Algebras of Differential Operators and D-Modules
FUCHS, Shay (Geometric Quantization) Spin^c quantization, prequantization and cutting
GERACI, Joseph (Quantum Information and Statistical Physics) On the Relation between Quantum Computation and Classical Statistical Mechanics
KLEIN, David (Symplectic geometry) Goldman Flows on Moduli Spaces of Flat Connections on Surfaces
KLEPER, Dvir (Operator Theory) Invariant Subspaces of Composition Operators on Weighted Hardy-Hilbert Spaces
LYNCH, Geoffrey (Algebraic Geometry) The Local Monodromy Operator as an Algebraic Cycle
QUINTANILLA, Maria Teresa (Mathematical Finance) Asymptotic Optimization of Risk Measures
SANTIAGO MORENO, Luis (Operator Algebras) Classification of Non-simple C*-algebras: Inductive Limits of Splitting Interval Algebras
SYLVESTRE, Jeremy (Representation Theory) Twisted Characters of Depth-zero Supercuspidal Representations of GL(n)
TIPU, Vicentiu (Number Theory) Polynomial Divisor Problems

2009
FITZPATRICK, Daniel Sean (Symplectic Geometry) Almost CR quantization via the Index of Transversally Elliptic Dirac Operators
HAMMERLINDL, Andrew (Dynamical Systems) Leaf Conjugacies on the Torus
HOVINEN, Bradford (Commutative Algebra) Matrix Factorizations of the Classical Discriminant
KISSOUNKO, Veniamine (Algebraic Geometry) The Converse of Abel's Theorem
KREPSKI, Derek (Symplectic Geometry) Pre-quantization of the Moduli Space of Flat *G*-bundles
LEE, Brian C. (Symplectic Geometry) Geometric Structures on Spaces of Weighted Submanifolds
LEE, Paul Woon Yin (Symplectic Geometry and Dynamical Systems) Symplectic and Subriemannian Geometry of Optimal Transport
LI, Chao (Automorphic Forms and Representation Theory) A Local Twisted Trace Formula and Twisted Orthogonality Relations
MALONEY, Gregory (Operator Algebras) Dimension Groups and C*-algebras Associated to Multidimensional Continued Fractions
MESARIC, Jeffrey (Partial Differential Equations) Existence of Critical Points for the Ginzburg-Landau Functional on Riemannian Manifolds
MORTARI DE LACERDA, Fernando (Operator Algebras) Tracial State Space of Higher Stable Rank Simple C*-algebras
SIGLOCH, Georg (Mathematical Finance) Utility Indifference Pricing of Credit Instruments
WESSLEN, Maria (Representation Theory) A Diagrammatic Description of Tensor Product Decompositions for SU(3)
ZHURAVLEV, Vladimir (Ergodic Theory) Two Theorems of Dye in the Almost Continuous Category
ZOU, Xiangqun (Partial Differential Equations) On Blow-up of One-dimensional Heat Equations with Polynomial Nonlinearities

2010
ARCHIBALD, Jana (Knot Theory) The Multivariable Alexander Polynomial on Tangles
ARIAN, Hamidreza (Mathematical Finance) Financial Engineering of the Stochastic Correlation in Credit Risk Models,
CLARK, Trevor (Dynamical Systems) Real and Complex Dynamics of Unicritical Maps
FIRSOVA, Tanya (Dynamical Systems) Dynamical Foliations
KONG, Wenbin (Nonlinear PDEs) Singularity Formation in Nonlinear Heat and Mean Curvature Flow Equations
LEUNG, Louis (Knot Theory) Classical Lie Algebra Weight Systems of Arrow Diagrams
MAZIN, Mikhail (Algebraic Geometry) Geometric Theory of Parshin Residues
MCLELLAN, Brendan (Differential Geometry) Non-Abelian Localization and U(1) Chern-Simons Theory
MONDAL, Pinaki (Algebraic Geometry) Towards a Bezout-type Theory of Affine Varieties
MORFIN RAMIREZ, Mario (Dynamical Systems) Grassmann Dynamics
SHORSER, Lindsey (Representation Theory) Scalar and Vector Coherent State Representations of Compact and Non-Compact Symplectic Groups in a Unitary Basis

