2016-2017
Cyclical Program Review of Mathematics

PROGRAMS:
- Honours BSc Mathematics
- Honours BSc Financial Mathematics
- Honours BSc Mathematics and Biology
- Honours BSc Mathematics and Chemistry
- Honours BSc Mathematics and Computer Science
- Honours BA Mathematics
- Honours BA Financial Mathematics
- Honours BA Financial Mathematics and Honours Bachelor of Business Administration
- Honours BA Mathematics in Combination with another Honours BA Program
- Honours BA Mathematics with Finance and Accounting Option
- Master of Science in Mathematics

Final Assessment Report
Submitted by: Dr. Pam Bryden, Dean of Science; Dr. Matthew Smith, Dean of the Faculty of Graduate and Postdoctoral Studies; Dr. Kathryn Carter, Associate Vice-President: Teaching and Learning; Dr. Paul Jessop, Vice-President: Academic

Date: December 15th, 2017
PART ONE: EXECUTIVE RESPONSE

A) EXECUTIVE SUMMARY OF REVIEW DOCUMENTS

Self-Study

- The self-study describes the growth and development of the Mathematics program at Laurier and the evolution into offering the suite of undergraduate programs, minors and options, and the Master of Science in Mathematics. Recommendations from the previous review were outlined, along with the steps the program took to implement them and contextualizes recommendations which were not able to be fully adopted. Self-study preparation was led by the Chair, Dr. Roman Makarov and included contributions from faculty in the program.

- The document articulates the program-level learning outcomes and describes the process by which they were developed. It outlines the alignment with Laurier’s Strategic Mandate Agreement and Academic Plan, demonstrating such core principles as developing research, preparing students for life-long learning, and creating experiential learning opportunities. Degree Level Expectations are clearly articulated for both the graduate and undergraduate programs.

- Program entry requirements for both the graduate and undergraduate programs are described and are consistent with the University's standard admission requirements. Alternative requirements are articulated, are consistent with University policy, and in the case of graduate programs, alternative requirements are approved by the Dean of Graduate and Postdoctoral Studies.

- The curriculum draws primarily upon disciplinary practice in Mathematics, but the program is also keenly aware of the interdisciplinary nature of Mathematics and how the discipline can augment and enhance other degrees. As such, there is much curricular emphasis on the interconnected suites of BA and BSc courses that include diverse electives available to students. Introductory courses are more general in nature and provide a consistent foundation that students can build on as they specialize in later years. The MSc in Mathematics emphasizes the applications of mathematics to problems in finance and science with particular focus on gaining insight into real-world problems. One distinguishing features is a required course in mathematical modelling taught by a Tier 1 Canada Research Chair.

- Courses are delivered face-to-face and with laboratory components as well as some blended and online learning formats. The program does a substantial amount of service teaching to the University in the undergraduate program, and there are Masters courses as well that are threaded into other graduate programs. High impact practices such as labs, seminar courses, blended learning, and research-intensive courses. The document describes proposed and recent curricular changes to continuously update and refine offerings to best align with student demand and trends in the discipline.

- Staffing levels are discussed and the document notes the close connections with the Math Assistance Centre which supports many of their students and activities in the program. The self-study notes that resources have been tight, especially in light of increasing student enrolment, but articulates the steps
that have been taken to mitigate and thrive in a limited resource environment. Physical space for the
department is of high quality, as are classrooms and laboratory facilities.

- Teaching evaluations in the program are consistently high and in line with Faculty and University
averages. Alumni and student surveys reveal the vast majority of students are satisfied or very satisfied
with the Mathematics programs. Faculty are successful in obtaining major research grants and funding,
and are actively engaged in their professional disciplines and in service to the University.

- The Mathematics department has worked to define its identity and continue to evolve into a diverse
teaching and research department and continues to offer programs that align with student demand, are
in line with Laurier’s mission and Strategic Mandate Agreement, and collaborate productively with other
departments at Laurier to foster interdisciplinarity throughout its programming. The members of the
program are dedicated to research, teaching, and service with a strong commitment to the program and
are well poised to continue leveraging their experience, creativity, and Laurier’s existing strengths.

External Reviewers’ Report

The external reviewers for the Mathematics cyclical review were Dr. Gary MacGillivray, Professor of
Mathematics and Statistics, University of Victoria; Dr. Marcos Escobar, Associate Professor of Statistical and
Actuarial Sciences, University of Western Ontario and Dr. Scott M. Ramsay, Professor of Biology, Wilfrid Laurier
University. The site visit took place on March 16-17, 2017 at the Waterloo Campus of Wilfrid Laurier.

Executive Summary

The reviewers are impressed by the department and its faculty. There are numerous positives, including:

- The quality, diversity and interdisciplinarity of the faculty’s research work.

