UNIVERSITY OF SASKATCHEWAN

Proposal for Academic or Curricular Change

PROPOSAL IDENTIFICATION

Title of proposal: Applied Mathematics

Degree(s): Bachelor of Science

Field(s) of Specialization: Applied Mathematics

Level(s) of Concentration: Honours, 4-year, 3-year, minor

Option(s):

Degree College: Arts and Science

Contact person(s) (name, telephone, fax, e-mail):

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Proposed date of implementation: September 2013

Proposal Document

RATIONALE

History

The process that led to the development of the present program began with the 2004 Systematic Program Review (SPR) of programs in the Department of Mathematics and Statistics. The SPR Review Team was composed of eminent scholars and academic policy-makers encompassing a wide expertise across Mathematics and its applications: David Brydges, Canada Research Chair at UBC, Mathematics; Martin Golubitsky, then Cullen Distinguished Professor of Mathematics at the University of Houston and now Distinguished Professor of Mathematics and Physical Sciences at Ohio State University; Stan Gudder, John Evans Professor of Mathematics, University of Denver and Chris Small, Statistics and Actuarial Science, University of Waterloo. The absence of a degree program in Applied Mathematics was explicitly noted by the review team, who further noted that the development of an Applied

Mathematics program would lead inevitably to an increase in enrolment in Mathematics and Statistics courses and graduation numbers in our degree programs.

During SPR, the Department of Mathematics & Statistics was facing many challenges and was not in a position to immediately address all of the Review Team's recommendations. Since 2004 the Department has undergone a significant rejuvenation with nine newly tenured or tenure-track faculty hired between 2007 and 2010. Three of these faculty, specializing in Applied Mathematics, have contributed significantly to the development of this Applied Mathematics program.

The proposed program, that provides a platform for the Three-Year, Four-Year and Honours BSc degrees, as well as a Minor in Applied Mathematics, was approved by the Division of Science at its faculty council meeting, 29 November 2011. The program will commence in the Fall term following approval by the Academic Programs Committee of Council. A previous submission of the program to APC was provided with practical feedback from committee members, including the recommendation that resources be secured prior to resubmission to APC.

Strong support for the proposed program has been received from within the Division of Science, as well as the Division of Social Sciences (Economics), and from the Colleges of Engineering and Medicine (Medical Imaging).
See Appendix 3 – letters of support.

Rationale

The rationale for the request can be summarized by the following three interconnected statements:

A goal of the Department is to train highly qualified personnel with the capacity to participate creatively and actively in a variety of employment or research endeavours in industry, the public sector or in academia. The Applied Mathematics program will facilitate this objective by increasing the numbers of students trained in senior-level Mathematics and Statistics along with their applications to solving real-world problems. This goal is well aligned with the goals of the University of Saskatchewan and the needs of the province of Saskatchewan.

Without an Applied Mathematics program the University is in a regrettable position among its U15 peers, where few lack such a program. The credibility of the Department and of the University, and potential success in student marketing or in attracting future research funds, are being negatively affected.

The above statements are addressed further below.

- **RELATION TO OTHER CANADIAN UNIVERSITY PROGRAMS**

We currently live, work and do research in an applied society, one in which Applied Mathematics manifests itself in many forms and contexts. On the current Canadian academic landscape, there are Departments of Applied Mathematics (such as Western and Waterloo) that offer a variety of interdisciplinary degree programs in Applied Mathematics and there are broader Mathematics departments that offer BSc degrees in Applied Mathematics (Simon Fraser, Alberta, Calgary, Manitoba, Western, Waterloo, York, Carleton, McGill, Concordia, Memorial). Uniquely, the Department of Mathematics at University of Toronto offers a BSc Specialist degree in Applied Mathematics. As well, double Honours, double Majors, joint degree and/or certificate programs in Mathematics and another subject are offered at British Columbia, Victoria, McMaster, Queen's, Ottawa, U de Montreal, Laval, New Brunswick, Dalhousie. Actuarial Science as a stand-alone degree or program is offered at Simon Fraser,

Calgary, Alberta, Regina, Waterloo, McMaster, Toronto, York, U Quebec à Montreal, and other universities (Table 1).

Table 1: Examples of Mathematical degrees offered across Canada. Despite different terminology the degrees listed below are quite comparable.