SOKIC, Miodrag (Set Theory) Ramsey Property of Posets and Related Structures
TZANETEAS, Tim (Mathematical Physics) Abrikosov Lattice Solutions of the Ginzburg-Landau Equations of Superconductivity
ZHANG, Yichao (Analytic Number Theory) L-functions in Number Theory
ZOGHI, Masrour (Symplectic Geometry) The Gromov Width of Coadjoint Orbits of Compact Lie Groups
ZWIERS, Ian (Nonlinear PDEs) Standing Ring Blowup Solutions for the Cubic Nonlinear Schroedinger Equation

2011
CARRASCO, Pablo (Dynamical Systems) Compact Dynamical Foliations
HOEHN, Logan (Continua Theory) Non-Chainable Continua and Lelek's Problem
JASINSKI, Jakub (Combinatorics) Hrushovski and Ramsey Properties of Classes of Finite Inner Product Structures, Finite Euclidean Metric Spaces and Boron Trees
LAI, Chung Lun Alan (Noncommutative Geometry) On the JLO Character and Loop Quantum Gravity
MARTINEZ RANERO, Carlos (Set Theory) Contributions towards a Fine Structure Theory of Aronszajn Orderings
PASS, Brendan (Geometric Analysis) Structural Results on Optimal Transportation Plans
SHARTSER, Leonid (Geometry and Topology) De Rham Theory and Semialgebraic Geometry
VODA, Mircea (Several Complex Variables) Loewner Theory in Several Complex Variables and Related Problems

APPENDIX D: THE FIELDS INSTITUTE FOR RESEARCH IN MATH SCIENCES

The Fields Institute for Research in Mathematical Sciences was created in November 1991 with major funding from the Province of Ontario, the Natural Sciences and Engineering Research Council of Canada, and McMaster University, the University of Toronto, and the University of Waterloo. In September 1996 it moved from its temporary location in Waterloo to its permanent site, a new building located at 222 College Street in Toronto, next to the University of Toronto Bookstore. In addition to the three principal sponsoring universities about twenty universities across Canada are affiliated with it.

The mandate of the Fields Institute specifically includes the training of graduate students and this function is given a higher profile than at other similar mathematics research institutes. All major programs run at the institution contain graduate courses which students at any university affiliated with the institute may take for credit and the organizers of major programs are expected to set aside some money to make it possible for graduate students to participate in their program.

APPENDIX E: 2011-12 INSTRUCTIONS FOR COURSE ENROLMENT ON THE STUDENT WEB SERVICE (SWS)

Graduate students are able to access the student web service to change personal information (addresses and telephone numbers), view their academic record and current courses and to enrol in, request or drop courses.

General Information

Student Responsibility

While academic advisors, faculty and staff are available to assist and advise, it is ultimately the student's responsibility to keep personal and academic information up to date at all times and to follow all University, SGS, departmental and program regulations, requirements and deadlines. The student web service makes it easier for students to check and correct this information. If questions arise about requirements, policies and procedures, students are responsible for seeking answers for these questions from staff and advisors.

Note: the department and other university offices may send important information to you by email. Please make sure that your email address, your mailing/permanent address and telephone number are up to date at all times. Under University policy, students are required to maintain a University based email account (e.g., UTOR, ECF, CHASS, OISE), record it in ROSI, and regularly check for messages. The account may be forwarded to another personal account but it is the University account to which the University will send official correspondence. New students are advised to validate their UTORID at the University Library early. The UTORID provides access not only to the @utoronto.ca email account but also to Blackboard, the University's student portal and learning management system. Many courses use the portal to provide online materials, discussion groups, quizzes etc. It is also used by the University and various student groups to make important announcements and administer elections.

Declaration

Use of the SWS to enrol in courses means that you agree to abide by all of the academic and non-academic rules and regulations of the University, the School of Graduate Studies and graduate unit in which you are registered, and assume the obligation to pay academic and incidental fees according to the policies and requirements of the University of Toronto. You normally use the SWS to add or cancel courses. If, for extraordinary reasons, you are unable to use the SWS contact your graduate unit as soon as possible.