- That all full-time research-stream faculty hold NSERC Discovery Grants (an exceptional achievement).
  They greatly outperform competitor institutions in the sense of outcompeting them at NSERC in
  success rates and funding amounts.

- The research centres in the department (M2NeT Lab: Modelling and Computational Mathematics, and
  MS2Discovery Interdisciplinary Institute) already make a significant impact, and have a fantastic
  potential.

- The department is supported by dedicated, highly competent Administrative Staff, Lab Staff, and
  Contract Academic Staff, all of whom have amply demonstrated that they will go above and beyond for
  the department and its students.

- The (new) space in Lazaridis Hall is excellent. In particular, the design of the Labs was well thought out,
  and makes effective use of technology. The Labs are an impressive resource, unique to Laurier, from
  which students appear to greatly benefit. They help to make the department very effective at delivering
course content.
• There is solid academic support available through the Math Assistance Centre. The calculus readiness test, the mock exams, and other assistance available make it a valuable resource for students.

• The department seems to be very responsive to concerns, desires, feedback and suggestions from other units in the university, and from Lab Staff or Contract Academic Staff internally.

• The department has continuously tried to improve, and continues to strive to improve student opportunities, education and outcomes though adding resources like extra Lab staff, or Labs in classes like MA122.

• The department is well diversified and has broad expertise in its focus areas given its size.

The undergraduate programs show a healthy number of applicants and substantial annual intake (with some variability between years), especially when compared against that of competitor universities. They have been highly successful in creating differentiating programs, and continue to do so with the proposed BSc in Data Science. There is good demand for the graduate program. The employment rate of graduates from Laurier’s mathematics programs is very good, as is alumni satisfaction. The reviewers feel that the programs in the Department of Mathematics are consistent with the strategic objectives outlined in Laurier’s “mission, vision and values”, the current Academic Plan, and the Science Strategic Plan which is being developed.

The reviewers are of the opinion that the admission requirements for the undergraduate programs are correct in the sense that the students ought to have the right training to accomplish the general goals set out. The stated criteria for progression appear to be sound. Attrition rates look high, especially from Year 1 to Year 2; the underlying reasons are likely to be many and varied. It may be that higher grades in prerequisite high school mathematics courses should be required in order to give entering students a reasonable chance of success. It may also be that some course delivery, student support, or curriculum adjustments are necessary. It is hard to assess the role played by individual courses in the absence of course-level learning outcomes, and difficult to assess the effectiveness of the overall curriculum in the absence of program-level learning outcomes and a thorough curriculum map. We note, however, that the undergraduate programs seem to be meeting the degree-level learning outcomes presented in the Self Study document.

The Master’s program appears able to accommodate a larger number of students, and the department appears to be well-positioned accommodate such and expansion and also to launch a PhD program. Expansion of the graduate program would greatly advance the research for faculty members, enable faculty to request larger grants, and offer Laurier students academic programs at all levels. Another positive is that graduate students can contribute to support of the undergraduate program through marking, leading labs and tutorials, and working in the Mathematics Assistance Centre. Successful growth of the graduate program may involve a variety of initiatives that include recruiting, adjustment in admission requirements / pathways, program length, delivery method, and curriculum adjustments.

**List of Recommendations**

The department is doing very well in many regards. There are places where improvements could be made or next steps taken. In some sense the entire goal of this report is to offer suggestions through which the department
could possibly enhance quality in various ways. The following main recommendations are offered as ways to move forwards. Other recommendations and suggestions in the same spirit are offered throughout the document. Detailed summaries of our thoughts regarding student success in the undergraduate programs and expansion of the graduate program are presented in Section 3.

1. Develop program-level and course-level learning outcomes, and means to assess them, to supplement the degree-level learning outcomes presented in the Self Study. Use these to assist in studying whether any changes within programs are warranted, and whether the skills necessary for advancement to the next level (year or course) are being adequately developed and measured.

2. Subject to recommendation 1, undertake a curriculum mapping exercise where, for each individual program, or group of related programs, the places where each outcome is introduced and the places where each one is reinforced are identified. A curriculum mapping exercise for the MSc program may give some insight into ways to streamline the program so that other enhancements can be made.

3. Supplementary to 2, undertake a thorough curriculum review for all programs at all levels. Possible goals include efficient use of resources to allow expansion of the graduate program, optimization of existing programs and the introduction of new programs like Data Science, and whether course content / sequencing provides adequate preparation for successor courses.

4. Undertake a program by program analysis of student success using data on hand, if such a study has not been done. Use the results to adjust admission requirements, curriculum, student support, or delivery as appropriate, and if necessary. Track student success changes that occur subsequent to any adjustments that are made, and make further adjustments as needed.

