Department of Mathematics
University of Western Ontario
Self Evaluation
March 2010
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This Self-Evaluation document is divided into four basic parts. Chapter 1 spells out the overview and priorities of our department. Chapter 2 examines the undergraduate program, and Chapter 3 discusses the graduate program. Finally, Chapter 4 provides a more detailed overview of the department. There are also six appendices (A –F), the first two of which contain information corresponding to the first two of the three self study parts, while the last four contain the Strategic/Academic plans of the university, the Faculty of Science, and the Department of Mathematics, and the proposal for a School of Mathematical Sciences at Western.
Chapter 1

Overview and Priorities

1.1 Introduction

The Department of Mathematics is one of four Mathematical Sciences departments at the University of Western Ontario. Research and teaching in the Department is traditionally concentrated in the area of pure mathematics, but the Department maintains strong intellectual and practical connections with the other mathematical science departments in the Faculty of Science, and its teaching mission reaches all of the University. The Department of Mathematics offers programs at all undergraduate and graduate levels of instruction, and its research team is well known nationally and internationally.

1.2 Priorities

The following is a summary of the Department’s highest priorities during the next five-year period.

- Securing long term stable funding for the departmental postdoctoral program. This is our single most important strategic initiative and its success is integral to the success of the next two priorities.
- Maintaining the reduced teaching load for faculty who are highly active in PhD supervision.
- Maintaining and even expanding our MSc program.
- Introducing full scholarships for Mathematics undergraduates.
- Using any retirements or resignations as an opportunity to hire new faculty to strengthen our existing research groups.

1.3 Faculty and Staff

In the current year, 2009-10, the Department’s complement consisted of 16 tenured, 4 probationary and 1 limited term full-time members. Included in our faculty is one Tier 1 CRC in Applied Homotopy Theory held by Rick Jardine. Jardine has recently had his CRC renewed for another seven year period.
1.4 Faculty Renewal

A major success of the Department over the past several years has been faculty renewal. Since 2000-01, the Department has recruited ten new mathematicians, resulting in a much higher research profile for the Department. Thus, nearly half of the Departments tenured faculty has been replaced within a nine-year period.

Some measures of the rise in impact of research include:

- Graduate enrollment has risen sharply from a previous high of 12 in recent years to 19 in 2006-07. Currently (2009-10) we have 31 graduate students. In addition, Dan Christensen has recently supervised two PhD students for the Department of Applied Mathematics.

- Discovery Grants in the Department have increased from 10 in 1999 to 17 in 2010, while total research expenditure has risen fourfold in the same period.

- During the period 2006-2010 faculty members will have organized or co-organized at least 30 conferences or thematic programs with budgets totalling over $1,000,000. This vigorous organizational activity has continued unabated since 2003.

But how quickly things change! We are now faced with the following retirements.

- March 2010: Richard Kane
- July 2010: Paul Milnes
- July 2011: Mike Dawes

As of July 2011 our department’s complement will be 13 tenured and 4 probationary with the retirements of Kane, Milnes and Dawes. In addition to the above retirements, we are faced with the possibility of Stuart Rankin retiring in the near future. There is deep concern that the current economic conditions may diminish our chances of obtaining much needed replacement positions.

The Department has two administrative staff: an Academic Officer and an Administrative Officer. This is not sufficient for our current needs. Recently, the position of Departmental Secretary was declared redundant and our Secretary was abruptly terminated as part of the Central Administration Strategy in the wake of the Financial Meltdown/Recession.
Chapter 2

Undergraduate Degrees and Courses

Documentation concerning Undergraduate teaching will accompany this Self-Evaluation document. Appendix A, at the end of this document, contains the following:

1. Teaching assignments
2. Cross unit teaching
3. Undergraduate class size and grade distributions
4. Five-year enrollment data for both programs and courses

Appendix I (in a separate booklet) contains:

1. Description of undergraduate programs, modules, course offerings, requirement, and regulations
2. Undergraduate course calendar copy
3. Current course outlines, final examinations, and grade distributions

2.1 Programs and Modules

The University of Western Ontario ("Western") has now fully transformed from a system of programs to a system of modules.

Modules.

For the Department of Mathematics, the module structure ("New Academic Choices") is based on nine kinds of modules:

1. Honors Specialization in Mathematics
2. Major in Mathematics
3. Specialization in Mathematics
4. Minor in Mathematics
5. Honors Specialization in Mathematics in Society
6. Specialization in Mathematics in Society
7. Honors Specialization in Mathematical Sciences

8. Concurrent Mathematics and Education Program–BSc/BEd

9. Minor for Concurrent Mathematics and Education Program

These modules are entered after first year. One major purpose in introducing this new structure is to give students more flexibility, while providing easily recognized standards which are institution-wide.

The official UWO calendar can be found at the following URL.

http://westerncalendar.uwo.ca/2010/pg686.html

It has an up-to-date list of all our current modules.

The following modules (mentioned above) were introduced in 2008-2009. We include a short description/rationale for these new programs.

### 2.1.1 Honors Specialization in Mathematics in Society

The intent of this module is to require exposure to a wide range of mathematical ideas at an honors level. This will benefit particularly future mathematics teachers and those who plan to enter professional programs, but is also appropriate for students for whom the BSc will be the highest degree. Students will be required to take courses in: Multivariable Calculus, Linear Algebra, Real Analysis, Complex Analysis, Logic and Discrete Structures, Abstract Algebra, and Number Theory. They also will be required to choose several courses from a broad selection of other mathematical topics, including Problem Solving, Differential Equations, Data Analysis and Signal Processing, Numerical Analysis, Combinatorics, Probability, Statistics, Conceptual Development of Mathematics, Logical Theory, Foundations of Mathematics, Philosophy of Mathematics, Mathematical Economics, Mathematics of Computing, and Financial Mathematics. This module will serve students pursuing an honors degree not leading to graduate work in Pure Mathematics but with a broad exposure to many areas of Mathematics. Graduates will be sought-after applicants to a variety of professional programs. It is also an appropriate Mathematics Module for students in the five-year concurrent Math and Education degree.

### 2.1.2 Specialization in Mathematics in Society

The intent of this module is to require exposure to a wide range of mathematical ideas. This will benefit particularly future mathematics teachers and those who plan to enter professional programs, but is also appropriate for students for whom the BSc will be the highest degree. Students will be required to take courses in: Multivariable Calculus, Linear Algebra, and Real Analysis. They also will be required to choose several courses from a broad selection of other mathematical topics, including Complex Analysis, Logic and Discrete Structures, Abstract Algebra, Number Theory, Problem Solving, Differential Equations, Data Analysis and Signal Processing, Numerical Analysis, Combinatorics, Probability, Statistics, Conceptual Development of Mathematics, Logical Theory, Foundations of Mathematics, Philosophy of Mathematics, Mathematical Economics, Mathematics of Computing, and Financial Mathematics. This module will serve students pursuing a non-honors degree with a broad exposure to many areas of Mathematics. Graduates will be well prepared for entry into a number of professional programs. It is an appropriate Mathematics module for students in the five-year concurrent Math and Education degree. Secondarily, it will serve as a temporary or permanent alternative for students who do not meet progression requirements for the Honors Specialization in Mathematics in Society.
2.1.3 Minor for Concurrent Mathematics and Education Programs

The proposed module structure will facilitate the counselling of concurrent students within New Academic Choices. The Faculty of Education will oversee student admission and progression through this Minor module while the Department of Mathematics will counsel concurrent students regarding their Mathematics module and their non-module BSc courses.

2.1.4 Concurrent Mathematics and Education Program

The Five-Year BSc Honors Mathematical Sciences and Bachelor in Education program is being reorganized to operate within the New Academic Choices framework. In addition, several improvements are proposed, which will provide students with greater flexibility in the mathematical requirements for the degree. In particular, the proposed program will be open to non-honors students.

2.2 Degrees.

The Modules described in Section 2.1 may be combined in three different degrees:

a) The Honors Bachelor Degree (Four Year) - (20.0 courses)

- 15.0 courses after first year, including at least an Honors Specialization or a Double Major as follows:
  - Honors Specialization (9.0 or more courses)
    
    This may be combined with a Major or a Minor or option(s)
  - Major (6.0 - 7.0) plus a Major (6.0 - 7.0) plus option(s) (3.0 - 1.0)
    
    This combination requires two Major Modules.

b) The Bachelor Degree (Four Year) - (20.0 courses)

- 15.0 courses after first year, including at least a Specialization module or a Major Module as follows:
  - Specialization (9.0 or more courses)
    
    This may be combined with a Major or a Minor or option(s)
  - Major (6.0 - 7.0) plus a Major (6.0 - 7.0) plus option(s) (3.0 - 1.0)
  - Major (6.0 - 7.0) plus Minor(s) or option(s)

c) The Bachelor Degree (Three Year) - (15.0 courses)

- 10.0 courses after first year, including at least a Major Module or a Double Minor as follows:
  - Major (6.0 - 7.0) plus option(s)
  - Major (6.0 - 7.0) plus a Minor or Option(s)
  - Minor (4.0 - 5.0) plus a Minor (4.0 - 5.0) plus option(s) (2.0 - 0) (This combination requires two modules.)
In the Mathematics Department, the Honors Specialization is intended to prepare students for
graduate study and has a higher number of fourth-year courses and a higher required average than
the Specialization. Students who are mathematically oriented but not headed to graduate school
may choose either a major or a specialization module. For example, the Mathematics component
of the previous four-year B.Sc. Honors in computer Science and Mathematics will approximately
correspond to a major in Mathematics.

2.3 Overview of Undergraduate Teaching

Our undergraduate teaching can be divided into four categories:

- **Service Courses.**
  Service courses taught by the Department constitute the vast majority of its undergraduate
teaching commitment; they are indicative of the pervasive use of mathematics in subject areas
throughout the University. Service courses are generally first-year; however the Department
does offer Math 2155a and 2156b (discrete mathematics) primarily for computer science
students.

- **Calculus and linear algebra.**
  These are the first and second year courses designed for students who are interested in pursuing
a program in mathematics or a field that has a large mathematical component. Calculus is
offered in two streams: first year: Calculus 1000 or 1100 then Calculus 1301 or 1501. second
year: Calculus 2302/2303 or Calculus 2502/2503. The latter stream (including 2502/2503) is
intended primarily for students from one of the mathematical sciences departments who are
pursuing an honors degree. The linear algebra stream consist of Math 1120 and/or Linear
Algebra 1600 followed by Math 2120/2121.

- **Rigorous Traditional Modules.**
  These are the Honors Specialization and Major in Mathematics modules. These are the
“core” modules that naturally lead students to specialization and graduate work in Pure
Mathematics.

- **Other Modules.**
  These are the other seven modules listed above. They are each designed to link up directly
with some other program (e.g. Education, Computer Science), or to instill a broad mathe-
matical literacy. These modules are an indication of the ubiquitous nature mathematics in
many subject areas throughout the University.

Selected courses are offered in Intersession (May-June) and Summer Session (July-August), and
by correspondence through distance Studies. Most of our part-time lecturers are hired to cover first-
year courses, although post-doctoral fellows contribute at all undergraduate levels. The Department
has a goal of staffing its core courses at all levels with active researchers.

2.4 Curricula

Like most academic units at Western, the Department has focused much of its recent curriculum
development on the switch from programs to modules. This mandatory reorganization has pro-
vided opportunities for rethinking, rationalizing, and modernizing our offerings. Several courses
were deleted or created, and the timing and pace of the honors module has been adjusted. This has strengthened our honors stream in both reputation and substance, and has helped us in the competing for the best students.

For example, the Department offers several successful and popular Special Topics courses: Math 3958a/b-3959a/b-4958a/b-4959a/b. Past topics have included elliptic curves, cryptography, commutative algebra, and differential geometry. Because of broad interest from other departments, enrollment in some of these courses is often significantly higher than in other advanced mathematics courses. Potentially such courses could draw outside students into our modules.

The second-year honors linear algebra sequence has been extensively reorganized (Math 2120a/b-2121a/b) and now also begins in the first term of second year, treating the calculation-based Linear Algebra 1600a/b in much the same way as calculus is a calculation-based introduction to analysis.

We have introduced a first-year “foundations” course, Math 1120a/b, directed at first year students who intend to enroll in one of our Mathematics modules, covering basic logic, set theory, relations, functions, number theory, complex numbers and polynomials. A major goal for the department is to help students to learn to write mathematical proofs coherently and correctly, to prepare them for the rigors of the formal axiomatic systems they will later encounter in algebra and analysis. For that reason, we also encourage students to take Math 2155a (discrete mathematics for computer science) as an alternative bridge for the gap between first-year calculus and linear algebra and abstract algebra.

We have recently introduced a special section of Calculus 1000. It is an enriched section for the mathematically gifted students. Our intention is to turn this into a separate course starting in September 2011.

In the coming year (2010-2011), we are offering a course in Game Theory, Mathematics 3958b. Topics covered will include the formal definition of a game, the concept of equilibrium, linear programming and constrained games. We anticipate that this will be particularly interesting to Economics and Philosophy students.

The primary honors abstract algebra sequence has been reduced to four half courses: Math 3020a/b (abstract algebra), Math 3120a/b (group theory), Math 4123a/b (commutative ring and module theory) and math 4120a/b (field theory). This streamlining has removed unnecessary overlap and allows for efficiencies: the fundamental theorem of finitely generated abelian groups can be proved more easily and effectively in the wider context of modules over PIDs, and much of the theory of canonical forms can be accomplished concurrently.

Other steps that have been made to modernize our courses and modules include the addition of new elective courses in algebraic curves (Math 3154a/b), algebraic geometry (Math 4153a/b) and algebraic number theory (Math 4151a/b). In addition, our elementary number theory courses (Math 3150a and 3151a/b) have been adjusted to suit students’ backgrounds and progression to other courses.

Finally, the Department has monitored the transition from Ontario high school mathematics to university studies. The removal of grade 13 and concomitant changes to the whole sequence of mathematics high school courses have decreased the background and maturity of our entering students noticeably. This has required careful adjustments to our first-year courses, in particular to Calculus 1000, to recognize and compensate for the changes in students’ level of preparation while still fulfilling our goals, outlined above, of starting a genuine honors stream as early as possible in second year. We have introduced a relatively new course, Calculus I with Fundamentals (1100), to help accommodate the changes in the high school system. More recently the grade twelve math courses in Ontario were reorganized; continued adjustments to changes in the high school curriculum are an ongoing commitment of our Department.
2.5 Student Recruitment and Outreach

The Department puts considerable effort into attracting and retaining well qualified students. The number of awards and scholarships available to our students continues to increase, supported by new external donations. In addition to such financial support, we have several other initiatives which we now describe.

- The Mathematics Scholars Group. The aim of this program is to create a community of young scholars in mathematics who will have considerable interaction with faculty, and with each other. The privileges of membership in the group include the possibility of an individually designed program. Members have easy access to faculty for advice on matters such as course selection, extra resource material, and financial assistance. A more formal assignment of a faculty mentor is available upon request. From time to time, representatives of corporation and other employers meet with the math Scholars Group to present employment and internship opportunities. The Department has set up a study room and a computer room for the exclusive use of members of the Group.

- Undergraduate Mathematics Pizza Seminar. In connection with the Math Scholars Group, the Department has an undergraduate seminar, which meets six to eight times per year. Faculty and visitors give talks on a variety of mathematical subjects, suitable for undergraduate students. The talks are usually informal, sometimes humorous, but always with real mathematical content, intended to broaden the audience’s horizons. Many follow the “what is?” theme and introduce new areas of mathematics. The talks are followed by a social hour with pizza. Attendance has far exceeded expectations. The seminar often attracts overflow audiences consisting of members of the Math Scholars Group, faculty members, visitors from other departments, and high school teachers and students.

- In an effort to raise the profile of the Department in schools in Ontario and Canada, the Department has become more involved in activities aimed at high school students interested in mathematics:
  - Poster.
    We now have a color poster advertising the undergraduate program to be sent to high school mathematics departments.
  - Mathematics Camps.
    Several department members participate in the regional annual summer Mathematics camp. In addition we have hosted the CMS National Mathematics camp. Sponsoring organizations for these camps have included the CMS, the Imperial Oil Charitable Foundation, the Fields Institute and the University of Western Ontario.
  - Math Challenge at Western.
    The Department, with the support of the Faculty of Science and the participation of the Western Ontario Mathematics Association, sponsors the Mathematics Challenge Group, which is weekly program of mathematics enrichment sessions for high school and senior public school students during the regular academic year. These students are prepared, under the guidance of a team of retired high school teachers with the participation of some Department members, for competing in several mathematical contests that include the Canadian Open Mathematics Contest, the Canadian Invitational Mathematics Challenge, the Canadian Mathematics Olympiad and the American Regional Mathematics
League. Over 400 students are regularly involved in the program, and several of them have placed in the top ten in their respective contests.

2.6 Enrolments

Enrolments have been fairly stable and increasing slowly from 2000 to the present, though the change from programs to modules has made it difficult to track this exactly. There has been a rise in the number of honours students for Mathematics which occurred previous to the introduction of the modular programs and which is mainly due to the Concurrent Program in Mathematics/Education established in 2002. (The bracketed numbers below indicate the portion of the Honours enrollment associated with the Concurrent Program.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Honours Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/05</td>
<td>49 (20)</td>
</tr>
<tr>
<td>05/06</td>
<td>56 (20)</td>
</tr>
<tr>
<td>06/07</td>
<td>49 (16)</td>
</tr>
<tr>
<td>07/08</td>
<td>68 (18)</td>
</tr>
<tr>
<td>08/09</td>
<td>41 (10)</td>
</tr>
<tr>
<td>09/10</td>
<td>37 (10)</td>
</tr>
</tbody>
</table>

The enrollment data available so far suggests that the flexibility of the module format is allowing a wider range of students to include mathematics among their subjects of concentration. Since 2004-2005, there is an increasing tendency for students to combine some Mathematics module with another program outside the department.

2.7 Challenges and Outlook

The Department has a strong commitment to undergraduate teaching, and two members (Minac and Sinnamon) have won teaching awards. Our main challenge continues to be to attract more and stronger students into our honors modules. The curriculum development and outreach activities specified above are essential parts of our plans to accomplish this goal. In addition, we must be alert to opportunities for further curriculum development, new teaching methods, and joint undergraduate offerings with other departments and faculties. For example, the concurrent Mathematics and Education program was extended to non-honors students in 2008-2009. Unfortunately, for budgetary reasons beyond our control, this (very successful) program has been indefinitely suspended.

2.8 Scholarships

Although Western does have a system of entrance scholarships that provide valuable support to students, we find that no matter how vigorous our outreach activities are, the very best students that are identified by these programs chose to study elsewhere (for example, at Waterloo) when they leave high school and enter university— even after taking one or more courses at Western for no fee under the Western’s Initiative for Scholarly Excellence (W.I.S.E.) program. The level of scholarships that are offered to them by Western just doesn’t compete with Waterloo.
2.9 Distance courses

The Department currently offers Math 1225, 1228, and 1229 (service courses for Social Science students) in online form. Due to budget cuts, these distance courses are now offered only in the summer. These web-based Math courses are particularly well-subscribed, and clearly address a need.
Chapter 3

The Graduate Program

In this chapter, we discuss our graduate program. Program regulations are described in Section 3.3. The major fields of research, as approved by OCGS, are described in Section 3.2 and a list of Faculty by fields in Section 3.5. Different resources, such as library, computers, and office space are described in Sections 3.10, 3.11, and 4.10, and financial support in Section 3.12. Enrollment and graduation data are provided in Sections 3.13, 3.14, and 3.15. The chapter ends with some projection concerning our graduate enrollment. This can be found in Section 3.16.

In Appendix B, we provide copies of our OCGS approval and assessment, and samples of our Ph.D. Comprehensive exams.

3.1 Brief listing of programs

The Department of Mathematics at The University of Western Ontario (UWO) offers graduate programs leading to the degrees of M.Sc. (M.A. before 2003) and Ph.D. The Master’s degree is an eight or twelve-month program of coursework work, with the option, used only rarely, of substituting a thesis for four half-courses. The Ph.D. is completed through a combination of course work and a thesis involving original research. Candidates for the Ph.D. degree must also pass comprehensive and oral examinations, and demonstrate reading knowledge of a language other than English. Instruction is available in several areas of algebra, analysis, geometry and topology, in connection with the research interests of Department members.

Our graduate program has always been of very good quality but our enrollment was very small until recently, with no more than a total of eleven or twelve students and as few as seven. An important change in 2005 in the graduate budget allocation mechanism to individual departments at UWO has allowed us to expand. We have had 17, 23 and 31 students in 2007, 2008 and 2009 respectively. We hope to grow to a total enrollment of about 35 students (between 20 and 25 Ph.D. students and between 10 and 15 M.Sc. students). This is an upper limit imposed by both our financial and physical capabilities at present (see Section 4.10, Section 3.12 and Section 3.16 for more details). We note that, at this time, all our graduate students have individual study space and computer facilities.

Admission to the Ph.D. program is normally restricted to students with a Master’s degree. If a student, after completing our M.Sc. program, wishes to consider entering our Ph.D. program, that student is required to make a new application so that the student’s ability, interests, and suitability for work at the doctoral level can be newly assessed in the light of performance at the master’s level.

A detailed listing of the requirements for the M.Sc. and the Ph.D. degrees is given in Section 3.3.
3.2 Fields in the program

Faculty members of the Department of Mathematics have active research programs in algebraic combinatorics, algebraic groups, algebraic K-theory, analytic geometry, combinatorial algebra, commutative algebra, complex analysis, harmonic analysis, homotopy theory, invariant theory, knot theory, mathematical physics, noncommutative geometry, number theory, quantization, symplectic geometry, and symplectic and toric topology. The departmental faculty research team presently includes Adamus, Boivin, Christensen, Denham, Dhillon, Foth, Franz, Jardine, Khalkhali, Lemire, Milnes, Minač, Pinsonnault, Rankin, Renner, Riley, Shafikov and Sinnamon.

Modern Mathematics is essentially a single subject. This unity is expressed in the research of this Department through a common focus on the study of algebraic and analytic invariants of geometric structures.

The major “fields” of research carried out by members of the department are most easily described as follows:

1. Algebra/Number Theory
2. Analysis
3. Geometry/Topology

These are the fields that were approved in the periodic appraisal by OCGS (Ontario Council on Graduate Studies) in 2009. It is important to realize that a number of our faculty pursue interests that cross the boundaries of our fields (see Section 3.5 for more details).

There were no review concerns expressed in the last periodic appraisal. Our graduate program was approved as “Good Quality”, the highest ranking.

3.3 Program Regulations

The Department of Mathematics offers a graduate program leading to the degrees of M.Sc. and Ph.D. The requirements for these degrees are listed below.

Despite our recent growth (see Section 3.13 for more details), the size of our graduate program is still relatively modest. We take advantage of this by providing an intimate, yet stimulating, intellectual environment for our graduate students. They all have ready access to their supervisors. The Department has regular seminars, and graduate students are encouraged to, and do, attend. Graduate students typically give presentations in graduate courses as part of the requirements of the course. Part II of the Ph.D. comprehensive examination typically consists of a detailed exposition of a research proposal for the student’s intended thesis topic. The courses offered each year are chosen with the needs and interests of our graduate population in mind. When graduate students have obtained research results of sufficient significance, they are encouraged to present them at conferences such as the Canadian Mathematical Society (CMS) or American Mathematical Society (AMS) meetings or at special conferences appropriate to their specialty.

Each fall, graduate students are evaluated by their chief supervisors, in consultation with their advisory committees and given a report on their progress to date. See Section 3.3.2.

3.3.1 Master’s Degree

The requirements below are in addition to the General Program Requirements listed in the UWO School of Graduate and Postdoctoral Studies Calendar.
M.Sc. DEGREE REQUIREMENTS

In the following, the term “course” means one full course or two half courses. Also the course numbering system in place since May 2008 has been used.

1. A candidate having an Honors Bachelor’s degree shall complete satisfactorily a minimum of four full mathematics courses numbered 4000 or above, of which at least three full courses must be numbered 9000 or above. A candidate may be permitted to substitute a thesis for at most two full courses. In undergraduate courses and combined undergraduate-graduate courses, graduate students must do more substantial work than is required of undergraduate students.

2. A candidate with a general Bachelor’s degree will be required to enroll in the Faculty of Science as a special undergraduate student and to complete satisfactorily a minimum of five undergraduate honors mathematics courses before being considered for admission to an M.Sc. program in mathematics.

Note: At the discretion of the student’s advisory committee, a candidate may be permitted to substitute certain graduate courses in other departments for mathematics courses.

3.3.2 Ph.D. Degree

The requirements below are additional to the General Program Requirements listed in the UWO School of Graduate and Postdoctoral Studies Calendar.

Ph.D. DEGREE REQUIREMENTS

In the following, the term “course” means one full course or two half courses. Also the course numbering system in place since May 2008 has been used.

1. In addition to fulfilling the thesis requirement, a candidate shall complete satisfactorily a minimum of seven full mathematics courses numbered 4000 or above, of which at least six full courses must be numbered 9000 or above. A candidate holding an approved Master’s degree may be exempted from at most four of these courses unless he or she has successfully completed more than the minimum number of courses required for this degree. In the latter case the candidate may be exempted from more than four courses. In undergraduate courses and combined undergraduate-graduate courses, graduate students must do more substantial work than is required of undergraduate students.

2. A candidate will be required to pass a comprehensive examination. This examination is in two parts. The first part consists of two written papers covering basic material in the areas of algebra and analysis. These papers must be attempted within eighteen months of entering the Ph.D. program. If either paper (or both) is not passed on the first attempt, one further attempt is permitted. If the second attempt is unsuccessful, the candidate is required to withdraw from the program. The second part is a project related to the candidate’s intended specialty. The format is decided in consultation with the candidate’s advisory committee. If the project is not deemed to have been completed satisfactorily, the candidate is required to withdraw from the program.

3. Each candidate will be required to present at least one paper at a graduate seminar on a subject to be approved by his or her supervisor.
4. A candidate will be required to pass a departmental language examination. The candidate must demonstrate a reading knowledge of at least one language (other than English) which is deemed by the department as being useful in his or her research, usually French, German or Russian. For non-native speakers of one of the aforementioned language, this is usually assessed by an examination where the candidate is asked to translate part of a mathematical paper or by passing a introductory language course. This requirement must be completed before a candidate is permitted to submit a thesis.

5. A candidate will be required to pass a departmental oral examination; this examination will be primarily concerned with the contents of his or her thesis, but may include questions of a general nature relating to his or her field of specialization.

Note: At the discretion of the student's advisory committee, a candidate may be permitted to substitute certain graduate courses in other departments for mathematics courses.

ANNUAL EVALUATION OF Ph.D. STUDENTS

Our School of Graduate and Postdoctoral Studies requires departments to conduct an annual evaluation of each graduate student and also provide feedback to the student concerning the evaluation. The exact regulation is as follows.

**Required Annual Evaluation:** In addition to being provided with timely feedback on performance on particular courses, examinations, essays and other requirements, students also must be evaluated on their general performance and progress. Written feedback should be provided to each student no less than annually and a record of this evaluation must be filed with the graduate chair. This does not apply to courses-only programs.

The Department of Mathematics has approved the following annual evaluation process of its Ph.D. graduate students, which has also been endorsed by the School of Graduate and Postdoctoral Studies.

1. **Timing:** The evaluation report will be due by November 15 and will assess the student’s performance in the one year period running from September 1 of the previous year to August 31 of the year in which the evaluation was taking place.

2. **Criterion For Evaluation:** The student’s “general performance and progress” will be measured against a scale which assumes that 4 years is the normal length of time required for a Ph.D. student to produce and defend a thesis. We note that this timetable agrees with the funding policy of the School of Graduate and Postdoctoral Studies. Ph.D. students are normally limited to four years of university funding. The expectations which will be communicated to the student are as follows:

   1st year: Student should focus on the absorption of background material (in particular via courses) and also on passing the written comprehensive exams and language requirement.

   2nd year: Student should begin to focus on research. By end of 2nd year should be able to state some precise problems on which he/she is working and, possibly, have done some original research. The current departmental requirement for a presentation within six months of completing the written comprehensive exams would also be satisfied in this year.

   3rd year: Student should definitely have done some original research. Ideally, a student should have results for thesis mapped out and be well on the way to solving them.

   4th year: Student should complete research and write up thesis.
3. **The Evaluation**: The student’s advisory committee (supervisor + two other faculty members) will be the body which conducts (and signs) the evaluation. The supervisor should play the dominant role in the evaluation. In particular, the actual evaluation report will be prepared by the supervisor. It is this report which will be signed by the committee members and submitted to the graduate chair, for distribution to the student. The general format will be for the committee to produce a report without meeting the student. However, if the evaluation report gives a rating of “not totally satisfactory” then the advisory/evaluation committee should meet face to face with the student to discuss the rating before submitting the report.

4. **Comments**: The primary purpose of the evaluation is to track the candidate’s progress against identified milestones by having the supervisor state, for the record, what progress has (or has not) been made by the student in the previous year, with the goal to keep the student on track. This can generate other activities (e.g. consultation) but the above is the main purpose.

### 3.3.3 Part-time studies

Our graduate program has not been offered on a part-time basis during the past fourteen years.

### 3.4 Graduate courses

Graduate courses offered during the last three years:

#### 2009–2010

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>9020b</td>
<td>Field Theory</td>
<td>S. Rankin</td>
</tr>
<tr>
<td>9021a</td>
<td>General Topology</td>
<td>R. Kane</td>
</tr>
<tr>
<td>9022b</td>
<td>Intro. to Measure Theory</td>
<td>P. Milnes</td>
</tr>
<tr>
<td>9023a</td>
<td>Rings and Modules</td>
<td>D. Riley</td>
</tr>
<tr>
<td>9052a</td>
<td>Algebraic Topology I</td>
<td>R. Kane</td>
</tr>
<tr>
<td>9053b</td>
<td>Algebraic Geometry</td>
<td>A. Dhillon</td>
</tr>
<tr>
<td>9054a</td>
<td>Functional Analysis I (Hilbert spaces)</td>
<td>M. Khalkhali</td>
</tr>
<tr>
<td>9056a</td>
<td>Complex Analysis I</td>
<td>R. Shafikov</td>
</tr>
<tr>
<td>9057b</td>
<td>Complex Analysis II</td>
<td>A. Boivin</td>
</tr>
<tr>
<td>9131b</td>
<td>Functional Analysis II (Banach spaces)</td>
<td>S. Randriambololona</td>
</tr>
<tr>
<td>9140b</td>
<td>Representation Theory</td>
<td>D. Christensen</td>
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<tr>
<td>9144a</td>
<td>Homological Algebra</td>
<td>R. Jardine</td>
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<tr>
<td>9147a</td>
<td>Intro. to Lie groups</td>
<td>M. Pinsonnault</td>
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<td>9151b</td>
<td>Homotopy Theory</td>
<td>R. Jardine</td>
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<td>9160a</td>
<td>Smooth Manifolds</td>
<td>M. Khalkhali</td>
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<tr>
<td>9303a</td>
<td>Several Complex Variables</td>
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</tr>
<tr>
<td>9406b</td>
<td>Profinite Groups</td>
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<tr>
<td>9410a</td>
<td>Topics in Galois Theory II (Étale Algebras)</td>
<td>J. Mináč</td>
</tr>
<tr>
<td>9507b</td>
<td>Topics in Toric Topology</td>
<td>M. Franz</td>
</tr>
<tr>
<td>9611b</td>
<td>Topics in Symplectic Geometry</td>
<td>M. Pinsonnault</td>
</tr>
<tr>
<td>9501b</td>
<td>Topics in Homotopy Theory II (Stacks)</td>
<td>R. Jardine</td>
</tr>
</tbody>
</table>

* Graduate course (i.e. 9000 level) cross-listed with an undergraduate course (4000 level). All courses listed are half-courses (i.e. one-term courses).
### 2008–2009

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>9020b</td>
<td>Field Theory</td>
<td>J. Mináč</td>
</tr>
<tr>
<td>9021a</td>
<td>General Topology</td>
<td>R. Kane</td>
</tr>
<tr>
<td>9022b</td>
<td>Intro. to Measure Theory</td>
<td>A. Dhillon</td>
</tr>
<tr>
<td>9043a</td>
<td>Combinatorial Mathematics I</td>
<td>J. Mináč</td>
</tr>
<tr>
<td>9051b</td>
<td>Algebraic Number Theory</td>
<td>J. Mináč</td>
</tr>
<tr>
<td>9052b</td>
<td>Algebraic Topology I</td>
<td>R. Kane</td>
</tr>
<tr>
<td>9054a</td>
<td>Functional Analysis I (Hilbert spaces)</td>
<td>T. Foth</td>
</tr>
<tr>
<td>9056a</td>
<td>Complex Analysis I</td>
<td>A. Boivin</td>
</tr>
<tr>
<td>9057b</td>
<td>Complex Analysis II</td>
<td>A. Boivin</td>
</tr>
<tr>
<td>9058a</td>
<td>Foundation of Mathematics</td>
<td>M. Dawes</td>
</tr>
<tr>
<td>9141b</td>
<td>Commutative Algebra</td>
<td>N. Lemire</td>
</tr>
<tr>
<td>9144b</td>
<td>Homological Algebra</td>
<td>G. Denham</td>
</tr>
<tr>
<td>9152a</td>
<td>Algebraic Topology II</td>
<td>D. Christensen</td>
</tr>
<tr>
<td>9170b</td>
<td>Methods of Quantum Computing</td>
<td>M. Khalkhali</td>
</tr>
<tr>
<td>9302b</td>
<td>Riemann surfaces</td>
<td>R. Shafikov</td>
</tr>
<tr>
<td>9403a</td>
<td>Topics in Linear Algebraic Groups (Topol. of Groups Embeddings)</td>
<td>L. Renner</td>
</tr>
<tr>
<td>9405b</td>
<td>Polynomial Identity Algebras</td>
<td>D. Riley</td>
</tr>
<tr>
<td>9409a</td>
<td>Topics in Galois Theory (Galois p-Groups)</td>
<td>J. Mináč</td>
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<tr>
<td>9500a</td>
<td>K-Theory</td>
<td>R. Jardine</td>
</tr>
<tr>
<td>9501b</td>
<td>Topics in Homotopy Theory I (Local Homotopy Theory)</td>
<td>R. Jardine</td>
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<tr>
<td>9601b</td>
<td>Symplectic Geometry</td>
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</tr>
<tr>
<td>9608a</td>
<td>Topics in Complex Analytic Geometry</td>
<td>J. Adamus</td>
</tr>
<tr>
<td>9609a</td>
<td>Morse Theory</td>
<td>M. Pinsnauult</td>
</tr>
<tr>
<td>9610a</td>
<td>Topics in Complex Geom. (Holom. Struct. in Noncomm. Geom.)</td>
<td>M. Khalkhali</td>
</tr>
</tbody>
</table>

* Graduate course (i.e. 9000 level) cross-listed with an undergraduate course (3000 or 4000 level).  
All courses listed are half-courses (i.e. one-term courses).