Users of the Student Web Service are expected to be responsible when using the SWS and should not attempt to flood the system with requests, or to automate the process of course enrolment. Such activity may clog the system so that other students may be denied access or experience degraded performance. Any student(s) attempting such activity may be denied access to the SWS until after the relevant registration period.

Personal Identification Number

Each time a student accesses ROSI via the web a personal identification is required in addition to a student number. The first time the system is accessed this will be derived from the student's date of birth (format YYYYMMDD). However, at that point the student will be required to change the PIN. Subsequent access to the system will require this new number, which should be known only to the student. The PIN and student number together constitute an "electronic signature". ***Never give your PIN or student number to someone else.***

Forgotten PIN numbers can be reset by the graduate office. To avoid having to contact the office in person or having to wait for office hours, students can enter answers to a set of questions on the SWS. When they first access the ROSI, the SWS will prompt students to choose three questions from a list. If at a later date the student forgets the PIN, the PIN can be reset online if two of the three questions are answered correctly.

Services Available

Change PIN number
View/Change address, telephone number, email

View final grades
View academic history or current timetable
Add/request/drop/list courses or waitlist requests
View student account information and update direct deposit details
Defer payment of tuition (for approved Ontario, Canada and some US government student loan recipients only – see note below)
Print “Educational Credit” tax forms (T2202A)
Order transcripts
Order graduation tickets
View transaction log

Updating & Checking Personal Information

Students may view or update their address, telephone number or email address through the Student Web Service. When entering new information, the "add" option should be used. "Change" should only be used to correct information in an otherwise correct record (e.g. typos).

Students can also check other personal information (immigration status, title etc). As immigration status affects fees, all students are advised to check this information at the beginning of each year.

Request to Register Without Payment (Deferrals) for OSAP, CSL and US student Loan recipients

Students who have received notification of an award through the Ontario Student Assistance Program for their U of T program may make their fees arrangements through the SWS up to the registration deadline instead of having to appear at SGS, if the amount of the loan covers the minimum payment and no outstanding fees are owing. Students still must appear in person to pick up their OSAP documents as soon as possible after registration. The online arrangements may also be available for recipients of Canada Student Loans and some US government loans. Please see the Office of Student Accounts website (www.fees.utoronto.ca) for details.

Requesting Courses

Students may begin requesting courses on August 1. All course requests must be approved by the graduate coordinator. In addition, requests for courses outside the department must also be approved by the other department’s graduate coordinator. Students must request their courses by no later than September 26. Courses will be approved or refused before the last date to add courses. Students should check the web for their request status before October 1.

The web service requires full information about a course when a request is being made. Please consult the attached lists from your department. Be sure to enter:

Course number:	e.g. HIS2651Y
Section Code:	usually F, S or Y. This indicates whether the course is offered in the fall session (F), the winter session, i.e., second term (S) or over both (Y).
Teaching Method:	all graduate courses have a teaching method of LEC (lecture).
Teaching Section:	the number of the class. Most graduate courses only have one teaching session (0101). Although there may be only one teaching section the information must still be entered on the system.

NB. Some courses may require instructor's approval *in addition to that given by the coordinator/academic advisor*.

Courses from outside the department

Not all graduate departments allow students to enrol in courses via the web. Before attempting to add a course outside your department check with your department and the host department about procedures.

Waiting Lists

Not all courses or meeting sections have waiting lists. If the department offering the course has opted to allow a waitlist and either your enrolment category in the course or the course itself is full you can choose to join a waiting list. If a space is opened in your category then ROSI will automatically place you in the course. *It is your responsibility to check the SWS to check on your status.* The SWS will inform you of your place on the waiting list and how many spaces are allotted for your category. You may "wait" in multiple meeting sections but if you are enrolled in one meeting section you may not simultaneously wait for another. Your unit may set a limit on the number of waitlisted course in your requests. One day before the final date to enrol in courses all waiting lists will be suspended and normal enrolment procedures will apply. Consult your own unit to find out if you are permitted to join waiting lists. Consult the unit offering the course to see if a waiting list is being used.