5. Investigate whether teaching support resources (e.g. Labs, tutorials, marking) being used to their fullest potential. There appear to be situations where tutorials have a role to play, for example in courses like MA121, MA250 and perhaps MA222, where one of the primary objectives is effective communication of detailed, technical, mathematical arguments in written English. Make any appropriate changes needed for the benefit of students' learning and success.

6. Expand the graduate program by increasing intake to a stable level of about 10 new students per year, possible lengthening of the Master's program in some cases, and introduction of a PhD program. Pro-actively seek graduates from the BSc programs to continue into the MSc program, and consider the introduction of a partially online "professionalized" Master's program. Explore the idea of a bridging program where students without specific training in, say, financial mathematics can take a suite of courses that will prepare them for graduate work in the area. Design strategies to make the transition into and between graduate programs simple, cost-effective and efficient.

7. Devise a strategy to stabilize and possibly increase the intake of students in the undergraduate programs. Consider seeking collaborations with international universities at the undergraduate level to maintain and improve the intake and quality of international students.

8. Review and clarify the roles and responsibilities of all “support” staff (administrative, Lab, TA, IA, CAS) as necessary.

9. The department needs more resources, should the university be able to provide them, in order to
maintain their highly diversified portfolio or programs, expand the graduate program, grow the undergraduate programs, reduce the number of courses taught by CAS, cope with increasing student numbers, decrease the student:faculty ratio, move to full co-op, continue to introduce innovative new differentiating programs, and deliver supports that should enhance student success and achievement. The reviewers feel that the department needs two more full-time faculty, additional Lab staff, and additional graduate student TAs to lead tutorials and provide feedback to students. We recommend that the department chart a course for its development and make a comprehensive proposal to the university. As part of the plan, the department should consider drafting a hiring plan that specifies the research areas for the next few faculty appointments.

10. Consider a fund-raising effort among successful alumni, perhaps led by several of them, in order to create a new suite of awards to cover most programs offered by the department.

Unit Response

The Unit Response was authored by the Chair of Mathematics, Dr. Roman Makarov, and provides a detailed response to each of the recommendations made by the external review committee in their report. There were two clarifications to the reviewers’ report provided related to lab instructor contracts and the interaction of lab coordinators and instructors.

For each of the ten recommendations included in the External Reviewers’ Report, the Department stated whether they agreed with the recommendation or not, what steps had already been taken toward implementation of recommendations, and what further action would or could be taken in the future. Recommendations that had already been completed (e.g. analysis of student success) were noted, as were recommendations that were ongoing (curricular review). It was also noted where the implementation of recommendations was outside of the department’s control or the scope of the review process.

The Mathematics Department acknowledges that they are in the process of refining their learning outcomes and undertaking a holistic curricular review, as well as increasing the graduate enrolment and fundraising strategies. The Department was appreciative of the review committee’s recommendations and support for the program.

B) IDENTIFICATION OF PROGRAM STRENGTHS

Acting Dean FOS: The Mathematics Department has a strong record of excellence in teaching at the undergraduate level coupled with a very strong research productivity. They should be praised on their effective use of existing resources while managing to grow enrolment. The Department’s key priorities for the next five years are sound, including engaging in a thorough program and curriculum review to create learning outcomes, ensuring student success for the undergraduate program through the measurement of student performance, and expanding graduate enrolment.

Acting Dean FGPS: Admissions to the MSc program in Mathematics in fall 2017 was strong; the program exceeded its intake target for both domestic (5 new students) and international (8 new students) students (13
new students in total). The program should be praised for attracting so many students, and should strive to maintain strong enrolment numbers, while not becoming overly reliant on international students, and continuing to focus on meeting domestic student targets. The proposed PhD program in Mathematical and Statistical Modelling is in the final stages of the internal approval process [expected to be considered by Senate at its October 2017 meeting], which makes September 2018 a realistic launch date. This new program should strengthen the academic and research mission of the department as a whole, including by supporting the undergraduate programs, by providing additional TA support.

C) OPPORTUNITIES FOR PROGRAM IMPROVEMENT AND ENHANCEMENT

Acting Dean FOS: The reviewers emphasize 1) a thorough review of the undergraduate curriculum (including course mapping, development of learning outcomes, examination of tutorial/laboratory resources) and 2) enhancement of the undergraduate student experience through measurement and tracking of student success; and 3) expansion of graduate enrolment. In particular, I would strongly suggest that the Department conduct the review of their undergraduate curriculum to remove barriers to success and engage students in their program.