### 2007–2008

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>507a</td>
<td>Functional Analysis I (Hilbert spaces)</td>
<td>G. Sinnamon</td>
</tr>
<tr>
<td>509a</td>
<td>Combinatorial Mathematics I</td>
<td>A.M. Dawes</td>
</tr>
<tr>
<td>511a</td>
<td>Smooth Manifolds</td>
<td>R. Shafikov</td>
</tr>
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<td>512a</td>
<td>Modular Forms</td>
<td>A. Dhillon</td>
</tr>
<tr>
<td>514a</td>
<td>Field Theory</td>
<td>J. Mináč</td>
</tr>
<tr>
<td>520a</td>
<td>Foundation of Mathematics</td>
<td>M. Dawes</td>
</tr>
<tr>
<td>547a</td>
<td>Homotopy Theory II</td>
<td>R. Jardine</td>
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<tr>
<td>548a</td>
<td>Homological Algebra</td>
<td>G. Denham</td>
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<td>551a</td>
<td>Cyclic Homology</td>
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<td>566a</td>
<td>Commutative Algebra</td>
<td>J. Adamus</td>
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<tr>
<td>576a</td>
<td>General Topology</td>
<td>J. Morton</td>
</tr>
<tr>
<td>584a</td>
<td>Topics in Noncommutative Geometry I</td>
<td>M. Khalkhali</td>
</tr>
<tr>
<td>501b</td>
<td>Algebraic Topology I</td>
<td>M. Khalkhali</td>
</tr>
<tr>
<td>503b</td>
<td>Complex Analysis I</td>
<td>T. Foth</td>
</tr>
<tr>
<td>510b</td>
<td>Combinatorial Mathematics II</td>
<td>G. Denham</td>
</tr>
<tr>
<td>513b</td>
<td>Rings and Modules</td>
<td>A. Dhillon</td>
</tr>
<tr>
<td>515b</td>
<td>Arrangements of Hyperplanes</td>
<td>G. Denham</td>
</tr>
<tr>
<td>516b</td>
<td>Complex Analytic Geometry</td>
<td>J. Adamus</td>
</tr>
<tr>
<td>520b</td>
<td>Foundation of Mathematics</td>
<td>M. Dawes</td>
</tr>
<tr>
<td>541b</td>
<td>K-Theory</td>
<td>R. Jardine</td>
</tr>
<tr>
<td>548b</td>
<td>Homological Algebra</td>
<td>G. Denham</td>
</tr>
<tr>
<td>549b</td>
<td>Introduction to Lie Algebras</td>
<td>D. Riley</td>
</tr>
<tr>
<td>588b</td>
<td>Lebesgue Integration and Fourier Series</td>
<td>P. Milnes</td>
</tr>
</tbody>
</table>

* Graduate course (i.e. 500 level) cross-listed with an undergraduate course (300 or 400 level).  
All courses listed are half-courses (i.e. one-term courses).
3.5 List of faculty by field

At The University of Western Ontario, supervision and teaching of graduate students is only permitted to faculty members who are also members of the School of Graduate and Postdoctoral Studies. Membership in the School of Graduate and postdoctoral Studies is not automatic. Faculty members are nominated for membership by the Chair of the Department’s Graduate Affairs Committee and the Chair of the Department, usually for a seven year period, after which they must be renominated. The nominations are considered for approval by the Office of the Vice-Provost (graduate and Postdoctoral Studies) on the recommendations of the Policy, regulations and Graduate Program Membership Committee, which is a subcommittee of the Graduate Education Council. Those approved for graduate student supervision are called the core faculty; some may be approved for doctoral supervision while others may be approved only for Master’s supervision. Note that Master’s supervision status allows co-supervision of a doctoral thesis with a member who has Doctoral supervisory status.

The Department of Mathematics has a total of 19 (as of March, 2010) full-time tenured or tenure-track faculty members. All of these are core faculty members. Four of these 19 have approval only for Master’s supervision: Adamus, Dawes, Franz and Pinsonnault. We have recently applied for Doctoral supervision status for Adamus and are confident this will be granted. Franz and Pinsonnault were recently hired (July 2008), and will likely be approved for doctoral supervision in the next year.

One of our full-time faculty members, Christensen, is also approved for doctoral supervision in the Department of Applied Mathematics. In addition, Professors Helmut Jürgensen, an Emeritus and Adjunct Research Professor of the Department of Computer Science, and John Bell, Professor in the Department of Philosophy, are also core faculty members in the Department of Mathematics. Professor Jürgensen is classified under our “Algebra/Number Theory” field, and Professor Bell’s research includes work in the Foundations of Mathematics, which we do not list among our “fields” because we have nobody in our Department who is active in that area. Professors Jürgensen’s and Bell’s involvement in our graduate program has not been large during the past seven years. Bell is approved only for Master’s supervision in our department, but an application for doctoral supervision status has been submitted.

Professor Kane and Professor Borwein are retired emeriti professors and are also among our core faculty. This brings our total present core faculty to 23.

Professor Milnes is scheduled to retire in July this year and Professor Dawes in July next year. It is anticipated that one more will retire within the next two to four years. Our three major research fields will all be affected.

With the abolishment of mandatory retirement, and very limited hiring at UWO over the next few years, it is hard to predict how the numbers above will change. It is possible that some retirements will not be replaced.

Table 1 lists the faculty members involved in the graduate program, identifies their field, and indicates gender.

As Table 1 shows, we have a diverse mix of faculty, spread over the various ranks, and covering a broad range of research areas in mathematics. The table also illustrates how many faculty work on research that spans multiple fields.
### Table 1
Faculty Members by Field, 2009–2010

<table>
<thead>
<tr>
<th>Name</th>
<th>Rank</th>
<th>M/F</th>
<th>Home Unit</th>
<th>Supervisory Privileges</th>
<th>Fields¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Adamus</td>
<td>Assistant</td>
<td>M</td>
<td>Mathematics</td>
<td>Master’s</td>
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</tr>
<tr>
<td>J. Bell</td>
<td>Professor</td>
<td>M</td>
<td>Philosophy</td>
<td>Master’s</td>
<td>X</td>
</tr>
<tr>
<td>A. Boivin</td>
<td>Professor</td>
<td>M</td>
<td>Mathematics</td>
<td>Full</td>
<td>X</td>
</tr>
<tr>
<td>J.D. Christensen</td>
<td>Professor</td>
<td>M</td>
<td>Mathematics</td>
<td>Full</td>
<td>X</td>
</tr>
<tr>
<td>D. Borwein</td>
<td>Emeritus</td>
<td>M</td>
<td>Mathematics</td>
<td>Full</td>
<td>X</td>
</tr>
<tr>
<td>A.M. Dawes</td>
<td>Associate</td>
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<td>Master’s</td>
<td>X</td>
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<tr>
<td>G. Denham</td>
<td>Associate</td>
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<td>T. Foth</td>
<td>Associate</td>
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<td>Mathematics</td>
<td>Full</td>
<td>X</td>
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<tr>
<td>J.F. Jardine</td>
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</tr>
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<td>R. Kane</td>
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<td>Mathematics</td>
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</tr>
<tr>
<td>P. Milnes</td>
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<tr>
<td>J. Mináč</td>
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<tr>
<td>M. Pinsoumault</td>
<td>Assistant</td>
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<td>Mathematics</td>
<td>Master’s</td>
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<td>S. Rankin</td>
<td>Associate</td>
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<td>L. Renner</td>
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<tr>
<td>D. Riley</td>
<td>Professor</td>
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<td>R. Shafikov</td>
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<td>Professor</td>
<td>M</td>
<td>Mathematics</td>
<td>Full</td>
<td>X</td>
</tr>
</tbody>
</table>


The bold X indicates the primary field.

### 3.5.1 Summaries of the research interests of the core faculty who are full-time members of the Department of Mathematics and who have approval for doctoral supervision

**J. Adamus**

Areas of research: Analytic geometry and commutative algebra.

Adamus works in the interface of analytic geometry and commutative algebra, two major branches of modern mathematics. They deal with the analysis of polynomial and analytic functions and the geometry of the spaces on which those live. Adamus’s research is particularly concerned with the study of the local singularities in mappings. Such minute degeneracies can completely destroy the geometric regularity of the objects defined by the mappings. It is important to know how to detect those degeneracies. The main thrust of Adamus’s current work is in establishing simple and effective algebraic criteria to control the local behaviour of a mapping.
A. Boivin

Areas of Research: Complex Analysis, approximation theory.

Boivin’s research is in complex analysis and approximation theory. The main theme of this research is analytic approximation. The point of view taken is more qualitative than quantitative, in the sense that the principal interest is to determine whether it is possible to do an approximation rather than to find efficient algorithms for computing approximations. One of the practical consequences of qualitative approximation theory is that one finds information about whether a certain approximation exists or not so that effort is not wasted in trying to compute something that, in fact, does not exist. The theoretical consequences provide a set of fundamental techniques which are used to simplify many arguments in certain areas of mathematics.

Boivin is especially interested in approximating functions by solutions of systems of differential equations. In particular, holomorphic functions, harmonic functions and other functions which are solutions of elliptic partial differential equations have been considered and generalizations (with applications) of Vituskin’s and Arakelyan’s theorems have been obtained. Boivin also has been interested by the theory of non-harmonic Fourier series, that is by the approximation properties of systems of exponentials \( \{ e^{i\mu nt} \} \). The questions addressed (do they form a basis? do they form a frame?) have considerable contemporary importance in view of the connections with control theory and signal processing.

Boivin has had four Ph.D. students in the last ten years.

J. D. Christensen

Areas of research: Homotopy theory in topology and algebra, quantum gravity.

Christensen’s primary research area is algebraic topology with an emphasis on stable homotopy theory and the application of homotopy theoretic methods in algebra. He is well known for his work on phantom maps and Brown representability in derived categories and other triangulated categories, and has recently worked on studying the generating hypothesis in the stable module category of a finite group. His research in this area forms part of the homotopy theory group, for which the department is highly regarded in Canada and internationally, and he is currently supervising several postdoctoral fellows and graduate students in this area.

Christensen also works on quantum gravity, using methods from representation theory and combinatorial topology to study spin foam models. This work involves a mix of theoretical results about the behaviour and properties of these models, and computational exploration directed at determining whether the models agree with observations. The computations involve the development of new algorithms in representation theory, and make heavy use of the SHARCNET supercomputers. Christensen’s group is one of the few in the world working on computational methods in quantum gravity, and attracts high quality graduate students.

G. Denham

Areas of research: Algebraic combinatorics, algebraic topology, arrangements of hyperplanes.

Denham’s research is centered around the interplay between algebraic topology and combinatorial structures. Topological methods can be applied to combinatorial problems, as in the use of rational homotopy theory in combinatorial commutative algebra. Combinatorial methods can also be used to construct and study families of “test” objects with interesting topological or geometric properties,
as in the theory of complex subspace arrangements and the theory of hyperplane arrangements. Symbolic computation sometimes plays a significant role by extending the range and sophistication of available examples on which to develop intuition and formulate conjectures.

His interests also include Farber’s notion of topological complexity for robot motion planning: this amounts to computing a certain sectional category by comparing homological lower bounds (combinatorics) with geometric upper bounds.

A. Dhillon

Areas of research: Algebraic geometry.

Dhillon’s research is in algebraic geometry, in particular moduli of bundles. In early work he studied relationships between Tamagawa numbers of algebraic groups and the geometry of moduli stacks of principal bundles over a curve. This work gives rise to certain motivic questions pertaining to these moduli spaces and a precise conjecture for the motivic volume of these stack has been written down in a joint work with Kai Behrend.

In joint work with Nicole Lemire he is now studying the essential dimension of these moduli stacks over curves. The essential dimension can be viewed as the transcendence degree of the function field of the non-existent moduli space of principal bundles over a curve.

In another current project the Hodge theory of gerbes banded by the multiplicative group is being studied. These gerbes can be though of as a categorical analogue of a line bundle. On a smooth projective variety there is a Hodge theoretic obstruction to an analytic gerbe being algebraic. The question being studied is that if this obstruction vanishes, then is the gerbe algebraic.

T. Foth

Areas of research: Analysis on manifolds.

Foth studies various analytic problems that arise in complex and symplectic geometry, related, in particular, to Toeplitz operators, manifolds parametrizing complex structures or Lie algebra structures, natural connections in certain vector bundles, and automorphic forms. Foth and her Ph.D. student recently wrote a joint paper where they study spaces of holomorphic k-differentials on an open Riemann surface obtained by removing a closed subset from a hyperbolic Riemann surface. Two more graduate students started working under Foth’s supervision in 2008, in the area of analysis and differential geometry. Since then, Pinsonnault has become a cosupervisor (with Foth) for these two students.

M. Franz

Areas of research: Transformation groups, computational algebra

Franz studies spaces with symmetries. The mathematical framework for this is the theory of transformation groups. Often, the group is a torus, which corresponds to spaces with rotational symmetry around one or more axes. Important special cases are algebraic varieties or symplectic manifolds; many spaces also admit a combinatorial description. This establishes links to algebra, geometry and combinatorics. Often, computer algebra is a useful tool to study examples.
J. F. Jardine

Areas of research: Algebraic K-theory, algebraic topology, algebraic geometry, category theory.

Jardine’s research is in homotopy theory and its applications.

Algebraic topology is the study of algebraic approximations of space, and has been one of the driving forces of Mathematics since early in the twentieth century; it effectively began with the work of Poincaré in the late 1890s. The theory acquired great depth and computational power over the years, and achieved a precise level of axiomatic simplicity with Quillen’s introduction of closed model structures in the 1960s. At the same time, the Grothendieck school in Paris began a grand project to apply the wealth of homotopy theoretic calculational methods to algebraic geometry and number theory, and this enterprise continues to this day. The modern period for this branch of homotopy theory began in the mid 1980s with the discovery of closed model structures for wide classes of simplicial objects in algebraic geometry by Jardine and Joyal, and has progressed in recent years with the introduction of motivic homotopy theory by Morel and Voevodsky in connection with Voevodsky’s celebrated proof of the Milnor Conjecture, and recent work by Jardine and others on cocycles and the homotopy theory of stacks. The local to global methods implicit in this theory are also central to the recent work of Hopkins, Lurie, Toen and others on derived algebraic geometry and its applications to elliptic cohomology theories, topological modular forms and conformal field theories.

Jardine is the coauthor, with Paul Goerss (Northwestern University), of the book “Simplicial Homotopy Theory”, which was published by Birkhauser, originally in 1999 in the Progress in Mathematics series, and then again in 2009 in the Modern Birkhauser Classics series. The book was the first to appear in the subject in over 25 years, and it describes much of the present state of the art in the combinatorial approach to homotopy theory. Combinatorial homotopy theory is used throughout modern Mathematics, and is finding new applications in Science and Engineering, particularly in the study of networks, the development of models for parallel processing, and geometric analysis of large data sets. In this realm, Jardine has recently solved the central open problem in geometric concurrency theory, which is to classify execution paths in higher dimensional automata. This was done with a simple, algorithmic 2-categorical model; this algorithm is the basis for a software package which is under continuing development at Western.

Homotopy theory, together with its traditional applications in Mathematics and the new developments in more applied subjects, is at the core of modern research in the mathematical sciences, and the University of Western Ontario is a major international centre in the field. We have a large group of talented graduate students, postdoctoral fellows, and faculty working in this area. Some of the former members of Jardine’s group are now international leaders in their respective research areas.

M. Khalkhali

Areas of research: Cyclic homology, noncommutative geometry, operator algebras.

Khalkhali’s research is on cyclic cohomology and non-commutative geometry, and applications to questions in geometry, analysis and mathematical physics. The standard applications are to index theory (Novikov conjecture, foliation index theorem), algebraic K-theory (topological cyclic homology), while the recent papers of Connes-Douglas-Schwartz and Seiberg-Witten have left no doubt that noncommutative geometry is bound to play a vital role in M-theory and string theory.

Khalkhali’s early work was concerned with the entire cyclic cohomology of Banach algebras.
The general concept was originally introduced by A. Connes to deal with questions in analysis and geometry in infinite dimensional (commutative and non-commutative) spaces; Khalkhali established some of the most fundamental properties of this theory, including homotopy invariance and Morita invariance. He later showed that well known results of Cuntz and Quillen could be used to find a homotopy formula for the Hochschild complex of algebras with finite cohomological dimension with good controls on the growth of cocycles.

The Deligne conjecture on the fine structure of the Hochschild cochain complex of associative algebras was proved a few years ago, independently, by Kontsevich, Voronov, McClure-Smith, and Tamarkin; this was a major breakthrough in deformation theory. In a recent paper, Khalkhali shows that many of the standard operations on cyclic cohomology are consequences of this conjecture.

N. Lemire

Areas of Research: (birational) invariant theory, algebraic groups, multiplicative invariants, Galois cohomology, representation theory, stable rationality, linearisation, moduli stacks and spaces, vector bundles over curves

One of Lemire’s main sources of research problems is birational invariant theory. A classical but notoriously difficult problem in algebraic geometry is to classify algebraic varieties up to birational isomorphism - a natural equivalence relation on the set of algebraic varieties. Rational algebraic varieties - those whose function fields are quotient fields of polynomial algebras over a base field - form a distinguished class under this equivalence relation. It is still a very difficult problem to determine which algebraic varieties are rational. The simplest known rational varieties are the linear varieties and the algebraic tori or multiplicative varieties. There are natural actions of finite groups on linear varieties and algebraic tori coming from representations of the groups. One may ask when the orbit space of a linear variety or algebraic tori under a finite group action is rational. This question was first posed by Emmy Noether while she was doing work on the inverse Galois problem. One may also compare an algebraic torus with a finite group action to the associated linear variety with a finite group action by asking when the two are birationally isomorphic with a birational isomorphism which is equivariant with respect to the finite group action. This question of equivariant birational linearisation is related to the question of finding conjugacy classes of finite subgroups in the classical Cremona group - the group of birational isomorphisms of projective space. It is also related to the classical problem of determining whether an algebraic group is Cayley - or equivariantly birationally isomorphic to its Lie algebra - a problem first studied by Cayley. Lemire previously did joint work on this problem with Vladimir Popov and Zinovy Reichstein. Among other things, they determined the set of simple algebraic groups over an algebraically closed field which are Cayley. Lemire studies analogues and generalisations of the rationality problem for algebraic tori under finite group actions and also the equivariant birational linearisation problem. She uses techniques coming from representation theory, Galois cohomology and birational geometry.

Another area of research for Lemire is essential dimension. This is a measure of the degree of complexity of an algebraic or geometric object defined over a base field. It was first defined by Buhler and Reichstein for finite and algebraic groups. The definition was generalised by Merkurjev and much work has been done in this area since then by such prominent mathematicians such as Brosnan, Chernousov, Karpenko, Merkurjev, Reichstein, Serre, Vistoli and Youssin to name a few. She did some earlier work on bounds on the essential dimension of algebraic groups. More recently, in joint work with Ajneet Dhillon, they are working on determining bounds on the essential dimension of moduli stacks of principal G-bundles over a curve using results from recent work of Brosnan, Reichstein and Vistoli.
P. Milnes

**Areas of research: Harmonic and functional analysis.**

Milnes’s research is centred around topological groups, compact right topological groups, flows and C*-algebras. These mathematical objects are both algebraic and topological in nature, are of great interest to mathematicians, and are widely studied by them; they are also very useful to physicists, statisticians and social scientists. Milnes’s study of these concepts uses powerful tools from harmonic analysis, topological dynamics and functional analysis.

One area of Milnes’s work has its origins at the beginning of the last century, in the work of Harald Bohr on almost periodic functions on the real line. Since then the subject has grown enormously and now includes the study of the algebras of weakly almost periodic functions, almost automorphic functions, distal functions and many other functions of “almost periodic type” on groups and semigroups $G$. As well as the tools mentioned above, a unifying concept in this work is the appropriate notion of compactification of $G$, which is like the Stone-Cech compactification, except that account is also taken of the algebraic structure of $G$. The structure of the relevant compactifications plays an important role in determining functional analytic and dynamical properties of the algebras and of $G$.

In other work, Milnes studies $C^*$-algebras generated from operator equations and the connection of these algebras with some special groups and flows. He also studies the representation theory of compact right topological groups. An important and interesting aspect of Milnes’s work is the study of examples, structure and other properties of flows and compact right topological groups. A notable success in this area was the discovery of Haar measure on compact right topological groups, that is, a probability measure on the group that is both left and right invariant, and unique as such; this discovery was made in joint work with coauthor J.S. Pym.

J. Mináč

**Areas of research: Algebraic number theory, Galois cohomology, motivic cohomology, Galois theory, profinite groups, graded Lie algebras, quadratic forms, field theory, Brauer groups, algebraic K-theory, stable module categories.**

Mináč’s main interest is the Galois theory of fields and its interaction with several areas of mathematics, including number theory, topology and algebraic geometry. Mináč loves interacting with students on all levels and learning and discovering mathematics together with his students.

In joint work with Michel Spira, published in the *Annals of Mathematics* in 1996, Mináč found quite a precise relationship between certain Galois groups of fields and Witt rings of quadratic forms. These groups and their topological invariants have been studied further with several other mathematicians including: A. Adem, D. Benson, D. Karagueuzian, N. Kuhn and J. Pakianathan, and they have already been used in some non-trivial calculations in group cohomology and in obtaining restrictions on absolute Galois groups of fields. The structure of absolute Galois groups is a long-standing, open central problem in current mathematics. Therefore these advances in this area are of interest. Related to this work is Mináč’s work with S. Chebolu and I. Efrat on absolute Galois groups. They were able to find new restrictions on possible absolute Galois groups. This work has also been studied in some of the “Galois Seminars” held in the Department of Mathematics, Pennsylvania State University, where A. Topaz delivered two lectures on this work: *Quotients of Galois groups and Galois cohomology (Parts I and II).*

In work with D. Benson, N. Lemire and J. Swallow, Mináč has made progress in obtaining a complete classification of certain significant quotients of these groups. This is the first instance
when such a classification in the non-trivial case has become possible. Two joint papers on this work were published in *J. Reine Angew. Math.* 613 (2007), 147-173 and 175-191.

In work with F. Chemotti, J. Swallow and A. Topaz, Mínáč succeeded in extending some of their previous work with A. Schultz and J. Swallow on the structure of $p$th-power classes of field extensions to non-cyclic Galois extensions. This is interesting, as the classification of the abstract modules in modular representation theory for these Galois groups, is out of reach. In work with D. Benson, J. Carlson, S. Chebolu, and J. Swallow, Mínáč has been working on several joint projects concerning some problems in Galois cohomology and modular representation theory. They have been working on refinements of the Bloch-Kato conjecture and the representation theory of Galois modules consisting of the square classes of units in some Galois extensions.

A long-standing conjecture of Peter Freyd called the *Generating Hypothesis* in stable homotopy theory claims that a map between finite spectra that is zero on stable homotopy groups is null-homotopic. With D. Benson, J. Carlson, S. Chebolu and D. Christensen, Mínáč formulated and solved the *Generating Hypothesis* in the stable module category of a finite group. In another project with J. Carlson and S. Chebolu, Mínáč has been studying some fundamental problems in Tate cohomology and Auslander-Reiten sequences using support varieties.

In work with A. Schultz and J. Swallow, Mínáč classified $K^*/K^{sp}$ as $\mathbb{F}_p[G]$-modules for all $K/F$-Galois cyclic $[K:F] = p^n, G = \text{Gal}(K/F)$.

This was a problem initially investigated by P. Borević and D. K. Faddeev in the 1960s in the case of local fields. The fact that there is no assumption about the base field is unexpected. Mínáč continued work with A. Schultz and J. Swallow on the wild case, where a solution was again obtained. It is a problem to extend the previous work of Mínáč, Schultz and Swallow, published in *Proc. London Math. Soc.* in 2006, to the case when $\mathbb{F}_p$ is replaced by any $\mathbb{Z}/p^s\mathbb{Z}, s \in \mathbb{N}$. The general modules over $\mathbb{Z}/p^s\mathbb{Z}[G]$ are not yet classified; yet in this case, classification of the Galois modules described above was obtained. The solution is complicated and their initial preprint is 115 pages long.

There has also been some further work carried out by Mínáč with Z. Reichstein on trace forms and with D. Benson and S. Chebolu on a refinement of the Bloch-Kato conjecture and work with J. Labute on maximal $p$-extensions with given ramification.

This area of absolute Galois groups and their applications looks ideal for attracting some graduate students to UWO, as it is a central and beautiful area of mathematics which is approachable from many different points of view. Currently this entire area is “on the move” in dramatic new ways. Strong specialists in this area with whom Mínáč has been collaborating include: A. Adem, D. Benson, J. Carlson, S. Chebolu, J. Labute, Z. Reichstein, A. Schultz, and J. Swallow. These same specialists also have already interacted with, or have the potential to interact with our graduate students here.

**M. Pinsonnault**

**Areas of research: Symplectic Geometry and Topology, Geometric Topology.**

Pinsonnault’s main interest is in symplectic topology and geometric topology. Currently, his research focuses on the homotopy theoretic, geometric, and algebraic properties of symplectomorphism groups. Symplectic geometry was initially developed as the mathematical framework of classical physics. It evolved into an independent field of research, very topological in nature, at the crossroads of differential topology, algebraic geometry, dynamics, and gauge theory. Because of its numerous ramifications in mathematics and mathematical physics, symplectic geometry offers many beautiful avenues to introduce graduate students to current research in modern geometry.
S. Rankin

Areas of research: Knot theory, graph theory, combinatorics.

Rankin’s primary research area is knot theory, largely from a combinatorial perspective. He is well known for his enumeration of prime alternating knots and links (joint work with Ortho Flint), and he maintains a web site that provides access to the current database of prime alternating links, as well as a knot drawing tool. The enumeration work is computationally intensive, and makes use of several high performance computation machines, as well as the departmental computing network.

Recently, he has investigated generalizations of the Fine-Wilf theorem, and has carried out an extensive study of the graphs that can be associated to sequences of positive integers in the context of the Fine-Wilf theorem. There are certain properties of these sequences that have been studied over the last 20 years, and Rankin has developed algorithms to enumerate those sequences which are extremal with respect to these properties. In the study of combinatorics on words, these extremal sequences correspond to important classes of words, the episturmian words.

Another recent area of interest for Rankin is the study of polynomial identities, in particular over finite fields, and more generally, over fields of prime characteristic. In one work, he answered a question posed by V. V. Shchigolev in 2000 pertaining to the finite-basedness of certain invariant, infinitely generated subspaces of the free associative algebra (over a field of prime characteristic different from 2) on a countably infinite set.

L. E. Renner

Areas of research: Algebraic groups and monoids, algebraic transformation groups, algebraic combinatorics.

Renner is known internationally for his work on algebraic monoids, a branch of algebra that he developed (along with M.S. Putcha at North Carolina State) starting about 1980.

The theory of algebraic monoids is a natural synthesis of algebraic group theory (Chevalley, Borel) and torus embeddings (Mumford, Kempf, et al). Renner’s contributions here contain decisive results on the following key issues: Cell decompositions (analogous to Schubert varieties) of compactifications of G; Finite analogues of reductive monoids; Important combinatorial properties of orbits; A precise analogue of the Bruhat decomposition; The classification of normal reductive monoids in terms of discrete data.

D. Riley

Areas of research: Noncommutative algebra.

Much of Riley’s research is in the area of Combinatorial Algebra. Its ancestor, Combinatorial Group Theory, includes the following basic areas: (i) groups presented by generators and relators, (ii) growth in groups, (iii) the Burnside Problem, and (iv) computational and algorithmic aspects, such as the Word Problem. Combinatorial Algebra extends these problems to include other algebraic structures such as associative algebras, Lie algebras, and restricted Lie algebras.

For example, a celebrated theorem of Gromov states that a finitely generated group has polynomial growth if and only if it is virtually nilpotent. Using entirely different techniques, Riley and
one of his doctoral students recently proved an exact analogue for restricted Lie algebras. Determining exactly which Lie and associative algebras have finite Gelfand-Kirillov dimension (that is, polynomial growth) remains an open problem and is a very interesting area of current research.

First posed in the early twentieth century, the General Burnside Problem for groups asks: Is every finitely generated periodic group finite? The Kurosh-Levitzki Problem is an associative algebra analogue: Is every finitely generated nil algebra finite-dimensional? A negative solution for the latter — first constructed by Golod and Shafarevich in the 1960’s — led immediately to a negative solution of the former. It was natural, therefore, to reformulate these problems with additional hypotheses. Indeed, Zel’manov won a Fields Medal in 1994 for his proof that every finitely generated periodic profinite group is finite. This solved the so-called Restricted Burnside Problem for groups. Recently, Riley and another of his doctoral students proved analogues of Zel’manov’s result for profinite Lie algebras and restricted Lie algebras.

Combinatorial Algebra is a fruitful area of fundamental research that continues to attract many new graduate students.

**R. Shafikov**

**Areas of research: Complex analysis in several variables**

Most of Shafikov’s research lies in two areas of several complex variables: holomorphic mappings and CR geometry. Boundary behaviour of proper holomorphic mappings between domains in complex spaces has been one of the pivotal questions in complex analysis. The problem is completely understood in dimension one, but in higher dimensions the question is open even in the case of domains with real analytic boundaries. Shafikov obtained certain results concerning analytic continuation and boundary regularity of mappings in the case when the target domain has real algebraic boundary, and some results concerning global analytic continuation for multiply connected domains.

Local holomorphic extension of CR functions from CR manifolds is one of the basic questions in CR geometry. The problem is well understood for smooth manifolds. However, the question is widely open for manifolds with singularities. Shafikov is working on finding sufficient and necessary conditions for such holomorphic extension in the case of singular real analytic hypersurfaces. This is a very promising long term project that will surely attract a lot of attention, and in particular it has a great potential to attract new graduate students.

**G. J. Sinnamon**

**Areas of research: Weighted norm inequalities, harmonic analysis**

The Fourier Transform converts information about the amplitude of a wave to information about its frequency. It is the most studied and most applied operator in all of mathematics. Estimates of the integral defining the Fourier transform have been intensively studied for well over a century. In 1998 Sinnamon developed new Fourier estimates, the first of their kind in thirty years. They are based on new, very sensitive techniques that take into account both amplitude and frequency. More recently, (2003, 2008, 2009) he developed an important link between estimates of the Fourier Transform and the powerful theory of positive operators.

Sinnamon revived and reworked the level function construction from the 1950’s in order to prove, in 1987, the last outstanding case of the weighted Hardy inequality. The construction improves estimates involving decreasing functions. His extensive work on monotonicity in function spaces
culminated in 2006 with the construction of a scale of "down" spaces that closely parallel the fundamental class of rearrangement-invariant spaces.

The Lebesgue norms are integrals which represent different notions of the size of a function and Schur’s Lemma is a standard tool to generate Lebesgue norm estimates. Simmamon’s sharp converse of Schur’s Lemma (1999, 2005) provides the best possible Lebesgue norm estimates for a large class of transforms and sets up a common framework for the study of all positive integral transformations.

For students with an interest in these topics, Western is a natural location since this internationally popular field is underrepresented in Canada.

### 3.6 External operating research funding

Table 2A presents the Natural Sciences and Engineering Research Council of Canada (or NSERC) Discovery Grants (individual research grants) received by the program by year for the past ten years, while Table 2B shows the same funding broken down by field.

In addition, we have received equipment grants and conference grants (see Sections 4.5.3 and 4.5 for more information).

#### Table 2A
NSERC Discovery Grants by Year

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<tbody>
<tr>
<td>2000–2001</td>
<td>151,458</td>
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<tr>
<td>2001–2002</td>
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<td>2002–2003</td>
<td></td>
<td>212,850</td>
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<tr>
<td>2003–2004</td>
<td></td>
<td>212,950</td>
<td></td>
<td></td>
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<tr>
<td>2004–2005</td>
<td></td>
<td></td>
<td>218,000</td>
<td></td>
<td></td>
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<tr>
<td>2005–2006</td>
<td></td>
<td></td>
<td></td>
<td>248,000</td>
<td></td>
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<tr>
<td>2006–2007</td>
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<td></td>
<td></td>
<td></td>
<td>248,000</td>
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<tr>
<td>2007–2008</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>214,000</td>
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<tr>
<td>2008–2009</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>226,000</td>
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<td>2009–2010</td>
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<td></td>
<td></td>
<td>265,000</td>
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</tbody>
</table>

#### Table 2B
NSERC Discovery Grants by Field and by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Algebra &amp; Number Theory</th>
<th>Analysis</th>
<th>Geometry &amp; Topology</th>
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</thead>
<tbody>
<tr>
<td>2001–2002</td>
<td>30,900</td>
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<td>65,000</td>
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<td>2002–2003</td>
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<td>79,000</td>
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<tr>
<td>2003–2004</td>
<td>80,950</td>
<td>53,000</td>
<td>79,000</td>
</tr>
<tr>
<td>2004–2005</td>
<td>80,000</td>
<td>57,000</td>
<td>81,000</td>
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<tr>
<td>2005–2006</td>
<td>83,000</td>
<td>81,000</td>
<td>84,000</td>
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<td>2006–2007</td>
<td>92,000</td>
<td>72,000</td>
<td>84,000</td>
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<tr>
<td>2007–2008</td>
<td>89,000</td>
<td>55,000</td>
<td>70,000</td>
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<tr>
<td>2008–2009</td>
<td>89,000</td>
<td>67,000</td>
<td>70,000</td>
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<tr>
<td>2009–2010</td>
<td>94,000</td>
<td>57,000</td>
<td>114,000</td>
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<td>2010–2011</td>
<td>102,000</td>
<td>82,000</td>
<td>112,000</td>
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</table>

1 The *primary* field of each faculty member is used here.
3.7 Graduate supervision

Table 3 lists completed and current thesis supervisions by faculty member. It does not include students who will start their program during 2010. And it only includes students who were supervised by current core faculty members in the Department.

Table 3

Completed and Current Numbers of Thesis Supervisions by Faculty Member

<table>
<thead>
<tr>
<th>Member</th>
<th>Completed</th>
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<th>Current</th>
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<th></th>
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<td>Master’s</td>
<td>Ph.D.</td>
<td>PDF</td>
<td>Master’s</td>
<td>Ph.D.</td>
<td>PDF</td>
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<td>J. Adamus</td>
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<td>3</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>A. Boivin</td>
<td>0(2)</td>
<td>3(2)</td>
<td>1.5</td>
<td>1(0)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>J.D. Christensen</td>
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</tr>
<tr>
<td>A.M. Dawes</td>
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<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Denham</td>
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<td>1.5</td>
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</tr>
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<td>A. Dhillon</td>
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<td>0.5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>T. Foth</td>
<td>1.5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>M. Franz</td>
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<td></td>
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<tr>
<td>J.F. Jardine</td>
<td>2</td>
<td>14</td>
<td></td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>R. Kane</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Khalkhali</td>
<td>3</td>
<td>1</td>
<td></td>
<td>3</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>N. Lemire</td>
<td></td>
<td>0.5</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. Milnes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. Minác</td>
<td>3.5</td>
<td>1</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Pinsonnault</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>S. Rankin</td>
<td>4</td>
<td>2.5</td>
<td></td>
<td>2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>L. Renner</td>
<td>4</td>
<td>1.5</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Riley</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. Shafikov</td>
<td>2</td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Sinnamon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Joint and co-supervision are indicated by half numbers. The numbers in parentheses for Christensen indicate students supervised in the Department of Applied Mathematics. Recall that our Master’s program is almost always accomplished solely through course work.

3.8 Commitment of faculty members from other graduate programs and/or from other institutions

Two faculty members, John Bell (Philosophy) and Helmut Jürgensen (Computer Science), have some involvement in our graduate program from time to time. Their contribution, while valuable, has not been substantive over the past ten years.

Courses in Representation Theory, Differential Geometry, Functional Analysis, Foundations of Mathematics and other topics offered by the Mathematics department have attracted students from Applied Mathematics, Engineering and Philosophy. Christensen also has supervised two Ph.D. students in Applied Mathematics. Various faculty members in Mathematics interact with faculty members in Applied Mathematics, Computer Science, Education, through seminars, grant applications, Ph.D. examinations, etc.
3.9 Other activities relevant to the graduate program

The Department of Mathematics has been able to develop a PDF program capable of supporting several PDF’s per year, currently ten(10) in 2009/10, and a total of nine(9) is expected in 2010-2011. For more details, see Section 4.3.

In 1997 the Department instituted an annual “Distinguished Lecture Series” normally held in the spring of each year. The purpose is to bring eminent mathematicians to visit the Department for a week. The visitor typically gives a series of research lectures, a general colloquium, and is available for consultation with faculty and students. A list of the mathematicians that have so far given lectures in this series can be found in Section 4.5.2.

Our PDF program, the Distinguished Lecture Series and our interaction with Research Centres (see Section 4.6) have all added significantly to the quality of the academic environment that we are providing to our graduate students.

3.10 Library resources

The Allyn and Betty Taylor Library, one of the seven locations that comprise Western Libraries, serves the Faculty of Science as well as the Faculties of Engineering and Health Sciences, and the Schulich School of Medicine and Dentistry. Because of the multidisciplinary aspects of the work in the Faculty of Science, it is convenient for the department to have a single source for all their information resources and services. The Taylor Library houses approximately 442,000 volumes, has 115 computer workstations and 24 laptop ports, and provides wireless access to the University’s network. The Library has seating for 1,250 and seven study rooms available for individual or group use. The Library is open for 100 hours each week during the regular academic year, and 117.5 hours during exam periods. Reference services are available in person and by telephone, as well as via email and instant messaging.

Western Libraries is the fourth largest research library system in Canada with more than three million volumes of monographs and serials. There are nearly six million other items (microforms, government publications, pamphlets, audiovisual materials, photographic negatives, music and sound recordings, CD-ROMs and machine-readable files, maps, etc.). Western Libraries maintains over 30,000 links to current and retrospective content in key electronic journals that support the University’s research and teaching interests. As well, there are subscriptions to approximately 300 bibliographic databases and 10,000 print serials (scholarly journals, magazines and newspapers, and monographic series).