Checking course status

Students are responsible for knowing the status of their course requests at all times. This information can be obtained via the web service. The following are the possible statuses:

REQ:	Course requested. Must be resolved/approved by the last date to add a course.
INT:	Course requested pending instructor approval in addition to coordinator's/advisor's approval.
APP:	Request approved. Student is enrolled in course.
REF:	Request denied. Student is not enrolled and may not make another request for this course via the web during this session.
CAN:	Course cancelled (student withdrew from course before deadline)
WAIT:	No room in the meeting section. Student has been placed on a waiting list based on category and will be enrolled automatically if space comes available.
DWAIT:	Student has cancelled place on the waiting list or been removed.

Cancelling or withdrawing from courses

Students may cancel or withdraw from individual courses using the web service up to certain deadline dates. Before doing this however, students are advised to consult with their advisor or departmental office. Please note that withdrawing from all your courses does not constitute a withdrawal from your program. To do so, you must complete a Program Withdrawal Form. Dropping courses prior to deadlines or withdrawing from a program without academic penalty does not guarantee a refund. Information on fee refunds and deadlines is outlined at www.fees.utoronto.ca.

<u>Deadline dates</u>:

August 8	First date students may request courses for the September 2011 and January 2012 sessions. (6:00 a.m. on the SWS)
August 11	First date students may request undergraduate courses for the September 2011 and January 2012 session
August 26	Recommended payment or deferral date. Fees should be paid at a chartered bank by this date to allow for funds transfer in time for the September 16 registration deadline. Students not registered by the deadline will have their eligibility and courses cancelled and will not be permitted further access to enrol by the SWS.
September 21	Last date for students to request fall and full year courses (F, Y sections) "online" for approval by department.
September 26	Last date to add fall and full year courses. Students will not be considered enrolled unless they have a course status of "APP".
October 31:	Last date to 'cancel' (i.e. withdraw) from a fall (F) course.
January 18	Last date for students to request winter session /second term (S) courses "online" for approval by department.
January 23:	Last date for students to request winter session/second term (S) courses. Courses requiring approval must be cleared with the department before this date.
February 27:	Last date to 'cancel' from a full year (Y) or winter session/second term course.

Final Results

Final grades in courses can be accessed through "Transcripts and Academic History". Grades can be viewed after the following dates. If a grade is not available, contact your instructor or the graduate unit offering the course.

2011 Summer Session (first term)	July 27
(full summer and second term)	September 21
2011 Fall Session	January 18
2012 Winter Session (and Fall/Winter courses)	May 16

System Availability

The student web service is normally available at the following times:

Monday	6:00 to 23:45
Tuesday to Thursday	0:15 to 23:45
Friday	0:15 to 18:00
Saturday	midnight to midnight
Sunday	midnight to 23:45

N.B. On the first day of enrolment, the service opens at 6:00.

Occasionally hours must be reduced for system maintenance. Please check the Student Web Service for details.

URL

The Student Web Service can be accessed at www.rosi.utoronto.ca. Instructions are located there. Please remember to log out after each use.

APPENDIX F: SGS Session Dates 2011-2012

Fall Session 2011

M	August	1	Civic Holiday
M	August	8	Registration for Fall session begins
	August	11	Undergraduate course enrolment begins (1)
F	August	26	Last date for payment of tuition fees to meet registration deadline
M	September	5	Labour Day
M	September	12	Most formal graduate courses and seminars begin in the week of September 12th (2)
R	September	15	Final date to submit final doctoral theses to SGS to avoid fee charges for 2011-12 (3)
F	September	16	Coursework must be completed and grades submitted for summer session courses and extended courses (4)
F	September	16	Registration for Fall session ends; after this date, a late registration fee will be assessed
W	September	21	Summer Session grades available for viewing by students on the Student Web Service
M	September	26	Final date to add full-year and Fall session courses
F	September	30	Final date for receipt of degree recommendations and submission of any required theses for master's degrees for Fall Convocation without fees being charged for the Fall session (5)
F	September	30	Final date to submit final doctoral thesis for Fall Convocation
M	October	10	Thanksgiving Day
M	October	31	Final date to drop Fall session full or half courses without academic penalty
	November		Fall Convocation Information and Dates are posted at: www.convocation.utoronto.ca, choose Fall
W	December	21	Winter break begins (for last day of classes before Winter break, consult graduate units concerned)