Degree	**Universities**
BSc degree in Applied Mathematics	Simon Fraser, Alberta, Calgary, Manitoba, Western, Waterloo, York, Carleton, McGill, Concordia, Memorial
BSc Specialist degree in Applied Mathematics	Toronto
Double Honours, Double Majors, joint degree or certificate programs including Mathematics	British Columbia, Victoria, McMaster, Queen's, Ottawa, Montreal, Laval, New Brunswick, Dalhousie.
Actuarial Science as a stand-alone degree or program	Simon Fraser, Calgary, Alberta, Regina, Waterloo, McMaster, Toronto, York, U Quebec à Montreal

A UofS Applied Mathematics program offering degrees in a similar, specialized vein to the universities listed above will better position the Department of Mathematics & Statistics to compete for undergraduate students within and outside of the province of Saskatchewan. Further, a functional (applied) approach to Mathematics will enhance avenues of interdisciplinary teaching and research for the Department across the campus. Such an engaged undergraduate cross-discipline population of students working on today's real-world issues will provide a research intensity that is currently unobtainable within the current undergraduate curriculum. It is anticipated that an increased awareness of such possibilities will lead to increased opportunities for graduate studies, resulting in a positive impact on the graduate program within the department.

The proposed Applied Mathematics program will offer degrees that while sharing features with existing undergraduate degrees in Canada involving Mathematics and a second subject, will also provide an unmatched depth of programming as embodied by the minor, Three-Year, Four-Year, and Honours degrees. Similarities notwithstanding, the program, owing to its emphasis on modelling and simulation, will not only be distinct in Canada but will be uniquely poised to address the existing and emergent needs of the Province of Saskatchewan – progressive resource industries, environmental and health-related agencies, and research and development companies.

The predominant Applied Mathematics degree currently being offered across Canada is the Honours degree. By offering a minor and Three-Year degree as well as the Four-Year and Honours degrees the program will appeal to those students, not necessarily of Mathematics, who would otherwise not be attracted to any program in Mathematics or Statistics … indeed students who are intimidated by our current programs and their lack of interdisciplinary applied content.

- **RELATIONSHIP TO UNIVERSITY OF SASKATCHEWAN GOALS**

This proposal is most timely in view of the ambitious plans of the University to foster institutes, such as the Global Institute for Water Security, the Global Institute for Food Security and the Sylvia Fedoruk Canadian Centre for Nuclear Innovation, each dedicated to research in support of the utilization of province-wide strategic resources. To maximize potential benefits and minimize environmental and financial risks it is vital to model the processes involved in the extraction and/or utilization of such

resources. These models will, of necessity, be of mathematical character and it is for the education and training of students in such model-building skills that the Applied Mathematics Program is essential.

With a greater flexibility in its 100 and 200-level course choices than the existing Mathematics Program, the Applied Mathematics program will be an attractive option for students pursuing degrees in other disciplines to augment such with a minor or second degree in Applied Mathematics. The double-honours option will remain as an alternative if a single combined degree is desired. The interdisciplinary nature of the new undergraduate program will facilitate a transition to graduate programs also of an interdisciplinary nature throughout the institution and its colleges, schools, institutes and centres.

Finally, this undergraduate program is fully consonant with the Curriculum Renewal exercise currently being undertaken by the Department of Mathematics and Statistics. Specifically, the Department has developed overarching program goals that align with those of the College of Arts and Science, explicitly; "In contributing to the Program Goals of the College of Arts and Science, the disciplines of Mathematics and Statistics teach students to think logically, precisely, critically, and analytically, and to apply these intellectual skills to contemporary real-world problems."

- **ENROLMENT AND RESOURCES IN THE U15 CONTEXT: COMPARISONS**

Currently, enrolment in Majors and Honours programs in Mathematics and Statistics at the University of Saskatchewan is low both in absolute numbers and in comparison to other U15 universities. To gain some perspective of this we include the enrolments from neighbouring institutions and Waterloo (an acknowledged leader in the education of Science students - most of whom are destined for industrial employment) for 2011-2012 in Mathematics (Pure, Applied, Mathematical Sciences, General Mathematics) (Figure 1).