The Taylor Library provides a comprehensive electronic and print collection of monographs and journals to support graduate programs in the Department of Mathematics. The Library purchases journals in electronic format, whenever possible, in order to facilitate access for students. The Library is actively transitioning to electronic books, while endeavouring to accommodate mathematicians’ preferences for print material. Subscriptions to key bibliographic databases for mathematics facilitate access to the research collections. Finally, easy access to Interlibrary Loan services also ensures quick delivery of materials not available through Western Libraries.

Information literacy instruction for graduate students is a priority of the Taylor Library, and the Library offers a workshop series for all graduate students, as well as personalized, one-on-one support and instruction as requested by students. Reference services are available in person, via phone, email and instant messaging, ensuring prompt research help for graduate students.

Overall, the Taylor Library provides a strong level of resources and services in support of Mathematics graduate programs. The collection also includes materials for the relevant subject
areas of mathematics, physics, and statistics.

3.11 Computer Facilities

Availability of computers for students or faculty:

Every faculty member, post doctoral fellow, and every graduate student in the Department of Mathematics is provided with a personal computer for his, or her exclusive use. These computers are kept up-to-date from both the hardware perspective, and the operating system. Presently, the department has Fedora Linux as its primary choice of operating system. Each is connected to the departmental LAN and hence the campus backbone. The department provides network file and print services, with centralized nightly backup so that user files are automatically backed up. The software provided and maintained by the department (available from the file server) consists of TeX, GAP (a system for computational group theory), Macauley (a system for computation in algebraic geometry and commutative algebra), and Nauty (a system for computation in graph theory), while the University maintains a campus wide all-platform site license for Maple, which is also available from the departmental server either for Linux or for Windows. The University also maintains licenses for many on-line databases. In particular, all on-line resources of the American Mathematical Society are available from each workstation in the department.

The department’s Linux computers are organized as a computational cluster, and in addition, the department has three dual-opteron server-class machines with large memory and disk space to aid in computationally intensive work. If necessary, all departmental members have access to the large cluster known as the Ontario SHARCNET (shared hierarchical academic research computing network).

The University of Western Ontario also provides a pre-set amount of access from off-campus, via modem, to the full suite of Internet applications (e.g. email, www, download files). Faculty, staff and graduate students are entitled to a monthly quota of 40 hours connect time at no charge. If more time is required, a written request from a department head or supervisor is required.

As well, students that are living in residence are able to purchase a direct 10Base-T network connection to the campus backbone.

3.12 Financial Support

Graduate students receive their stipends from a variety of sources. These are (1) External scholarships like the Natural Sciences and Engineering Research Council of Canada (or NSERC) Scholarships, the Ontario Graduate Scholarships (or OGS), and Ontario Graduate Scholarships in Sciences and Technology (or OGSST), (2) Graduate Teaching Assistantships (or GTA), (3) University Scholarships (WGRS), (4) Research Assistantships (or GRA) funded almost entirely from core faculty NSERC individual Discovery Grants. Master’s students are rarely offered GRA’s because our Master’s program is almost always accomplished solely through course work and completed in two or three terms.

In 2005, a new funding model for graduate programs was put in place at UWO which more than doubled the money made available by UWO to the Department of Mathematics that year alone. This has allowed our graduate program to grow without compromising quality.

Each department is now allocated a special fund, the Graduate Student Scholarship and Training Fund (G.S.S.T. Fund) based on the number of eligible graduate students in the program on November 1st of each year. A student is eligible if his/her average is above 70%, following rules
provided by the School of Graduate and Postdoctoral Studies. The amount in the G.S.S.T. Fund is calculated as follows. On November 1st, each eligible domestic student in our program generates $4,500, of which the Department receives $4,150, and each eligible international student generates $10,800, of which the Department receives $10,450 = $4,150 + $6,300. The difference between the amount generated and received, i.e. $350 per student, is used by the Faculty of Science to support special initiatives, such as the Faculty of Science Special Award program mentioned below. The amount received is for the period May to April.

To explain the difference in the amounts generated by domestic and international students, we note that in 2009-2010, tuition and ancillary fees for domestic students are about $7131 per year, compared to about $14,241 per year for international students. This is a difference of $7,110 per year, an amount somewhat larger but comparable to the $6,300 extra they generate. Note that in addition, international students must pay $252 per term for medical coverage.

For new Ph.D. students, the Faculty of Science makes available, through a competition, a limited number of Special Awards, each valued at $7,000 per year and valid for four years. These additional funds are added to the G.S.S.T. fund. The G.S.S.T. fund is then used to offer University Scholarships to eligible students, the so-called Western Graduate Research Scholarships (or WGRS).

The Department of Mathematics has also been allocated sixteen (16) full Teaching Assistantships in recent years, valued at $10,694 (or $9,464 plus benefits) each in 2009-10. This is a real bottleneck, as sixteen (16) full GTA would limit our total enrollment to about twenty (20) students not holding major scholarships.

Since 2007, the Government of Ontario has put in place a temporary program (Reaching Higher) which provides additional funding to the Universities in the Province based on their increase in the number of Canadians and Permanent Residents in graduate programs. Using this money and other funds, the School of Graduate and Postdoctoral Studies and the Faculty of Science at UWO makes available a funding package totalling (in 2009-10) almost $17,700 for each incremental domestic graduate student in our graduate program. That is $7,000 student support plus one full Graduate Teaching Assistantship. Our domestic contingent had increased by six (6) and eight (8) students in 2008-2009 and 2009-10 respectively, compare to 2006-07. Without this increase in funding, totalling $141,552 in 2009-10, we could not have achieved the growth we have had in the last three years. It is not known for how much longer these temporary measures will remain in place.

The table below shows a typical example of the funding of a domestic Ph.D. student. The funding is shown for a student without an external scholarship.

<table>
<thead>
<tr>
<th>Type of Support</th>
<th>Source of Support</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Assistantship (TA)</td>
<td>Faculty of Science</td>
<td>$2,366</td>
<td>$3,549</td>
<td>$3,549</td>
<td>$9,464</td>
</tr>
<tr>
<td>TA supplement</td>
<td>School of Graduate Studies</td>
<td>$865</td>
<td>$865</td>
<td>$865</td>
<td>$2595</td>
</tr>
<tr>
<td>University Scholarship (WGRS)</td>
<td>School of Graduate Studies</td>
<td>$2,119</td>
<td>$1,386</td>
<td>$936</td>
<td>$4,441</td>
</tr>
<tr>
<td>Research Assistantship</td>
<td>NSERC Operating Grant</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$7,350</td>
<td>$7,800</td>
<td>$7,350</td>
<td>$22,500</td>
</tr>
</tbody>
</table>

Now some remarks are in order.

1. The figures in the above table are for the period May 1, 2010 to April 30, 2011.
2. As mentioned above, the amount in WGRS funding received by the Department is $4,150 for a domestic student. This is for the period May to April, even if a student starts in the program in September, as most of our new students do. This allows us to commit a slightly higher WGRS amount ($4,441) to our continuing students.

3. Since 2007, as a recruitment incentive, Year 1 domestic students were offered an extra $1700 provided by the Faculty of Science. This will not be available for incoming domestic students in September 2010 as this program is being discontinued, but the Department of Mathematics intend to come up with the fund to offer it for one more year.

4. Years 1 & 2 Ph.D. international students receive $29,700 annually, that is $7,200 more than their domestic counterparts (before the domestic student recruitment incentive). This is almost exactly the difference in tuition fees between these two groups but more than the WGRS received. Again, this is made possible because new students starting in September received support only for two terms.

5. The financial commitment to funding a Ph.D. student is four years, at about the level given in the above table, subject to satisfactory academic performance by the student. Typically, in Years 3 and 4, Ph.D. students received an extra $500 per year.

6. M.Sc. students received $400 less per term than Ph.D. students. The funding commitment for M.Sc. students is for eight or twelve months. In recent years, it has been typically for twelve months, and this is the standard that we would like now to apply to most of our Master’s students.

7. All our eligible students at present are funded at least at the level explained above. We actually guarantee $20,000 for domestic Ph.D. students. The university minimum funding requirement is “full-time tuition” + $12,000 = $18,000 (approximately).

The next table is a summary of total amount of financial support per year since 2001. Due to the small number of students in our Master’s program, with moreover some students receiving support for only eight months, the M.Sc. funding only appears to be highly variable from year to year.
## Table 5
Financial Support for Graduate Students
Mathematics

<table>
<thead>
<tr>
<th>Year</th>
<th>Degree Level</th>
<th>External Scholarship(^2)</th>
<th>University Scholarship(^3)</th>
<th>TA(^4)</th>
<th>RA</th>
<th>Other(^5)</th>
<th>Total</th>
<th>#(^6)</th>
<th>%(^7)</th>
<th>Ave ($/Funded Student)(^8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2002</td>
<td>Master’s</td>
<td>0</td>
<td>1,500</td>
<td>13,572</td>
<td>1,000</td>
<td>0</td>
<td>$16,072.00</td>
<td>2</td>
<td>100.0%</td>
<td>$8,036.00</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>12,733</td>
<td>47,793</td>
<td>40,456</td>
<td>18,454</td>
<td>0</td>
<td>$119,438.00</td>
<td>7</td>
<td>87.5%</td>
<td>$17,062.57</td>
</tr>
<tr>
<td>2002-2003</td>
<td>Master’s</td>
<td>17,300</td>
<td>7,311</td>
<td>11,750</td>
<td>2,000</td>
<td>0</td>
<td>$38,362.00</td>
<td>2</td>
<td>100.0%</td>
<td>$19,181.00</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>19,100</td>
<td>51,536</td>
<td>47,134</td>
<td>24,157</td>
<td>4,500</td>
<td>$146,428.00</td>
<td>7</td>
<td>100.0%</td>
<td>$20,918.29</td>
</tr>
<tr>
<td>2003-2004</td>
<td>Master’s</td>
<td>15,000</td>
<td>26,405</td>
<td>23,921</td>
<td>1,100</td>
<td>0</td>
<td>$66,426.00</td>
<td>3</td>
<td>100.0%</td>
<td>$22,142.00</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>50,858</td>
<td>66,051</td>
<td>71,472</td>
<td>33,401</td>
<td>9,315</td>
<td>$231,098.00</td>
<td>16</td>
<td>100.0%</td>
<td>$21,008.91</td>
</tr>
<tr>
<td>2004-2005</td>
<td>Master’s</td>
<td>0</td>
<td>4,403</td>
<td>26,701</td>
<td>18,078</td>
<td>0</td>
<td>$49,183.00</td>
<td>4</td>
<td>100.0%</td>
<td>$12,295.75</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>35,000</td>
<td>72,325</td>
<td>84,776</td>
<td>42,000</td>
<td>4,941</td>
<td>$239,043.00</td>
<td>9</td>
<td>100.0%</td>
<td>$26,560.33</td>
</tr>
<tr>
<td>2005-2006</td>
<td>Master’s</td>
<td>0</td>
<td>26,900</td>
<td>27,016</td>
<td>2,150</td>
<td>0</td>
<td>$56,066.00</td>
<td>3</td>
<td>100.0%</td>
<td>$18,688.67</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>43,750</td>
<td>85,450</td>
<td>77,158</td>
<td>34,350</td>
<td>14,824</td>
<td>$255,532.00</td>
<td>11</td>
<td>100.0%</td>
<td>$23,230.18</td>
</tr>
<tr>
<td>2006-2007</td>
<td>Master’s</td>
<td>0</td>
<td>46,076</td>
<td>36,824</td>
<td>3,500</td>
<td>0</td>
<td>$86,401.00</td>
<td>6</td>
<td>100.0%</td>
<td>$14,400.17</td>
</tr>
<tr>
<td></td>
<td>Doctoral</td>
<td>35,000</td>
<td>135,145</td>
<td>119,954</td>
<td>44,600</td>
<td>10,672</td>
<td>$345,372.00</td>
<td>16</td>
<td>100.0%</td>
<td>$21,585.75</td>
</tr>
</tbody>
</table>

1 Fiscal Year with May start point. (May, Sept and Jan).
2 External Scholarships (includes OGSST, OGS and NSERC)
3 University Scholarships (includes SUS, PSGS, GTS, IGSS, Exigency, Graduate Bursary and Misc. Awards)
4 TAs (includes Departmental Teaching Assistantships and FGS funded Teaching Assistantships (TA’s))
5 Others (includes Faculty salary)
6 Number of funded students
7 % of the total number of full time students
8 Average funding per funded student
9 In the academic year 1998-99 Western began using a new software system (Peoplesoft). Because of the changeover, data for 1998-99 is somewhat unreliable.
10 In the academic year 1999-00 the new software system allows FGS to capture all university employment.
3.13 Enrolment and graduation

3.13.1 Master’s program

We recall that in 2002, our request to change the name of our master’s degree from M.A. to M.Sc. was approved by OCGS. The change took effect in the academic year 2003-2004.

We note from the following tables that the enrollment in our Master’s program has grown recently. Between 1998-99 and 2004-05, we had a total enrollment of only one or two students, while we had five or six in the last four years, and eight students are projected to be enrolled in September 2010. This is in large part due to a change in the funding model for graduate programs at UWO which occurred in 2005 (see Section 3.12 for details). Our Master’s program is almost always accomplished solely through course work in two or three terms, and we note that three terms is becoming the norm.

Table 6
New Enrolments, Withdrawals and Graduation in the M.Sc. Program
by Year of Admission

<table>
<thead>
<tr>
<th>Year</th>
<th>New</th>
<th>12pt within 6 terms</th>
<th>within 9 terms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Trans</td>
<td>Withd</td>
</tr>
<tr>
<td>2001-02</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002-03</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2003-04</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004-05</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005-06</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2006-07</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2007-08</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008-09</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2009-10</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1 Academic year starting Sept 1 with three entry points: (Sept, Jan and May).
2 Sum of intake for each entry point of a given academic year.
3 All student from that cohort who had transferred to the PhD within six terms of entry point.
4 All students from that cohort who had withdrawn within six terms of entry point.
5 All students from that cohort who had completed the program within six terms of entry point.
6 All students from that cohort who were still in the program or on leave after six terms of entry point.
7 All student from that cohort who had transferred to the PhD within nine terms of entry point.
8 All students from that cohort who had withdrawn within nine terms of entry point.
9 All students from that cohort who had completed the program within nine terms of entry point.
10 All students from that cohort who were still in the program or on leave after nine terms of entry point.
11 Even if 6 (or 9) terms have not elapsed for that cohort, indicate results to date.
**Table 7**  
12pt M.Sc. Total Enrolments, Transfers, Withdrawals and Graduations by Year (Flow-Through Data)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Enrol$^2$</th>
<th># Female$^3$</th>
<th>% Female$^3$</th>
<th># Visa$^4$</th>
<th>% Visa$^4$</th>
<th>Total Transfers$^5$</th>
<th>% Transfers$^5$</th>
<th>Total Withd$^6$</th>
<th>% Withd$^6$</th>
<th>Total Grad$^7$</th>
<th>% Grad$^7$</th>
<th>Total Cont$^8$</th>
<th>% Cont$^8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>2</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>50%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>50%</td>
</tr>
<tr>
<td>2002-03</td>
<td>2</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2003-04</td>
<td>3</td>
<td>2</td>
<td>67%</td>
<td>1</td>
<td>33%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>2004-05</td>
<td>3</td>
<td>1</td>
<td>33%</td>
<td>2</td>
<td>67%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>2005-06</td>
<td>3</td>
<td>1</td>
<td>33%</td>
<td>2</td>
<td>67%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>2006-07</td>
<td>5</td>
<td>1</td>
<td>20%</td>
<td>4</td>
<td>80%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>4</td>
<td>80%</td>
</tr>
<tr>
<td>2007-08</td>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>17%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>4</td>
<td>67%</td>
</tr>
<tr>
<td>2008-09</td>
<td>8</td>
<td>2</td>
<td>25%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>6</td>
<td>75%</td>
</tr>
<tr>
<td>2009-10</td>
<td>9</td>
<td>4</td>
<td>44%</td>
<td>6</td>
<td>67%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>7</td>
<td>78%</td>
</tr>
</tbody>
</table>

1 Academic year starting Sept 1 with three entry points: (Sept, Jan and May).
2 All students registered in the program in that academic year continuing and new.
3 Number of female students and (%).
4 Number of visa students and (%).
5 All students who transferred to the PhD within that year with (%).
6 All students who withdrew within that year with (%).
7 All students who completed the program within that year with (%).
8 All students who were still in the program or on approved leave in that year with (%).
Table 8

<table>
<thead>
<tr>
<th>Year</th>
<th># graduating*</th>
<th>Median</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00-1.00</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00-0.00</td>
</tr>
<tr>
<td>2003</td>
<td>2</td>
<td>0.83</td>
<td>0.83</td>
<td>0.67-1.00</td>
</tr>
<tr>
<td>2004</td>
<td>2</td>
<td>1.17</td>
<td>1.17</td>
<td>1.00-1.33</td>
</tr>
<tr>
<td>2005</td>
<td>3</td>
<td>1.00</td>
<td>0.89</td>
<td>0.67-1.00</td>
</tr>
<tr>
<td>2006</td>
<td>3</td>
<td>1.00</td>
<td>0.89</td>
<td>0.67-1.00</td>
</tr>
<tr>
<td>2007</td>
<td>4</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00-1.00</td>
</tr>
</tbody>
</table>

* based on graduating cohort in calendar year

3.13.2 Doctoral program

We note from the following tables that we have low withdrawal rate and an impressive times-to-completion record. We attribute this success to our careful selection of candidates before they arrive and our good mentoring practice after their arrival. Also noteworthy is our high ratio of international students, which is not unusual in the mathematical sciences.

Table 9

<table>
<thead>
<tr>
<th>Year1</th>
<th>New2</th>
<th>12pt within 12 terms12</th>
<th>within 18 terms12</th>
<th>within 21 terms12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12pt</td>
<td>Withd3</td>
<td>Compl4</td>
</tr>
<tr>
<td>2001-02</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2002-03</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2003-04</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2004-05</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005-06</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2006-07</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>2007-08</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>2008-09</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2009-10</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

1 Academic year starting Sept 1 with three entry points: (Sept, Jan and May).
2 Sum of intake for each entry point of a given academic year. (includes students who transferred from Masters)
3 All students from that cohort who had withdrawn within twelve terms of entry point.
4 All students from that cohort who had completed the program within twelve terms of entry point.
5 All students from that cohort who were still in the program or on leave after twelve terms of entry point.
6 All students from that cohort who had withdrawn within eighteen terms of entry point.
7 All students from that cohort who had completed the program within eighteen terms of entry point.
8 All students from that cohort who were still in the program or on leave after eighteen terms of entry point.
9 All students from that cohort who had withdrawn within twenty-one terms of entry point.
10 All students from that cohort who had completed the program within twenty-one terms of entry point.
11 All students from that cohort who were still in the program or on leave after twenty-one terms of entry point.
12 Even if 12 (or 18, or 21) terms have not elapsed for that cohort, indicate results to date.
### Table 10

**PhD Total Enrolments, Transfers, Withdrawals and Graduations by Year (Flow-Through Data)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Enrol</th>
<th># Female</th>
<th>% Female</th>
<th># Visa</th>
<th>% Visa</th>
<th>Total Withd</th>
<th>% Withd</th>
<th>Total Grad</th>
<th>% Grad</th>
<th>Total Cont</th>
<th>% Cont</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>17%</td>
<td>5</td>
<td>83%</td>
</tr>
<tr>
<td>2002-03</td>
<td>9</td>
<td>1</td>
<td>11%</td>
<td>1</td>
<td>11%</td>
<td>1</td>
<td>11%</td>
<td>2</td>
<td>22%</td>
<td>6</td>
<td>67%</td>
</tr>
<tr>
<td>2003-04</td>
<td>10</td>
<td>1</td>
<td>10%</td>
<td>4</td>
<td>40%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>10%</td>
<td>9</td>
<td>90%</td>
</tr>
<tr>
<td>2004-05</td>
<td>9</td>
<td>1</td>
<td>11%</td>
<td>4</td>
<td>44%</td>
<td>1</td>
<td>11%</td>
<td>2</td>
<td>22%</td>
<td>6</td>
<td>67%</td>
</tr>
<tr>
<td>2005-06</td>
<td>9</td>
<td>0</td>
<td>0%</td>
<td>5</td>
<td>56%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>11%</td>
<td>8</td>
<td>89%</td>
</tr>
<tr>
<td>2006-07</td>
<td>15</td>
<td>2</td>
<td>13%</td>
<td>10</td>
<td>67%</td>
<td>1</td>
<td>7%</td>
<td>3</td>
<td>20%</td>
<td>11</td>
<td>73%</td>
</tr>
<tr>
<td>2007-08</td>
<td>15</td>
<td>2</td>
<td>13%</td>
<td>12</td>
<td>80%</td>
<td>1</td>
<td>7%</td>
<td>1</td>
<td>7%</td>
<td>11</td>
<td>73%</td>
</tr>
<tr>
<td>2008-09</td>
<td>20</td>
<td>3</td>
<td>15%</td>
<td>14</td>
<td>70%</td>
<td>0</td>
<td>0%</td>
<td>2</td>
<td>10%</td>
<td>18</td>
<td>90%</td>
</tr>
<tr>
<td>2009-10</td>
<td>24</td>
<td>4</td>
<td>17%</td>
<td>15</td>
<td>63%</td>
<td>0</td>
<td>0%</td>
<td>5</td>
<td>21%</td>
<td>19</td>
<td>79%</td>
</tr>
</tbody>
</table>

1. Academic year starting Sept 1 with three entry points: (Sept, Jan and May).
2. All students registered in the program in that academic year continuing and new.
3. Number of female students and (%).
4. Number of visa students and (%).
5. All students who withdrew within that year with (%).
6. All students who completed the program within that year with (%).
7. All students who were still in the program or on approved leave in that year with (%).

### Table 11

**Mean (Range) and Median Times-to-Completion of Doctoral Program (in Years)**

<table>
<thead>
<tr>
<th>Year</th>
<th># graduating*</th>
<th>Median</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>2</td>
<td>3.83</td>
<td>3.83</td>
<td>3.67-4.00</td>
</tr>
<tr>
<td>2002</td>
<td>2</td>
<td>3.92</td>
<td>3.92</td>
<td>3.67-4.17</td>
</tr>
<tr>
<td>2003</td>
<td>2</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00-4.00</td>
</tr>
<tr>
<td>2004</td>
<td>1</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00-4.00</td>
</tr>
<tr>
<td>2005</td>
<td>2</td>
<td>3.83</td>
<td>3.83</td>
<td>3.67-4.00</td>
</tr>
<tr>
<td>2006</td>
<td>1</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00-4.00</td>
</tr>
<tr>
<td>2007</td>
<td>3</td>
<td>4.00</td>
<td>3.89</td>
<td>3.67-4.00</td>
</tr>
</tbody>
</table>

* based on graduating cohort in calendar year
### 3.14 Employment of graduates

INITIAL EMPLOYMENT (OR STATUS) OF STUDENTS GRADUATING OVER PAST SEVEN YEARS

#### Master’s Program

<table>
<thead>
<tr>
<th>Name</th>
<th>Convocation</th>
<th>Initial Employment or Status (if known)</th>
<th>Continuing Employment or Status (if known)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do, Minh-Tri</td>
<td>2009</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Dean, R.</td>
<td>2009</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Zheng, X.</td>
<td>2009</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Rogelstad, M.</td>
<td>2009</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Al rubeaa'i, S.</td>
<td>2009</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Muthukrishan, D.</td>
<td>2009</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Wu, E.</td>
<td>2008</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Prince, T.</td>
<td>2008</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Farah, J.</td>
<td>2008</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Cui, K.</td>
<td>2008</td>
<td>no info</td>
<td>no info</td>
</tr>
<tr>
<td>Deshpande, P.</td>
<td>2007</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Kadri, A.</td>
<td>2007</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Singh, K.</td>
<td>2007</td>
<td>Returned to Calgary</td>
<td>no info</td>
</tr>
<tr>
<td>Askaripour, N.</td>
<td>2006</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Hassanzadeh, M.</td>
<td>2006</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Misamore, M.</td>
<td>2005</td>
<td>Ph.D., Math., U.W.O.</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Dong, B.</td>
<td>2005</td>
<td>Returned to China</td>
<td>no info</td>
</tr>
<tr>
<td>Ruggiero, R.</td>
<td>2005</td>
<td>IT position, CTV Studios, Toronto</td>
<td>same</td>
</tr>
<tr>
<td>Uren, J.</td>
<td>2004</td>
<td>Ph.D., Math., Toronto</td>
<td>continuing Ph.D. studies</td>
</tr>
<tr>
<td>Smith, D.</td>
<td>2003</td>
<td>Ph.D., Math., U.W.O.</td>
<td>no info</td>
</tr>
<tr>
<td>Moise, M.</td>
<td>2003</td>
<td>no info</td>
<td>no info</td>
</tr>
</tbody>
</table>

We note that many of our Master’s students are continuing to do a Ph.D., often with us. This reflects our careful selection of high quality students and the intimate and stimulating intellectual environment we provide to them.
### Ph.D. Program

<table>
<thead>
<tr>
<th>Name</th>
<th>Convocation</th>
<th>Initial Employment or Status (if known)</th>
<th>Continuing Employment or Status (if known)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pourkia, A.</td>
<td>2009</td>
<td>PDF, UWO</td>
<td>same</td>
</tr>
<tr>
<td>Misamore, M.</td>
<td>2009</td>
<td>PDF, Essen (Germany)</td>
<td>same</td>
</tr>
<tr>
<td>Beck-Ochir, C.</td>
<td>2008</td>
<td>no info</td>
<td></td>
</tr>
<tr>
<td>Shirbisheh, V.</td>
<td>2007</td>
<td>Instructor, Tarbiat Modarres Univ., Tehran, Iran</td>
<td>same</td>
</tr>
<tr>
<td>McInnes, L.</td>
<td>2007</td>
<td>Scientist, Canadian Security Intelligence Service</td>
<td>same</td>
</tr>
<tr>
<td>Smith, D.</td>
<td>2007</td>
<td>no info</td>
<td></td>
</tr>
<tr>
<td>Usefi, H.</td>
<td>2006</td>
<td>PDF, Saskatchewan</td>
<td>NSERC PDF, UBC</td>
</tr>
<tr>
<td>Bhandari, G.</td>
<td>2005</td>
<td>Adjunct Professor and Research Assistant, Math., U.W.O.</td>
<td>Instructor, Mt. Royal University Calgary, AB</td>
</tr>
<tr>
<td>Luo, Z.</td>
<td>2004</td>
<td>Post-Doc, Haifa Univ., Israel</td>
<td>Ph.D., Stat., Guelph</td>
</tr>
<tr>
<td>Jiang, B.</td>
<td>2003</td>
<td>Lecturer, Acadia Univ. and M.Sc., Biostat., U.W.O.</td>
<td>Statistician, Abbott Diagnostics, Chicago</td>
</tr>
<tr>
<td>Rangipour, B.</td>
<td>2003</td>
<td>PDF, U. of Victoria Hans J. Zassenhaus Assistant Prof., Ohio State</td>
<td>Assoc. Prof, Math, UNB</td>
</tr>
<tr>
<td>Alderson, T.</td>
<td>2002</td>
<td>Assist. Prof, Math, UNB-St-John</td>
<td>Assoc. Prof, Math, UNB-St-John</td>
</tr>
</tbody>
</table>

Of the sixteen (16) Ph.D. graduates in the last eight years, six (6) of them received a postdoctoral fellowship. Currently, three are still holding a postdoctoral fellowship and five others have academic positions. At the time of the writing of this report, two of our recent graduates were still looking for employment.

#### 3.15 Publication

All (100%) of our Ph.D. graduates, during the past seven years, have had at least one publication, or work accepted or submitted for publication, emanating directly from their graduate work. On average, one to three publications are expected from a Mathematics Ph.D. thesis.

A list of those publications is provided below. Most of these publications have appeared or been
accepted in research journals of at least the calibre as those of the American, Canadian, or London Mathematical societies.

NOTE: The order of the author’s names is as on the published paper. It is customary in Mathematics to list authors in *alphabetical order*.

1. Khalkhali, M.; **Pourkia, A.**
   “A Super Version of the Connes-Moscovici Hopf Algebra.”
   16 pages. Submitted.

2. Khalkhali, M.; **Pourkia, A.**
   “Hopf Cyclic Cohomology in Braided Monoidal Categories.”
   53 pages. Submitted.

3. **Misamore, M..**
   “Nonabelian $H^1$ and the Étale van Kampen Theorem.”
   34 pages. Submitted.

4. **Misamore, M..**
   “Étale Homotopy Types and Bisimplicial Hypercovers.”
   32 pages. Submitted.

5. **Bekh-Ochir, C.; Riley, D.M.**
   “On the Grassmann $T$-space.”

6. **Shirbisheh, Vahid.**
   “$K$-theory tools for local and asymptotic cyclic cohomology.”

7. **McInnes, L.; Riley, D.M.**
   “Pro-finite $p$-adic Lie algebras.”

8. **Rankin, Stuart; Flint, Ortho (aka Smith, D.); Schermann, John.**
   “Enumerating the prime alternating knots. I.”

9. **Rankin, Stuart; Flint, Ortho (aka Smith, D.); Schermann, John.**
   “Enumerating the prime alternating knots. II.”

10. **Rankin, Stuart; Flint, Ortho (aka Smith, D.).**
    “Enumerating the prime alternating links.”

11. **Riley, David; Usefi, Hamid.**
    “Lie algebras with finite Gelfand-Kirillov dimension.”

1. **Riley, David Usefi, Hamid.**
   “Restricted Lie algebras with subexponential growth.”
   Groups, rings and algebras, 289–294, Contemp. Math., 420,
2. Riley, David; Usefi, Hamid.
   “The isomorphism problem for universal enveloping algebras of Lie algebras.”

   “On the completeness of the system \( \{ z^{\tau_n} \} \) in \( L^2 \).”

4. Boivin, André; Zhu, Changzhong.
   “The growth of an entire function and its Dirichlet coefficients and exponents.”

5. G. Bhandari; N. Lemire; J. Mináč; J. Swallow.
   “Galois module structure of Milnor \( K \)-theory in characteristic \( p \).”

   “Higher principal bundles.”

7. Boivin, A.; Jiang, B.
   “Uniform approximation by meromorphic functions on Riemann surfaces.”

8. Boivin, A.; Jiang, B.
   “Bounded pointwise approximation on open Riemann surfaces.”

9. Jiang, B.
   “Uniform approximation on Riemann surfaces by holomorphic and harmonic functions.”

10. Khalkhali, M.; Rangipour, B.
    “A new cyclic module for Hopf algebras.”

11. Khalkhali, M.; Rangipour, B.
    “Invariant cyclic homology.”

12. Khalkhali, Masoud; Rangipour, Bahram.
    “Cyclic cohomology of (extended) Hopf algebras.”
    Noncommutative geometry and quantum groups (Warsaw, 2001), 59–89,

13. Khalkhali, M.; Rangipour, B.
    “On the cyclic homology of Hopf crossed products.”
    Galois theory, Hopf algebras, and semiabelian categories, 341–351,

14. Khalkhali, M.; Rangipour, B.
    “Para-Hopf algebroids and their cyclic cohomology.”
15. Khalkhali, Masoud; Rangipour, Bahram.
   “Cup products in Hopf-cyclic cohomology.”

16. Khalkhali, M.; Rangipour, B.
   “A note on cyclic duality and Hopf algebras.”

17. Khalkhali, Masoud; Rangipour, Bahram.
   “Introduction to Hopf-cyclic cohomology.”
   Noncommutative geometry and number theory, 155–178,

18. Alderson, T.
   “Extending arcs: an elementary proof.”

19. Alderson, T. L.
   “Extending MDS codes.”

20. Alderson, T. L.
   “On MDS codes of dimension 3.”

21. Alderson, T. L.
   “(6,3)-MDS codes over an alphabet of size 4.”

22. Akbarpour, R.; Khalkhali, M.
   “Hopf algebra equivariant cyclic homology and cyclic homology of crossed product algebras.”

23. Akbarpour, R.; Khalkhali, M.
   “Cyclic homology of Hopf comodule algebras and Hopf module coalgebras.”

24. Akbarpour, R.; Khalkhali, M.
   “Equivariant cyclic cohomology of $\mathcal{H}$-algebras.”

25. Li, Zhenheng.
   “The cross section lattices and Renner monoids of the odd special orthogonal algebraic monoids.”

26. Li, Zhenheng.
   “Cell decompositions of the special orthogonal algebraic monoids.”

27. Li, Zhenheng; Renner, Lex E.
   “The Renner monoids and cell decompositions of the symplectic algebraic monoids.”
28. Li, Zhenheng.  

29. Chen, Tieling.  

30. Chen, Tieling; Sinnamon, Gord.  


### 3.16 Projected Graduate Enrolments

Summary: Enrolments depend on conflicting forces that cannot always be accurately predicted. It is true, however, that future enrollments in our graduate programs will depend largely on the following four factors:

1. The numbers of qualified applicants.

2. The availability of financial support from the Faculty of Science, School of Graduate and Postdoctoral Studies, and NSERC operating grants.

3. The availability of core faculty in our department to perform graduate instruction and thesis supervision.

4. Any commitments from the Dean of Science to allow us to fill the positions of faculty members as they retire.

An elaboration on these four points follows.

1) **Applicants:** We receive consistently sufficient numbers of applications from eligible students. It is our policy though to admit only those international students whose applications show them to be of sufficient quality to be comparable to a recipient of an Ontario Graduate Scholarship. Domestic students applying to our Master’s program are usually required to have maintained a B+ (or 78%) average in the last two years (or twenty courses) of their undergraduate degree.

   Since we try to maintain this high standard in our admissions, we are in strong competition for these graduate students with other Canadian and U.S. universities. While this may result in “below capacity enrollment,” we do not believe it wise to change our policy.

2) **Financial Support:** We have already discussed this in detail in Section 3.12. Since each student generates an increase in G.S.S.T. Fund available (see Section 3.12), our capability to support financially a new student is limited only by the number of Teaching Assistantships allocated to the Department (currently sixteen (16)) and the amount of money available from the research operating grants of the supervisors. The Faculty of Science has created a Special Award to help in the latter. They are available through a competition, and our Department currently holds four (4) such awards, each valued at $7,000 per year. This has to be close to the maximum we can hope to hold at present.
This success is due to the quality of our applicants but also to the recognition by our Faculty of Science of the smaller size of research grants in Pure Mathematics.

3) **Available Faculty:** In Section 3.5 we identify our core faculty according to field. The table below indicates current enrollments (Academic year 2007-2008) in our Ph.D. program along with an estimate of the capacity of our department to supervise Ph.D. students.

<table>
<thead>
<tr>
<th>Field</th>
<th># of Core Faculty</th>
<th># of Ph.D. Students</th>
<th>Capacity for Ph.D. Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>5</td>
<td>3</td>
<td>8-9</td>
</tr>
<tr>
<td>Algebra/Number Theory</td>
<td>6</td>
<td>8</td>
<td>8-9</td>
</tr>
<tr>
<td>Geometry/Topology</td>
<td>4</td>
<td>7</td>
<td>8-9</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>15</strong></td>
<td><strong>18</strong></td>
<td><strong>24-27</strong></td>
</tr>
</tbody>
</table>

1 Full-time Department Faculty members with doctoral supervisory privileges only

The indicated capacities for Ph.D. students are what we may reasonably aspire to during the next five years if they were no financial or physical restrictions (see Section 4.10.2 and Section 3.12) and a sufficient number of high quality applicants. Taken into consideration were also the facts that one recent hires in Analysis and two recent hires in Geometry/Topology will likely have gained full supervisory status at the next year or two and that two current core faculty are unlikely to accept new Ph.D. students, as they are near their (non mandatory) retirement.

As can be seen in Table 6 (Section 3.13.1), our M.Sc. enrollment has grown in recent years, but it is still very modest at only six new students per year. If it was not for financial restrictions or lack of a sufficient number of high quality applicants, we could easily double this enrollment.

This means we could aim at a total of close to forty (40) graduate students. Note that this is also the limit of individual spaces that the Department can have in the near future (see Section 4.10.2).