Winter Session 2012

M	January	9	Most formal graduate courses and seminars begin in the week of January 9th (2)
F	January	13	Final date for registration of students beginning program in Winter session; after this date, a late registration fee will be assessed
F	January	13	Coursework must be completed and grades submitted for Fall session courses (4)
M	January	16	Final date to submit doctoral theses without fee payment for Winter session
W	January	18	Fall Session grades available for viewing by students on the Student Web Service
M	January	23	Final date to add Winter session courses (4)
F	January	27	Final date for receipt of degree recommendations and submission of any required theses for March or June graduation for master's students without fees being charged for the Winter session (5)
F	January	27	Final date for all students to request that their degrees be conferred *in absentia* in March
F	January	27	Fall dual registrants must be recommended for the master's degree by this date to maintain their Ph.D. registration (5)
M	February	20	Family Day
M	February	27	Final date to drop full-year and Winter session courses without academic penalty (6)
	March		March Graduation *In absentia* Information is posted at: www.convocation.utoronto.ca, choose March *in absentia*
	April		For last day of winter classes, consult unit concerned

Summer Session 2012

F	April	6	Good Friday
F	April	20	For students obtaining degrees at June Convocation, course work must be completed and grades submitted for full-year and Winter session courses
F	April	20	Final date for receipt of degree recommendations and submission of any required theses for master's degrees for June Convocation (5)
F	April	20	Final date for submission of final doctoral thesis for students whose degrees are to be conferred at the June Convocation (3)
F	April	20	Final date for degree recommendations of Winter dual registrants for the master's degree to maintain their Ph.D. registration (5)
	May		For first day of summer classes, consult graduate unit concerned.
F	May	4	Final date for registration for May session
F	May	11	Final date to enrol in May-June or May-August session courses
F	May	11	Course work must be completed and grades submitted for full-year and Winter session courses (except for extended courses) (4)
W	May	16	Winter Session grades available for viewing by students on the Student Web Service
M	May	21	Victoria Day
	June		Spring Convocation Information and Dates are posted at: www.convocation.utoronto.ca, choose Spring
F	June	1	Final date to drop May/June F section courses without academic penalty (6)
F	June	22	Final date to enrol in July-August courses (6)
F	June	22	Final date to drop May-August session Y section courses without academic penalty (6)
M	July	2	Canada Day Holiday
F	July	20	Final date to drop July-August S section courses without academic penalty (6)
F	July	20	Coursework must be completed and grades submitted for May/June F Section Courses (4)
W	July	25	Grades for May/June F Section Courses available for viewing by students on the Student Web Service

(1) Graduate students may only enrol in undergraduate courses with the approval of their supervisor or graduate unit. Students are responsible for meeting the deadlines and requirements of the undergraduate course as presented in class and in the undergraduate division's calendar. Graduate students will be graded under the graduate grading scale. Students should consult the undergraduate Arts and Science Calendar for enrolment and dates.

(2) The precise dates of commencement of courses are determined by the graduate units; students are urged to contact the relevant graduate units for information. The University policy states that the first day of classes in the Fall session in all teaching divisions should not be scheduled on the first and second days of Rosh Hashanah (from 1 1/2 hours before sunset on Wednesday, September 28 to about 1 1/2 hours after sunset on Friday, September 30) or on Yom Kippur (from about 1 1/2 hours before sunset on Friday, October 7 to about 1 1/2 hours after sunset on Saturday, October 8).

(3) A final thesis is the corrected, approved version of thesis, which is submitted to SGS following the Final Oral Examination.

(4) Graduate units may establish earlier deadlines for completion of course work and may prescribe penalties for late completion of work and for failure to complete work, provided that these penalties are announced at the time the instructor makes known to the class the methods by which student performance shall be evaluated.

(5) For final dates for completing degree requirements, students should consult their own graduate unit.

(6) Graduate units may establish earlier deadlines to add/drop courses. Please note that the last date to cancel a course or registration with no academic penalty is not the same as the last date to be eligible for a refund.

(7) Students starting their program in the summer and OISE students are required to register by this date by paying the minimum tuition amount stated in their invoice.