Acting Dean FGPS: The department has identified several interesting and innovative ideas for ways to enhance and expand its graduate program offerings, including the introduction of fields to the MSc program, the introduction of a coursework “professional” Master’s program, and developing an online MSc program (Response to Recommendation #6). Each of these ideas merits further consideration, but should be explored and prioritized as part of the comprehensive departmental review and proposal that is identified in the response to Recommendation #9 of the reviewers. Among the factors to consider when setting priorities for graduate program expansion, is the capacity of the department to accommodate additional graduate students (especially in light of the identified shortage of FT faculty), and the fact that the new PhD program is expected to launch in September 2018, and may need some time to mature before engaging in further program expansion. When considering the possibility of introducing fields in the MSc program, it will be important to articulate why the introduction of formal fields is needed, as opposed to simply identifying areas of research strength, if the goal is primarily to market the program more effectively.

D) PRIORITIZATION OF RECOMMENDATIONS APPROVED FOR IMPLEMENTATION

Acting Dean FOS:

Undergraduate Curriculum-related Recommendations

Course Mapping, Curriculum Review, Program and Course Level Learning Outcomes (Recommendations 1, 2, and 3): The Department should begin immediately to engage in course mapping, with the guidance of the Teaching and Learning Centre. In conjunction with course mapping, the Department should conduct a thorough curriculum review of all programs, to ensure the courses offerings for each program are based on sound pedagogical decisions. Finally, program level and course level learning outcomes can be articulated. Given the number of programs and courses, this work will likely take considerable time to complete.
Teaching Support Resources (Recommendation 5): The reviewers suggest investigating the effective and efficient use of labs and tutorials for courses offering within the Department. Additional labs have been added to 2 courses this past summer. However, as part of the course mapping/curriculum review exercise, the offering of lab/tutorials should also be examined.

Teaching Support Staff (Recommendation 8): As indicated in the Department response, there are already processes in place for some review of roles and responsibilities of staff, CAS members, and IA/TAs. A worthwhile activity, given the large number of CAS members in the Department, is to ensure that such instructors have a handbook outlining University, Faculty, and Department specific policies (e.g., deferred midterms, office hours, medical notes, deferred examinations, assignments in the last week of classes). As noted by the Department, additional training of IAs and TAs would be worth exploring. Department specific workshops could be offered.

Student Awards (Recommendation 10): The development of student awards is an excellent idea, though perhaps this would be better managed at the Faculty level.

Graduate Program Recommendations

Expand Graduate Program (Recommendation 6): The Department is currently working on expanding their graduate program, through the addition of a new PhD program currently under review, as well as other initiatives to differentiate their programs from nearby competitors. The Department should work towards articulating a clear plan for how International students within the program will be managed on a go forward basis. The development of online programs, while clearly an excellent potential idea, must wait until after the curriculum review process, and any enhancements to the undergraduate program, have been completed.

Acting Dean FGPS: I agree with the Dean FoS, that graduate program expansion and differentiation is an important initiative, but that launching the proposed PhD program, and planned undergraduate program enhancements should be prioritized in the near term. Prioritizing new graduate program initiatives for the medium- and longer-term will be an important part of the planned comprehensive review/proposal. Articulating a clear plan for how international students in the graduate program will be managed (funded) should also be prioritized, as the program seems to rely heavily on international students, as is reflected by the current year’s domestic (5) vs. international (8) intake numbers. Maintaining a healthy number of international students cannot come at the expense of meeting domestic (funded) student targets.

Recruitment, Student Success, and Retention Recommendations

Undergraduate Enrolment (Recommendation 7): While the reviewers potentially suggest increasing the incoming class size, the Department is at capacity, particularly with the addition of the new Data Science program in the upcoming years. The Department suggests some ways of diversifying some course offerings that may help stabilize undergraduate enrolments. Such ideas can be considered once course mapping and curriculum review processes are completed.

Evaluation of Student Success Data (Recommendation 4): Metrics for evaluating student success, broadly defined, are important for the Department to consider, alongside the work currently being done at the Faculty of Science level. A new FoS Student Success Committee has been struck to move forward new initiatives to both measure and improve student success. The Department should ensure they have representation on this
committee. In addition to the work already being done by the Department, it is important to begin measuring and tracking student performance through the Department’s various programs.

**Recommendations with Resource Implications (Recommendation 9)**

Recommendations were made for new faculty, new laboratory staff, and graduate TAs. A new faculty member has been budgeted into the new Data Science program, which should eliminate some of the strain on the Math Department. However, that said, with the growth in Science over the last couple of years, resource allocation will be considered where the needs are greatest, and Math has certainly taken on additional students over the past couple of years.

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**SIGNATURES**

Pam Bryden  
September 19, 2017

Matt Smith  
September 19, 2017

Kathryn Carter  
November 30, 2017

Paul Jessop  
December 15, 2017
PART TWO: IMPLEMENTATION PLAN

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