As explained in Section 3.12, the real bottleneck in recent past has been the number of Teaching Assistantships. This number was allowed to increase very recently due to special initiatives of the provincial government and the university. But these measures are only temporary and could end very soon. Projecting only a very modest and more realistic increase in the number of GTA available to the Department after these current programs end, a more realistic enrollment goal would be for a total of between twenty-five and thirty students, that is between eighteen and twenty Ph.D. students (for an average of about one Ph.D. student per core faculty), and between five and ten Master’s students. It is expected that a large proportion of these new intake will be international students.

The next table shows projected enrollments for the next five years. It is assumed that the current special initiatives supporting the growth of our graduate program will end in 2012 to be replaced by a very modes growth in our GTA allocation.
Table 12
PROJECTED INTAKE AND ENROLMENTS
Master’s (M) and Doctoral (D) Programs

<table>
<thead>
<tr>
<th>Year</th>
<th>Intake</th>
<th>Enrolments</th>
<th>Total Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>D</td>
<td>M</td>
</tr>
<tr>
<td>2010-11</td>
<td>8</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>2011-12</td>
<td>8</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>2012-13</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2013-14</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2014-15</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

1 We do not expect to offer part-time enrollment in the next five years (see Section 3.3.3).

4) Replacements of retiring faculty. With the abolishment of mandatory retirement, and predicted very limited hiring at UWO over the next few years, it is hard to predict how the Department will be affected. We hope to remain at the current levels, but it is possible that some future retirements will not be replaced. While there are no guarantees, we are encouraged by the support in the past of the Dean of Science and the Provost in their support of our Department in approving the hiring of new faculty.

Conclusion: The Faculty of Science and the School of Graduate and Postdoctoral Studies have maintained a strong commitment to our graduate program in the past five years. We hope this to continue but do not expect that some of the current special initiatives will be maintained indefinitely. With our considerable contingent of recently appointed young faculty with vibrant research programs, we expect our enrollment to remain stable and close to thirty (30), plus or minus five, during the next ten years. The items listed in Section 3.11 “Other activities” are added encouragement for the growth and prosperity of our graduate program.
Chapter 4

The Departmental Profile

This section is intended to summarize the most significant changes which have taken place in the Department of Mathematics over the past five years. The first three parts are devoted to faculty profile. After providing some faculty demographics in Section 4.1 we highlight, in Sections 4.2 and 4.3, the two most significant and positive developments of the last few years: faculty renewal and the continued development of a viable Post Doctoral program. Each has added innovation and energy to the Department. Sections 4.5 and 4.8 deal with the two primary functions of the Department: research and teaching. The impact of younger faculty is clearly apparent in the discussion of research activities. Finally, Section 4.9 deals with outreach activities.

4.1 Faculty Demographics

We begin with a broad perspective. If one considers the Department of Mathematics and its faculty profile over the past 25 years then there is a marked contrast between the first ten years and the last fifteen. A period of diminishing resources has been succeeded by a period of renewal and of significant growth in research activity. Some limited growth in resources has also been achieved, primarily through success in accessing alternative funding sources. There is a sense of great potential for the Department in the years to come, if we can overcome the threat proposed by a predictable loss of positions; and the recent devastation to the global economic system.

The following chart presents a summary of the numbers of departmental academic personnel at various intervals since the mid 80’s.

<table>
<thead>
<tr>
<th>Year</th>
<th>Tenured</th>
<th>Probationary</th>
<th>Limited Term</th>
<th>PDF</th>
<th>Part Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986/87</td>
<td>21</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1990/91</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1994/95</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1998/99</td>
<td>18</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2002/03</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>5(*)</td>
</tr>
<tr>
<td>2004/05</td>
<td>16</td>
<td>4</td>
<td>2(#)</td>
<td>6</td>
<td>5(#)</td>
</tr>
<tr>
<td>2005/06</td>
<td>15</td>
<td>5</td>
<td>2(#)</td>
<td>5</td>
<td>7(#)</td>
</tr>
<tr>
<td>2006/07</td>
<td>14</td>
<td>5</td>
<td>2(#)</td>
<td>8</td>
<td>9(#)</td>
</tr>
<tr>
<td>2007/08</td>
<td>12</td>
<td>6</td>
<td>1(#)</td>
<td>8</td>
<td>6(#)</td>
</tr>
<tr>
<td>2008/09</td>
<td>14</td>
<td>6</td>
<td>2(#)</td>
<td>6</td>
<td>2(#)</td>
</tr>
<tr>
<td>2009/10</td>
<td>16</td>
<td>4</td>
<td>2(#)</td>
<td>8</td>
<td>2(#)</td>
</tr>
</tbody>
</table>

(*) The number of part time instructors in 2002/03 and 2004/05 also includes those doing summer
teaching. These instructors are not counted for the previous years cited. For an explanation of the reason for the inclusion, see the discussion of “Summer Teaching” in 4.8.2).

(#) There was one Limited Temp appointee (Vicki Olds) who teaches only for the Department, and another (Carol Jones) who was shared with other departments.

As the above chart illustrates, departmental resources contracted somewhat during the latter part of the 1980’s and for much of the 1990’s as well, under the impact of ongoing budget cuts. Notably, several full time positions, as well as several limited term positions, disappeared during that period. This was a discouraging period of shrinking resources. Over the next five years, the department was in a “steady state” mode with all retiring faculty but one being replaced by new faculty. Moreover, the number of hirings in the past few years has been significant, and in the same period the department has also maintained an active PDF program. These trends, which will be discussed below, have provided the department with a very welcome (and hopefully not temporary) boost. Unfortunately the Department is now facing the possibility of shrinkage again. We currently carry a very large base budget debt resulting from the mandatory 3% initial budget deficit (ritual self-mutilation) imposed annually. This was increased to 5% in the most recent Budget and will likely remain at 5% in the next Budget. In years before The Collapse, the money generated from this cut was redistributed by the University on a competitive basis. This is no longer true. No monies are being redistributed and there are no "new" (UPIF) positions being created. This also means the salaries of the three retiring members mentioned above will be used in large part - if not entirely - to pay off our department’s base budget debt. We will be fortunate in today’s monetary climate to replace only one of these three positions. Needless to say, the recent recession could have a murderous effect on the demographics of the Ontario University System.

4.2 Faculty Renewal

As with most Canadian mathematics departments, the Department of Mathematics at Western is now feeling the effects of the retirement of a large number of its former faculty that were hired in the 1960’s and 1970’s, and replacement of most of these with a new generation of mathematicians. Based on the normal retirement age of 65, the Department of Mathematics (with a complement of approximately 20 full time members) will have a total of 16 retirements during the period 1995-2011. Early retirements have already accelerated this process and may continue to do so in the future, although the end of mandatory retirement has had some effect. Three more retirements are scheduled during the period 2009-2011; Milnes, Kane, Dawes, with Rankin likely to retire shortly thereafter.

Replacement of faculty began in earnest in 2000, and continued evenly through the decade. The table below gives hirings since 1995:

<table>
<thead>
<tr>
<th>Hirings since 1991</th>
<th></th>
<th></th>
<th>2003</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1995 Khalkhali, Larusson*</td>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996 -</td>
<td>2004</td>
<td>Foth, Shafikov</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997 -</td>
<td>2005</td>
<td>Dhillon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998 -</td>
<td>2006</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999 -</td>
<td>2007</td>
<td>Adamus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000 Christensen, Riley</td>
<td>2008</td>
<td>Franz, Pinnsonault</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001 Denham</td>
<td>2009</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002 Lemire</td>
<td>2010</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*since resigned and replaced by M. Franz
These hirings represent replacements for eleven retirements (of the above-mentioned sixteen). Three of these positions have been or will be lost to the Department. Lemire had been bridged against Florence’s retirement; Dhillon against Cass’s retirement. With these retirements, the department’s complement could shrink by a total of four members by July 2010. At UWO, retirements are not automatically replaced. In fact, units are required to plan for a 3% budget cut in each and every year; the cuts are returned to central administration which redistributes them on a competitive basis. As mentioned above, the budget has recently been changed to 5%. The only way that the Department can adjust to these cuts, in the absence of UPIF is to shrink its complement.

Remark: all departmental decisions regarding hiring are made by the Appointments Committee, consisting of the Chair and six elected members. The basic approach of the Committee when hiring has been to seek applicants from a wide variety of areas. Choosing the most “suitable” candidate has typically involved a discussion not only of research credentials but also of teaching ability and of the likelihood of the person being a “good colleague”, notably through effective service on committees or by helping to organize departmental activities. As a final comment, four of the hirings listed above follow an interesting pattern of providing solutions to “two body” problems.

4.3 Post Doctoral Fellows

The Department has been able to develop a vigorous PDF program capable of supporting numerous PDF’s per year (currently ten). The following table lists PDF’s since 1998/99, with area of research and supervisor.
<table>
<thead>
<tr>
<th>Research Area</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Theory, Homology of Linear Groups</td>
<td>Jardine</td>
</tr>
<tr>
<td>K Theory, Triangulated Categories</td>
<td>Jardine, Larusson, Minac</td>
</tr>
<tr>
<td>Complex Analytic Geometry</td>
<td>Larusson</td>
</tr>
<tr>
<td>Algebraic Combinatorics, Algebraic Varieties</td>
<td>Renner, Riley</td>
</tr>
<tr>
<td>Algebraic Stacks</td>
<td>Jardine</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Christensen</td>
</tr>
<tr>
<td>Motivic Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Commutative Algebra</td>
<td>Renner</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Quantum Gravity</td>
<td>Christensen</td>
</tr>
<tr>
<td>Complex Analysis and Diff. Equations</td>
<td>Larusson</td>
</tr>
<tr>
<td>Quantum Gravity</td>
<td>Christensen</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Non-Commutative Geometry</td>
<td>Khalkhali</td>
</tr>
<tr>
<td>Topology &amp; Computer Science</td>
<td>Jardine</td>
</tr>
<tr>
<td>Combinatorics</td>
<td>Lemire, Renner</td>
</tr>
<tr>
<td>Complex Variables</td>
<td>Boivin, Shafikov</td>
</tr>
<tr>
<td>Algebraic Topology</td>
<td>Jardine</td>
</tr>
<tr>
<td>Topology</td>
<td>Jardine</td>
</tr>
<tr>
<td>Motives</td>
<td>Jardine</td>
</tr>
<tr>
<td>Lie Algebras</td>
<td>Riley</td>
</tr>
<tr>
<td>Math. Physics</td>
<td>Christensen</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Cobordism Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Categorical Homotopy</td>
<td>Jardine</td>
</tr>
<tr>
<td>Arithmetic Geometry</td>
<td>Foth, Renner, Riley</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>NonComm. Geometry</td>
<td>Khalkhali</td>
</tr>
<tr>
<td>Approximation by Exponentials</td>
<td>Boivin</td>
</tr>
<tr>
<td>Coindgression Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Homotopy Theory</td>
<td>Jardine</td>
</tr>
<tr>
<td>Algebraic Geometry</td>
<td>Jardine</td>
</tr>
<tr>
<td>Algebraic Topology</td>
<td>Jardine</td>
</tr>
<tr>
<td>Operator Theory</td>
<td>Boivin, Shafikov, Sinnamon</td>
</tr>
<tr>
<td>Lie Groups</td>
<td>Dhillon, Lemire, Renner</td>
</tr>
<tr>
<td>Homological Combinatorics</td>
<td>Denham, Franz</td>
</tr>
</tbody>
</table>

The presence of these additional researchers in the Department each year has contributed to the academic quality of the Department. The Department feels itself quite fortunate in the quality of researchers it has been capable of recruiting. They have certainly enhanced research and graduate
training in the Department. Also, the PDF’s are each teaching 2 half courses per year. The ability
to handle part of the excess teaching load of the Department (i.e. that which cannot be handled by
current full time faculty) with PDF’s has helped preserve the focus of the Department as a research
oriented enterprise. Short of having full time faculty to handle such teaching, the PDF’s provide
the best solution to this dilemma.

The key to the development of a PDF program has been the ability of the Department to
access new sources of funding. There are two traditional sources of funding PDF’s in the Canadian
university system—the NSERC research grant of the supervisor and salary from teaching. The
relatively small size of research grants for mathematicians means that the above two sources cannot
provide total support. And additional university funding of PDF’s is rare. So other sources are
needed to complete the financial package.

The current presence of ten PDF’s per year in the Department reflects our ability to develop
new funding. In the early part of this decade, we had the help of The Esso Centre for Mathematical
Education, which helped us fund four PDFs (Joita, Noohi, Thomas and Sadykov), and D. Chris-
tensen’s PREA which helped fund four other PDFs (Bauer, Roendigs, Hawkins, and Chebolu). The
University of Western Ontario is a Principal Sponsoring University for the Fields Institute. Until
recently, the Fields Institute provided funding for a PDF position at Western. Our Department
used this to fund Atabey Kaygun in 2005-06. Unfortunately these three sources of funding have now
ended. New sources will need to be found to help maintain the current vigorous level of activity.

4.4 Canada Research Chairs

The Canada Research Chair Program (CRC) was originally established by the federal government
with the goal of creating 2,000 special research chairs in Canadian universities between 2000 and
2005. The number of CRC’s that a university can nominate is proportional to the funding that
researchers affiliated with that university are receiving from Canada’s three federal granting agen-
cies: NSERC (Natural Science and Engineering), CIHR (Health), and SSHRC (Social Science and
Humanities). A university is expected to nominate researchers whose work is consistent with that
university’s strategic research plan. The 2001 Research Plan for the Faculty of Science envisaged
a CRC for the Department of Mathematics, and this plan was fulfilled when Rick Jardine received
a Senior (Tier 1) Chair. Such Chairs are worth $200,000 a year for seven years and are renewable;
they are opportunities to build and strengthen a research team, and provide funding for PDF’s.
Recently Jardine has had his CRC renewed for another seven years.

4.5 Research Activities

Over the past eight years, the research in the Department has increased both in level of activity
and breadth of perspective. These two assertions are justified in 4.5.1 and 4.5.3. These develop-
ments reflect the series of appointments of talented young researchers, and bode well for the future
development of the Department.

4.5.1 Increasing Research Profile

As one indication of the increased research activity in the Department, the number of full time
faculty with NSERC research grants has risen from 10 in 1999 to 17 in 2005 and the total value
of such grants has increased over fourfold. It is anticipated that within a few years everyone in
the Department will have a NSERC research grant. As another index, faculty members have been
awarded a number of distinctions. Since 2000, in addition to the PREA, UFA, and CRC noted above, Jan Minac received a Faculty of Science Distinguished Research Professorship.

**Applied Homotopy Group**

Increased research strength is very apparent in the areas of algebra and topology. Two hirings since 2005 are in these areas: Dhillon (algebraic geometry) and Franz (algebraic topology). As well, the algebra/topology group has greatly benefited from the above discussed PDF program. The algebra/topology group runs a very active seminar.

This group is also known as the “applied homotopy theory group” because of the many research programs of the group which are exploring deep connections between homotopy theory and other areas: algebraic geometry (Dhillon, Jardine), computational mathematics (Christensen, Jardine), noncommutative geometry (Khalkhali), number theory (Jardine, Minac), toric topology (Denham and Franz), and physics (Christensen). Altogether, this group comprises fourteen faculty and five postdoctoral fellows.

**Analysis Group**

The other major research group, in analysis, currently comprises six faculty and one postdoctoral fellow. Two recent hirings–Martin Pinsonnault (symplectic geometry), Janus Adamus (analytic geometry)–have contributed to creating a very strong research presence for the Department in analysis. This is particularly evidenced in a revitalized Analysis Seminar, and in the effective group in geometric analysis created by the new hirings.

**Mathematical Physics**

A developing group in mathematical physics is now present: Dan Christensen is actively involved in loop quantum gravity, is supervising two postdoctoral fellows (and has recently graduated two PhD students) in this area of physics, and is affiliated with the Perimeter Institute. Tatyana Foth does research in geometric quantization, studying problems in analysis and complex geometry that are motivated by quantum mechanics and classical mechanics. Masoud Khalkhali is an expert in noncommutative geometry, an area intrinsically linked to physics, and has major interests in physics.

**4.5.2 Distinguished Lecture Series**

The Department has developed a successful Distinguished Lecture Series which is now in its ninth year. This series highlights significant research programs in the mathematical world. The speakers in this series have been:

- 2010: Ivan Fesenko, University of Nottingham
- 2009: Fred Cohen, University of Rochester
- 2008: Florian Pop, University of Pennsylvania
- 2005: Marc Levine, Northeastern University
- 2004: Yum-Tong Siu, Harvard University
- 2003: Joachim Cuntz, Westfalische Wilhelms-Universitat Munster
- 2002: Vladimir Voevodsky, Institute for Advanced Study
- 2001: Haynes Miller, Massachusetts Institute of Technology
- 2000: Stephen Lichtenbaum, Brown University
- 1999: Lisa Jeffrey, University of Toronto
  Steve Gersten, University of Utah
  James Stasheff, University of North Carolina
- 1998: Kumar Murty, University of Toronto
- 1997: Paul Baum, Pennsylvania State University
Further details of the content of the various lectures are available at the website

http://www.math.uwo.ca/dist-lect.html

Many faculty members are involved in organizational activity. During the period 2006-2010 faculty members will have organize or co-organize at least 20 conferences or thematic programs with budgets conservatively totaling over $1,000,000. The following are some recent and upcoming events:

- Masoud Khalkhali, BIRS conference on Noncommutative Geometry in 2006;
- Rick Jardine, co-organizer of a program entitled “Computational Applications of Algebraic Topology”, which will be held at MSRI in Berkeley August–December, 2006 (web page: http://www.msri.org/calendar/programs/ProgramInfo/243/show_program), to which MSRI has committed 225K US;
- Rick Jardine and Dan Christensen, Fields Institute Thematic Program on Geometric Applications of Homotopy Theory in 2007;

4.5.3 Interactions of the Department within UWO

Various interactions with other departments have developed over the past years. Masoud Khalkhali taught a graduate course on Quantum Computing, which led to the creation of an interdepartmental discussion group on the topic. Gordon Sinnamon has taught a graduate course on Wavelets, with an unusually high enrollment of 15. The Department initiated several courses in “Applied Algebra”. Jan Minac has offered a course on Elliptic Curves; David Riley offered a very successful course on Cryptography.

As another aspect of growth in Applied Algebra, the Department participates in The Ontario Research Centre for Computer Algebra (ORCCA). This Centre, with labs at both Waterloo and Western, performs fundamental research and development in mathematical software, focusing on computer algebra.

Dan Christensen has developed a Quantum Gravity component for the long-running UWO Theoretical Physics group centred in Applied Mathematics. He regularly supervises Ph.D. students, as well as post-doctoral students, in Applied Mathematics. This development has been reinforced by the relationship with the Perimeter Institute (see 4.6 below) pioneered and managed by Christensen.

UWO continues to develop high level computing resources, building on the success of SHARCNet. In the Department of Mathematics, this top-of-the-line facility has been used mostly by Dan Christensen and Stu Rankin. SHARCNet also provides funding for undergraduate and graduate students, PDF’s, visitors, and teaching release. Christensen and Rankin have been awarded equipment grants from NSERC as well as from the UWO Academic Development Fund. More recently, the Department has used a CFI grant and NSERC equipment grants to build a high speed research computing environment, consisting of 46 CPUs configured as part of a “Condor pool”. This is a networked system involving most computers in the department which allows jobs to be run on these machines when idle. There is growing use of this network for both numeric and symbolic computation—Dan Christensen (mathematical physics), Graham Denham (algebraic geometry) and Stu Rankin (knot theory)—plus their students.
4.6 Interactions with Research Institutes

4.6.1 Fields Institute

The Department, and more generally all the mathematical science departments, have a growing level of interaction with the Fields Institute. As noted above, UWO is a Principal Sponsoring University for the Institute. The former Dean of Science was instrumental in arranging funding to cover the annual $75,000 fee required for this high level of affiliation, which carries the possibility of funding for onsite activities, and funding for a PDF position (mentioned above).

The Fields Institute program entitled “Geometric Applications of Homotopy Theory” held during January-June, 2007 (Jardine/Christensen) was allocated $250K for the program. See the web page:

http://www.fields.utoronto.ca/programs/scientific/06-07/homotopy/

4.6.2 BIRS (Banff International Research Station)


Minac 2006: Co-organizer (with V. Chernousov, R. Elman, A. Merkurjev and Z. Reichstein) of Banff International Research Station Workshop “Algebraic Groups, Quadratic Forms and Related Topics”, to be held September 2-7, 2006


4.6.3 Perimeter Institute for Theoretical Physics (PI)

There are solid links between the Department and PI, located in Waterloo. At the moment Dan Christensen is the principal liaison. He is an Affiliate Member of PI and participates in a Quantum Gravity research group there. There is great potential for shared visitors and shared PDF’s.

4.7 Faculty of Science Academic Plan

The Department of Mathematics has been very successful in following the main goals of the academic plan of the Faculty of Science in every area: undergraduate education, the development of a robust graduate program, and in developing internationally recognized areas of research strength. In particular, the Applied Homotopy Group is considered to play an important role in the latter category. The director of this vigorous group is our Canada Research Chair, J. F. Jardine.

It should be noted that an external review of the research theme of the Faculty of Science that pertained to the mathematical science departments was carried out near the end of 2007. During the reviewer’s visit and in their report submitted afterwards, there were ideas floated regarding
the formation of a “School of Mathematical Sciences” to provide a focus for (and to promote interdisciplinary activities between) the four “mathematics” departments, namely Mathematics, Applied Mathematics, Statistical & Actuarial Science, and Computer Science. Recently, David Riley (chair of the Mathematics Department) has held planning meetings with the other three chairs to examine the merits of forming such a School. There is a clear consensus in favour of forming a School of Mathematical Sciences at Western, and the chair’s group has explored various options for its role and organizational structure. These discussions are still ongoing, and we are hopeful of a successful outcome in the near future.

Sadly, it must be noted that many of the departments within the Faculty of Science, Mathematics included, do not have a significant role in the Strategic Plan of the University of Western Ontario.

4.8 Teaching Commitments

Undergraduate instruction by the Department has a clear demographic pattern. There are a very large number of first year students, mostly in service courses, and far fewer students in upper level courses, particularly in the courses of third and fourth year. The main theme over the past eight years has been rationalization with the twin goals of:

1. dealing effectively with first year students without being overwhelmed by this heavy teaching load;

2. maintaining and enhancing the quality of our program for mathematics majors.

The academic aspects of the changes made to achieve the above goals are discussed in Chapter 2, notably in Sections 2.3 and 2.4. The present section deals with the “delivery” of undergraduate instruction, i.e. how the Department has deployed its limited human resources to carry out undergraduate instruction.

As a preliminary remark, we note that formerly (as recently as 2002) the Department of Mathematics had a distinctive profile in the Faculty of Science because of its commitment to using regular faculty members, as much as possible, in first year instruction. All sections of its core courses (Calculus and Linear Algebra) in first year were taught by such instructors.

4.8.1 Attrition of Teaching Resources

The teaching resources of the department have reached a critical state.

The Department has undergone a long period of retrenchment with respect to teaching resources. As non-researchers retired, researchers were hired. Fewer sections were offered and student-teacher ratios increased. Furthermore, within the next 15 months our complement will decrease from 20 to 17 unless something is done. Traditionally the number was 21.

If one considers the period 1995-2010 then the Department will have replaced only 11 of the 15 retiring faculty. As the department becomes more research-intensive it becomes increasingly difficult for us to maintain our undergraduate teaching mission.

The Department has made major adjustments to handle this decrease in teaching resources, particularly through the creation of large sections of Math 1225, 1228 and 1229 (service courses, largely for Social Science), as well as utilizing our PDFs for much of the first year teaching load. It is clear that the decrease in human resources is the most dramatic factor affecting our teaching mission.
The fall and winter teaching responsibilities of the Department in 2009-10, expressed as half courses, total 64 sections: 29 first year, 11 second year, 14 third and fourth year (including 8 cross-listed courses), and 10 graduate only. Note that this count does not include 5 reading courses. In future years, any cutback at the undergraduate level would be balanced by strategic increases in graduate courses in accordance with UWO’s policy of expanding the graduate program.

The current breakdown (2009-10) of the type of instructor that teach this configuration of fall/winter courses is 44 taught by tenured/probationary faculty, 5 taught by limited term faculty, and 15 taught by part time faculty.

The projected breakdown of the type of instructor that will teach this configuration of fall/winter courses for 2011-2012 (after the retirement of Dawes takes full effect) is as follows:

<table>
<thead>
<tr>
<th>Type of Instructor</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Tenured/Probationary</td>
<td>35</td>
</tr>
<tr>
<td>Limited Term</td>
<td>4</td>
</tr>
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<td>Part Time</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
</tr>
</tbody>
</table>

A corollary of the above demographics is that a large portion of first year teaching is in the hands of part time instructors. The Department has now reached an arrangement which leaves no margin of error. Even the disappearance of one more Full Time faculty member in a given year will leave Calculus 1000, 1301 and 1501 totally in the hands of part time instructors for the year. The added duty of co-ordinating these courses is another significant problem.

We remark that the Department has gone from offering about 90 sections per year in 2000 to 77 in 2004-05, to the present offering of 64 sections. There are no more savings to be had by any further reduction in our course offerings.

### 4.8.2 Summer Teaching

Until recently, summer teaching was done by part-time faculty and non-researchers. Any summer teaching by researchers was limited, almost always being done as a trade for relief during the fall or winter terms. Now we are all active researchers. Furthermore, there is also a clear desire, on the part of the Department, to have certain “core courses” (Calculus 1000, 1100, and 1501, Linear Algebra 1600, Mathematics 2155/2156) taught in the summer by full time faculty. At the present time, a significant number of summer courses are being taught by retired faculty members. In order to maintain a presence of full time faculty in summer teaching, the department has had to assign more researchers to summer teaching as part of their regular teaching duties. Overall, this has provided some flexibility as well as enhancing the quality of our summer teaching. However there are only 18 of us at the present time, very soon to be 17. It is not likely that we can maintain our entire mission with our dwindling personnel.

### 4.8.3 Reduction in Fall & Winter Sections

The Department has made a determined effort to reduce the number of undergraduate sections taught. This has been achieved by the consolidation of many sections into few for each of our first year course offerings, and more importantly, by the elimination of all non-honors courses beyond first year. This greatly reduces the choices available to our students.
4.9 Outreach Activity

Much of the outreach activity conducted by the Department has been covered elsewhere in this document. At the undergraduate level the Department continues to support the Mathematics Scholars Group, which has recently become a University Student Council sponsored club (the “Math Society”), and the Pizza Seminar.

In outreach to secondary school students, the Department has organized and run a successful Math Camp for thirty Grade 9 students from the greater London area. It is also associated with and helps provide support for several activities centred around Tom Griffiths, a retired high school teacher. He has been the principal organizer of the three week CMS National Camp, held in June at Western for gifted Grade 9-10 students from across Canada. He is the organizer and driving force of a variety of weekly or monthly enrichment sessions involving over 400 London high school students who meet in the Department during the school year. Griffiths has received a special award from the Faculty of Science in recognition of these achievements.

4.10 Space

In 1993, the department completed a long-planned program of renovations and consolidation on the main floor of Middlesex College. Moreover the department will acquire control of one more classroom this summer in the building. After some renovations are completed, it will have sufficient space, adequately equipped, to maintain its graduate program. Here is a summary of its space allocation.

4.10.1 Faculty

All faculty members have individual offices, ranging in size from 8.92 to 17.37 sq. metres.

4.10.2 Graduate Students

This year, for the first time, we had more graduate students than individual spaces for them. All our Master’s students were thus temporarily located in the Physics building, awaiting the obtaining of more space in Middlesex College. This space will be made available this summer, but due to a major renovation of the Physics building that was not initially planned to resume this year, our Master’s students had to be re-located again, this time in Talbot College.

After the renovation of our new space in Middlesex College is completed, all our full-time graduate students will have individual study space adequately located in Middlesex College, either in the form of a carrel or in an office holding two to three people.

The carrels are presently in two rooms, with a third room to be added this summer: one is 29.73 sq. metres and holds seven carrels; another is 24.43 sq. metres and holds six carrels; the third room will be approximately 70 sq. metres and should hold fifteen to eighteen desks. The carrels are separated by dividers at the side (to minimize distraction in the user’s peripheral vision) and have a lamp, shelf space, several drawers, and a corkboard. Each carrel has its own power circuit and a jack for connecting a student’s computer to the university’s computer networks via ethernet. Each of the rooms has (or will have), in addition to the carrels, a desk for telephone placement and occasional work. Also, the Department has four small offices which hold two students each.

All-in-all, after the summer renovation are completed, it is estimated that the Department will be able to host comfortably thirty-six (36) graduate students, but no more than forty (40).
The main departmental lounge has been adopted as a meeting place for faculty and graduate students alike. Because of the increased need for graduate students to share space, a small conference room (about 16.72 sq. metres) has also been set aside for this use.

To summarize: the Department could have dedicated space for up to 40 students, but more realistically would be hard-pressed to accommodate more than 35, or perhaps one or two above that.

### 4.10.3 Visitors and Post-Docs

In recent times, the Department has had from 7 to 10 post-docs per year, and we have been able to provide a small private or semi-private office to each post-doc, complete with computer and phone. Visitors are now housed in various ways, depending on the space available at the time of the visit.

### 4.10.4 Support Staff

There are three people on the support staff at present. Two, the Department’s administrative assistant, and the undergraduate counsellor and secretary for graduate affairs, have small (10.41 sq. metres and 8.92 sq. metres) individual offices. They need individual offices because they maintain or have access to confidential information. Another essential support person handling general secretarial work for the Department was lost due to budgetary cuts last year. The third support staff member is a computer administrator. His duties are shared among the Departments of Mathematics, Applied Mathematics, and Statistics and Actuarial Science, and the Office of the Dean of Science. He is provided with a small office (8.92 sq. metres).

### 4.10.5 Other

The Department has three classrooms, seating 24-32 people, and two small seminar rooms which holds five or six for working seminars. These rooms are used for upper level undergraduate and graduate courses, tutorial sessions for lower level courses, seminars and colloquia, and for other one-time needs. All of these rooms have good blackboard space and most have screens for overhead projectors. All have network access.

There is, in addition, one room reserved for the “Mathematics Scholars group” which consists of undergraduate students in our programs together with some specially talented first year students. The students in the “Mathematics Scholars group” have access to private accounts on shared computer facilities.
Appendix A

Undergraduate Program

A.1 Teaching Activity

<table>
<thead>
<tr>
<th>Year</th>
<th>Distance Learning</th>
<th>On-Campus</th>
<th>Graduate FTEs</th>
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<td></td>
<td></td>
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<tr>
<td>Year 1</td>
<td></td>
<td></td>
<td>S</td>
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<tr>
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</tr>
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S: Summer  F/W: Fall/Winter  CP: Concurrent Program Students  Year 1: 1000-level  Upper: 2000-, 3000-, and 4000-levels
A.2 UnderGraduate Cross Unit Teaching

Undergraduate Cross-Unit Teaching

Office of Institutional Planning & Budgeting

Faculty: SCIENCE
Department: MATHEMATICS

Fall / Winter Course Registrants

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<th>Distance Learning</th>
<th>On-Campus</th>
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</thead>
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Year 1: 1000-level     Upper: 2000-, 3000-, and 4000-levels

Summer Course Registrants

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Office of Institutional Planning & Budgeting

62
## A.3 UnderGraduate Class Size

### Undergraduate Class Size

**Faculty:** SCIENCE  
**Department:** MATHEMATICS

### Fall / Winter Sections (On-Campus)

<table>
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<tr>
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<th>Avg Size</th>
<th>FCE Sections</th>
<th>Avg Size</th>
<th>FCE Sections</th>
<th>Avg Size</th>
<th>1 to 10</th>
<th>11 to 25</th>
<th>26 to 50</th>
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<th>101 to 200</th>
<th>Over 200</th>
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### Summer Sections (On-Campus)

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<th>Avg Size</th>
<th>FCE Sections</th>
<th>Avg Size</th>
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### Notes
- **Year 1**: 1000-level
- **Upper**: 2000-, 3000-, and 4000-levels
- **FCE**: Full-Course Equivalent
## Undergraduate Grade Distribution

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**Department:** MATHEMATICS

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Yr 1: 000-level  
Gen: 100-level  
Hon: 200-, 300-, and 400-levels
# Undergraduate Program Enrollments

**Program Enrolment**

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| Department: | MATHEMATICS |

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Spec: Special Students
Prof: Professional Students
CP: Concurrent Program Students
Oth: Other

Office of Institutional Planning & Budgeting
Room 5300, Support Services Building, London, Ontario, Canada, N6A 3K7 • Tel: 519-661-3536
Updated October 20, 2009 by Jimmy Chien
See our policies on Privacy and Web Standards
## A.6 UnderGraduate Course Registrants

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Appendix B

Graduate Program

B.1 OCGS Approval

September 25, 2009

Dr. Linda Miller, Vice-Provost
(Graduate and Postdoctoral Studies)
School of Graduate and Postdoctoral Studies
University of Western Ontario
London, ON N6A 5B8

Dear Dr. Miller:

This is to indicate that the following programs;

- MSc/PhD, Mathematics
- MSc/PhD, Applied Mathematics

Have been approved by the Ontario Council on Graduate Studies at its meeting on September 25, 2009.

John ApSimon
Executive Director, OCGS

JA/pi
PERIODIC APPRAISAL

UNIVERSITY OF WESTERN ONTARIO — MSc/PhD, MATHEMATICS

At its meeting of September 21, 2009, the Appraisal Committee (Section 2) decided to recommend to Council that:

(a) The above program be approved to continue.

(b) The following fields be approved:
   - Algebra/Number Theory
   - Analysis
   - Geometry/Topology

(c) The program be classified as of good quality.

The above recommendation is based on the Committee's consideration of the University's written submission, the consultants' reports and the University response.

Consultants:

Dr. Keith Taylor
Mathematics and Statistics
Dalhousie University
Halifax, NS

Dr. H Campbell
Arts & Administration
Memorial University of Newfoundland,
St John's, NL

Ronald Barron
Co-Chair

JA/pi
B.3 Sample Algebra Comprehensive Examinations

THE UNIVERSITY OF WESTERN ONTARIO
LONDON CANADA
DEPARTMENT OF MATHEMATICS

Ph. D. Comprehensive Exam (Algebra)

October, 2009

3 hours

Instructions: Answer completely as many questions as you can. More credit will be given for a complete solution than for several partial solutions.

1. (a) State the three Sylow theorems.
   (b) Determine, up to isomorphism, all groups of order 21.

2. Let $p$ be a prime and $n$ a positive integer. Prove that any group of order $p^n$ is solvable.

3. Prove or disprove each of the following statements.
   (a) If $H_1$ and $H_2$ are groups and $G = H_1 \times H_2$, then any subgroup of $G$ is of the form
       $K_1 \times K_2$, where $K_1$ is a subgroup of $H_1$ and $K_2$ is a subgroup of $H_2$.
   (b) If $G$ is a group and $H$ and $N$ are subgroups of $G$ with $H$ normal in $N$ and $N$ normal
       in $G$, then $H$ is normal in $G$.
   (c) If $G_1$ and $G_2$ are groups, $N_1 \leq G_1$, $N_2 \leq G_2$, $N_1 \cong N_2$, and $G_1/N_1 \cong G_2/N_2$,
       then $G_1 \cong G_2$.

4. Prove that for any positive integer $n$, if $G$ is a nonabelian simple subgroup of $S_n$, then
   $G \subseteq A_n$.

5. Let $R$ be an integral domain, and let $Q_R$ denote its field of quotients. Let $P$ be a prime
   ideal of $R$, and define $L_P = \{ \frac{a}{b} \in Q_R \mid n \notin P \}$. Prove that $L_P$ is a subring of $Q_R$.

6. Let $R$ be a finite commutative ring with unity. Prove that every prime ideal of $R$ is
   maximal.

7. (a) Give an example of a principal ideal domain that is not a field.
   (b) Give an example of a unique factorization domain that is not a principal ideal domain.
   (c) Give an example of an integral domain that is not a unique factorization domain.

8. Let $V$ be a finite-dimensional, real inner product space with inner product $\langle , \rangle : V \times V \rightarrow \mathbb{R}$.
   Let $f : V \rightarrow \mathbb{R}$ be a linear functional.
   (a) Prove that there exists $w \in V$ such that $f(v) = \langle v, w \rangle$ for all $v \in V$.
   (b) Prove that $w \in V$ above is uniquely determined by $f$.

See over ...
9. Find four non-conjugate, six-by-six, complex matrices, each with characteristic polynomial \((t^2 - 1)(t^4 - 1)\).