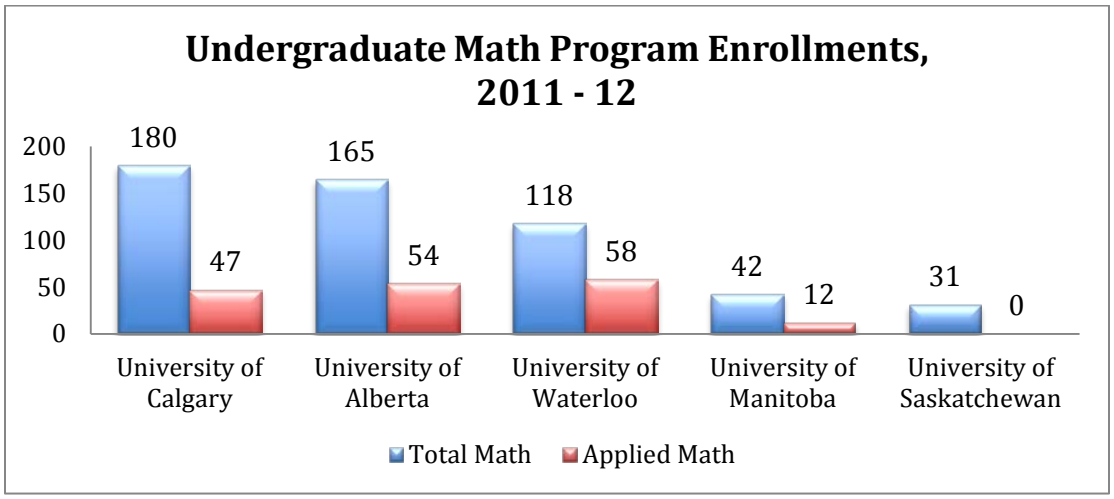

Figure 1: Undergraduate Math Program Enrollments, 2011-12.

Other than the UofM, each of the comparator universities in Figure 1 has a total student enrollment in the Mathematics between 3-9 fold higher than the UofS. More relevant to this discussion, between 25-50% of each enrolment is comprised of students in their respective Applied Mathematics programs. We would suggest that at the minimum we could expect a similar trend at the UofS, with the introduction of an Applied Mathematics program resulting in at least a 25% increase in student enrollment in the Department of Mathematics and Statistics. The logical connection between institutional support for a discipline and successful recruitment into that discipline is amply illustrated at the University of Waterloo which has devoted resources to a full and diverse Faculty of Mathematics with 200 full-time

professors, 7,000 graduate and undergraduate students, and a rich selection of 500 courses in Mathematics, Statistics, and Computer Science. http://math.uwaterloo.ca/math/

- **ENROLMENTS AND THE NEW APPLIED MATHEMATICS PROGRAM**

For recruitment purposes, the focus of the Department/College will initially be on the BSc Three-Year Applied Mathematics degree and minor with a subsequent promotion of and filtering into, both the Four-Year and Honours programs. This bottom-up approach is in marked contrast to the Department's traditional top-down approach of emphasizing the Honours degree and it is believed, will result in higher student registration in Mathematics and Statistics courses and subsequent graduation rate than at present. This is consistent with the beliefs expressed in 2004 by the SPR reviewers.

The nature of Applied Mathematics requires a constant infusion of ideas and expertise from other disciplines to inform and direct mathematical analysis and research. It is essential that other departments in the College of Arts and Science, the College of Medicine, the College of Engineering, other Colleges, Schools, Institutes and Centres in the University are engaged and excited by the possibilities an Applied Mathematics program could provide to them. There must be sufficient flexibility within the program to encompass the needs of these disciplines such that an integration of applied quantitative methods (mathematical and statistical) with the existing and planned future scientific initiatives of the UofS is achieved. Strong support for the proposed program has been received from within the Division of Science, and the Division of Social Sciences (Economics), as well as from the Colleges of Engineering and Medicine (Medical Imaging). See Appendix 3 – letters of support.

Central to the Three and Four-Year Applied Mathematics programs are the two new modelling courses, Math 336.3: Mathematical Modelling I, and Math 436.3: Mathematical Modelling II. An early indication as to the value and attractiveness of these two courses and the program in general is captured in the testimonial by a third-year student, one of a small number of students who were offered the special topics class MATH 398.3 as a trial run of the proposed MATH 336.3 (Appendix 4).
Based on the success of MATH 398.3, extensive Departmental experience in student advising and 2008-2011 enrollment data, we project an enrollment of 20 students per year for MATH 336.3 and 10 students per year for MATH 436.3, with both courses open to all students from across campus.

