# Final Assessment Report
# Applied Mathematics (MMath, PhD)
# June 2018

**Summary of the Program Review:**

In accordance with the University Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response and assessments of the MMath and PhD programs delivered by the Department of Applied Mathematics. A self-study (Volume I) was submitted to the Office of the Associate Provost, Graduate Studies on July 21, 2015. The self-study presented the program descriptions, learning outcomes, an analytical assessment of these two programs, and program data which included data collected from a student survey along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). Appended were the course outlines for all courses in the program and the CVs (Volume II) for each full-time faculty member in the Department.

Two arm's-length external reviewers (Volume III), (Dr. Nicholas Kevlahan, Professor of Mathematics, McMaster University and Dr. Ralph Smith, Distinguished Professor of Mathematics, North Carolina State University) were chosen by the Associate Provost, Graduate Studies, in addition, one internal reviewer (Dr. John Garcia, Professor of Practice/ School of Public Health and Health Systems) was selected by the Associate Provost, Graduate Studies.

They reviewed the self-study documentation and then conducted a site visit to the University on May 9-10, 2016. The visit included interviews with the Vice-President Academic & Provost; Associate Provost, Graduate Studies; Dean of the Faculty; Faculty Associate Dean of Graduate Studies, Chair of the Department, Faculty members, staff and meetings with a group of current graduate students, and support staff.

This final assessment report is based on information extracted, in many cases verbatim, from the self-study, the external reviewers' report and the program response.

**Program characteristics:**

The Department of Applied Mathematics was created in 1967 when the Faculty of Mathematics was established. Applied Mathematics has traditionally been seen as providing a bridge between Mathematics and Science through the construction and analysis of mathematical models. It can be said that the discipline of Applied Mathematics arose from the intimate connections between Mathematics and Physics.

**Summary of strengths, challenges and weaknesses based on self-study:**

**Strengths**

- Very strong students (based on undergraduate performance and past academic records)
- Students are assigned 3 teaching assistantships per year usually in two out of the three terms, in order to allow for time devoted exclusively to research in the third term.
- Diverse research carried out by faculty members of the Department; from development of theoretical and computational methods to the application of those methods to study cutting-edge problems in science and engineering.
- The breadth of research and novel teaching facilities provided by experimental labs.

**Challenges**

- Lack of space for growth; at or near capacity for offices for faculty, students, postdoctoral fellows.
- Lack of sufficient funding to support graduate students for some faculty members – more specifically, AM Faculty are required to commit on average $15K/year to support a graduate student. Several members of the department obtain funding primarily from the NSERC Mathematics Panel where the average grant is on the order of $15K.
- More staff support required for current level of departmental activity.(ie grad student expansion, increased number of postdocs, increased number of academic visitors, 5 experimental labs)

**Weakness**

- Inadequate job preparedness of graduates (in terms of interview strategies, CV structuring and other practical considerations for the general job market) other than for positions in academia.

**Summary of key findings from the external reviewers:**

The external reviewers rated both programs as "excellent and internationally competitive graduate programs". They commented on several aspects of the programs, noting that for a mathematics department, "the faculty have excellent funding levels and top-level research programs and publication records." Additionally, the external reviewers' remarked that the four laboratories are unique internationally and are a highly distinctive aspect of graduate training in the Department. They found the facilities to be of high quality, but did note that there appears to be lack of space for further growth of graduate enrollment. Lastly, they commended the program for implementing a graduate recruitment day which they found to be extremely important as it positively impacts the programs.

**Program response to external reviewer recommendations:**

**Recommendations**

1. *Graduate student net pay should be equalized on a monthly basis and increased at a rate commensurate with inflation and cost of living in the Waterloo area.(our rates remain on a par with Math Faculty recommendations, but clearly would be great to increase support which has lagged behind inflation and cost of living)*

   **Response**
   All scholarships are paid at the beginning of the term through the Graduate Studies Office. The Department does not have any control over this; however, the Department tries to ensure that graduate student pay is distributed equally between the three terms. Graduate students are provided with a letter at the start of each term which outlines what their gross financial support for the term will be and how it will be distributed between scholarships and teaching assistantships. The Department further revised the letter to outline which funding support will come on a monthly basis and which is paid out once per term. Students will also be informed at Orientation how and when they can expect to be paid. The Department is also committed to reviewing graduate student support on an annual basis and will use the change in Teaching Assistantship rate and increases in graduate tuition to determine the appropriate rate of increase for Graduate Research Assistantships.

2. *The University should support the development of a co-op/internship opportunity for graduate students in Applied Mathematics. Ideally, these opportunities would not increase the overall time to completion.*

   **Response**
   In the past, internships have been difficult to arrange as they relied on the student or the supervisor having a contact in industry. In general, the introduction of co-op tends to inevitably increase time to completion for a degree program. However, the Department will pursue a formal co-op option for the Master's program. If co-op is successful, expanding the option to the PhD program may be considered. At the same time, the Department will also facilitate students participating in internships through the MITACS Accelerate program which can facilitate internships on a financial basis but the help of the University Research Outreach Team and the Managers for Corporate Research Partnerships will be needed in order to establish contacts with industry.

3. *Provide institutionalized in-department training for research and job skills and ensure students are made aware of and encouraged to take advantage of similar opportunities at the University level. Examples include preparation of CV' s and resumes, preparation of research and teaching statements, explanation of career opportunities, interview strategies, and skills development in poster design, as well as oral and written communication.*

**Response**
The Department will implement a mandatory first year course milestone that would meet once per week with guest speakers presenting seminars/workshops on various research and job skills. They will also incorporate some modules available through GradVenture into the course, to provide excellent professional opportunity training.