10. Let \(V\) be a finite-dimensional vector space over \(\mathbb{C}\) and let \(f : V \to V\) be a linear transformation.
    (a) Define the rank of \(f\).
    (b) Define the minimal polynomial \(m(f)\) of \(f\).
    (c) Find a linear transformation \(f : \mathbb{C}^5 \to \mathbb{C}^5\) such that \(\text{rank}(f) = 4\) and \(m(f) = (t-1)^2\).

11. Let \(V\) be an \(n\)-dimensional vector space over \(\mathbb{C}\) and let \(f : V \to V\) be a linear transformation. Prove that there exists a basis \(B = \{v_1, \ldots, v_n\}\) of \(V\) such that \(f\) is in upper-triangular form with respect to \(B\).

12. Let \(f(x) = x^3 - 2x^2 + 3x - 5\). Assume that \(f\) has roots \(\alpha, \beta\) and \(\gamma\). Calculate \(\alpha^3 + \beta^3 + \gamma^3\).

13. (a) Find the splitting field \(K\) of \(f(x) = x^2 - 2\) over \(k = \mathbb{Q}\).
    (b) Find the splitting field \(K\) of \(f(x) = x^2 + 2\) over \(k = \mathbb{R}\).
    (c) Find the splitting field \(K\) of \(f(x) = x^n - 1\) over \(k = \mathbb{Q}\).
    (d) Find the degree of each splitting field in (a), (b) and (c) and identify the Galois group \(G = \text{Gal}(K/k)\) in each case.

14. Let \(k \subseteq K\) be a finite extension of fields.
    (a) Define what it means for \(k \subseteq K\) to be separable.
    (b) Define what it means for \(k \subseteq K\) to be normal.
    (c) Let \(0 \neq f \in k[t]\) and let \(f'\) be the formal derivative of \(f\). Prove that if \(f\) and \(f'\) have a common factor of degree \(\geq 1\) then \(f\) has a multiple zero in its splitting field over \(k\).
October 2008

Answer completely as many questions as you are able. More credit will be given for several complete solutions than for many partial solutions.

NOTE: For any ring $R$, and any positive integer $n$, $M_n(R)$ shall denote the ring of all $n \times n$ matrices with entries from $R$, and $GL_n(R)$ shall denote the multiplicative group of all invertible $n \times n$ matrices with entries from $R$.

1. Let $p$ be a prime.
   (a) Prove that the automorphism group of a cyclic group of order $p$ is cyclic of order $p - 1$.
   (b) Prove that the only action of a cyclic group of order $p$ on itself is trivial.

2. Suppose that $E$ is an algebraic field extension of a field $k$ and that $R$ is a subring of $E$ which contains $k$. Prove that $R$ is a field.

3. Prove that $GL_3(\mathbb{Z})$ has no element of order 7.

4. (a) Prove that for any finite groups $H$ and $K$, $\text{Aut}(H \times K) \cong \text{Aut}(H) \times \text{Aut}(K)$ if $|H|$ and $|K|$ relatively prime.
   (b) Prove that any group of order 765 is abelian.

5. The conjugation action of $GL_4(\mathbb{C})$ on $M_4(\mathbb{C})$ determines an equivalence relation on $M_4(\mathbb{C})$ called similarity; that is, for $A, B \in M_4(\mathbb{C})$, $A$ and $B$ are said to be similar if there exists $P \in GL_4(\mathbb{C})$ such that $B = P^{-1}AP$. How many similarity classes of $M_4(\mathbb{C})$ consist of matrices $M$ with the property that $M^4 = M^2$ but $M^3 \neq M$?

6. Let $R$ be a principal ideal domain and let $I$ be an ideal of $R$ with $I \neq \{0\}$ and $I \neq R$. Prove that there are only finitely many ideals $J$ in $R$ for which $I \subseteq J$.

7. Let $R$ be a commutative ring with identity, and suppose that there exist ideals $I, J$ of $R$, both different from $R$, such that $I + J = R$.
   (a) Prove that $IJ = I \cap J$.
   (b) Prove that for any $a, b \in R$, there exists $c \in R$ such that $c - a \in I$ and $c - b \in J$. 

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8. Let $L : M_n(\mathbb{R}) \to M_n(\mathbb{R})$ denote the linear operator on $M_n(\mathbb{R})$ defined by $L(A) = A + A^T$ for all $A \in M_n(\mathbb{R})$, where $A^T$ denotes the transpose of $A$.

(a) Let $n = 2$. Find bases for $\ker(L)$, the kernel of $L$, and $\text{Ran}(L)$, the range of $L$.

(b) For all $n \geq 2$, find the dimensions of $\ker(L)$ and $\text{Ran}(L)$. Provide an explanation to support your answer.

9. Let $k$ be a finite field, $f \in k[x]$ irreducible over $k$, and $E$ be a field extension of $k$. Prove that if $E$ contains one root of $f$, then it contains every root of $f$.

10. Find the Galois group of the splitting field of $x^4 - x$ over $\mathbb{F}_2$, the field of order 2.
May 2008

Instructions: Answer completely as many questions as you can. More credit will be given for a complete solution than for several partial solutions.

(1) Let $E/F$ be a Galois extension of fields of degree 100. Show that there is a unique intermediate field $M$ of degree 4 over $F$ and that $M$ is Galois over $F$.

(2) For a prime number $p$ let $\mathbb{F}_p$ be the field with $p^n$ elements.
   (a) List all intermediate fields of the extension $\mathbb{F}_{p^4}/\mathbb{F}_p$. Draw a diagram illustrating all inclusions between these fields.
   (b) Determine the number of elements of $\mathbb{F}_{p^4}$ such that $\mathbb{F}_{p^4} = \mathbb{F}_p(a)$.

(3) Let $H$ be a subgroup of a group $G$ of finite order, and $(G : H)$ equal to the smallest prime that divides the order of $G$. Prove that $H$ is normal.

(4) Let $G$ be a group. Suppose that $m$ and $n$ are relatively prime integers such that
   \begin{align*}
   x^n y &= y x^n, \\
   y^m x &= x y^m
   \end{align*}
   for any $x, y \in G$. Prove that $G$ is abelian.

(5) Let $H$ be a normal subgroup of a finite group $G$ such that $(G : H)$ is relatively prime to $p$ where $p$ is a prime number that divides the order of $G$. Prove that $H$ contains every $p$-Sylow subgroup of $G$.

(6) (a) Give an example of ideals $I$ and $J$ of a ring $R$ such that $IJ \neq I \cap J$.
   (b) Let $A$ be a commutative ring with unity, and let $a \subseteq A$ be an ideal such that every element of $1 + a$ is invertible. Let $M$ be a finitely generated $A$-module, and $M' \subseteq M$ be any submodule. Then $M' + aM = M$ implies that $M' = M$.

(7) Let $V$ be the space of polynomials of degree at most 2 over $\mathbb{C}$, and let $T : V \to V$ be the linear operator
   \[ T(p(x)) = -p(x) - \frac{d}{dx}(p(x)). \]
   (a) Is $T$ diagonalizable?
   (b) Find a Jordan canonical form of $T$.

(8) Let $k$ be a field, and let $x_0, x_1, \ldots, x_n$ be $n + 1$ algebraically independent variables over $k$. Show that the dimension of the $k$ vector space $A, k[x_0, x_1, \ldots, x_n]$ of degree $i$ homogeneous polynomials is equal to $\binom{n+i}{i}$.
B.4 Sample Analysis Comprehensive Examinations

Student's Name (print)  Student Number
Ph. D. Comprehensive Examination (Analysis)  October 2009
Time allowed: 3 hours

Answer completely as many questions as you are able. More credit will be given for several complete solutions than for many partial solutions.

1. Let \( \mathbb{R} \) be the real numbers with the usual metric and let \( \mathbb{R}_1 \) be the set \( \mathbb{R} \) with the distance function \( \rho(x, y) = |\tan^{-1} x - \tan^{-1} y| \).
   (a) Prove that \( \rho \) is a metric.
   (b) Prove that the identity map from \( \mathbb{R} \) to \( \mathbb{R}_1 \) is a homeomorphism.
   (c) Prove that \( \mathbb{R}_1 \) is not complete.
   (d) Define a metric on the set \( X = \{1/n : n = 1, 2, \ldots \} \) for which \( X \) is complete.

2. A function \( f : \mathbb{R} \rightarrow \mathbb{R} \) is called convex if

\[
f(ax + (1-a)y) \leq af(x) + (1-a)f(y), \quad x, y \in \mathbb{R}, a \in [0, 1].
\]

Prove that a convex function is continuous on \( \mathbb{R} \).

3. Evaluate

\[
\int_0^1 \int_y^1 \sin(x^2) \, dx \, dy.
\]

4. Find a Taylor series and two Laurent series for

\[
f(z) = \frac{1}{z} + \frac{1}{z-3}
\]

about \( z = 1 \) and state the region where each series converges.

5. Let \( G \) be a bounded, open, connected subset of \( \mathbb{C} \). Suppose that \( f \) is continuous on \( \overline{G} \) and analytic on \( G \), and that there is a \( c > 0 \) such that \( |f(z)| = c \) for all \( z \in \partial G = \overline{G} \setminus G \). Prove that \( f \) is constant on \( G \) or else \( f \) has a zero in \( G \).

6. Let \( X \) be a metric space and let \( \mathcal{U} = \{U_\alpha : \alpha \in I\} \) be an open cover of \( X \). A positive real number \( \lambda \) is called a Lebesgue number for \( \mathcal{U} \) if every subset \( Y \) of \( X \) whose diameter is less than \( \lambda \) is contained in (at least) one of the sets \( U_\alpha \).
   (a) Prove that every open cover of a compact metric space \( X \) has a Lebesgue number.
   (b) Find an open cover of \( \{x \in \mathbb{R} : 1 \leq x < 2\} \) that has no Lebesgue number.

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7. Classify (as removable, essential or pole) the singularities of

\[ f(z) = \csc z - \frac{1}{z} \]

in the Riemann sphere \( \mathbb{C} \cup \{\infty\} \).

8. Let \( X \) be compact and let \( \{f_n\} \) be a sequence of continuous functions from \( X \) into \( \mathbb{R} \). Suppose \( f \) is a continuous function on \( X \) such that \( \lim_{n \to \infty} f_n(x) = f(x) \) for each \( x \in X \). If \( f_n(x) \leq f_{n+1}(x) \) for all \( n \) and all \( x \in X \), prove that \( f_n \to f \) uniformly on \( X \).

9. Evaluate

\[ \int_0^\infty \frac{dx}{x^5 + 1}. \]
1. Suppose $f$ is a nonconstant entire function. Show that $f(\mathbb{C})$ is dense in $\mathbb{C}$.

2. Suppose that $X$ and $Y$ are metric spaces and $f : X \to Y$ is continuous. Show that if $X$ is compact and $f$ is onto, then $Y$ is complete.

3. A function $f : \mathbb{R} \to \mathbb{R}$ is called Lipschitz with constant $C \in [0, \infty]$ provided

$$|f(x) - f(y)| \leq C|x - y|$$

for all $x, y \in \mathbb{R}$. Suppose $f_n$ is Lipschitz with constant $C_n$ for $n = 1, 2, \ldots$ and suppose that $\lim_{n \to \infty} f_n(x) = f(x)$ for each $x \in \mathbb{R}$. Prove that $f$ is Lipschitz with constant

$$C = \limsup_{n \to \infty} C_n.$$ 

4. Compute

$$\int_{|z|=3} \frac{e^{z^{-1}}}{z - 2} \, dz.$$ 

5. Find the number of zeroes of the function

$$f(z) = z^7 - 3z^5 - 12z^4 + z^2 + z + 1$$

in $D = \{z \in \mathbb{C} \mid |z| < 1\}$.

6. Show that

$$\int_0^\infty \frac{1}{1 + z^3} \, dz = \frac{2\pi}{3\sqrt{3}}.$$

Hint: Set $\omega = e^{i\pi/3}$, let $M$ be a positive real number, and let $\gamma_M$ be the closed, positively oriented contour consisting of the two segments $[M\omega^3, 0]$, $[0, M]$ and the circular arc from $M$ to $M\omega^2$, centred at $0$. Use the residue theorem to compute the integral of $1/(1 + z^3)$ over the contour $\gamma_M$. 

October 2008

3 hours

Answer completely as many questions as you are able. More credit will be given for several complete solutions than for many partial solutions.
7. Let $R$ be the region in the first quadrant bounded by the curve $x^3 + y^3 = 1$. Make the change of variable $u = x^3 + y^3$, $v = y/x$ to evaluate

$$\int \int_R x \, dx \, dy.$$ 

You may use the result of Question 6.

8. Either give an example of a function that is analytic on $D = \{ z \in \mathbb{C} \mid |z| < 1 \}$ and satisfies $f(0) = 0$, $f(\frac{1}{2}) = i$, and $|f(z)| \leq 2$ for all $z \in D$ or prove that such a function does not exist.

9. Show that the boundary value problem $y' = y^2 + x$, $y(0) = 0$, has no continuously differentiable solution that is valid on the interval $[0, \infty)$. (Hint: Show that $y(4 - 2^{-n}) \geq 2^{n+2}$ by induction.)
1. Let \( f : X \to Y \) be a map between metric spaces.
   (a) Prove that \( f \) maps closed sets onto closed sets if and only if \( f(\overline{A}) \supseteq \overline{f(A)} \) for all \( A \subseteq X \).
   (b) If \( f \) is continuous, prove that \( f(\overline{A}) \subseteq \overline{f(A)} \) for all \( A \subseteq X \).

2. (a) For a subset \( A \) of a metric space, define the terms \textit{boundary} of \( A \) and \textit{limit point} of \( A \).
   (b) Prove that the boundary \( \partial A \) and the set of limit points \( A' \) are closed.
   (c) Can \( \partial A \) be a non-empty open set? Prove your answer.

3. Find the number of zeroes (counting multiplicities) of \( f(z) = 3e^z - z^{2007} \) in \( 1 \leq |z| < 2 \).

4. Find all solutions of the equation \( \cos(2z) = 5 \).

5. Evaluate \( \int_{|z|=2} \frac{e^{z^4}}{z^3 + z^2} \, dz \).

6. Let \( S = \{ z \in \mathbb{C} : |z| = 1 \} \) be the unit circle. Let \( f(z) = \overline{z} \). Prove that \( f|_S \) cannot be approximated by holomorphic polynomials (i.e. polynomials in \( z \)) uniformly on \( S \).

7. Prove that all the roots of the \textit{Legendre polynomials}
   \( P_n(x) = \frac{1}{2^n n!} \frac{d^n}{dx^n} (x^2 - 1)^n \)
   belong to the interval \((-1, 1)\) for \( n = 1, 2, 3, \ldots \).
\textit{Hint:} Find inductively the roots of the polynomials \( \frac{d^k}{dx^k} (x^2 - 1)^n \), \( k = 1, 2, \ldots, n \) counting multiplicities.

8. A function \( f \) defined on a subset \( E \) of \( \mathbb{R} \) is said to be upper semi-continuous (u.s.c.) if
   1. \( -\infty \leq f(x) < \infty \)
   2. For each \( \alpha \in \mathbb{R} \), the set \( \{ x \in \mathbb{R} : f(x) < \alpha \} \) is open.
   Note that \( f \) is allowed to attain the value \(-\infty\).
   A function \( f \) is said to be lower semi-continuous (l.s.c.) if \(-f \) is upper semi-continuous.
   (a) Prove that a function \( f : \mathbb{R} \to (-\infty, \infty) \) is continuous if and only if it is both u.s.c. and l.s.c.
   (b) Prove that an u.s.c. function \( f : [0, 1] \to (-\infty, \infty) \) attains its maximum on \([0, 1]\).
Appendix C

Faculty of Science Academic plan

Faculty of Science

Academic Plan 2007-2011
Year 3 Update & Progress on Implementation
November 2008

Photo by Felix Lee of the Chemistry Department
Report on Faculty of Science 2007-2011 Academic Plan:
Year 3 Update & Progress on Implementation
November 2008
(submitted November 26, 2008)

The 4-year Academic Plan (AP) was prepared in the fall of 2006 and submitted along with its companion 4-year Budget Plan in November 2006. The content outline of the 2007-2011 Academic Plan is as follows:

A. Preamble
B. Vision & Objectives for the Faculty
C. Academic Staff, Support Staff, & Research Staff
D. Undergraduate Education: Students & Programs
E. Graduate Education: Students & Programs
F. Research
G. Space
H. Interdisciplinarity
I. External Relations
J. Performance Indicators and Comparative Assessments

The following update and progress report forms part of the fall 2008 planning process. This report, which constitutes part of the fall 2008 planning process, provides a combined update and progress report for each Secs. C – J of the Academic Plan. Sec. A is expository and is omitted here. Sec. B is foundational and unchanged – it is reproduced to provide context.

B. VISION & OBJECTIVES FOR THE FACULTY:

Vision for Faculty of Science
The vision is twofold:
1) The Faculty would be, or would be on threshold of becoming, the destination of choice for science education in Canada.

2) The Faculty would be the Canadian or world leader in selected research areas and would be emerging as a leader in other areas.

This vision is entirely consistent with, and supportive of, the University goal of providing the best student experience at a research intensive university in Canada. Student experience and research intensity are two themes that weigh heavily in the University’s new Strategic Plan, “Engaging the Future”

The role of the vision statement is to provide a destination that we seek to attain. Becoming the destination of choice for science education and a world leader in selected research areas are lofty goals, ones that are intrinsically difficult, perhaps impossible, to measure quantitatively. But if we do not strive for them then we assuredly will not get there. The length of the path to these goals and the pace with which we can move along the path are not known at the outset. This will make the journey interesting, exciting and, at times, unpredictable. The journey may not be complete by the end of this 4-year plan in 2011 but can enthusiastically be continued in the next planning cycle.

Objectives
The Faculty has identified seven primary objectives that are consistent with achieving the vision. All elements of the AP support one or more of these objectives.

(1) Establish national reputation as a learning intensive Faculty

(2) Increase research intensity

(3) Develop a robust research strategy that fosters discovery while enabling agile responses to needs of society

(4) Graduates distinguished by differential training in communications skills, career skills, & appropriate technical skill.

(5) Proactive recruitment and career development strategies

(6) Facilities & infrastructure that enhance research, learning, and recruitment

(7) Enhanced external relations

These primary objectives are the lenses through which we focus our efforts to achieve the vision described above.

C. Academic Staff, Support Staff, & Research Staff

Tenure-track/tenured academic staff (faculty)

There were 10 tenure-track/tenured and 5 limited term appointments in the first year (2007-08) of the current four-year plan (includes all released positions with an approved start date in 07-08) and 7 tenure-track/tenured and 2 limited term appointments in the second year (2008-09). The Faculty was given permission to split an unfilled CRC 1 into two CRC 2’s in 2007-08. Both CRC 2’s have been filled: one in Chemistry (incumbent took up position in 2007-08); and the other in Physics & Astronomy (incumbent has been recruited and will take up position in 2009-10). Three UFA applications were successful in the 2007 competition (one in Physics & Astronomy, one in Biology, and one joint Biology-Applied Math). The Biology-Applied Math candidate subsequently withdrew and the other two candidates took up their appointments in the summer of 2007. For the last UFA competition (2008), the Faculty adjudicated an internal competition for permission-to-recruit a UFA candidate and approved three applications to go forward to NSERC (two in P&A and one in Earth Sciences); however neither of these applications was successful. No NSERC Industrial Research Chairs (IRCs) were established in 2007-08 or 2008-09. One IRC is currently under development in Stats and Actuarial and has a reasonable chance of securing the required industrial sponsor, although the process may be delayed by the current contraction in the resources sector. The earliest conceivable start date for this IRC is sometime in 2010-11.

Professional development for faculty

A new program to provide accelerated professional development for academic faculty (tenure-track & limited-term) was proposed in the Academic Plan. This program, now known as the New Faculty Network (NFN) was created in the spring/summer of 2007 and delivery is coordinated by Tom Haffie, the Faculty’s Learning Development Coordinator. The NFN was launched August 2007, ran throughout the fall & winter terms of 2007-08, and the fall term of 2008-09. It is targeted towards
relatively new faculty members (the vast majority of participants are in the 1st or 2nd year of appointment) but is open to all. The program covers a wide variety of topics and all aspects of an academic job description in the areas of research, supervision, classroom teaching, service, outreach, promotion & tenure process, etc. The participation rate in NFN events/workshops has dropped in the fall term of 2008-09, presumably because there were only 7 new faculty members taking up their positions in 2008-09 versus 14 in 2007-08 and because probationary faculty hired before 2007-08 took advantage of the programming in its first year of operation (2007-08) and such a “backlog” no longer exists. Given that the maximum number of new faculty expected to start in 2009-10 is 7, a decision has been made to discontinue the NFN and create a faculty and staff support program under the direction of the Assistant Dean Diversity & Outreach but with workshop development and leadership provided by Chairs, Associate Deans, and the Dean. This support program will be open to all faculty and staff and will build on the experience gained in developing the NFN programming to support the professional development.

Women in Science
(1) Postgraduate and Faculty Women in the Faculty of Science
This initiative completed its 4th year of operation under the leadership of the Coordinator, Betsy Skorakis-Doyle at the end of the 2007-08 academic year. Responsibility for all matters pertaining to the support of, and improvement of the workplace culture for, women in the Faculty of Science, as well as to ongoing efforts to improve the representation of women in the graduate student, postdoctoral, and faculty cohorts now rests with the Assistant Dean Diversity & Outreach who takes up this new position in January 2009 (plan for this position is described below).

(2) Status of representation of women in the faculty complement
The gender balance has improved significantly over the last four years. The fraction of full-time female faculty has increased from 12.8% in 2003-2004 to 17.4% in 2006-07 to 21% in 2007-08 and remained at 21% in 2008-09. Of 3 NSERC Industrial Research Chairs and 20 CRCs, 2 and 8 are held by female faculty members, respectively. Seven female faculty have been awarded NSERC UFAs in the past 5 years and three applications were submitted to the final UFA competition in October 2007 (but all were unsuccessful). Recruited female faculty will continue to be supported by the University policy of providing 50% of non-externally funded salary in 1st year of appointment. A Faculty of Science priority in the upcoming University fundraising campaign is the establishment of funds dedicated to the support of outstanding female scholars at the graduate, postdoctoral, and faculty levels through funding mechanisms appropriately targeted to each level.

Assistant Dean Diversity & Outreach
Priorities and Objectives for 2009–2011: The priorities and objectives outlined below encompass four broad areas including diversity, outreach and workplace culture. These initiatives are designed to enhance our diverse community of faculty, staff, and students, to develop further a welcoming, tolerant, and respectful working environment, and to improve safety in the Faculty of Science and throughout Western.

Goals:
To strengthen the internal and external image of Western Science through outreach activities and initiatives related to diversity on campus.

(a) Through consultation with faculty, staff, students, alumni, external stakeholders, advisory groups, and through other forums, develop a mission statement and a plan (that includes timelines and
success criteria for tracking progress) to improve diversity in the workplace within the Faculty of Science.

- Provide a forum so that ideas, strategies and suggestions related to diversity can be considered.
- This plan will include specific programs to focus on the appointment and support of women and First Nations faculty, as well as efforts to increase the representation of other under-represented groups on campus. The existence of under-represented groups within Science is a sign that barriers are present; we need to find a way to remove these. Such programs will require dedicated funding which will be sought through some combination of incremental funding in a future annual budget process, reallocation of funds within the existing Faculty budget, and the upcoming University Campaign (in which a priority theme for Science is funding for women in science initiatives).
- Educate faculty, staff, and students to raise awareness about biases—direct and indirect—that may be present on campus. The document entitled “Employment Equity Guide” will be used as a reference to educate faculty and staff involved in promotion and tenure processes, annual performance evaluation processes, and serving on any type of appointment committee. All members of the above-mentioned committees will be required to read this guide prior to participation in any of these activities.
- The Assistant Dean will serve as the Dean’s delegate on appointment committees and annual reviews to ensure that the committee members become educated and sensitive to unconscious biases or exclusionary behaviours.

(b) Coordinate all outreach activities through the Faculty of Science office in order to present a united and complimentary set of programs across all Departments.
- Present this unified outreach plan through organized, updated, Faculty of Science outreach web pages.
- Maintain an inventory of Departmental outreach activities.
- Work with Departmental outreach committees to secure funds in support of outreach activities.

(c) Ensure that all outreach activities reflect a welcoming, diverse, tolerant Western community. In this way, outreach activities can enhance efforts related to diversity issues.

(d) Communicate progress reports to other members of Western Science so that everyone can embrace the goals of our diversity programs. Through awareness and education we will continue to build a welcoming environment where everyone is willing to work together to ensure the success of all members.

(e) Safe Campus Initiative
- Create a web page resource about safety issues for the Faculty of Science that includes the policies, regulations, and support available across campus. After consultation with other interested groups on campus and members of the Faculty of Science, develop a mission statement to reiterate expectations for conduct on campus. The initiatives taken by the Faculty of Science are meant to supplement, not supersede, other policies already in place at Western.
- The Department of Chemistry has instituted a comprehensive Risk Management Policy which aims to promote and encourage the adoption of a safe work culture through education and by example. Further, Chemistry’s Continuous Improvement Plan is a statement of their mandate to diligently continue to develop a safer work place. This is achieved by being proactive in
safety matters, to evaluate and implement improved procedures and to communicate openly with Supervisors and Workers. Following Chemistry’s lead, other Departments engaged in experimental science will be encouraged to adopt a Risk Management Policy and Continuous Improvement Plan with assistance from Occupational Health & Safety. The next Department in line appears to be Earth Sciences.

- Creation of a Faculty-wide incident reporting form, whereby a student’s aggressive, inappropriate or anti-social behavior can be documented and reported the Dean’s office by faculty or staff in charge of a classroom or laboratory. Patterns of ‘low-threat’ but repeat behavior will be reported to campus Police for evaluation of further action.

- A review of security situation and practices in Faculty Office was undertaken in 2008 by Campus Police and the bulk of the ensuing recommendations have since been implemented.

(f) Creating an Environment of Respect Initiative

- Respect for others is an obligation for everyone on campus, and everyone must share in this responsibility. Faculty members must provide leadership and need to be motivated, educated, and activated to take a principal role in achieving systemic improvements in this area.

- Within Science, a committee consisting of faculty, staff, and students will be formed to maintain ongoing dialogue within all departments to guarantee that the policies, resources, and regulations adopted to ensure a respectful and tolerant climate on campus are implemented, and to identify any deficiencies that currently exist.

- Partner and promote participation in educational sessions related to these issues, developed by other interested groups on campus. For example, the sessions developed by Human Resources entitled, “Saying YES to Respect” and “Respect in Action” should be advertised and promoted within Science.

- The Department of Chemistry is about to offer a workshop (on Dec. 8, 2008) entitled “Safe Campus Initiative” which will cover the following topics:
  - Harassment identification and prevention
  - Safe Campus initiatives
  - Occupational Health & Safety
  - Fire Safety
  - Violence Continuum and avoidance

Selected Departments in Science will be encouraged to follow suit with their own, suitably adapted workshops with assistance from the Chair of Chemistry and Assistant Dean Diversity & Outreach.

(g) Faculty & Staff Professional Development

- Coordinate the creation and implementation of programming (printed & web resources, workshops, events, etc.) to provide opportunities for all faculty & staff to develop skills, to become aware of policies, processes, and procedures, to learn best practices, to facilitate career development, and to foster life-long learning.

A PASF to support the women in science program and the new Assistant Dean position was awarded in response to a fall 2007 budget request.
Details: $10K per annum for years 2, 3, and 4 of the current planning cycle.

D. Undergraduate Education: Students & Programs

Numerous initiatives in undergraduate education and recruitment have been undertaken since the previous academic plan update of November 2007.
Phone Campaign, March 2008
In March of this year, a small army of volunteers, most of whom were senior students, made over 1000 phone calls to the top-listed students who had been given offers to the Faculty of Science/ BMSc programs. The success rate as measured by the number of calls answered was around 70%. So roughly 700 students and/or parents were personally congratulated, and given the opportunity to ask questions about programs and campus life. It is difficult to gauge the impact of such campaigns, but we are confident that in nearly all cases, the students and parents were thrilled to get a call and were most appreciative of the personal contact. We plan to repeat this effort in 2009.

Teaching Awards Advisory Committee
This committee, created in 2008 was given the following mandate:
- raising awareness of the influence of teaching on the student learning experience
- promoting good teaching by increasing the number of applicants for teaching awards and grants
- celebrating excellence in Science teaching & learning via the recognition associated with teaching awards and grants

This committee, which has representation form 5 departments across the Faculty of Science, has already been actively pursuing its mandate and has also developed the criteria for a new teaching award in Graduate Education.

Science/BMSc Internship Program
The preparation for, and the completion of a Science Internship, including workshops on such topics as: writing of cover letters and resumes, presentations skills, concise writing, etc., as well as the required written report and presentation amounts to a substantial commitment by students, and by necessity, includes a significant academic component. The Faculty of Science believes that the awarding of academic credit is appropriate, and will help to attract more students into this program. It is also felt that the awarding of a ‘With Internship’ designation on the degree certificate is appropriate recognition that these students have obtained a significant academic qualification above and beyond their degree. It has long been the practise in Science to have this designation on the transcript only (the designation is given on the degree certificate in the Faculty of Engineering). It is believed that the designation on the degree certificate will also help to attract more students into this program. Furthermore, International Students have not been permitted to participate in the Science Internship Program due to government regulations which require that a co-op/internship be a mandatory (i.e., for credit) component of the academic program. Signifying this designation on the degree certificate, along with awarding academic credit for the internship, will allow International Students to participate in this program. This will allow these students to gain experience which will significantly aid them in securing future employment in Canada. Proposals for this change have been approved by Math/Physical and the Med/Bio EPCs, and will shortly be forwarded to SCAPA.

Workshop for First Year Instructors
In the fall of this year, prior to the start of term, we brought together first-year instructors and other representatives from all departments in the Faculty to organise what we believed to be the first workshop of its kind at UWO. There were over 50 participants, including representatives from the learning Development Centre, and the Vice Provost (Academic Programs & Students)
Our desired outcomes from this workshop, included:
- creating awareness of course content, learning objectives, and anticipated student outcomes outside the home department
● sharing best practices in teaching and learning methods
● creating a sense of community amongst first year instructors
● exchanging ideas, in particular with relevance to curriculum development
● assessing skills intended to be acquired in first year and begin to develop a first-year student skills inventory
● begin to assess first-year workload for student taking the typical suite of introductory Science courses
● recognise opportunities for common policies
● announce and discuss any pending changes

The workshop was indeed very successful and has lead to potentially significant changes in the way that first year courses are delivered (this initiative is outlined briefly in the next paragraph) and to a first year committee that will pursue other action items emerging from the workshop, provide a forum for discussing other 1st year initiatives, and providing a steering group for future workshops.

First-year program in Science
i) Creation of a first year program in Science using one-semester courses only
Being able to offer students the most possible flexibility in choosing their programs, and importantly, being able to *alter their path* after the first semester is not only internally consistent and beneficial, but it is also consistent with the goals of the Bologna Accord, which is designed to allow students to adapt their programs to involve more than one University. Biology, Chemistry and Physics are the only departments in Science who still offer full year courses. The Departments of Mathematics/Applied Mathematics went through the exercise last year of dividing all remaining first year courses into half-course options, and we are now actively and perhaps ambitiously encouraging the remaining departments to do the same. For some students, being able to complete their studies in chemistry and/or biology and/or physics after one semester, and so be able to try an introductory Earth Science or Computer Science course, another math course, or even a non-science course in the second semester would be a huge reprieve. It would also of course, be of great benefit to the departments of Computer and Earth Sciences, which have struggled with attracting students away from the traditional ‘Math, Chemistry, Physics and Biology’ first year schema that is required by the BMSc program. First year half-courses in these subjects also increases the flexibility for non-Science students wishing to take these subjects for interest or to fulfill the breadth requirement whereas full courses often constitute a significant barrier to students seeking to take courses outside of their area of specialization.

ii) First-year course guarantee
The Faculty of Science will continue to guarantee places in all first-year courses to all qualified first-year students. That is, provided a student meets the prerequisite/co-requisite requirements, she/he will not be denied access to any chosen first-year courses offered in the Faculty of Science.

Articulation Agreements with Community Colleges
This year saw the construction of such an agreement between UWO Department of Chemistry and the Chemical Production and Engineering Technology (CPET) program at Lambton College. This agreement will allow BSc Chemistry students an accelerated path through the CPET program, and from there into well paying jobs in the resource sector.
We have initiated informal discussions with Sheridan, St Clair, and Fleming Colleges and there are clearly several opportunities for very lucrative bilateral agreements here, which shall be pursued imminently. We continue to support and have recently updated an agreement with Fanshawe College between their Science Laboratory Technology/Environmental Technology programs, and our
Environmental Sciences and Chemistry Modules; this arrangement has attracted a steady flow of students.

**Major Review of all Programs offered by the Department of Statistics and Actuarial Sciences**

In January 2007, the Department of Stats & Acc. Sci. began a comprehensive review of all courses and modules offered by the department. The motivation for this review was guided by the following principals:

- University Strategic Plan and Science Strategic Plan, to provide enhanced student engagement in the department’s courses.
- Possible accreditation with the Statistical Society of Canada
- Maintenance of already outstanding program with the Society of Actuaries
- Strengthening all programs with the department

The review, which is near completion, will result in the deletion of 9 courses, the introduction of (or replacement of) 10 courses and consequent major revisions to all modules offered by the department.

**Dean’s Advisory Committee on Undergraduate education**

This committee, consisting of Faculty, Student and Administrative Staff representatives, has undertaken a comprehensive review of the way that undergraduate education is delivered in the Faculty of Science. In the short term, this committee will produce a summative report/blueprint to address issues such as emerging trends and new programs in Ontario and Canada, curriculum design and development, student engagement learning, evaluation of academic performance, the impact of the Bologna accord.

Over the course of several meetings, the committee was given the opportunity to discuss these issues with:

- Representatives from the Faculty of Education
- Representatives from Sheridan College
- The (former) Vice-Provost (Academic Programs & Students)
- The Provost
- International Program Development Coordinator

A report is expected in the Spring of 2009. Some of the ideas generated through committee deliberations and the dialogue with visitors to the Committee (as listed above) have been initiated and are in various stages of implementation.

**Counseling Service**

A thorough review of every aspect of the current counseling operation was performed by three external reviewers in February 2007. The ensuing report contains an extensive set of recommendations, the leading one being the creation of a new senior staff (PMA) position of Academic Manager to oversee the counseling operation and improve the quality of counseling services available to undergraduates. This position was filled in February 2008 (Penny Westmacott) and the incumbent has since implemented the vast majority of the report’s recommendation and has succeeded in re-organizing the operation, in filling all vacant and new positions, and in achieving an immense improvement in the level of customer service and satisfaction. The Academic Manager position has removed responsibility for management and of the counseling operation from the Associate Dean Academic, thus enabling the latter to turn much of his time and effort to providing academic leadership in undergraduate education. The results of this change are evident everywhere, including this section (Undergraduate Education) of the present academic plan update document.

**Learning Development Update**
The Academic Plan states a goal for the Faculty to become the destination of choice for science education in Canada. Part of the responsibility for supporting the Faculty in achieving this goal lies with the Learning Development Coordinator. Initially grown out of a jointly supported Faculty Associate position with the Teaching Support Center (2006), the position of Learning Development Coordinator was created in 2007 as a 40% secondment (10% in TSC). Now, in 2008, PASF funding has supported the expansion of the position to 60% (50% in Faculty of Science plus 10% in Teaching Support Center) through June 30, 2011. This position secures leadership for three existing projects and provides for the development of new programming in the future.

i) First Year BioLiteracy Project
Western is one of several sites across the province selected to participate in a HEQCO-funded project to study the impact of various interventions on student engagement in higher education. The local intervention, The First Year BioLiteracy Project, looks at the implementation of a writing-to-learn tutorial curriculum for the nearly 1800 students in first year Biology (1222 and 1223). Pre-intervention surveys and skills assessments were conducted with the previous class in the spring of 2008 and with the current class in September 2008. Curriculum development and delivery is on-going. Post-intervention data collection is scheduled for spring of 2009. One widely considered measure of student engagement is the National Survey of Student Engagement (NSSE). This instrument was administered to all first and fourth year students in the Faculty of Science in Spring of 2008. A targeted NSSE administration will poll only first year Biology students in Spring of 2009.

ii) Growing Intensity: Undergraduate Learning in the Faculty of Science
The Academic Plan declares our intention to become known as a “learning-intensive” Faculty. Realizing this intention will require the various functional groups in the Faculty (i.e. faculty, staff, graduate students and undergraduates) to collaborate in the development and implementation of a wide range of new procedures, programs and learning experiences. Under joint facilitation by Tom Haffie (Learning Development Coordinator), Natasha Patrito, (Teaching Support Center), Fred Wu (Science Students’ Council) and Melanie Tinney (Science Students’ Council), the Faculty of Science is conducting an inquiry into the notion of “learning intensity” in the experience of undergraduates. This Inquiry is designed to engage the Faculty as a whole - faculty, students, staff, alumni and emeriti - in generating broadly supported programs and/or pilot projects to promote more intensive learning. It will address questions such as, “What does undergraduate learning intensity look like in the Faculty of Science?” “What conditions are we creating that foster it?” “How can we create more of it in the future?”