- **FUTURE ACTION ITEMS**

To engage students from other disciplines across the UofS the Department will:

- at the 100-level, consult with departments and units to determine the mathematical needs of their programs and improve access to such requirements where possible;

- at 200 to 400-levels, integrate, mathematical modeling more thoroughly throughout the curriculum through the use of simulations involving extensive numerical computations essential to a broad range of disciplines to highlight the utility of Applied Mathematics;

- review the possibility of a subsequent expansion of the program to accommodate a new stream in Computational Applied Mathematics

- in the future, establish an experimental laboratory in which experiment and theory will coexist, providing stimuli for each other and the training of students in a modern-day arena of Applied Mathematics worthy of a research intensive institution producing highly qualified graduates.

DESCRIPTION OF PROGRAM CHARACTERISTICS

C1 - C5 Requirements for Honours, Four-year and Three-year programs

C1 Science Requirement (minimum 15 credit units)
Choose **6 Credit Units** from the following:

- CMPT 111.3 (Introduction to Computer Science and Programming) or CMPT 116.3 (Computing I)
- CMPT 115.3 (Principles of Computer Science) or CMPT 117.3 (Computing II)

Remaining credit units to be selected from the following areas, such that no more than 6 credit units are from any one area:

Physics & Astronomy

- ASTR 103.3 (Descriptive Introduction to Stellar Astronomy)
- PHYS 115.3 (Physics and the Universe)
- PHYS 117.3 (Physics for the Life Sciences) or PHYS 125.3 (Physics and Technology)
- PHYS 128.3 (Introduction to Quantum and Relativistic Phenomena)

Chemistry

- CHEM 112.3 (General Chemistry I Structure Bonding and Properties of Materials)
- CHEM 115.3 (General Chemistry II Chemical Processes)
- CHEM 250.3 (Introduction to Organic Chemistry)

Earth Science

- GEOG 120.3 (Introduction to Global Environmental Systems
- GEOL 121.3 (Earth Processes)
- GEOL 122.3 (Earth History)

Biological Science

- BIOL 120.3 (The Nature of Life)
- BIOL 121.3 (The Diversity of Life)

C2 Humanities Writing Requirement (6 credit units)

C3 Social Science Requirement (6 credit units)

C4 Mathematics/Statistics Requirement (6 credit units)
Choose **6 Credit Units** from the following:

- MATH 110.3 (Calculus I) and MATH 116.3 (Calculus II)
- MATH 123.3 (Calculus I for Engineers) and MATH 124.3 (Calculus II for Engineers)
- (MATH 121.3 (Mathematical Analysis for Business and Economics) or MATH 125.3 (Mathematics for the Life Sciences)) and MATH 128.3 (Calculus II for Applications)

C5 General Requirement (6 credit units)

B.Sc. Honours Applied Mathematics

C6 Major Requirement (66 credit units)

The program does not require the specification of a concentration area. However, some students will find it to be a useful option to build their program around specific courses with applications in particular areas. For example, students with an interest in the physical sciences (chemistry, geology and geophysics, physics, engineering) might choose to emphasize ‘continuous’ mathematical tools such as differential equations, whereas students with interests in the life sciences (biology, biochemistry, biomedicine, biostatistics, epidemiology) and the social sciences (economics, psychology, sociology) might direct their study towards ‘discrete’ mathematical methods such as linear programming, graph theory, combinatorics or towards statistical methods.

Ideally, by the time of graduation, every student will have been exposed to aspects of continuous, discrete, and probabilistic and statistical methods.

MATH 211.3 (Numerical Analysis I)
MATH 238.3 (Introduction to Differential Equations and Series)

MATH 313.3 (Numerical Analysis II)
MATH 327.3 (Graph Theory)
MATH 336.3 (Mathematical Modelling I)
MATH 338.6 (Differential Equations II)
MATH 352.3 (Introduction to Differential Geometry)
MATH 366.3 (Linear Algebra II)
MATH 371.3 (Metric spaces and Continuous Functions)
MATH 379.3 (Complex Analysis)
MATH 436.3 (Mathematical Modelling II)
MATH 438.3 (Methods of Applied Mathematics)
STAT 241.3 (Probability Theory)

Choose **3 credit unit**s from the following:
It is recommended that this course be taken in the first year, if possible.

MATH 264.3 (Linear Algebra)
MATH 266.3 (Linear Algebra I)

Choose **6 credit units** from the following:
It is recommended that these courses be taken in second year, if possible.