4. *Invigorate the colloquium to enhance the scientific culture and cohesiveness of the department and the broader training of the graduate students. One way to do this might be to establish a Lecture Series with four lectures per year with the goal of inviting speakers at the level of plenaries at major national and international conferences. They should be planned well in advance and widely advertised to the campus community.*

**Response**
The Department has been trying to run the aforementioned colloquium since 2012. However, due to poor attendance the 2015-16 colloquium has been cancelled. As a result, the Department will be implementing a milestone for graduate students which will require them to attend a certain number of seminars/colloquia during their graduate studies. To this end, the Applied Math Colloquium has been revamped, and with an increased allocated budget, we expect to have 4-6 very high profile speakers over the course of the year. It is expected that attendance of the majority of the Applied Math Colloquia will be a requirement for all graduate students (once approved by the AM Grad Committee)

5. *Continue to prioritize the recruitment of women and underrepresented minorities. This goal should be included explicitly as a weighting or factor in ranking student applications.*

**Response**
The Department is committed to continuing this practice by promoting scholarships for women, underprivileged and visible minorities. Supervisors will be informed that such scholarships exist. The Department will also explore ways to increase the number of applications from women such as leveraging the publicity of the HeForShe campaign and participating in outreach activities such as the summer schools for undergraduate women which have previously been held in Waterloo in August 2013 and August 2014. Other initiatives to reach out to the undergraduate cohort of students, that are currently on

campus, will be through female AM Faculty members giving talks at the undergrad societies of the Math Faculty.  In June/July of 2018, the Dept of Applied Math will be running an "Advances in Applied Mathematics" three-day workshop, where all invited speakers are leading female researchers in various areas of applied mathematics.

**Recommendations that were not selected for implementation:**

1. *Update course requirements and content to reflect evolving trends in Applied Mathematics. Specific recommendations include the following: (i) reduce the breadth requirement from three to two courses, (ii) increase options for acceptable courses, (iii) update course content to reflect emerging trends in applied mathematics research, (iv) rotate instructors for core courses, (v) develop a core modelling course.*

   **Response**
   Regarding item (i), the Department feels that the current breadth requirement of three courses is necessary to cover essential applied mathematical tools (analysis, approximation methods and computational methods), and is not too onerous.  With respect to item (ii), students are permitted to take any course they want outside of their breadth requirement and students who did their degree at another university can count an equivalent course towards their degree. With reference to item (iii), courses are updated periodically to reflect modern developments and perspectives. Regarding item (iv), the Department notes that the majority of core courses are taught, at most, two times by the same instructor. With respect to item (v), the Department feels that many of the Applied Math courses already incorporate aspects of modelling (which is an essential aspect of Applied Math), and thus it would be artificial and unnecessary to develop a stand-alone modelling course. The Department also found items (i) and (v) in conflict as the former suggested reducing the breadth requirement of courses while the latter recommended adding another requirement.  The Department proposes to do a full review of the graduate core curriculum during the 2017-18 academic year during which they will determine what will be "minimum necessary academic credentials" for both the Applied Mathematics Master's and PhD graduates.

2. *Explore the possibility of developing an interdisciplinary field to train graduate students for non-academic careers including government laboratories and industry and academic careers.*

   **Response**
   The Department feels that the students receive enough interdisciplinary training with expertise in mathematics and/or computing and an area of application. Students are

encouraged to take courses outside of the department as dictated by their research interests. Additionally, students who do not wish to do in-depth research in a particular field can pursue the Essay option, which allows them to take more courses.

**Implementation Plan:**

| | Recommendations | Proposed Actions | Responsibility for Leading and Resourcing (if applicable) the Actions | Timeline for addressing Recommendations |
|---|---|---|---|---|
| 1. | *Development of a co-op/internship opportunity for graduate students in Applied Mathematics* | Talk with Coop Office Follow same template as the Comp Math Program | Chair & Associate Chair Grad Studies | Start MMath Coop Program in Fall 2018 |
| 2. | *Provide institutionalized in department training for research and job skills (preparation of CV' s research and teaching statements career opportunities interview strategies and skills poster design oral and written communication.* | Test training module in one of the current Graduate Courses (in fact we will be incorporating Wat CV into the first 2 weeks of some of our core courses) | Chair & Associate Chair Grad Studies | Ongoing (currently being tested) |
| 3. | *Invigorate the colloquium (establish a Lecture Series with the goal of inviting major speakers)* | Departmental Colloquium Committee to address this | Chair & Departmental Colloquium Committee | Ongoing |
| 4 | *Continue to prioritize the recruitment of women and underrepresented minorities* | Departmental Graduate Committee to prioritize this through "women in mathematics" workshops/discussion groups, and through the use of incentive scholarships to women and underrepresented minorities | Chair & Associate Chair Graduate Studies | Ongoing |

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.

**UNIVERSITY OF WATERLOO**

**Date of next program review:** _____ 2022
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**Signatures of Approval:**

_____        25 January 2018
Chair/Director                                     Date


_____        _____
AFIW Administrative Dean/Head (For AFIW programs only)        Date


_____        2018-01-25
Faculty Dean                                       Date


_____        _____
Associate Vice-President, Academic                  Date
(For undergraduate and augmented programs)

_____        June 29, 2018

_____        _____
Associate Provost, Graduate Studies *               Date
(For Graduate and augmented programs)


*Note: The Associate Provost, Graduate Studies title was changed to Associate Vice-President, Graduate Studies and Postdoctoral Affairs