The basic design will see a broadly representative Working Group gathering stories of learning intensity through one-on-one interviews. These learning experiences will then be analyzed in a way that formulates Provocative Propositions – statements of learning intensity that the Faculty would like to see in the future. The community as a whole will then gather in a Town Hall style meeting to develop and rank specific ideas for further support and implementation. The ideas emerging from the Town Hall meeting and the Working Group activities will guide the creation and specification of Faculty Learning Initiative Awards, beginning in fall 2009. Individual or team awards (four per year, selected on a competitive basis) will be given to develop innovative projects in Faculty of Science courses or other educational activity. The Working Group (13 people) has been recruited with representation from current faculty, staff, undergraduate and graduate students as well as alumni and emeriti. Interviews are scheduled to begin late in November; the Town Hall meeting is in late January.

iii) New Programming
There are many opportunities to introduce programming in support of better learning in the Faculty. The two projects described above (“BioLiteracy” and “Growing Intensity”), combined with the associated enhanced NSSE data survey data#, the associated application of the Classroom Survey of Student Engagement (CLASSE) survey, plus other Science Student Council-led research projects will provide the most comprehensive survey of student experience and satisfaction ever been undertaken in the Faculty of Science. Specific ideas that are likely to be successful will be generated by the Growing Intensity project described above. The recently formed First Year Science group emerging from the First Year Instructors’ Workshop will also identify areas for development. Plans are already in hand for a Conference Week “Professional Development” Day, as well as Instructional Skills Workshops for Sessional Faculty.

A PASF to support the Learning Development Coordinator position and the “Growing Intensity” project was awarded in response to a fall 2007 budget request.

Details: ~$60-70K per annum for years 2, 3, and 4 of the current planning cycle.

# The HEQCO funded BioLiteracy project described above provides for 100% NSSE sampling of all first and fourth year Science students over a three-year period, as opposed to the standard sampling rate of 15% every other year.

E. Graduate Education: Students & Programs

Creation of New Programs

The following programs have been accredited by OCGS since submission of the Academic Plan in November 2006:

- Masters in Environment and Sustainability [Category 2, accredited in summer 2007; began operation in September 2007 with enrolment of 24; current September 2008 enrolment of 26]
- Collaborative Program in Environment and Sustainability (MSc and PhD; formerly Environmental Science) [accredited in Nov. 2007; current enrolment is 37 (18MSc + 19 PhD)]
- Collaborative Program in Planetary Science (MSc and PhD) [accredited in Oct. 2007; began accepting students in Jan. 2008; current enrolment is 18 (14 MSc + 4 PhD) with potentially 5 additional students to start in January 2009]
- Geophysics and Geology (Accelerated MSc) [Category 1; Geophysics was approved by FGS with OCGS consent in spring 2007; delayed start due to resignation of Dr. D. Eaton in Oct. 2007; first offering in Sept 2009]

No other new graduate programs have reached the stage of submitting a proposal that would trigger the process of seeking accreditation. Future possibilities are the Collaborative Program in Financial Mathematics, Materials Science, and Bioinformatics. For differing reasons, development of these programs appears to have stalled in years 1 and 2 of the current planning period. Forcing the issue in a “top-down” approach is unwise since it would likely lead to a poorly run program lacking that essential core of sufficiently commitment and engaged faculty members. The Faculty of Science remains poised to facilitate the creation of any of these proposed programs as soon as professorial leadership and passion for the program emerges at the department level or from an interdisciplinary unit. At the time of writing it appears that Financial Mathematics is the lead candidate for formation of new program in year 3 or 4.

Enrolment Situation at Nov. 1, 2008 and Projections

The Faculty of Science has increased its total graduate student enrolment by 69 % from 185 MSc and 172 PhD students in 2000-01 (baseline is Nov. 2000 headcount) to 294 MSc and 314 PhD students in 2008-09 (based on count at Nov.1, 2008. The growth over the baseline year in MSc and PhD is 59% and 83%, respectively. The Faculty of Science aims to achieve a graduate enrolment complement that reflects a ratio of graduate students per tenured/tenure-track faculty member of 3.5:1, a ratio that would place
Western Science competitively among other Faculties of Science (or equivalent) in the G13 comparator group. The ratio as of Nov. 2008 is 3.23:1 (608 students and 188 tenured/tenure-track faculty) which is up from the ratio of 3.0:1 at November 1, 2007 and 2.8:1 at November 2006. With an anticipated faculty complement of approximately 182 by 2010-11, this 3.5:1 target ratio translates into target of approximately 640 graduate students which represents an increase of ~ 80% over the Nov. 2000 baseline. Using a linear growth scenario to measure progress provides a simple tracking tool. Linear growth for a decade starting Nov. 2000 would imply that 8/10ths of the target of an overall increase of 80%, i.e., 64% growth, would be achieved by Nov. 2008. The actual growth at Nov. 2008 is 69%.

Enhanced grad funding model
For the 2008-09 academic year the Faculty is continuing an incentive-based funding model for incremental growth in domestic graduate enrolments (over Nov. 2006 baseline) on a departmental basis. This scheme is entirely analogous to the Provost’s GEF+ funding scheme for incremental domestic growth at the Faculty level. In December 2008 or January 2009, each Department will receive $7K per incremental domestic student over the 2006 baseline. The $7K consists of the GEF+ ($4K) and the Faculty of Science GEF++ ($3K; funded by a UPIF spanning years 1-4); the $7K goes to the Department but must be allocated to direct support of graduate stipends. In addition for 2008-09, the Faculty provided a $1700 entry scholarship (GTSS – Graduate Tuition Scholarship in Science) to all newly enrolled domestic graduate students. This scholarship combined with the WGRS at $3750 approximately covers the cost of domestic tuition. The GEF+/GEF++ incentive scheme and the entry scholarship will be continued for 2009-10. In addition, a full Teaching/Research Assistantship ($10,700) will be awarded for each incremental domestic student in Departments where there is demonstrated need. With this multi-component finding package we have attempted to lower significantly, if not remove, the stipend support obstacle to graduate student enrolment growth.

Professional Development for Graduate Students
As outlined in our planning document last year and to address a need identified in the Faculty of Science annual survey of undergraduates in Science, we have embarked upon a 4-year plan to enhance the graduate student experience for our international graduate TAs and the learning experience of Science undergraduates. The Science Teaching Assistantship Training (STAT) program has as its goals to develop discipline-specific TA materials for each of the 8 Departments in Science. Building on the successful Chemistry pilot project last year, discipline-specific materials designed to improve the teaching abilities of the TAs, with obvious concomitant benefits for the undergraduates, are being developed, in collaboration with the Teaching Support Centre, at a rate of two per year according to the following schedule:

<table>
<thead>
<tr>
<th>Year</th>
<th>Departments</th>
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<tr>
<td>2007-08</td>
<td>Biology + Physics</td>
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<tr>
<td>2008-09</td>
<td>Mathematics + Applied Mathematics</td>
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<tr>
<td>2009-10</td>
<td>Earth Sciences + Astronomy</td>
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<tr>
<td>2010-11</td>
<td>Statistics and Actuarial Sciences + Computer Science</td>
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The Chemistry, Biology, and Physics modules are being offered this year to TAs enrolled in the course Communication in the Canadian Classroom being offered by TSC. Mathematics and Applied Mathematics modules are currently being developed.

F. Research

Support for training of highly qualified personnel who are not in the graduate student cohort
Undergraduate summer research: The search for funding to establish a set of summer undergraduate research assistantships to be awarded on a competitive basis across the Faculty has been shifted from a UPIF request (in year 1) to the upcoming major University fundraising campaign.

Postdoctoral fellowships: The search for funding to establish systematically a set of Postdoctoral Fellowships (two-year tenure) to be awarded in a cross-Faculty competition has been shifted from a UPIF request (in year 1) to the upcoming major University fundraising campaign.

Industrial research and commercialization of research

The Faculty of Science Academic Plan (2007-11) called for the creation of a Business Development Manager position in order to expand relationships with industry and to increase industrially sponsored research and technology transfer (patents and licensing of intellectual property) in the Faculty of Science. In this pilot project, the incumbent Patrick Therrien is funded by the Faculty of Science and reports to WORLDiscovers™, formerly Industry Liaison (IL).

The role of the Faculty of Science Business Development Manager is to add value through advice and assistance on industry research grants, Proof of Principle programs, contracts and intellectual property matters. Focus will be placed on leveraging the funds necessary for product development through various funding sources including government agencies, industrial partners, and investor community.

Goals for the remainder of the current 4-year cycle are:

1. Increase industrially sponsored research.
2. Increase the quantity and quality of Report-of-Inventions (ROIs).
3. Increase number of applications and success rate for industry sponsored grants and Proof of Principle programs.
4. Significantly increase the engagement of two Departments in the spectrum of industrial research and commercialization of research results as measured by research contracts, grants-in-aid of research from industry, tech transfer, consulting, adjunct appointments of industrial scientists.
5. Work directly with Science Internship and Career Services to increase industrial research experience for graduate students, and internship placements for undergraduates.

New agreements with other institutions/organizations

A formal agreement (Letter of Understanding) between the Dept. of Biology and Bird Studies Canada was reached in the winter of 2008. Its provisions include: collaborative research projects and research funding, adjunct appointments of qualified BSC staff, co-supervision of graduate students, and controlled access to UWO library resources.

Organization of research enterprise

i) Biotron Centre

The year 2008 has seen considerable advances with regard to the organizational structure of the Biotron, starting with its designation of formal status as a UWO Centre in spring 2008. In accordance with the management plan contained in the Centre document, there have been changes to the leadership. In particular, the new Scientific Director (J. McNeil) was appointed in August 2008 and a new position of Managing Director was created in September 2008. As regards the latter position, the first incumbent is R. Poole who is serving on an acting basis, pending the search for a permanent incumbent. This reorganization also involved the creation of a Steering Committee in September 2008 (as per the governing structure specified in the application for Centre status) and the elimination of the previous two positions of Business Manager and Technical Director. A detailed plan to achieve readiness for
operation and full utilization of facilities, as well as to sustain operations beyond the five years of CFI Infrastructure Operating Funds (IOF), was submitted to the Steering Committee in October 2008. A plan to achieve readiness for operation and full utilization of the Biotron is provided in the fall 2008 Faculty of Science planning document.

ii) Surface Science Western (SSW)
The Strategic Plan for SSW is provided in the fall 2008 Faculty of Science planning document. The key points are as follows:
- The relocation to the Research Park has been agreed upon and the funding model is in place to support incremental occupancy costs. The move from the current space in Western Science Centre is scheduled to take place shortly after completion of new research building in the Research Park. Tentatively, completion is anticipated for summer 2009.
- The business activities of SSW have seen a decrease in industrial revenues due to the economic downturn; SSW management has responded with an expenditure reduction program.
- There have been increases in academic activity and in revenue from collaborative grants with industry in the last 12 months; plans call for continued expansion in this direction.

iii) Centre of Planetary Science & Exploration (CPSX)
The planetary science researchers (an interdisciplinary group mainly in Physics & Astronomy and Earth Sciences) obtained recognition as a Centre (see write-up on CPSX in Sec. H below) in 2008. Other initiatives were vigorously pursued by this group, including formal links with NASA and the spearheading of the proposed Canadian Astromaterials Facility (through a CFI national project).

iv) Nanofabrication Laboratory (Nanofab Lab)
The search for a new Director was conducted in the spring 2008 as the three-year term of Silvia Mittler was drawing to a conclusion. The new Director was selected by a search committee on basis of an open internal competition. There were several applicants, and the unanimous selection of the committee was B. Kraatz (Chemistry) who started a three-year appointment in August 2008. A new operational plan has been formulated, aiming at increasing the Nanofab Lab usage, both within UWO and externally (at other universities and industry). A new Users’ Committee has been established to advise and provide feedback on accessibility issues, user fees, etc. It is hoped that, with the new operational plan, the Nanofab Lab will be able to achieve fiscal sustainability.

v) Environmental Research Station (the Farm)
The current Director will be stepping down Feb. 28, 2008. It is proposed that a new Director will be identified through a search committee on the basis of an open internal competition, following the model adopted recently for the Nanofab Director search. This personnel change will provide an opportunity to formalize and expand the organizational structure of the Farm. A Steering Committee for the Farm will be formed by January 2009, and the Director will report to and be an ex officio member of this Committee. The new Director (in conjunction with the Steering Committee) will develop operational and long-term plans for the Farm. New developments include the arrival of ICFAR, providing some unprecedented opportunities and a few new operational/management challenges, and a scheduled relocation in summer 2009 to the Farm of the Light Detection and Ranging (LIDAR) facility for atmospheric research currently located at the Delaware site to the Farm in summer 2009.

vi) Materials & Biomaterial Institute (MBI)
It is proposed to reorganize (and rename) the Western Institute of Nanomaterials Science (WINS) as the Materials and Biomaterial Institute (MBI). The background is that in the fall 2007 an ad hoc committee
was commissioned by the Dean and chaired by the Associate Dean Research to prepare a report and recommendations for a new management approach and organizational structure to provide coherent and visionary stewardship over the Materials & Biomaterials research theme, the largest research enterprise among the Faculty’s five themes. A report was submitted and the ad hoc committee met with the Dean in the Spring 2008 to discuss the proposals. The recommendations to formalize the organizational structure of the Institute through a Steering Committee and the formation of other committees for specific activities (such as graduate teaching, outreach through seminars and workshops, etc) were accepted by the Dean. It was also decided that there would be a renaming to Materials and Biomaterials Institute (MBI) to reflect better the overall research activities of the members and to conform to the name of the research theme as it appears in the strategic research plans for Science and UWO. It is anticipated that the formal proposal to rename and restructure the Institute will be made to the VP Research early in 2009. Following that, there will be a search for its first Director.

vii) Institute for Mathematical Sciences
An external review was carried out near the end of 2007 of the research theme of Computational Sciences, one of the Faculty’s five themes. During the reviewers’ visit and in their report submitted afterwards, there were ideas floated regarding the formation of an “Institute for Mathematical Sciences” to provide a focus for (and to promote interdisciplinary activities between) the four “mathematics” departments, namely Mathematics, Applied Mathematics, Statistical & Actuarial Science, and Computer Science. In the last few months David Riley (chair of the Mathematics Department) has held planning meetings with the other three chairs to examine the merits of forming an Institute. There is a clear consensus in favour of forming an Institute, and the chairs’ group has explored various options for its role and organizational structure. These discussions are ongoing, and a vision is being formulated of how the Institute might develop in years 3 & 4 of the current 4-year cycle (i.e., without any fiscal or space resources) as well as beyond that time frame. Following wider consultations, we anticipate bringing forward a proposal for an Institute later in 2009.

viii) Centre for Chemical Physics (CCP)
The role and activity level of CCP has diminished considerably in recent years. This is partly through changes in the nature of interdisciplinary research in this field and the formation of other groups (such as WINS/MBI). It has been decided that base-funding to CCP from the Faculty of Science will be eliminated at end of the 2008-09 fiscal year. The current Directors’ term ends on June 30/09 and he has already indicated he does not wish to be reappointed. The CCP membership now needs to decide on the future of CCP, given that there will be no base-funding, the need to conduct the search for a new Director, and the generally low level of recent CCP activities. Some activities of CCP might usefully be embodied in the new MBI (such as a modestly-funded visitors’ program).

Strategic Research Plan
In the winter term of 2008-09, the Faculty will prepare a strategic research plan for the five-year period 2009-10 to 2014-15. The development of the plan will be led by the Associate Dean Research and informed by:
- consultations with stakeholders in the Faculty and cognate stakeholders in other Faculties (including Engineering, Schulich, and Social Science), the Office of the Vice-President Research, Research Western, WORLDiscovers, etc.
- the external reviewers’ reports on each of the 5 existing research themes (and internal feedback that these reports have generated).
- internally generated reports from the major facilities (Sharcnet, SSW, Biotron, Nanofab Lab, Environmental Research Station, Centre for Planetary Science & Exploration, Centre for Environment & Sustainability, WINS/MBI).
- the University’s new Strategic Research Plan (2008) and the University Strategic Plan (2006): Engaging the Future.
- existing and anticipated relationships with external organizations, including Fields Institute, Perimeter Institute, Institute for Catastrophic Loss Reduction, University of Guelph and Agriculture Canada (in connection with the Biotron), Canadian Light Source, Ontario Photonics Consortium, Bird Studies Canada, National Research Council Industrial Materials Institute.

International research
The development of definitive, Faculty-wide programs that enable sustainable research efforts involving international partners has not yet occurred and remains both a challenge and an opportunity for the Faculty of Science. The primary goal remains the establishment of a well-defined, formal collaborative arrangement involving graduate students and research between the Faculty of Science and one foreign partner institution. It is recognized that formal arrangements are preceded by extensive exploratory discussions, exchange visits, and trial collaborative research projects by individual faculty in order to build a relationship to the point where an agreement can be undertaken at the institutional level. Thus a parallel objective over the remainder of the planning cycle is exploration of new links with a wide spectrum of Departments/Institutions on other continents. Since Nov. 2007 the following activities have, or will have, taken place:

- meeting with Vice-President of Hong Kong Science & Technology Park (visited UWO, Nov. 2007)
- trip to Rwanda for meetings at National University of Rwanda, Kigali Institute of Technology and government ministers (Dean was part of senior UWO delegation that visited Rwanda in Dec. 2007)
- Ongoing discussions to establish collaborations with India (Associate Dean Research. L. Lau, R. Lipson, M. Singh, P. Krishna). Several Science faculty members are organizing and/or participating in a nanomaterials/photonics conference in Allahabad in January 2009.
- Ongoing discussions to renew an exchange program with the federal universities in Fortaleza and Natal in Brazil (Associate Dean Research).
- Meetings with German representatives of Ontario-Baden-Wurttemburg program (Associate Dean Research met with visiting delegation in 2007). There have been promising increases in the number of Canadian students participating.

Stewardship of grant and award applications
The Faculty of Science has established a rigorous process to pre-review in a systematic fashion tri-council operating grant applications (mostly NSERC, but a few CIHR and SSHRC). Participation is voluntary and researchers who participate are given a $1000 research grant in support of their own research program. This exercise is coordinated by the Associate Dean Research. Draft versions are submitted early to the Dean’s Office (about 6 weeks prior to the external deadline). These grant applications are then reviewed by a pool of senior researchers, many of whom have served on NSERC grant selection committees, and constructive feedback is provided to the applicants. The uptake in the first year of operation (fall 2007) was 26 participants, about 45% of the total and higher than anticipated. The goal is to increase both the success rate for tri-council funding and the average dollar value of individual NSERC Discovery (or other operating) Grants. Analysis of the data from the first year indicated that those who participated in the program and were renewing fared slightly better (on average by about $3,500) compared with non-participants. Also the rather smaller group of first-time applicants who participated had a slightly better success rate than those who did not. In the fall 2008 tri-council...
submissions there were 30 faculty members who participated. We will continue to track the effectiveness of this program.

G. Space
The reader is referred to the updated Faculty of Science space plan that accompanies the fall 2008 budget submission; it contains extensive modifications from the space plan prepared one year ago.

Summary of space allocation/renewal since submission of the fall 2006 Faculty planning document:
- Several minor reallocations of existing space within the Faculty;
- Completion of Phases 1 & 2 of B & G renovation and reoccupation of renovated space; commencement of Phase 3;
- Occupation of the undergraduate space (1st year labs for Chemistry & Physics) in the Materials Science addition; outfitting of the research space on the lower level and the two uppermost levels is ongoing and occupation of research laboratories is expected to occur throughout 2009;
- Renovation of one undergraduate lab in the Chemistry Addition.
- No acquisitions of additional space;

Anticipated space reallocation/renewal during the remainder of the 4-year planning period:
- Completion of Phases 3 & 4 of the B & G renovation and reoccupation of renovated space
- Release of all space assigned to Science in Staging Building
- Acquisition of space occupied by FIMS in North Campus Building (tentative) and assignment of that space to Biology.
- Completion of the Physics & Astronomy renovation (may be further delayed and reach completion beyond current 4-year planning period).
- Move of SSW to Research Park and reassignment of SSW space in WSC to Earth Sciences

H. Interdisciplinarity

Interdisciplinary Programs & Initiatives in Science
(i) Undergraduate programs
Significant revisions to the Physics & Astronomy-based courses supporting the Materials Science program (involving Physics & Astronomy, Chemistry, and Earth Sciences) together with some restructuring of the modules took effect for the 2008-09 initiated by a thorough review by the Interdisciplinary Curriculum Committee in 2007-08. The goal is to develop an attractive yet rigorous program that will attract more than the very small numbers who have taken this program to date. It is too early to determine the impact of these revisions on enrolment in materials sciences modules.

The Interdisciplinary Development Initiative (IDI) entitled “The Interface of Science and Medicine” received one-time funding in July 2008 to develop two undergraduate half-courses in medical physics. These second-year courses are being offered for the first time in the 2008-09 academic year (Medical Biophysics 2128A/B, “Fundamental Concepts of Medical Imaging”, started Sept. 2008; “Problem Solving Techniques in Biophysics”, starts January 2009). The Departments of Physics & Astronomy and Medical Biophysics have assumed responsibility for the ongoing administration of these courses and have included them as part of their overall departmental teaching loads. Enrolment in the first offering of the fall term course “Fundamental Concepts of Medical Imaging” is 9.
Programs and modules in Bioinformatics (a joint program between the departments of Computer Science and Biochemistry) will be reviewed under OCAV guidelines early in 2009. A sub-committee of SUUPR will undertake the review.

(ii) Graduate programs
The Masters in Environmental & Sustainability (MES) is an interdisciplinary graduate program (Science is host Faculty; Engineering & Social Science are participating Faculties) was approved by OCGS in summer 2007. This one-year, category 2 Masters program began operation in Sept. 2007; enrolment was 24 in 2007-08 and is 26 in 2008-09. Modest enrolment increases of perhaps 5 per year are planned for each of years 3 and 4 of planning cycle. A Steering Advisory Committee for MES was formed in Oct. 2007 and was subsequently merged with Steering Advisory Committee for the Environment & Sustainability (E & S) Initiative. A Program Advisory Committee to oversee graduate programs in E & S (MES and Collaborative Masters and PhD) was formed in the summer of 2008.

The Collaborative Program in Environmental & Sustainability is a revised and renamed version of the previous Collaborative Program in Environmental Science. The revised program was approved by OCGS in November, 2007. Enrolment for 2007-08 was 36 students and for 2008-09 (Nov. 1, 2008 count) is 37 students, consisting of 18 Masters and 19 PhD students from ~10 departments in four Faculties.

The Planetary Sciences Collaborative Program (involving Physics & Astronomy and Earth Sciences) was approved by OCGS in October, 2007 and began accepting students in January 2008. Current enrolment (Nov. 1, 2008) is 18 (14 MSc + 4 PhD) with the potential of up to 5 additional students to start in January 2009.

The Biomedical Engineering Program (interdisciplinary graduate program involving Engineering, Schulich, and Science) currently has 2 students supervised by faculty in Science (one in Physics & Astronomy and one in Applied Math).

(iii) Environment & Sustainability Initiative
Background
An Interdisciplinary Development Initiative in Environmental & Sustainability (E & S) was approved in July 2007 and funded in the amount of $560,000 over three years. The initiative will combine interdisciplinary graduate, undergraduate, and continuing education with research activities in the area of environment and sustainability. Over 130 faculty members from the three Participating Faculties (Science (Host), Engineering, and Social Science) as well as several other Faculties have expressed interest in participating in activities of the initiative.
Governance
This initiative is overseen and managed by a Steering/Advisory Committee (SAC) consisting of decanal and faculty representatives from the Participating Faculties plus ex officio directorship representation (Acting Co-Directors for E & S programs for 2008-09 followed by new Director for Centre for E & S in 2009-10). The SAC currently provides governance for the (non-thesis) Masters of E & S (MES) Graduate Program, the PhD Collaborative Program in E & S, Environmental Research Western (ERW) and the Undergraduate Program in Environmental Science.

Centre for Environmental & Sustainability
A longer term goal is the creation of an academic unit, tentatively a School of Environment & Sustainability. A necessary intermediate step is establishment of a non-academic unit, in this case a
formally constituted Centre. The first draft of the proposal for a Centre of E & S (CES) is currently being prepared; it is anticipated that the proposal will be submitted to the VP Research for first consideration by January 2009 with final approval expected several months thereafter. Among other things, the centre status will encode a governance model (Steering/Advisory Committee) and an administrative structure that includes a Director\(^1\). The Centre will assume responsibility for the MES Graduate Program, the PhD Collaborative Program in E & S, the Undergraduate Program in Environmental Science\(^2\), ERW (or its successor, if any), and for leadership and facilitation of interdisciplinary and multidisciplinary research in E & S at Western and with other institutions.

\(^1\) The Acting Co-Directors for Programs in E&S will become the Acting Co-Directors for the Centre for E&S once the Centre is established (anticipated winter 2009). Recruitment of a Director is underway and it is anticipated that the first Director for the Centre will be in place July 2009 or shortly thereafter.

\(^2\) It is anticipated that interdisciplinary undergraduate programming in Environment & Sustainability will be developed by the Centre; this new programming may subsume or replace the current program in Environmental Science.

**Academic Staffing**
The goal is to have four to five “core” faculty positions that will have a significant portion of workload (circa 50%, likely more for the Director) assigned to the Centre plus a greater number of affiliated faculty who will have a minor or modest portion of workload (say 10-30%) assigned to the Centre by the end of year 1 of the next 4-year planning cycle (2011-12). The core positions are described below, following a description of “affiliation”.

The process for affiliation of faculty with CES is now specified in a Letter of Understanding with UWOFA (as of November 2008). Applications for affiliation from existing faculty members will be considered by a standing CES “Appointments” Committee. Those approved for affiliation will have a formal letter of affiliation that specifies what portion of the incumbent’s workload will be performed in the home unit and in CES and the term (length) of the arrangement. The Director will assign teaching and service duties and assignable research duties or tasks in accord with the fraction of workload assigned to CES, and in consultation with the Chair of the home unit.

The so-called core faculty positions consist of: a Director, a Tier 2 NSERC CRC in environmental science recently assigned to the Faculty of Science, and two-three regular faculty positions identified in the IDI proposal. The search for the Director is in progress (short-list interviews anticipated in February 2009). The search for the CRC 2 is at the interview phase (Nov.-Dec. 2008). Given the time required to prepare a CRC application and the timing of the thrice yearly competitions, the earliest conceivable start date is January 2010 for an external candidate and somewhat earlier for an internal candidate. If selected candidate is external, offer of employment will be contingent on successful CRC application. Decisions on the timing, teaching/research areas, and the procurement of sustainable funding for the 2-3 regular faculty positions is deferred until the new Director is in place and an Academic Plan for CES has been created.

\((iv)\) **Planetary Science & Exploration Initiative**
An Interdisciplinary Development Initiative in *Planetary Science & Exploration* was approved in July 2008. The main goals of this IDI are:

- Develop clear leadership in Planetary Science and Exploration research in Canada by developing linkages between the Faculties of Science, Engineering and Social Science, attracting quality students and Postdoctoral researchers;
- Promote growth in student enrolment in the undergraduate and graduate Planetary Science modules through funding for targeted outreach and curriculum development and explore ways to develop collaborative programs between Science and Engineering;
- Develop expertise in space systems design, which will attract high calibre undergraduate and
graduate students interested in this demanding area of Engineering.

The IDI proposal is intimately linked with three additional initiatives at Western:
- The Centre for Planetary Science and Exploration (CPSX), established in Aug, 2008, whose objectives are:
  a. Develop clear leadership in Planetary Science and Exploration research in Canada by developing interdisciplinary linkages between various faculties at Western;
  b. Create a vibrant, research-intensive learning environment, which will attract high calibre undergraduate and graduate students to Western;
  c. Establish strong partner linkages with the Canadian Space Agency by providing a service to the CSA by running summer schools, courses, and workshops for the Canadian space community;
  d. Form strategic partnerships with NASA, ESA, and Canadian space companies, such as MDA and Odyssey Moon;
  e. Become Canada’s only node in the newly established NASA Lunar Science Institute network and build a lunar science community in Canada;(This took effect in fall 2008.)
  f. Establish a national Canadian Astromaterials Facility (CAF) with the infrastructure necessary to meet Canada’s space exploration vision and to prepare for the return of samples from the Moon, Mars and other planetary bodies, and to allow for the handling and analysis of extraterrestrial samples already collected;
- The Canadian Network for Lunar Science and Exploration (CNLSE), established in Aug, 2008, whose main objective is to develop expertise and to train highly qualified personnel in lunar science and exploration. This will be Canada’s link with NASA’s new Lunar Science Institute (NLSI) network.
- The Canadian Astromaterials Facility (CAF) CFI proposal, submitted in October, 2008. The objective of this proposal is creation of a National Facility at Western for the characterization, analysis and development of sampling techniques for studying astromaterials in the 21st century.

I. External Relations
Alumni Relations and Development activities continue to be a priority for the Faculty of Science. The plan for the remainder of the current 4-year planning cycle is to:

1) Motivate all Departments to undertake targeted smaller-scale fundraising for specific departmental programs/activities that would appeal to potential sponsors. Obtaining external funding for selected programs/activities frees up departmental funds for other programs/activities, thus providing some relief from the budget downturn facing the University for the remainder of the planning cycle;
2) Advance one or two Departments from marginal participants in alumni relations and development to Departments with a systematic, sustained development program;
3) Continue to support, in collaboration with the University’s Office of Development, the Department of Earth Sciences to achieve the fundraising goal associated with its established Initiative to Enhance Economic and Energy Resource Geology;
4) Increase the intensity, breadth, and effectiveness of development activity at the Faculty level in the run-up to, and opening active phase of, the upcoming University Campaign scheduled for launch in 2009;
5) Elevate the profile of the Faculty of Science and assist in its marketing to prospective students, staff, and faculty, to prospective providers of internship placements and post-graduation employment, to industries with science-based R&D needs, and to government.
J. Performance Indicators and Comparative Assessments

The Faculty is adopting quantitative performance indicators enabling a balanced evaluation of undergraduate programs, graduate programs, and research. Wherever possible indicators that achieve the dual purposes of self-tracking over a period of time and comparison to Faculties of Science (or equivalent unit) at the G13 and/or Ontario universities have been selected. These indicators have been selected on the assumption that the relevant data and survey results are available from other sources (normally central administration) so that the Faculty itself will not need to be involved in extensive data gathering. Appropriate baseline years for each area need to be established and it is anticipated that this will depend on the particular indicator. The parenthetical note following each indicator indicates the comparative group and the source/status of the data. The requisite data is currently assembled in the Faculty Office only for a few of the research indicators. The rest (graduate and undergraduate and some of the research indicators) is being gathered with the assistance of IPB, Research Western, and WORLDDiscoveries in Dec. 2008/January 2009. The goal is to release a Faculty of Science Performance Indicator report in the winter of 2009 at which time relative strengths and weaknesses can be identified and indication given as to how address areas of poor performance and leverage areas of strong performance.

Research:
- NSERC Discovery Grant funding per eligible faculty member (G13; available from IPB; Faculty specific)
- Total NSERC funding per eligible faculty member (G13; exists but not yet available; Faculty specific)
- Average number of refereed publications per full-time faculty member (G13; Faculty specific; subject to periodic availability of data and assessment of scope of publication database).
- Ratio of full-time graduate students to full-time tenure-track/tenured faculty (G13; available from IPB; Faculty specific)
- Total number of each of contracts, patents, licensing agreements, and software releases (UWO, and possibly G13; UWO data available from Research Services and WORLD)

Graduate Education:
- Selected questions from the Graduate and Professional Student Survey (G13; available from IPB; not known to be Faculty specific):
  - If you were to start your graduate education over again, would you choose the same university?
  - If you were to start your graduate education over again, would you choose the same faculty supervisor?
  - Quality of your overall experience at this University?
  - Quality of your graduate/professional program?
  - The relationship between faculty and graduate students?
  - Quality of academic advising and guidance?
  - Opportunities to engage in interdisciplinary work?

- Fraction of graduate students holding major external scholarships, such as NSERC, OGS, etc. (G13 and Ontario; available from IPB?)

Undergraduate Education:
- Selected questions from NSSE (G13; survey is conducted biannually/triannually?; Faculty specific):
  - Mark the box that best represents the extent to which your examinations during the current
school year challenged you to do your best work.
Acquiring a broad general education
Thinking clearly and analytically
Quality of relationships with faculty members.
Overall, how would you evaluate the quality of academic advising you have received at your institution?
How would you evaluate your entire educational experience at this institution?
If you could start over again, would you go to the same institution you are attending now?

- Selected questions from Western’s Survey of Graduating Students (survey is conducted annually):
  Overall satisfaction with education received
  Overall satisfaction- courses taught in your own Faculty
  Overall satisfaction- courses taught in other Faculties
  Learning experience was intellectually stimulating
  Evaluation was fair
  Programs had sufficient practical focus
  Class participation encouraged
  Instructors provided helpful feedback
  Would recommend UWO to a friend
Appendix D

Department of Mathematics
Academic Plan (2007-2010)

A. Introduction

The Department of Mathematics is one of four Mathematical Sciences departments at the University of Western Ontario. Research and teaching in the Department is traditionally concentrated in the area of “pure” mathematics, but the Department maintains strong intellectual and practical connections with the other computational science departments in the Faculty of Science, and its teaching mission reaches all of the University. The Department of Mathematics offers programs at all undergraduate and graduate levels of instruction, and its research team is well known nationally and internationally.

B. Priorities

The following is a summary of the Department’s highest priorities during the next four-year period.

- Securing long term stable funding for the departmental postdoctoral program. This is our single most important initiative and its success is integral to the success of the following two priorities.
- Reducing teaching load for faculty who are highly active in PhD supervision.
- Expanding our MSc program.
- Introducing full scholarships for Mathematics undergraduates.
- Obtaining a larger classroom and more office space.

The objective behind each of these initiatives is outlined in the relevant sections below.

C. Faculty and Staff

In the current year, 2006-07, the Department’s complement consists of 14 tenured, 5 probationary and 1 limited term full-time members. Included in our faculty is one Tier 1 CRC in Applied Homotopy Theory held by Rick Jardine and one NSERC UFA held by Nicole Lemire.

Faculty renewal

A major success of the Department over the past several years has been faculty renewal. Since 2000-01, the Department has recruited seven new mathematicians, resulting in a much higher research profile for the Department. Two more probationary positions are
slated for appointment in 2007 with one anticipated retirement; thus, nearly half of the
Department’s faculty will have been replaced within a seven-year period.

Some measures of the rise in impact of research include:

- Graduate enrollment has risen sharply from a previous high of 12 in recent years
to 19 in 2006-07. In addition, Dan Christensen currently supervises 2 PhD
students for the Department of Applied Mathematics.
- Discovery Grants in the Department have increased from 10 in 1999 to 17 in 2006
while total research expenditure has risen fourfold in the same period.
- During the period 2003-2007 faculty members will have organized or co-
organized at least 21 conferences or thematic programs with budgets totalling
over $1,000,000.

We have four anticipated retirements in the next four years. That is to say, the following
faculty members will reach the age of 65 years:

- July 2007: John Florence
- July 2008: Paul Milnes
- July 2009: Richard Kane
- July 2010: Stuart Rankin

The resignation of Finnur Lárusson sometime in the spring of 2007 is also expected. If he
does resign, his replacement would be appointed in 2008-09.

The Department will use any retirements or resignations as an opportunity to hire new
faculty to strengthen our existing research groups. See Part F for details.

The Department has three administrative staff. This is sufficient for our current needs.
We do not anticipate any staff retirements during the next four years.