MATH 223.3 (Calculus III for Engineers) ***and*** **MATH 224.3** (Calculus IV for Engineers)
MATH 225.3 (Intermediate Calculus I) ***and*** **MATH 226.3** (Intermediate Calculus II)
MATH 276.3 (Vector Calculus I) ***and*** **MATH 277.3** (Vector Calculus II)

Choose **6 credit units** from the following:

MATH 213.3 (Linear Programming and Game Theory)
MATH 328.3 (Combinatorics and Enumeration)
MATH 361.3 (Algebra I)
MATH 373.3 (Integration Theory)
STAT 242.3 (Statistical Theory and Methodology)
STAT 341.3 (Probability and Stochastic Processes)

Choose **3 credit unit**s from the following:

MATH 314.3 (Numerical Analysis III)
MATH 315.3 (Applications of Numerical Methods)
CMPT 394.3 (Simulation Principles)

Choose **6 credit units** from the following:

MATH 431.3 (Ordinary Differential Equations)
MATH 432.3 (Dynamical Systems and Chaos)
MATH 433.3 (Applied Group Theory)
MATH 434.3 (Applied Topology in Physics and Chemistry)
MATH 439.3 (Partial Differential Equations)
MATH 452.3 (Introduction to Modern Differential Geometry)
MATH 465.3 (Introduction to Cryptography)
MATH 485.3 (Elements of General Topology)
(MATH 498.3 (Special Topics in Applied Mathematics)**)**
STAT 442.3 (Statistical Inference)
STAT 443.3 (Linear Statistical Models)

See the samples of concentrations – to be displayed as links in the online calendar.
NOTE: one need not follow a 'concentration' as outlined here.

Sample program #1 – Continuous Modelling and Differential Equations
Sample program #2 – Discrete Modelling
Sample program #3 – Probabilistic and Statistical Modelling

C7 Electives Requirement (21 credit units)

These are courses to complete the requirements for the 120 credit unit four-year program, of which at least 66 cu must be at the 200-level or higher. Students may also select more courses in MATH and STAT depending upon their interests.

Students are encouraged to select courses from other disciplines and perhaps construct a double-honours or a minor in another subject.

B.Sc. 4-year Applied Mathematics

C6 Major Requirement (45 credit units)

The program does not require the specification of a concentration area. However, some students will find it to be a useful option to build their program around specific courses with applications in particular areas. For example, students with an interest in the physical sciences (chemistry, geology and geophysics, physics, engineering) might choose to emphasize 'continuous' mathematical tools such as differential equations, whereas students with interests in the life sciences (biology, biochemistry, biomedicine, biostatistics, epidemiology) and the social sciences (economics, psychology, sociology) might direct their study towards 'discrete' mathematical methods such as linear programming, graph theory, combinatorics or towards statistical methods.

Ideally, by the time of graduation, every student will have been exposed to aspects of continuous, discrete, and probabilistic and statistical methods.

MATH 211.3 (Numerical Analysis I)
MATH 238.3 (Introduction to Differential Equations and Series)
MATH 336.3 (Mathematical Modelling I)
MATH 436.3 (Mathematical Modelling II)
STAT 241.3 (Probability Theory)

Choose **3 credit unit**s from the following:
It is recommended that this course be taken in the first year, if possible.

MATH 264.3 (Linear Algebra)
MATH 266.3 (Linear Algebra I)

Choose **6 credit units** from the following:
It is recommended that these courses be taken in second year, if possible.

MATH 223.3 (Calculus III for Engineers) ***and*** **MATH 224.3** (Calculus IV for Engineers)
MATH 225.3 (Intermediate Calculus I) ***and*** **MATH 226.3** (Intermediate Calculus II)
MATH 276.3 (Vector Calculus I) ***and*** **MATH 277.3** (Vector Calculus II)

Choose **12 credit units** from the following:

MATH 213.3 (Linear Programming and Game Theory)
MATH 327.3 (Graph Theory)
MATH 328.3 (Combinatorics and Enumeration)
MATH 338.6 (Differential Equations II)
MATH 352.3 (Introduction to Differential Geometry)
MATH 366.3 (Linear Algebra II)
MATH 379.3 (Complex Analysis)
STAT 242.3 (Statistical Theory and Methodology)
STAT 341.3 (Probability and Stochastic Processes)

Choose **3 credit unit**s from the following:

MATH 313.3 (Numerical Analysis II)

MATH 314.3 (Numerical Analysis III)
MATH 315.3 (Applications of Numerical Methods)

Choose **6 credit units** from the following:

MATH 431.3 (Ordinary Differential Equations)
MATH 432.3 (Dynamical Systems and Chaos)
MATH 438.3 (Methods of Applied Mathematics)
MATH 439.3 (Partial Differential Equations)
MATH 452.3 (Introduction to Modern Differential Geometry)
MATH 465.3 (Introduction to Cryptography)
MATH 485.3 (Elements of General Topology)
(MATH 498.3 (Special Topics in Applied Mathematics)**)**
STAT 442.3 (Statistical Inference)
STAT 443.3 (Linear Statistical Models)

See the samples of concentrations – to be displayed as links in the online calendar.
NOTE: one need not follow a 'concentration' as outlined here.