**D. The Undergraduate Program**

The Department offers four principal modules:

- *Honors Specialization in Mathematics*
- *Specialization in Mathematics*
- *Major in Mathematics*
- *Minor in Mathematics*

We are also a primary partner in three joint programs:

- *The Five-Year BSc Honors Mathematical Sciences and Bachelor in Education
  Concurrent Degree Program*
- *Honors Specialization in Mathematical Sciences*
• Honors Specialization in Applied Quantitative Information Technology

Much of our undergraduate teaching efforts are directed at first year students. In fact, in 2005-06, we had 1,939 Undergraduate Course Registrants in first year out of a total 2,619 across all years. These students are enrolled in many different programs throughout the University. The total number of students (across all years) enrolled in one of the Department’s modules was 82. Nearly half of those were also enrolled in a module from an outside department.

So, first year courses and other “service” courses constitute a large part of our teaching obligation. Several of those courses are offered jointly with the Department of Applied Mathematics. Namely, these courses are Calculus 050a/b, 051a/b, 081a/b, 091a/b, 250a/b, 251a/b, 280a/b, 281a/b, and 250a/b; Linear Algebra 040a/b; and, Differential Equations 215a/b.

It may be worth noting that the slight drop in our total enrollments in the past few years can be attributed largely to the significant drop in enrollments in Computer Science modules.

Recruitment for the honors modules

The major goal for the Department’s undergraduate program is to improve both the quality and quantity of our honors students. Honors Mathematics programs in Canada are generally small and the Department’s program is no exception. But, in order for our Honors program to be a truly successful experience for the students enrolled, it must grow. Therefore, improved recruitment is the main thrust of our plans for the undergraduate program in the next four-year period. Some of our specific initiatives in this regard are outlined below.

(i) The Mathematics Scholars Group

A few years ago, the Department took a significant step to enhance the experience of its Honors students with the formation of the Mathematics Scholars Group. A total of about twenty undergraduates are invited to join the Group each year. The students are given dedicated study space and computer facilities, and access to faculty mentoring if desired. They are the nucleus of the audience for the also recently formed Pizza Seminar series, which meets once a month during the regular academic term and has become the Department’s most popular continuing colloquium series. The Mathematics Scholars Group is a natural destination for employer recruiting. The importance of the group was recognized through a software donation from Microsoft. The Department intends to strengthen the presence of the Group in the coming years. We believe this initiative should help with our recruitment goals.

(ii) High school outreach
The Department has developed a strong outreach program at the high school level by realizing a series of effective partnerships with teams of high school teachers.

First, the Department, with the support of the Faculty of Science, sponsors the very successful Mathematics Challenge Group. This is a program of mathematics enrichment sessions held weekly for high school and monthly for senior public school students during the regular academic year. The classes are run under the guidance of a team of retired high school teachers and with the participation of some Department members. At the moment, 360 students are registered in the program. A particular function of the sessions is to prepare students for competing in a group of national mathematics contests that include the Canadian Open Mathematics Contest, the Canadian Invitational Mathematics Challenge, the Canadian Mathematics Olympiad and the American Regional Mathematics League. Several students have achieved striking success in their respective contests.

This group of local students is a very natural platform for recruitment into the Department’s undergraduate program. At the moment, a number of the students regularly attend the Pizza Seminar series and some have also taken courses in the Department. The interaction with high school students through the Mathematics Challenge Group should be enhanced and expanded.

Second, for the past six years, the Department has organized a regional summer Mathematics camp called Math Experiences. The sponsoring organizations include the Canadian Mathematical Society, the Imperial Oil Charitable Foundation, UWO and the Fields Institute. The regional camp is organized by a combination of departmental members and high school teachers. Participation is by invitation only and the goal is to expose students to a series of new and exciting mathematical concepts. The CMS National Mathematics Camp was also hosted at the University of Western Ontario for the five-year period 2000-2004.

The Department of Mathematics intends to maintain its present high level of involvement in outreach activities in the future.

(iii) The introduction of specialist full scholarships

Students in our Honors programs are increasingly well supported financially. It remains the case, however, that the Department’s entry-level scholarships are not at all competitive with those offered at Waterloo or Toronto.

Thus, the Department intends to campaign for the introduction of a few “geek scholarships”, that is to say, specialist scholarships that are entirely academic based as opposed to Western’s standard “all around” scholarships. In order to be effective, these scholarships would need to be on the order of a full tuition fee waiver. We feel that the introduction of three or more of these scholarships targeted at aspiring mathematicians would lead to an increased enrollment well beyond their actual number. Indeed, good students attract other good students.
The students involved in our outreach programs are natural candidates for these scholarships. These programs may also help attract external funding for such a scholarship program.

**Improving the experience in first and second year**

Another goal of the Department is to preserve the quality of its first and second year offerings as much as possible given its shrinking resources due to the retirement of “teaching” faculty and the expansion of our graduate program.

- As a general operating principle, the Department will continue to use full-time faculty or research mathematicians as much as possible in our core first and second year courses. The presence of a number of postdoctoral fellows in the Department each year has considerably aided this effort.

- The Department views Science students as a priority and will continue to maintain a departmental policy of limiting enrollment to 125 students per section in Calculus 050, 051, 081.

- The Department (in conjunction with the Department of Applied Mathematics) would like to use some of the increased GTA funding from its expanded graduate program to create a formal tutorial hour for first and second year calculus. Every week graduate students would hold one-hour problem-solving sessions for smaller groups of up to about 30 students at time. Each session would end with a written quiz. See Part E below.

- The Pizza Seminar series, which offers monthly mathematical talks by faculty designed for undergraduate students, continues to be the Department’s most popular colloquium series. This seminar requires a larger venue than we can currently accommodate within the Department controlled classrooms. We would like to obtain MC 105 in order to accommodate this event as well as some of our honors courses. See Part H below.

- The Mathematics Scholars Group provides dedicated study space, computer facilities, and faculty mentoring to a selected group of 20 students. The students have augmented the MSG with their own USC recognized “Math Society” which organizes both mathematical and social activities.

**The minor and major modules as training for professional degrees**

A great many of the students enrolled in our minor and major modules intend to go on to do a professional degree of some sort, including degrees in business, law and medicine. Mathematics is seen as a discipline in which the students learn to think and write logically and abstractly. The Department intends to review its second and third year course offerings to better suit this audience.
Restructuring the calculus stream

Another challenge for us during the next three or four years stems from the Province of Ontario’s revision of the high school mathematics curriculum. More to the point, it appears that calculus will no longer be required for admission to the Faculty of Science. This means we shall require a substantial restructuring of our first year calculus streams. These changes will need to be coordinated with interested parties at both the university and provincial levels.

E. The Graduate Program

In the past decade, our total graduate enrollment has never exceeded 14 students with a maximum of 12 in the recent past. In the current year of 2006-07, however, we have realized a major improvement. We have a total of 19 students (15 PhD and 4 MSc). In addition, Dan Christensen supervises 2 PhD students under the auspices of Applied Mathematics. This one-to-one graduate student to faculty ratio puts the Department on par or better with the pure mathematics divisions of all the major Canadian mathematics departments. That said, the Department believes its graduate student cohort can still grow.

Target numbers for the forthcoming four-year period

With its significantly enhanced research profile, the Department has the human resources to handle approximately 20-25 PhD students on an ongoing basis. Because our MSc program is normally course-based, we could easily accommodate 10-15 new MSc students each year. The Department, therefore, could potentially supervise up to 40 graduate students. Various constraints outlined below, however, mean that we can reasonably accommodate only a maximum of 22 students. Thus, assuming nothing can be done to alleviate these impediments, our goal for the next four years is to reach and maintain an enrollment of 22 students (approximately 16 PhD and 6 MSc).

- The newly introduced system of financial support for graduate students has been conducive to our recent expansion. Further expansion, however, would require another increase in GTA support. The Department would like to use this increased GTA support to reintroduce a formal tutorial hour for our first and, hopefully, second year calculus courses. This would be a definite win-win situation for both our graduate and undergraduate programs. See Part D for more details.

- The minimum funding for our PhD students is currently $20,700 (Canadian) and $26,900 (international) per year. Included in this total is typically $6,000 from the supervisor’s NSERC grant. This is slightly more than half of the median NSERC grant awarded (nationally and departmentally) in pure mathematics. Consequently, it is difficult for most faculty members to supervise more than one PhD student at a time; thus, the Department cannot readily afford more than a
one-to-one faculty to PhD student ratio. Additional sources of funding, therefore, would be required for any substantial expansion.

- The recent growth in our graduate program is putting significant new pressure on our already stretched teaching resources. The expansion of our graduate program has generated a need to offer a greater number of graduate courses. Notably, there is now a need to offer, on a much more regular basis, a series of basic courses for MSc students, distinct from the more advanced courses for the PhD students that were already being offered. See Part F for a related discussion about teaching loads and our international postdoctoral program.

- Another issue of serious concern is space. All students in the Department’s graduate program are given individual study space; namely, they each have a desk with a computer in a shared office. By eliminating all but one seminar room and all but one emeriti office, the Department can squeeze in at most three more graduate students. This is the source of the precise bound of 22 graduate students given in our target. This number is also in line with our current GTA support.

- Finally, recruiting strong graduate students is an ongoing challenge. With its recently enhanced research strength, the Department has a much better ability to attract new graduate students, particularly through personal contact with researchers elsewhere. Other measures have been taken over the past three years to improve the recruitment of graduate students. The Department has mailed a poster and information about its graduate program to about 1,000 universities in North America, Europe, and Asia. Nearly 90% of applications are now online. These efforts have had considerable effect, both with respect to the quality and number of applicants. The number of applicants has stabilized at roughly 100 per year, a tripling of historical levels.

**Expansion of the MSc program**

Unlike our PhD program, which is now running near full capacity, our MSc program remains underdeveloped. However, we see real opportunity for growth in this program. First of all, the new format for funding graduate students has made a positive contribution in that it is now financially tenable for us to recruit international students at the master’s level. A rise in the international enrollment at the MSc level has occurred over the past three years and we expect this expansion to continue. Secondly, we have yet to successfully attract suitable numbers of qualified Canadian MSc students. This reflects the strong competition for Canadian students within Ontario. Recruitment of Canadian MSc students will be receiving future emphasis. We believe that our MSc program should have a particular appeal to Canadian students, one that has never been appropriately promoted. In particular, it fills a special niche in that it is typically course-based and completed in eight months.

**Interdisciplinary graduate courses**
The Department intends to increase the number of graduate courses of fundamental interest to students from other departments. A number of such courses, when offered in past years, have attracted many graduate students from Applied Mathematics, Computer Science, Physics, and Engineering. These include courses on cryptography, differential geometry, functional analysis, representation theory, and wavelets.

**Teaching experience for PhD students**

As part of their fundamental training and in order to be able to compete successfully on the academic job market, the Department would like to introduce a policy that all of our PhD students be given the opportunity to teach at least one half-course during their final year. We realize that this may be inappropriate for particular students. However, such experience is becoming expected in the North American academic market – even for postdoctoral fellowships. Any students without genuine teaching experience are at a significant disadvantage. The Department is aware of the conflict between the GTA Union, UWOFA, and the University regarding graduate student teaching. We hope that this can be overcome for the sake of our students’ careers.

**F. Research Initiatives**

Faculty members in the Department of Mathematics have active research programs in a broad spectrum of subjects including algebraic combinatorics, algebraic geometry, algebraic groups, algebraic K-theory, analytic geometry, combinatorial algebra, complex analysis, complex and symplectic geometry, Galois theory, harmonic analysis, homotopy theory, invariant theory, knot theory, mathematical physics, noncommutative geometry, number theory, quantization, representation theory, several complex variables, and topology. Traditionally, our researchers have been divided into two large research groups. The more narrowly defined of the two is the Analysis Group. The remaining two-thirds of our faculty have interests that lie within the areas of algebra, geometry, number theory, mathematical physics, and topology, but are known collectively as the Algebra Group.

Within the Algebra Group, homotopy theory is the strongest common thread. The subject has applications throughout mathematics, in algebraic geometry, number theory, topology and analysis, as well as (more recently) in fields such as computer science and physics, and some areas of economics. These interdisciplinary applications fall naturally within the Computational Science theme of the Faculty’s Academic Plan. A concentration in areas related to homotopy theory within the Algebra Group has led to the formation of a large and vital Applied Homotopy Theory Group. The Applied Homotopy Theory Group at UWO is the premier research group in its area in Canada, and contributes significantly to the Department’s excellent international reputation in research.

The Algebra Group has received strong federal and provincial support, including a Tier 1 Canada Research Chair, a Premier’s Research Excellence Award, and a NSERC University Faculty Award. The Department will appoint a new geometer to the Algebra Group.
Group to begin in 2007. Currently the Algebra Group supervises 15 PhD students (2 of which are in the Department of Applied Mathematics) and 8 postdoctoral fellows.

Two new hires in 2004 have contributed to a stronger research presence in the Analysis Group. In particular, an effective group in geometric analysis was created. In order to further build research strength in analysis, as well as expand our graduate program, the Department has been granted leave to hire a new analyst for 2007.

The Analysis Group will need to deal with the anticipated loss of Finnur Lárusson. If he leaves, it is imperative that Lárusson be replaced by an analyst of similar research fit and high stature.

The Analysis Group currently supervises two PhD students and one postdoctoral fellow. It is expected that the recent and upcoming hires in the Analysis Group will soon attract more graduate students.

An incipient group in mathematical physics is also present within the Department. Dan Christensen is actively involved in loop quantum gravity, is supervising one postdoctoral fellow as well as two PhD students in this area of physics, and is an Affiliate Member of the Perimeter Institute for Theoretical Physics. Masoud Khalkhali is an expert in noncommutative geometry, an area intrinsically linked to physics, and has major interests in physics. Tatyana Foth also does related work in quantization. Mathematical physics is also represented within the Department of Applied Mathematics and the Department of Physics and Astronomy. The Department of Mathematics intends to further develop the mathematical component of this interdisciplinary venture during the next four-year period.

The international postdoctoral program and teaching loads

Postdoctoral training is an integral part of every mathematician’s education. One of the most important and successful initiatives in the Department over the past six years has been the development of a now thriving postdoctoral program. It was based on funding from one CRC grant, one PREA grant, NSERC grants, the Fields Institute, and the Imperial Oil Charitable Foundation. So far, 22 different postdoctoral fellows have participated, typically for two-year terms. The Department has a demonstrated ability to attract postdoctoral fellows of the highest international caliber from top universities in Europe and the United States. The use of PDF’s to help deal with the Department’s chronic sessional teaching needs has also helped preserve the focus of the Department as a research oriented enterprise.

This year, we have nine PDF’s in the program. Five of these are funded by Rick Jardine’s CRC. This is two more than he normally supports. The remaining PDF’s are funded from various sources of one-time funding. Much of our past sources of funding (PREA and Imperial Oil) for this crucial program have all but disappeared. Long term stable funding for the departmental PDF program is our single highest priority. Therefore, the
Department will seek base funding for two postdoctoral fellowships. This will be the basis of our next UPIF proposal.

There is another issue that base funding for postdoctoral fellowships would help alleviate. Many mathematics departments in Canada offer a standard 3 half-course teaching load, which is one half-course less than our normal teaching load. This issue has become one of faculty retention for the Department.

In particular, the Department currently finds it difficult to fairly compensate our faculty who are heavily involved in PhD supervision. The Department would like to begin to address this problem by reducing the normal teaching load of those faculty members who are heavily involved in both research and PhD supervision to 3 half-courses per year. The teaching resources (4 half-courses per year) provided from two postdoctoral fellowships would enable the Department to accomplish this initiative.

**G. External Relations**

The Department would like to find external co-sponsors for both our specialist scholarship and postdoctoral funding initiatives. In addition to reducing their cost to the University, the “naming” of such awards would increase their prestige.

High school outreach is addressed at length in Section D.

**H. Space Requirements**

The Department has reached the absolute limits of its current space and there is no way to reorganize it more efficiently. In order to accommodate an increasing number of graduate students, postdoctoral fellows and faculty, we need more office space. In addition, the classrooms under the Department’s control are too small to hold our larger audiences such as for our Distinguished Lecture Series, our larger honors courses, or our very successful undergraduate Pizza Seminar.

The Department proposes, therefore, that it receive exclusive control of the (larger) classroom MC 105, which accommodates about 50 persons. We further propose to then divide one of our other classrooms, MC 108, for example, into four offices to be used by two faculty members (or postdoctoral fellows) and approximately 8 graduate students.
Appendix E

Proposal for Western’s School of Mathematical Sciences

Summary

This proposal is to create a new umbrella over the three mathematical sciences departments -- Applied Mathematics, Mathematics, and Statistical and Actuarial Sciences -- called Western’s School of the Mathematical Sciences, or possibly Western’s Institute for Mathematical Sciences. Its mission would be to develop and maintain a centre of excellence and prominence in the mathematical sciences with respect to undergraduate and graduate education, as well as pure and applied research.

By combining these three departments under a common umbrella, we can achieve the following goals:

- Raise our research profile and build awareness nationally and internationally
- Promote interdisciplinary research within the constituent departments
- Develop and maintain a unified academic plan for the mathematical sciences
- Achieve economies of scale in administering undergraduate and graduate programs
- Create a more efficient and effective committee structure
- Make more effective use of space on campus
- Unify outreach and fundraising efforts for the mathematical sciences

Structure of the School

Director

The Director of the School will have overall responsibility for its operation and will supervise all staff allocated to the school. She/he will report to the Dean of the Faculty of Science. The Director will be chosen by a selection committee chaired by the Dean with representation from all three departments and will normally serve in this position for five years.

Staff

Each department will contribute one staff member to the School. One will serve as administrative assistant to the Director. The other two will serve as undergraduate assistant and graduate assistant.
Committees

The School will have the following committees, which need not exist at the department level once the School is established.

Planning (Chaired by the Director, comprised of the Chair and one other member from each department elected annually by the department).

Graduate Education (Comprised of the Graduate Chair from each department, Chair rotates annually among the Graduate Chairs)

Undergraduate Education (Comprised of the Undergraduate Chair from each department, Chair rotates annually among the Undergraduate Chairs)

Awards (Comprised of one member of each department, Chair rotates annually)

Outreach (Comprised of one member of each department, Chair rotates annually)

Industry Relations (Comprised of one member of each department, Chair rotates annually)

Space

The school will facilitate a sharing of space that will enhance communications and collaborations among the departments. Specifically,

• The School’s Director and staff members as well as the Chairs and staff members of the three departments will be located in the same main office area;
• A common kitchen and lounge will be used by faculty staff and graduate students of all three departments;
• Common conference rooms, seminar rooms, and classrooms will be used by all three departments;
• A common computer lab will be used by undergraduate students in all three departments;
• Graduate students in the three departments will share office space.

Operation of the School

Planning

The Planning Committee will be responsible for short- and long-term planning for the School, including the development and on-going revision of the School’s Academic Plan.
This committee will play a fundamental role in determining the direction of the School. It will identify a number of research themes that recognize the areas of strength within the three departments as well as the emerging areas of potential collaboration among the three departments and with other units at the University. These themes will be central to the Academic Plan of the School and will influence decisions related to academic programs and to faculty renewal within the three departments.

**Graduate programs and courses**

The Graduate Education Committee will make recommendations on the creation of new graduate programs and revision/elimination of old programs, consistent with the School’s Academic Plan.

The GEC will monitor graduate course offerings and delivery and make recommendations to the department chairs on curricula for all graduate programs offered by the School.

The GEC will be responsible for implementing and overseeing coordinated graduate student recruitment efforts.

Finally, graduate student admissions will be centralized so that applications for all programs within the School are processed by the School’s Graduate Assistant.

**Undergraduate programs and courses**

The Undergraduate Education Committee will make recommendations on the creation of new undergraduate programs and revision/elimination of old programs, consistent with the School’s Academic Plan.

The UEC will monitor undergraduate course offerings and delivery and make recommendations to the department chairs on curricula for all undergraduate programs offered by the School.

The UEC will also monitor service course offerings of the three departments and make recommendations regarding coordination of offerings and resource sharing.

**Outreach and Fund Raising**

The Outreach and Industrial Relations Committees will enable the School to develop a unified approach to student recruiting and fund raising.
Appendix F

UWO Strategic Plan (2008-2011)

Strategic Research Plan, 2008-2011*

The University of Western Ontario

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* Approved by the Senate and Board of Governors, June 2008
**Introduction**

With annual research income of over $220M, Western (including its newly integrated Robarts Research Institute and its affiliated Lawson Health Research Institute), ranks within the top ten research-intensive universities in Canada. The University has performed exceptionally well in a range of Federal granting programs, including the Canada Foundation for Innovation, ranking seventh overall in Canada and second in Ontario in terms of allocated funding to date. Provincially, the University places second in Federal Tri-Council funding, and second in receipt of competitive research funding from Provincial sources.

Officially adopted in the fall of 2006, Western’s Strategic Plan, *Engaging the Future*, affirms Western’s objective to maintain and to enhance its stature as a leading Canadian research intensive University “through strategic investment in areas of established and emerging research strength.” According to the Plan, these aspirations “will be realized through attention to faculty recruitment and retention, emphasis on graduate programs and enrolment, recruitment of postdoctoral fellows, and construction and renovation of appropriate space.” In addition, the plan commits to providing “the research infrastructure and support required to ensure a strong position among Canada’s leading research universities,” through an abiding focus on:

- Facilitating the alignment of people, resources and space so as to maximize research synergies and success
- Increasing the involvement of undergraduates, graduate students and postdoctoral fellows in the research enterprise
- Emphasizing the importance of knowledge transfer and collaborative research with community partners
- Promoting interdisciplinary and international research
- Tracking performance and celebrating our research successes

Rooted firmly in *Engaging the Future*, the Strategic Research Plan (SRP) establishes a proactive template for supporting both the culture and the practice of research at the University through the selection of key areas for research focus and the establishment of appropriate structures and resources for maintaining and advancing Western’s position as one of Canada’s premiere research-intensive institutions. Conceived as a living document, the SRP results from consultations involving Departments, Schools, and Faculties and has evolved in accordance with the changing research capacities and opportunities emerging across campus in recent years. Its primary objectives are to:

- Identify specific areas of existing and potential research strength at Western
- Assist the recruitment, training, and retention of highly qualified faculty, students, postdoctoral fellows, and staff at Western, and ensure that such individuals are able to access the resources required to undertake their research
- Encourage propagation of the collaborative and interdisciplinary research models required to tackle increasingly sophisticated research issues
• Provide direction to facilitate the development of infrastructure and services required to promote excellence in research, and to meet specified targets for research performance for Western as compared to other research-intensive universities in Canada
• Promote opportunities for researchers to transfer the knowledge they have generated to the benefit of Canadians through engagement with community agencies, commercialization of invention and other means as appropriate to their discipline
• Cultivate broader research partnerships in London and Southwestern Ontario, the province, the nation, and internationally.

**Defining and Promoting our Research Strengths**
The primary goal of research and researchers is to generate new knowledge and to facilitate application of that knowledge in the service of humankind. Academic freedom,
a cornerstone of the institution that is strongly enshrined in Engaging the Future, assures individual researchers of the ability to pursue scholarly pursuits of their own choosing, subject to compliance with existing external and internally derived legal and ethical requirements. At the same time, within this context at Western—and indeed other post-secondary institutions—researchers have often collaborated to pursue more complex areas of investigation that are better or more thoroughly understood using a collective approach. In many cases, the definition and promotion of such areas has enhanced the impact, reputation and funding prospects of both researchers themselves and the University itself.

At Western, whether oriented purely towards discovery or to direct application in the service of the public and or private sectors, the strength of such areas is typically defined by the research excellence demonstrated by both individual scholars and research groups associated with them. Measuring research excellence can of course be challenging, requiring a balance of both quantitative and qualitative measures and an abiding sensitivity to disciplinary norms.
For individual scholars, important outcome measures of scholarly achievement include funding levels and sources of funds, publication of books and articles in refereed journals, participation in the education and training of highly qualified personnel, presentations at important academic conferences, involvement in the scholarly community through review of grants, manuscripts, and monographs, membership on editorial boards, participation in scholarly associations, as well as success in translating research to the public and private sector through knowledge and technology transfer, policy formulation, or other mechanisms. For its part, assessment of group performance depends on the synergy and value added by having members work together on singular projects or broader thematic areas of investigation. All of this, of course, occurs in a context where excellence in teaching and the enhancement of the student experience remain important goals of the institution and its professoriate.

Based upon the Faculty Academic Plans submitted during the annual planning exercise and using an iterative process involving the Deans, Associate Deans (Research) and the Offices of the Provost, and the Vice-President (Research & International Relations), respectively, Western has identified four primary research fields which capture the breadth of work done at the University: Life Sciences and the Human Condition; Culture, Analysis and Values; The Human and Physical Environments; and Social Trends, Public Policy, and Economic Activity. Within each of these fields, some 50 specific areas of research strength have presently been identified for which individuals and groups have achieved national recognition by some or all of the standards of excellence cited above. These areas of strength are listed in Chart 1.

Among these areas of strength, moreover, some stand out for their contribution in helping to define the University as one of the top research-intensive institutions in the country. As such, they combine with a limited range of educational programs for which Western has long been known across Canada and around the world. As part of a broader institution-wide effort to enhance our profile in an increasingly competitive educational and research environment, therefore, it will be important to continue to promote such “signature areas” widely within and beyond our community and thus consolidate our position within the public imagination as one of Canada’s preeminent post-secondary institutions. If we are successful in this effort, our ability to influence the following target audiences is likely to be significantly enhanced:

- Prospective faculty, staff, undergraduates and graduate students, and postdoctoral fellows who may view Western as a destination of choice
- Governments, agencies, and foundations—both within and beyond Canada—that fund research and educational initiatives
- Politicians and senior government officials who set policy of critical importance to the University’s mission
- Potential donors to the University
- Members of the general public who will be better able to promote Western’s interests
How this more limited set of signature areas is to be identified of course presents a serious challenge. In fact, the criteria which might be used in the designation of such areas at Western will very much differ by category. In research, signature areas might be identified by consistent and long-term accomplishments of individuals and groups in:

- Publication of scholarly monographs and or articles in prestigious journals
- Attraction of outstanding graduate students or postdoctoral fellows
- Success in achieving national and international awards and distinctions
- Attracting a disproportionate number of Canada Research or other Chairs
- Achieving unusual success in securing funding for infrastructure, equipment and/or facilities

In teaching and educational programs, other criteria may be applied, as follows:

- National and international reputation as indicated by published rankings
- Ability to attract students of high quality as measured by entering grades and awards
- Success of graduates in their chosen careers, as measured by their accomplishments

With these criteria in mind, an initial set of 10 signature areas for Western may be identified. These are briefly described below:

- **Business**, as indicated by global reputation and ranking success of the Ivey School of Business, and the achievements of our faculty in areas related to the study of management and economics

- **Environmental Sustainability and Green Energy**, as recognized through the accomplishments of the large number of faculty working collectively through the newly approved Interdisciplinary Initiative (IDI), our expertise and state-of-the-art facilities in climate-change research, and in our world-leading work in alternate energy and biomass conversion to bio-oil

- **Health Education**, as indicated through high quality of instruction offered across a variety of disciplines and professions at Western, including our wide range of continuing education and graduate programs, as well as unique programming in undergraduate medical sciences, nursing care and public health

- **Imaging**, as recognized by the broadly acknowledged leadership at Western/Robarts and the Lawson Health Research Institute in the use and development of imaging technologies across the disciplinary spectrum, including sophisticated tools used in medical diagnostics and advanced analysis of materials and paleontological and anthropological artifacts
• Literature and Cultural Theory, as indicated by our national and international reputation and recognition in the study of literature, critical theory and the critical examination of contemporary popular culture

• Materials and Biomaterials, as shown by our pioneering work in the development and application of synchrotron radiation to materials science, leading to the establishment of the Canadian Light Source, our broadly recognized leadership in the synthesis, characterization, and application of materials, and our emerging work in chemical biology and proteins

• Music, as demonstrated by national recognition of program quality, library resources, and the success of our graduates

• Neuroscience/Brain and Mind, as indicated by internationally recognized research undertaken in a variety of disciplinary areas pivotal to an understanding of brain, its functioning and health, linking cell biology, brain imaging and psychology

• Philosophy of Science, as demonstrated by our position as one of the world's acknowledged leaders in research on conceptual issues concerning the origins and nature of scientific theories, relations among theories as well as between theories and the world, and the impact of scientific theories on contemporary society.

• Wind Engineering and Natural Disaster Mitigation, as recognized through our global leadership in the wind tunnel testing of some of the world’s most recognizable buildings, bridges and structures, and related work in the sciences and social sciences in hazard assessment, simulated structural testing and the development of policies and programs to help mitigate the devastating effects of natural disasters including wind, earthquakes, and floods.

By defining these as our current set of signature areas, we are collectively recognizing the significant success of our colleagues in building strong collaborative initiatives with existing and broadly acknowledged international reputations. We also are collectively celebrating their success in developing outstanding research teams and their ability to disproportionately attract top undergraduate and graduate students, postdoctoral fellows, funding and other resources—both to the benefit of the groups themselves and to other researchers at Western. As an expression of this recognition, consequently, we are in effect agreeing to lend these areas an enhanced profile in Western’s representations external to the university in the form of publicity, fund-raising efforts, and in general the presentation of Western to the world. This in turn may require that on occasion signature areas receive supplementary support as appropriate or required through discretionary allocations as may be available from the appropriate Deans, the Provost’s Academic Support Fund (PASF), or funds available through the Vice-President (Research & International Relations). Funding for special initiatives in support of these or other priority areas may also be requested by the Deans through the annual planning process.
This is not to say that our internal funding mechanisms and support structures for research at Western will be oriented exclusively or even disproportionately to these areas. In fact, such areas at Western may be less in need of such resources than other fields of current or emerging strength. As has been the case in the past, all researchers and research initiatives, whether part of a signature area or not, will be eligible on a competitive basis—subject to peer review—to internal granting programs such as the Interdisciplinary Initiatives (IDI) Fund, the Academic Development Fund, the Course Internationalization Fund, and so forth. In addition, researchers in all areas of endeavour will continue to receive the support of Research Western in proposal development and application, especially those which have had less access to external funding sources.

It should be stressed as well that in defining the signature areas, the intent is not to develop a core set of competencies once and forever and to the exclusion of the many other areas of research and teaching excellence at Western. Indeed, it is expected that some of these other areas will eventually become signature areas in their own right. It will thus be important to review the list of signature areas on a periodic basis. It is expected that this review will occur on a four-year cycle, to be led jointly by the Provost and the Vice-President (Research & International Relations).

### Attracting and Retaining Canada’s Best Researchers

**Recruiting and Retaining Outstanding Faculty**

Overall, the research prowess of the University—whether conceived within or well beyond the context of signature or other defined areas of strength—is inextricably linked to the quality of its faculty. Maintaining and building upon our broader research profile thus requires that attention be paid to retaining our existing faculty, and in turn to recruiting new faculty who are clearly outstanding in their respective fields of endeavour.

In support of both of these objectives, the Office of the Vice-President (Research & International Relations) commits to working with the Provost, the Vice-Provost (Academic Planning, Policy and Faculty) and the Deans, within existing structures and agreements, to:

- Encourage appointment committees to recruit the very best researchers and to align their recruitment with University research priorities as detailed in the SRP, while at the same time promoting opportunities for women and designated groups
- Maintain the highest standards for recruitment, promotion, and granting of tenure for faculty members
- Make optimal use of federal and provincial programs such as the Canada Foundation for Innovation (CFI), the Canada Research Chairs (CRC) program, the Ontario Research Fund (ORF), and the Province’s Early Research Awards (ERA) program to attract and retain the very best researchers in areas of research focus and strength
• Encourage and support the Faculties in expanding the mentoring of new faculty members by experienced faculty
• Recognize outstanding faculty members through specialized internal programs such as the Hellmuth Awards, the Distinguished University Professors and Faculty Scholars awards
• Work with the Faculties and Chairs of internal funding programs (e.g. SUPAD) to establish a rigorous procedure for the identification and nomination of deserving faculty to distinguished external awards as offered by the Tri-Council, the federal and provincial governments, and other national and international agencies and foundations
• Identify an academic colleague and champion to help coordinate nomination activity for prestigious awards and work with applicants to develop winning applications
• Communicate and support development opportunities for faculty members, especially where these support emerging areas of research strength

Building the Collaborative Model
Within an institutional context that supports academic freedom as a primary value, both research excellence and the research agenda at Western are without question firmly rooted in the research interests and engagement of the individual scholar. Thus, our continued excellence in research depends upon a sustained commitment to individual scholarship through the mechanisms as currently exist for this purpose. These include provision of start-up funding for faculty members, access to research support for faculty members in areas of importance to Western (especially in areas less likely to attract targeted funding from external sources), assisting faculty in identifying funding opportunities through existing and potential new sources, and creating opportunities for public recognition and celebration of individual research achievements.

At the same time, many researchers recognize that some of the more complex and vexing issues of the day can only be addressed through a more collaborative approach to discovery. This is true, moreover, across the disciplinary spectrum, from life sciences, to science and engineering, arts and humanities, and the social sciences. These collaborations are clearly recognized and supported through the structure of many new and existing funding programs offered by both provincial and federal agencies which overtly stress the need for more collaborative approaches to achieve success in funding.

Historically, Western’s faculty members have been engaged in a wide variety of collaborative—and often interdisciplinary—research projects. Many of these have been formally established in research groups, centres, and institutes. For example, within The Human and Physical Environments field, the Centre for Chemical Physics, Interface Science Western, and Surface Science Western are early examples of this approach. Today, Surface Science Western is firmly established as the leading facility in Canada for the characterization and analysis of surface materials and their reactivity. Similarly, the Western Institute for Nanomaterials Science (WINS) has quickly established itself as a
leading group in Canada for research on materials at the nanoscale. More recently, Western researchers from Earth Sciences and Physics and Astronomy have created a rapidly developing group focused on research and graduate education in Planetary Science. This group, augmented by researchers from Geography and Mechanical and Materials Engineering, has begun to focus on the collection and analysis of extraterrestrial materials and to plan for the procurement of specialized equipment and facilities that will allow for characterization of materials brought back to Earth from planned future missions to Mars and other planets. Together, these entities have established Western as a world leader in characterization of materials and will allow it to explore new, leading-edge research programs in materials and related research. In future, this area will also count on the innovative research now underway at the threshold of the natural and life sciences in the field of chemical biology and proteins. The Institute for Catastrophic Loss Reduction has engaged researchers from Social Science, Science and Engineering in the study of human and natural disasters and the means to mitigate such events. The Boundary Layer Wind Tunnel has attracted a strong interdisciplinary team of researchers from Engineering, Social Science and Applied Mathematics. It has been a world leader in the development of experimental techniques for modeling the behavior of structures in response to wind loading. In recent years, a critical mass of researchers at Western has focused on nuclear power generation and safety, particularly as related to the integrity of materials used in the production of nuclear power and the disposal of nuclear waste. This group has also forged strong and important partnerships with the nuclear industry in Canada. Increasingly as well, researchers in Biology are bringing expertise, leadership, and entrepreneurship to the study of evolutionary ecology and genetics. As a result, Western is poised to become a global centre of excellence in the study of interactions involving fish, birds, insects and mammals from the molecular to whole organism level. In the field of Culture, Analysis and Values, the Centre for Study of Theory and Criticism engages about a hundred scholars across campus in collaborations that cross many of the established disciplines of the Faculties of Arts and Humanities, Social Science, and Information and Media Studies. In addition, with its research partners in London, Western has fostered the development of outstanding research groups within the Life Sciences and the Human Condition field, including the Centre for Brain and Mind and the imaging groups at the Lawson and the Robarts Research Institute, the Ontario Institute for Cancer Research Imaging Program and Platform, the Health Policy Initiative, the Canadian Surgical Technologies and Advanced Robotics (CSTAR) team, the Canadian Centre for Activity and Aging, the National Centre for Audiology, and the Canadian Language and Literacy Research Network (CLLRNet). Social Trends, Public Policy, and Economic Activity incorporates a number of leading research groups of national and international importance including the Centre for American Studies, the Population Studies Centre, and the Political Economy Research Group. Researchers from a variety of disciplines are collaborating as well to help improve the capacity of municipal governments to engage in effective public policy formation and implementation. And finally, colleagues from the Ivey School of Business are leading a national initiative to enhance sustainability practices within industry.
In an increasingly competitive environment which emphasizes and rewards collaborative approaches to research, the University must continue its strong support for collaborative and interdisciplinary research by:

- Supporting the continued selective allocation of resources (through programs such as the Interdisciplinary Initiatives [IDI] program) to assist and promote key interdisciplinary and collaborative research and teaching strengths
- Ensuring adequate funding and staffing to assist faculty members and teams with collaborative proposal development and management for both the established funding programs, and in the new collaborative funding programs offered through the federal granting agencies
- Encouraging and strengthening linkages between University and institute-based researchers in the formulation of research projects and initiatives, and by working to remove barriers that limit integration of research activities
- Ensuring that interdisciplinary research groups, centres and institutes are actively contributing to the mission of the University through periodic review and renewal
- Facilitating access to highly sophisticated electronic collaborative tools such as SHARCNET’s Access Grid and other vehicles for web-based videoconferencing

The Canada Research Chairs Program
A vital tool in faculty recruitment, retention and the development of research strengths in key areas is the Canada Research Chairs (CRC) program. In total, Western has been awarded 68 CRCs, in accordance with the proportion of funding the University receives annually from each of the Tri-Council agencies. Of these, all have now been assigned to Faculties, with 14 in the SSHRC area, 26 in the CIHR area, and 28 in the NSERC areas. To date, 63 have been filled, with five appointments yet to be made. In accordance with the review process at Western, all CRC nominations are forwarded by the Faculties and approved by both the Vice-President (Research & International Relations) and the Provost. In the selection process, particular emphasis is placed upon the proposed Chair’s fit with Departmental, School, and Faculty academic plans, and the University’s SRP. In many cases, particular emphasis has been placed on making interdisciplinary appointments that serve the needs of more than one Faculty.