Sample program #1 – Continuous Modelling and Differential Equations
Sample program #2 – Discrete Modelling
Sample program #3 – Probabilistic and Statistical Modelling

C7 Electives Requirement (36 credit units)

These are courses to complete the requirements for the 120 credit unit four-year program, of which at least 66 cu must be at the 200-level or higher. Students may also select more courses in MATH and STAT depending upon their interests.

Students are encouraged to select courses from other disciplines and perhaps construct a minor in another subject.

B.Sc. 3-year Applied Mathematics

C6 Major Requirement (30 credit units)

The program does not require the specification of a concentration area. However, some students will find it to be a useful option to build their program around specific courses with applications in particular areas. For example, students with an interest in the physical sciences (chemistry, geology and geophysics, physics, engineering) might choose to emphasize 'continuous' mathematical tools such as differential equations, whereas students with interests in the life sciences (biology, biochemistry, biomedicine, biostatistics, epidemiology) and the social sciences (economics, psychology, sociology) might direct their study towards 'discrete' mathematical methods such as linear programming, graph theory, combinatorics or towards statistical methods.

Ideally, by the time of graduation, every student will have been exposed to aspects of continuous, discrete, and probabilistic and statistical methods.

MATH 211.3 (Numerical Analysis I)
MATH 238.3 (Introduction to Differential Equations and Series)
MATH 336.3 (Mathematical Modelling I)
STAT 241.3 (Probability Theory)

Choose **3 credit unit**s from the following:
It is recommended that this course be taken in the first year, if possible.

MATH 264.3 (Linear Algebra)
MATH 266.3 (Linear Algebra I)

Choose **6 credit units** from the following:
It is recommended that these courses be taken in second year, if possible.

MATH 223.3 (Calculus III for Engineers) ***and*** **MATH 224.3** (Calculus IV for Engineers)
MATH 225.3 (Intermediate Calculus I) ***and*** **MATH 226.3** (Intermediate Calculus II)
MATH 276.3 (Vector Calculus I) ***and*** **MATH 277.3** (Vector Calculus II)

Choose **9 credit units** from the following:

MATH 213.3 (Linear Programming and Game Theory)
MATH 313.3 (Numerical Analysis II)
MATH 314.3 (Numerical Analysis III)
MATH 315.3 (Applications of Numerical Methods)
MATH 327.3 (Graph Theory)
MATH 328.3 (Combinatorics and Enumeration)
MATH 338.6 (Differential Equations II)
STAT 242.3 (Statistical Theory and Methodology)

See the samples of two concentrations – to be displayed as links in the online calendar.
NOTE: one need not follow a 'concentration' as outlined here.
Sample program #1 - Continuous Modelling and Differential Equations
Sample program #2 - Discrete and Statistical Modelling

C7 Electives Requirement (21 credit units)

These are courses to complete the requirements for the 90 credit unit three-year program, of which at least 42 cu must be at the 200-level or higher. Students may also select more courses in MATH and STAT depending upon their interests.

Students are encouraged to select courses from other disciplines and perhaps construct a minor in another subject.

Minor in Applied Mathematics (24 cu)

Requirements

MATH 110.3 (Calculus I) **or MATH 123.3** (Calculus I for Engineers)
MATH 116.3 (Calculus II) **or MATH 124.3** (Calculus II for Engineers)
MATH 211.3 (Numerical Analysis I)
MATH 336.3 (Mathematical Modelling I)
STAT 241.3 (Probability Theory)

Choose **3 credit unit**s from the following:

MATH 264.3 (Linear Algebra)
MATH 266.3 (Linear Algebra I)

Choose **6 credit units** from the following:

MATH 223.3 (Calculus III for Engineers) ***and*** **MATH 224.3** (Calculus IV for Engineers)
MATH 225.3 (Intermediate Calculus I) ***and*** **MATH 226.3** (Intermediate Calculus II)
MATH 276.3 (Vector Calculus I) ***and*** **MATH 277.3** (Vector Calculus II)

RESOURCES

The program includes two new modelling courses for the B.Sc. 4-year and B.Sc. Honours degrees, the first of which is also required for B.Sc. 3-year and Minor degrees. These two courses are essential in that they provide students with an opportunity to work on practical problems (population dynamics, biological modelling, financial mathematics, etc.). The College of Arts & Science will provide Sessional funding to allow faculty specialists to teach these courses; Sessional Lecturers will be hired to teach introductory courses in mathematics.

RELATIONSHIPS AND IMPACT OF IMPLEMENTATION

The aim of the program is to attract more students to Mathematics and Statistics. The program is broad by design and it is anticipated that most of the upper level courses will be positively impacted. The program also provides an umbrella for a steady group of students who are interested in Applied Mathematics, take courses in Mathematics and Statistics, but receive degrees from other departments.

7. BUDGET

The College of Arts & Science has committed the sessional funding required for this program for a trial period of 5 years. At the end of the trial period the success of this program, and that of the current programs in Mathematics and in Statistics, will be reviewed to determine whether this arrangement will continue or whether funding will be redistributed from current programs.

College Statement

From Peta Bonham-Smith, Acting Vice-Dean of Science, College of Arts & Science

The College of Arts and Science is supportive of the degree in Applied Mathematics. The proposal is well aligned with the IP3 goal for "Innovation in Academic Programs and Service" as identified in the Division of Science integrated plan:

> ***Applied Mathematics---*** *Mathematical models are widely used in all avenues of science and engineering, in fields as diverse as economics, bioinformatics, image processing, epidemiology, as well as the more traditional fields of physics or chemistry. An undergraduate program in Applied Mathematics will be designed to equip students with the modeling skills needed for their choice of field of application. The novelty of the program will be its flexibility in recognizing the contribution of the field of application. In a broad sense, the objective of the program will be to improve mathematical literacy of students engaged in other fields of application and as such the program will be aimed equally at students in the College of Arts and Science, as well as other colleges of the University of Saskatchewan.*

The program also aligns well with the following goals around "Knowledge Creation: Innovation and Impact" in the College of Arts & Science integrated plan:

> *- Recognizing and building upon our unique interdisciplinary knowledge creation potential and*
> *- Increasingly involving undergraduate students in research.*

and with the College's goals around "Innovation in Academic Programs and Service":

> *Building on foundations laid under IP2, over the next four years the College will introduce innovative academic programming and enhanced student services designed to provoke broad and deep learning, boost recruitment, raise the profile of the College, improve retention rates, enrich the student experience, and meet the evolving needs of twenty-first century society.*

The program will also provide a new option when advising interdisciplinary students, a student body that the College has identified as in need of assistance and support, as identified in the College of Arts and Science integrated plan:

> *Phase I focuses primarily on the needs of first year students, Aboriginal students, and students in interdisciplinary programs because these are the students most urgently in need of assistance and support.*

With respect to the IP3 goals of the **University** under "Innovation in Academic Programs and Service", the program is well aligned with the following commitments:

> *- increase the number of students engaging in experiential learning, including community-service learning, internships, undergraduate research, international student exchanges and co-op experiences*

within their academic programs
- improve student ratings on their learning environment through improvements in National Survey of Student Engagement (NSSE) scores.

The program is also well-aligned with the following strategies:

- Focus on Learner-Centred Programming and Curricular Innovation:

Students increasingly choose universities on the basis of the degree programs offered …
While we cannot tailor our programs and services to address all possibilities, we can design them with flexibility at their core. We also need to design them to meet the needs and expectations of today's and tomorrow's students, including meeting them where they live and providing experiences that they enjoy.

- Foster Student Creativity and Innovation:

We will expand and create new opportunities for hands-on, active learning and applied innovation in student-oriented and student-driven initiatives.

This proposal was developed by Drs. W. Abou Salem, J. Brooke, G. Patrick, A. Shevyakov, A. Sowa and J. Szmigielski and approved by the Department of Mathematics and Statistics. The proposal was approved by the Division of Science on November 29, 2011.