Overall, however, the goal is to optimize the strategic impact of the CRC program by creating the best avenue for fostering and developing internationally competitive research programs in key areas of strength as defined earlier in this document. Thus, in the Life Sciences and Human Condition field, four CRCs have been allocated to Biomedical Imaging, and an additional four to the related Neuroscience area. Three have been directed towards support of Immunology, Chronic Disease and Transplantation. In Social Trends, Public Policy and Economic Activity, one chair has been allotted to Engaging Emerging Markets, and two to Social Demography and Change, while in Culture, Analysis and Values, one has been awarded to Literature and Cultural Theory.
and another to Bioethics. In the Human and Physical Environments field, seven Chairs have been allocated in support of Materials and Biomaterials, five to Environmental Sustainability and Green Energy, six to Computational Sciences, two to Wind Engineering, Natural Disaster Mitigation and Management, and one to the Philosophy of Science.

The appointment of female faculty members to CRC positions is a key priority for Western. To date, our record of appointments within the NSERC and SSHRC areas has been consonant with extant male/female ratios among the faculty. Of the 14 Tier I and II CRC award-holders in the SSHRC area, 5 (33 percent) are female, a figure which compares favourably to female representation within the faculty generally at nearly 30 percent. In the NSERC areas, where about 12 percent of faculty are women, females have been awarded 6 of 28 (21 percent) of Tier I and II chairs. Women are still underrepresented in the CIHR area, and hold just 4 of 26 (15 percent) of Chairs awarded. The Vice-President (Research & International Relations) has committed to work closely with the Provost and the Deans of the relevant Faculties to increase the rate of appointment of female faculty as Chairs come up for renewal. Our goal is to achieve a level of representation of women within the CIHR area at approximately 23 percent.

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<th>University</th>
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<tr>
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<td>249</td>
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<tr>
<td>UBC</td>
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In order to maximize the benefits of the CRC program with respect to faculty recruitment and enhancement of our primary research strengths, the University will continue to:

- Ensure that remaining new, and all renewed CRC appointments are made in...
areas of priority research strength

• Work with the Provost and Deans of the relevant Faculties to ensure that the number of women appointed to Canada Research Chair positions within each of the CIHR, SSHRC, and NSERC areas is at least proportionate to their representation on faculty

Research Chairs Funded from Other Sources

Western has made significant inroads in recent years in the establishment of research chairs using funds from other sources. Private donors, for example, have contributed partial or full funding (through endowments) for the establishment of dedicated research chairs, especially in areas including the arts, humanities and social sciences. The life sciences have attracted a significant number of named chairs as well, reflecting a strong desire on the part of donors—including governments—to contribute to medical discoveries in areas of interest to them. Examples include Western’s Ontario Research Chair in Autism Studies, endowed by the Ministry of Training, Colleges and Universities, and the Meighan Family Foundation Community Nursing Professor for Studies in Family Nursing.

Increasingly as well, we are starting to see an increase in the number of industrial research chairs established in partnership with funding from both the granting agencies (particularly NSERC) and partners in industry. Importantly, approximately half of the industrial research chairs now in place at Western are held by women. In general, such chairs greatly facilitate access by faculty and students to areas of applied research and development of importance to Ontario and Canada, while at the same time enhancing their skills and expertise to new fields and subfields—all within a context where research direction is ultimately decided by the researcher and which strongly respects the importance of academic freedom within the academy. The linkages created through these programs also provide ready access to employment opportunities for our students.

Examples of areas where industrial research chairs have been emplaced to the benefit of researchers, students, and our industry partners include nuclear power, disaster mitigation, energy from residual forestry products, and materials science. To further build and promote the industrial research program at Western, we must seek to:

• Work with Development and Alumni relations to identify areas of strength where funding might be solicited for the establishment of prestigious research chairs
• Utilize the resources of our Research Development team to identify and assist faculty in competing for endowed or other research chairs established on a competitive basis by governments, foundations, and other sources
• Work closely with the granting agencies to identify areas where industrial research chairs might be pursued at Western in support of existing and emerging areas of strength
• Identify companies, agencies, and associations willing to engage as partners in our industrial chairs program

Building the Support Infrastructure for Research Excellence
Core Facilities and Physical Infrastructure

The University has invested in the past, and will continue to invest significant funds in building and maintaining the infrastructure utilized by researchers across campus. Such infrastructure includes not only office and laboratory space, but also core facilities including the Library System—a key resource in the development of virtually all research projects at the University. The role of the Library in this regard has been further enhanced in recent years through aggressive deployment of information resources online, allowing researchers to access information at their own desks, and through the construction of the Archives and Research Collections Centre, which will allow researchers unparalleled access to critical archival materials. Western’s Information Technology Services also plays a vital role by providing the “backbone” for electronic information transfer and access to information across campus and around the world, greatly facilitating collaborative opportunities for faculty at Western.

In addition to these resources, researchers and research groups have worked diligently with staff across the University to seek external funding for the establishment of an impressive inventory of research space and facilities which are now heavily utilized not only by faculty, students, and postdoctoral fellows on campus, but by researchers across Ontario and Canada and in many cases around the world. With funding from the Canada Foundation for Innovation (CFI), the Ontario Innovation Trust (OIT), the Ontario Research & Development Challenge Fund (ORDCF), the Ontario Research Fund (ORF), industry partners, internal and other sources, the total value of these projects has now exceeded $350M, placing Western in the very top tier of Canadian universities in terms of availability of leading-edge research space and equipment in a broad variety of fields.

Core facilities in the Life Sciences and Human Condition field include the recently completed London Regional Innovarium, a $35M CFI-OIT project which provides state-of-the-art animal care facilities supporting the work of biomedical research teams from the London region and beyond. Other key facilities include the CFI-OIT/ORF funded Centre for Brain and Mind, designed to facilitate the study of cognitive function and dysfunction in a broad range of neurological and psychiatric disorders. With a recent contribution of $12M from the Ontario Research Fund for new imaging equipment to be emplaced at the Robarts Research Institute—complementing an existing broad array of imaging equipment and expertise at both Robarts and the Lawson Health Research Institute—Western is arguably the leading centre for imaging in Canada, and a global leader in this field. Robarts is also home to the London Regional Genomics Centre, one of the top rated facilities of its kind in the world for sequence quality that provides service to more than 300 laboratories across Canada. Other key research facilities include the National Centre for Audiology, a renowned CFI-OIT/ORF funded audiology and hearing science teaching, research, and clinical service facility, and the Biomedical Hybrid Imaging Facilities at Lawson. The London Regional Proteomics Centre houses a number of facilities for protein discovery and analysis, including the ORDCF-funded Western-led Ontario-Wide Protein Identification Facility, that enable collaborative research designed to investigate the precise role of proteins in health and disease and to develop knowledge-based approaches for the effective molecular targeted prevention and treatment of disease. The recently announced expansion of the Nursing Research Unit...
will support research and scholarly activity of faculty and graduate students in the School of Nursing. Finally, CSTAR is a leading Canadian facility for research on robotic-assisted minimally invasive surgery that has pioneered many clinical firsts through its partnerships with London hospitals.

In the Human and Physical Environments field, the Western-based $100M Shared Hierarchical Academic Research Computing Network (SHARCNET) provides high performance computing (HPC) resources to researchers at 16 institutions across Ontario, making it Canada’s largest HPC consortia and one of the top 500 computing constellations worldwide. The processing capabilities provided through SHARCNET enable cutting-edge research in a variety of areas from economics and business to chemistry, applied math and the life sciences. Funded by CFI-OIT, Western’s Nanofabrication Laboratory provides services to both researchers and industrial clients seeking to both image and fabricate materials at the nano scale. As such, it is a critical Canadian resource for investigators across Canada and around the world. Surface Science Western provides Canada’s largest and most comprehensive platform for the interdisciplinary study of materials, and is accessed by researchers and industries representing a wide range of fields, from the life sciences to engineering. Our capacity for materials characterization is set to expand as well with the planned construction of the Canadian Astromaterials Facility (CAF), providing what will be the planet’s most advanced centre for the analysis of extraterrestrial material. The $35M renewal of the Biological and Geological Sciences Building is providing not only new laboratories for research in mineral, petroleum and water resources but a bridgehead to the establishment of novel programming in economic geology and professional geosciences. The Boundary Layer Wind Tunnel has long been recognized as Canada’s premier wind testing facility for large-scale civil construction projects, including some of the most recognizable structures in North America, Europe, and Asia. Western’s capacity for wind testing and disaster mitigation increased markedly in 2006 as well with the construction of the Insurance Bureau of Canada Laboratory Facility for Better Homes. Located at London International Airport, this one-of-a-kind CFI-OIT/ORF, insurance industry-funded venture will allow researchers to test—at full scale—the ability of houses to withstand forces of nature including hurricanes, tornadoes, and earthquakes. Western’s $28M CFI-OIT funded Biotron project, led by colleagues in the Department of Biology and built in partnership with researchers at the University of Guelph, is the world’s most advanced climate-controlled research facility, allowing for unprecedented opportunity to study the effects of climate change on crop production and ecosystems in a laboratory setting. Together, Western and the University of Guelph possess the largest inventory of climate-controlled research space in Canada. Adding to our current array of full-scale simulation research facilities is the soon-to-be-completed CFI-ORF supported Advanced Facility for Avian Research (AFAR). AFAR will provide state-of-the-art access to biology and psychology researchers examining the effect of wind on bird behaviour. Finally, Western’s $18M CFI-ORF funded flagship Lassonde Pavilion will lead cutting-edge work on alternative energy and assist researchers across Canada in developing new energy sources and environmentally friendly chemical processes.
There has been significant growth and expansion of the research facilities supporting work in the *Culture Analysis and Values* and *Social Trends, Public Policy, and Economic Activity* fields. Of note here is the establishment of the Statistics Canada Research Data centre in the Faculty of Social Science, which provides on-site the full array of StatsCan data accessible for use by researchers in London and region from a variety of disciplines from sociology to business, economics, health care, and geography. The Faculty of Arts and Humanities has also led the way in the creation of the Science, Epistemology, and Ethics Research (SEER) lab, a state of the art physical and virtual meeting and discussion space linking researchers, practitioners, students and community members with interests in the pursuit of value questions related to medicine and to science more broadly.

To ensure that Western researchers are well equipped to continue their work both within the context of their discipline and collaboratively, we will continue to:

- Work in collaboration with the Deans to ensure the financial viability, functionality of, and broad access to our current network of core research facilities in key areas of strength
- Identify existing external programs providing support for infrastructure development and renewal, and provide support to researchers through all phases of the project development process, from application, to implementation and project management
- Identify and advocate for large-scale infrastructure projects of broad significance to research and researchers in London and region which may be funded through alternate sources including direct approaches to government and the private sector
- Fund the institutional costs of supporting research (including such things as utilities, maintenance, renovation, research administration, and library and electronic resources) by working towards recovery of an amount equivalent to 40 percent of direct project costs from federal and provincial funding agencies, and 40 percent of direct project costs from research funded by industry

**Supporting the Work of our Researchers and Establishing Targets**

Across the University, support for the research funding application process has expanded markedly in recent years. Each of the Faculties has now named an Associate Dean or senior administrator who is responsible for promotion of research objectives in cooperation with other Faculties and the Office of the Vice-President (Research & International Relations). Since the last SRP was formulated in 2003, Research Western has added staff to provide direct support to researchers through the full spectrum of the research funding process, from assistance with proposal development and application to infrastructure, Tri-Council, and international programs, to management of accounts, assistance with development of financial and budget plans where warranted, support in ensuring compliance with University and external regulations concerning the ethical conduct of research, and knowledge transfer. As part of this unit’s proactive mandate, the various teams within Research Western also seek to remove administrative and other roadblocks originating inside and beyond the institution before these become
impediments to research success. To this end, Research Western works closely with other key administrative units such as Purchasing, Research Accounting, and the Department of Physical Plant and Operations. In addition, Research Western oversees an expanding array of internal funding programs, valued at approximately $3M per year. A good portion of this funding is targeted towards disciplinary areas which may have fewer sources of external funding, especially in the arts and humanities and the social sciences. In many cases, the beneficiaries of these internal funding programs are new faculty members working to establish their independent research programs before applying to provincial, national, or international funding agencies.

In order to build and better align these services with the needs of researchers, we will continue to work towards:

- Developing effective and close ties between Research Western, the Faculties and service units across campus to create an effective and supportive environment for researchers on campus
- Aligning staff support to proposal development with discipline specific, researcher needs and the increasing array of strategic opportunities available through the federal and provincial governments, industry, and international sources
- Ensuring oversight, communication, and development of effective research support strategies through advisory bodies such as the Core Planning Group, and the Associate Deans (Research) group
- Ensuring that internal funding programs are well managed and advertised across campus, and targeted to provide researchers—especially those with limited access to external funding—with the support they need to more fully develop their research programs

In addition, to help orient and focus our efforts and to ensure that our research support programs reflect our firm resolve to maintain and enhance our status as a leading Canadian research university, we shall:

- Establish and work towards achieving a target of 5th place or better among the G-13 institutions in cumulative Canada Foundation for Innovation research funding (up from 7th place currently)
- Establish and work towards achieving a target of 5th place or better among the G-13 institutions in each of the Tri-Council agencies in funding per researcher (up from 7th-10th place nationally, depending upon the program)
- Establish and work towards achieving a target of 2nd place among Ontario institutions in cumulative Canada Foundation for Innovation funding, in each of the Tri-Council agencies in both funding per researcher and total annual research funding, and in cumulative Ontario-based research funding (thus maintaining our current 2nd place standing)

Enhancing Undergraduate, Graduate-Level and Post-Doctoral Contributions to Research
Western's reputation as a research university of the first rank is directly linked to its ability to attract faculty members with a passion for their scholarship and an understanding of the linkage between research and teaching at all levels. This in turn provides a vital link to undergraduates and their engagement in the research enterprise of the University. “Providing the best student experience” requires in fact that our undergraduates are both aware of, and—as possible—participate meaningfully in the research programs of our faculty across campus. This presents a serious challenge insofar as funding for programs supporting undergraduate research, such as NSERC’s Undergraduate Student Research Award program, is limited. Further, what is available internally is subject to restrictions based upon financial need (e.g. Western’s Work Study program).

The recruitment of top graduate students and growth in the graduate student cohort are presented as key objectives in Engaging the Future. Not only does this help ensure growth in the numbers of highly qualified personnel graduating from Western—in the service of career development and economic development more broadly—it also contributes to the expansion of the research enterprise at the University as growing numbers of graduate students engage in a diverse range of research programs and offer assistance to the development of programs instigated by faculty. Western remains dedicated to providing academic and financial support to recruit exceptional graduate students who can perform research at the highest level and graduate in a timely manner.

Postdoctoral fellows constitute another key cohort within the research system at Western. While at the University, postdoctoral fellows pursue independent research programs which—especially in the life and physical sciences and engineering—often overlap with and complement those of their faculty supervisors. Indeed, in many cases, postdoctoral fellows make an essential contribution to the research programs of their faculty mentors and colleagues. Upon completion of their training period, many postdoctoral fellows take up academic positions at institutions around the world, thus enhancing the University’s reputation as a leading research institution.

To enhance the quality of research training for undergraduates, graduate students and postdoctoral fellows at Western, and to ensure their continued contribution to the research enterprise at Western, we commit to:

- Widely promote access to external (e.g. NSERC Undergraduate Student Research Awards) and broaden eligibility for internal funding programs which provide opportunities to undergraduates to participate in research on campus
- Encourage researchers to hire undergraduates as research assistants wherever possible using resources obtained through internal and external research grants
• Increase enrolment in existing masters programs with identifiable capacity, quality and demand, and double enrolment in Ph.D programs across campus
• Develop new graduate programs in areas of research strength, with special emphasis on programs in interdisciplinary areas
• Enhance the profile and the visibility of postdoctoral fellows on campus, and ensure that the conditions under which they are contracted are commensurate with those at other Canadian universities
• Maintain competitive financial support for graduate students, including guaranteed minimum support for Ph.D Students
• Better recognize and acknowledge the contribution of undergraduates, graduate students and postdoctoral fellows to research at Western by encouraging their participation in Faculty Research Days and other events

Enhancing Research Impact by Expanding Opportunities for Knowledge Mobilization and Transfer

Over the last decade, increasing numbers of faculty on campus have expressed an interest in applying the benefits of their research to the service of the community and society more broadly. This is especially true in areas such as Education, Medicine & Dentistry, and Health Sciences, and Law, where faculty are heavily involved in projects designed to improve the quality of life for individuals, whether in Canada or abroad. In some cases, researchers have secured funding from the Tri-Council agencies precisely for this purpose. For example, the SSHRC Knowledge in Society Award won by faculty at the Ivey School of Business to help Canadian companies adopt environmentally friendly practices of benefit both their own operations and the public at large.

In addition, the University has increased the amount of support provided internally to collaborative research with community partners. Such support has included administrative assistance provided to faculty in establishing formal agreements with non-governmental and community groups, companies, and government ministries and other agencies. Assistance is provided as well through our Research Development unit in the procurement of external funding to facilitate such activity. Further, the University has encouraged participation in organizations with a specific university-private and public sector bridging objectives, such as the Federally-funded Network of Centres of Excellence (NCEs), and Ontario Centres of Excellence (OCE).

Western also has greatly enhanced its capacity to assist faculty in engaging in commercialization and related ventures. To this end, Western has actively encouraged intellectual property disclosure and assignment, assisted faculty in the management of intellectual property, and has worked with researchers in the formation of spin-off companies. Through the $400,000 Western Innovation Fund, Western has additionally provided researchers in disciplines ranging from education and psychology to the life sciences and engineering with direct assistance in product and technology development. Moreover, members of Western’s Technology Transfer and Commercialization Council—made up of several Deans and community-based entrepreneurs—have provided
hands-on assistance to inventors through the project development and/or company start-
up process. The University has further contributed to commercialization by celebrating
the contribution of faculty members to the community through awards and other forms of
recognition.

In an effort to improve and expand our knowledge transfer capacity, the University’s
technology transfer office has made great strides in recent years to align its operations
with the business development offices at the Lawson Health Research Institute and—
prior to its integration with Western—the Robarts Research Institute. Western, its
Robarts Research Institute and the Lawson announced in March 2008, in fact, their
intention to form a single, city-wide office for the managing technology transfer.
Already, reporting together annually to bodies such as StatsCan and the Association of
University Technology Managers, Western and its affiliates have emerged as one of
Canada’s university leaders in knowledge management and transfer. Western has
extended the collaborative model to other universities in the region as well through the
formation of the C4, which in effect pools the knowledge transfer skills and services of
consultants working at Western and three partner institutions: Waterloo, Guelph, and
McMaster. The consortium recently received federal and provincial funding in excess of
$5M to build this new and expanded service model.

The University’s Research and Development Parks in London and Sarnia provide
physical facilities and a nurturing environment for new commercial ventures, many of
which have emerged from Western. The London Park is home to the Stiller Centre for
Biotechnology Commercialization, a collaborative venture established by Western, the
Lawson Health Research Institute, the Robarts Research Institute, and the City of
London. This $10M facility helps small biotechnology companies get started and
develop their technologies and services into commercially viable products. The Centre is
one element helping to ensure that research and development opportunities in one of
Western’s key fields of research strength—Life Sciences and the Human Condition—are
fully exploited. In Sarnia, the Research Park is already established as a major employer
in the area, and is rapidly emerging as an important Canadian centre for research and
development in the field of renewable energy. In the summer of 2007, the Park received
a grant of $10M from the Ontario government to establish pilot plant, laboratory, and
office facilities to stimulate industry and academic research and training related to
biofuels production. This initiative is designed to exploit the full potential of
southwestern Ontario as a producer, manufacturer and end user of various types of
alternative energy, and particularly biofuels.
These various activities in turn provide a visible symbol of Western’s commitment to service by promoting economic development in the London region and well beyond. The University, through both Research Western and its research parks is an active participant on the governing bodies of organizations such as TechAlliance and the London Economic Development Corporation Board. In the spring of 2006, Western led the development of the Southwestern Ontario Economic Assembly (SWEA), a venture linking private and public sector partners across the region in an effort to promote economic growth and prosperity.

To further its goals with respect to the transfer of knowledge in the service of our city, our region, our province and our country, the University will continue to:

- Be proactive in encouraging and supporting faculty engagement in collaborative research with community groups, industry, and government agencies while protecting academic freedom and the integrity of the research process
- Increase the number of invention disclosures to achieve a rank of 5th place or better among the G-13 research institutions
- Actively seek external funding to support knowledge and technology transfer and commercialization activities undertaken by faculty members at Western
- Establish clear and transparent policies and procedures for faculty and institutional interactions with industry, including clear descriptions of
intellectual property ownership, overhead and royalty expectations and partnership agreements
• Together with the Lawson Health Research Institute, Western’s Robarts Institute and other prospective partners (including the National Research Council), work to build our newly-established city-wide technology transfer office as a means to reduce existing duplication and enhance service to researchers and other inventors in London and region
• Acknowledge and celebrate the contributions of Western researchers to knowledge and technology transfer
• Support and nurture the growth of faculty-based start-up companies based at Western
• Develop and implement intellectual property policies for undergraduate and graduate students, administrative staff, and postdoctoral fellows at Western

As mandated by the University’s Strategic Plan, Engaging the Future, we shall also work towards meeting stated targets with respect to:

• Doubling the value of contract research work with the private sector over the next five years
• Doubling the value of licensing and royalty income from Western-based inventions over the next five years

Establishing Key Partnerships for Research
Within academe, Western has led or been an active partner in several major inter-institutional initiatives. One of the largest current examples of partnerships supporting research in the Human and Physical Environments, is the establishment of the Canadian Light Source, first formed as a joint venture of the University of Western Ontario and the University of Saskatchewan. Instigated and led by Western scientists, this multi-million dollar project has major funding from the Federal, Ontario and Saskatchewan governments as well as from municipal, industrial and academic sources and has been described as Canada's biggest scientific research facility in more than 30 years. There is a long history of collaboration as well between researchers in Engineering, the Schulich School of Medicine & Dentistry, and London’s National Research Council (NRC) facility in a range of areas including automotive design, manufacturing process, robotics and medical devices. Other significant examples include collaborations involving faculty working on planetary and lunar science with colleagues at the Canadian Space Agency (CSA), new initiatives to develop closer ties with the mineral and petroleum industries in the Department of Earth Sciences, and ongoing engagement between researchers in the Department of Biology and Agriculture Canada’s Southern Crop Protection and Food Research Facility. Western has also led the formation of SHARCNET, a project funded by CFI and OIT/ORF and involving 16 other post-secondary institutions across Ontario to build a shared, massively parallel, high performance computing environment using high capacity network facilities. In addition, with the Insurance Council of Canada and ORDCF, Western has established the Institute for Catastrophic Loss Reduction, with a mandate to research ways to mitigate the impact of natural disasters. Western researchers were key players, with Carleton and UBC, in creating POLARIS, a CFI-OIT and ORDCF
funded project supporting earthquake research in Canada. Western, Waterloo and Waterloo Maple software created the ORDCF funded Ontario Research Centre for Computer Algebra (ORCCA) to research and exploit advances in mathematical software. Western is also a member of the University of Toronto-led Centre for Microelectronics Assembly and Packaging, and participates in other NCEs and centres of excellence including the Canadian Institute for Photonics Innovations (CIPI), the Institute for Robotics and Intelligent Systems (IRIS), the Sustainable Forest Management Network (SFM), the Mechanical Wood-Pulps Network, and Materials and Manufacturing Ontario, and the Fields Institute. In support of the Social Trends, Public Policy and Economic Activity, and Culture, Analysis and Values fields, respectively, Western researchers are engaged in SSHRC-funded collaborative research initiatives, in areas such as the information technology sector of the new economy, globalization, French Studies, and the survival of the baroque in Europe and Latin America. Partnered with social agencies, the University also hosts two SSHRC Community-University Research Alliance projects, one involving applied research to assist children with special needs, and another which looks at ways of improving the quality of life for former psychiatric patients now resident in the community. In each case, projects draw upon large teams of researchers located at institutions across Canada and around the world. Western is host to two SSHRC Research Clusters, bringing together investigators from institutions across Canada to study population trends and ecological history, respectively.

In the Life Sciences and the Human Condition field, Western has created the CFI-OIT funded National Centre for Audiology, a multidisciplinary centre focused on improving the quality of life for those with hearing impairments. Western participates in several NCE’s such as the Health Evidence Application and Linkage Network (HEALNet), Canadian Stroke Network, Inspiraplex, and the Canadian Arthritis Network. Similarly, Western participates in the Consortium for Assistive Technology Outcomes Research (CATOR; funded by the US National Institute on Disability and Rehabilitation Research), the Ontario Rehabilitation Technology Consortium, and the Ontario Rehabilitation Research Network (Western and its partner health care and health research institutions in London are home to 3 of 4 Provincial strategic teams). Western is also home to the NCE funded Canadian Language and Literacy Research Network (CLLRNet) building on the presence of the National Centre for Audiology, and to the Institute of Infection and Immunity, one of the 13 institutes operating under the umbrella of the Canadian Institutes of Health Research (CIHR).

Further, the University—together with the Schulich School of Medicine & Dentistry and its Robarts Research Institute—have established vital partnerships with all of the key life sciences research institutions in the London area, including the Lawson Health Research Institute (the Lawson) and its London Regional Cancer Program (LRCP) and the Children’s Health Research Institute. Collectively, Western and its affiliated research institutes constitute one of Canada’s most successful health sciences research clusters. Western’s Vice-President (Research & International Relations), the Dean of the Schulich School of Medicine & Dentistry, and the Scientific Directors of Robarts and the Lawson are jointly responsible for city-wide research planning. These partners have collaborated in the development of a number of initiatives, including the state-of-the-art city-wide
Innovarium project, and the CSTAR initiative, Canada’s leading centre for research on robotics and image-guided surgery. More recently, such collaborative work includes the Life-Cycle Research Network, linking universities and hospitals across southwestern Ontario in an effort to build capacity in the clinical trials area, and the Centre of Excellence in Family Medicine Project, a joint initiative of the Schulich School, the City of London, and the Province of Ontario which will see the establishment of a state-of-the-art clinical and research home-base facility in the Research Park at Western and satellite offices throughout London and region. University researchers, institute scientists, the National Research Council, London TechAlliance and local companies are collaborating as well in the establishment of Canada’s first institute dedicated to research, development, and commercialization of medical devices.

Western’s partnership activities on all these fronts, often conducted in close partnership with the Office of the Vice-President (External) and Alumni Relations and Development, are critical for enhancing the quantity and the quality of collaborative research within our areas of research strength, thus enhancing the University’s research profile both regionally and beyond. To further promote and enhance the benefits of the partnership process, the University shall undertake to:

- Review and strengthen agreements between the University and its affiliated research institutions and continue to encourage collaborations across institutions and with the community generally
- Establish stronger working relations at the institutional level with federal laboratories in London, including both the National Research Council, and AgCanada’s Southern Crop Protection and Food Research Centre
- Strengthen communication and interaction between the University and local government, non-governmental organizations, and the private sector
- Encourage activities that bring leaders in government, the private sector, and members of the local community onto the campus for research-related events and announcements
- Establish closer working relationships with local, provincial, and national economic development bodies
- Provide support for and promote use of regional facilities involving Western and its affiliated research institutions
- Work closely with Alumni Relations and Development to consolidate community and private sector links and to secure funding as necessary to support the acquisition of critical infrastructure and operating funding

**Extending our Reach by Building International Linkages**

At Western, a number of scholars and research groups have helped to establish an international reputation for Western in several areas of strength. Currently, there are strategic research partnerships with institutions on every continent, with particularly strong collaborations in India, China, Mexico and the Caribbean, East Africa, the United States, and France. Within *Life Sciences and the Human Condition*, researchers in the Schulich School of Medicine & Dentistry are working with partners in China to develop
and expand global production and consumption of traditional Chinese medicine. A team from both the Schulich School of Medicine & Dentistry and the Faculty of Health Sciences is working with post-secondary and other institutions in Rwanda to rebuild that country’s health care system in the aftermath of the genocide of the mid 1990s. And faculty, students and staff from across the University, Brescia University College, the Lawson and partner institutions in other parts of Canada are developing AIDS awareness programs and promoting the benefits of probiotic therapies in East Africa. In the Human and Physical Environments, faculty from Engineering have led the way in the establishment of broad collaboration agreements with Indian Institutes of Technology in Roorkee and Kanpur respectively, with emphasis on a range of fields including disaster management, power systems, and chemical reactor engineering. Faculty from Engineering, Science and Social Science have created the first Canada-Mexico joint institute for environmental research.

Researchers in the field of Culture, Analysis and Values have longstanding international research programs and affiliations in the area of culture and language, including collaborative work with scholars in the History of Medicine at the University of Würzburg, participation in a nationally funded German research project at Jena, visiting professorships and collaborative research at the Free University of Berlin, and collaborative research in Trans-Atlantic Studies, which includes faculty from Brown University and the Institute for Ibero-American Studies at the University of Salamanca, Spain. In addition, Humanities researchers are active in pursuing research exchanges and collaborations with scholars in France. In Cuba, Western researchers have been instrumental in the establishment of a Canadian Studies program and have collaborated with colleagues in the field of sociolinguistics. Within the Social Trends, Public Policy, and Economic Activity field, Western’s Centre for Research on Violence against Women and Children has engaged with partners in Costa Rica to study and combat family violence in that country, with lessons applied elsewhere in Latin America.

Internationalization will remain a priority at Western, as both individual researchers and research teams seek out global partnerships which allow them to tackle more complex issues and attract the resources necessary for this purpose. The various forms of international collaboration pursued will continue to be varied, from traditional scholarship leading to publication, to joint development of intellectual property and patenting, start-up venture formation, consulting work for private and public sector agencies, and international development assistance and aid. It is incumbent upon us collectively to recognize these various forms of contribution not only as legitimate expressions of academic freedom, but also as valid scholarly contributions which are appropriate to each researcher’s disciplinary field as he or she interprets it.

In 2003, the University officially adopted a Strategic Plan for Internationalization. Through this Plan, the University has sought, and through its renewal will continue to seek to:

- Help our researchers to develop innovative international projects which build on their achievements in Canada by facilitating linkages with researchers at other institutions worldwide within our key fields of strength
• Help ensure their work is well funded by making faculty members aware of opportunities and by exploring new opportunities for funding in conjunction with other administrative units
• Identify key partner institutions possessing complementary research strengths and—in consultation with Faculties and individual researchers—establish or reinforce broad cooperation agreements with these institutions
• Develop faculty exchange activities with international partner institutions, and actively facilitate these through administrative planning and centralized funding
• Provide financial support for activities related to international research (e.g. travel for academic visitors to Western, international conferences, and seed money for research)
• Provide central support and assistance with the generation and refinement of funding proposals for international research
• Ensure that researchers conducting international work of various types feel that their work is valued and supported, and actively encourage colleagues to recognize both traditional and non-traditional international scholarship in decisions regarding tenure, promotion, and performance appraisal

Measuring and Promoting Our Success
As we develop our key research themes and pursue the collaborative model, it is important to establish milestones and to measure our success in achieving our research goals. In the past, a key measure of success has been research productivity as measured by faculty publications. Such measures are now well-established quantitatively, and appear in University and other reports listing numbers of books, articles, and other products of scholarly initiative authored by faculty members, including scholarly journals housed at Western or edited and directed by Western faculty, and participation on major editorial boards for journals and academic presses in the international peer review process. Qualitative measures are also available through published reviews of books authored by Western faculty, citation indices, and in assessments produced at the department and Faculty level.

A related measure of success is the number of awards and distinctions earned by faculty for work in their respective research fields. These include prestigious book awards, fellowships in the Royal Society of Canada, Tri-Council agency medals and other forms of recognition, and various international prizes.

A third important measure of success relates to research funding. In 2006-2007, the University and its affiliates received over $220 million in research funding for ongoing projects, placing Western in 10th place nationally. Since 1998, we have received some $270 million from provincial and federal sources to support large-scale infrastructure projects with a total project value of $350 million. Performance in the Tri-Council competitions is particularly important as this drives two other key measures: the number of Canada Research Chairs awarded to the University, and the amount transferred annually from the Federal government in support of the indirect costs of research.
A fourth measure of research “success” is related to technology transfer and commercialization, and is typically measured by such indicators as invention disclosures, patents awarded, and licensing income received. As the number of annual invention disclosures continues to rise (having doubled to 60 between 2004 and 2007) our licensing income has concomitantly risen year over year. With our other research partners in London, we now rank within the top tier of the G-13 universities in licensing income. Notably as well, the value of contract research has more than doubled over the past three years to approximately $14M annually. Including clinical trials conducted at both the Robarts and Lawson Institutes, the value of work with non-government sources approaches $30M.

These successes have been communicated widely, both within the University community and beyond. We have developed new promotional materials which speak to the broad array of research activities undertaken at Western, both by individuals and our primary research groups. We now publish a semi-annual research newsletter, Research Western, in which we celebrate our research accomplishments and profile the research programs of investigators from across campus. We have aggressively pursued opportunities for advertising in local and national publications, and in collaboration with Communications and Public Affairs, have prepared special articles and news items for distribution to media sources. We have mounted exhibits at key events across Canada, and have taken an active role in sponsoring scholarly conferences at which Western research is featured.

In order to measure and monitor more effectively our successes in promoting collaborative research, and concomitantly, research excellence within and beyond our areas of strength, and to develop more effectively a broad “culture” of research at Western, we must develop additional indicators and find means to disseminate such information broadly. We must:

- Closely track our research performance in the publication of books, journal publications, awards and distinctions, and our success in meeting targets in research funding and commercialization as established in this document
- Report to the University and broader community on this performance through publication of an annual report by the Vice-President (Research & International Relations)
- Seek ways to better understand and quantify the contribution of research to the economic, social, and cultural development of the local region, the province, and the country, especially in areas where such contributions may be less well known, in the arts, social sciences and humanities
- Work with Communications and Public Relations to develop a quantitative and qualitative database of our research accomplishments through publication or other activities
- Publish the RW newsletter Research Western at least twice yearly, and update promotional materials regularly
- Work with the Office of the Vice-President (External) to develop presentations, media releases, stories, and advertising emphasizing the contribution of our research to society, with particular emphasis on areas
which have historically received less attention than others (such as the Arts, Humanities, and Social Sciences)

- Ensure that the Research Western “brand” is well established, and through event sponsorship and other opportunities ensure that the RW brand is present at research related events within and beyond the local community

**Conclusion**

Rooted solidly in *Engaging the Future*, this Strategic Research Plan defines key areas of research strength at Western and sets a clear strategy for developing and supporting research excellence both within and beyond these. It is, in effect, a living document to be reviewed and updated as circumstances within the University warrant, and as opportunities arise. Implemented through the Office of the Vice-President (Research & International Relations), in collaboration with the Provost and the Faculties, its ultimate goal is to firmly establish and enhance the culture and the practice of research in all units at Western, and to firmly entrench the University’s status as a top research-intensive institution in Canada.
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