Related Documentation

Notice of Intent
Response from Planning and Priorities Committee of Council
Letters of support
Testimonial – 29 JAN 2013.docx

Consultation Forms At the online portal, attach the following forms, as required

Required for all submissions: □ Consultation with the Registrar form
[available from the Office of the University Secretary]

Required for all new courses: □ Calendar-draft list of new and revised courses

New Courses

MATH 336.3 Mathematical Modelling I
1 or 2 (3L) The course is designed to teach students how to apply Mathematics by formulating, analyzing and criticizing models arising in real-world situations. An important aspect in modelling a problem is to choose an appropriate set of mathematical methods - 'tools' - in which to formulate the problem mathematically. In most cases a problem can be categorized into one of three types, namely: continuous, discrete, and probabilistic. The course will consist of an introduction to mathematical modelling through examples of these three basic modelling types.
Prerequisites: MATH 211.3, MATH 264.3 or 266.3, STAT 241.3, 6cu in 200-level calculus: (MATH 223.3 and 224.3) or (MATH 225.3 and 226.3) or (MATH 276.3 and 277.3)
Instructor(s): Mathematics Faculty

MATH 436.3 Mathematical Modelling II
1 or 2 (3P) This course is a continuation of MATH 336.3, and is designed to further develop students' capacity to formulate, analyze and criticize mathematical models arising in real-world situations. This course will place emphasis on student activities rather than on lectures. Students will be expected to work in small groups on problems chosen by the instructor and to develop their independent skills at the formulation, analysis and critique of specific problems, and ultimately come to a greater understanding of the modelling process.
Prerequisites: MATH 336.3 or permission of the instructor
Instructor(s): Mathematics Faculty

Notice of Intent for a New Program in Applied Mathematics

Introduction

The Department of Mathematics and Statistics proposes a new degree program in Applied Mathematics with the levels of concentrations: Minor, B.Sc. 3-year, B.Sc. 4-year, B.Sc. Honours.

Motivation for this program

The main goal of the proposed program is to provide an outlet for undergraduate students in the College of Arts and Science to pursue a study in Mathematics with an emphasis on the utility of the subject toward the quantitative study of *a different* discipline other than Mathematics; that is, the program is aimed at educating students to the power of Mathematics as a tool of application. The intention is to emphasize those areas where Mathematics has been and may in the future be expected to make significant contributions to the development of other disciplines. In this it is expected to increase B.Sc. graduations through the Department of Mathematics and Statistics and, therefore, the College.

Yet another motivation - not entirely distinct from the stated goal to increase graduation numbers - is to offer an attractive and viable *second degree* option for students with interest in Applied Mathematics by potentially improving career options for those students who take a substantial load of Mathematics courses. In essence those students would be awarded a second degree - in Arts and Science - commensurate with their mathematical experience. A number of the students targeted in this secondary consideration will come from the professional colleges; for example: Engineering, Education, Commerce, Medicine.

Demand

It is expected that the bulk of the demand for the program will come from science students pursuing science degrees in the College of Arts and Science and from students in other colleges (Engineering, Commerce, Education, Medicine). In general, students with some mathematical abilities pursuing other degrees - be they in the Sciences or Humanities - and who recognize the need for at least a Minor in Applied Mathematics or perhaps a second degree, will most likely be attracted to this program.

Typical examples of groups from within the College of Arts and Science who would potentially be newly-attracted to the program are students in Geological Sciences and Geophysics, and students in Biology - students who have traditionally not taken Mathematics courses beyond second-year. One would expect a slight increase in the number of students from Computer Science and Physics to be interested in the program.

From beyond the College there is already a group of students for whom this program should be attractive, namely, students of Engineering Physics who now receive only the B.E. degree. The intent then would be to facilitate the attainment of an Arts and Science degree simultaneous with (or within one year) the attainment of the B.E. degree. Although not for every Engineering Physics student, there has been long-observed the inclinations toward
Applied Mathematics demonstrated for several decades by students of Engineering Physics. Interest by students of Engineering Physics in the international *Mathematical Contest in Modelling* since the U of S's first involvement in 1996 demonstrates a commitment to the sort of educational directions propounded by this program. The program thus seems to be a reasonable capitalization of those natural inclinations.

Perceived needs within the University and the Province

Existing provincial and federal initiatives such as the Canadian Light Source, the proposed Canadian Center for Nuclear Innovation, the Global Institute for Water Security will inevitably result in the need for employees with increased competence in Applied Mathematics in addition to being specialists in their respective fields.

Perceived national needs

In order for Canada to successfully undergo a transition from the resource-based economy to the knowledge-based economy the country will embrace the need for a skilled work-force which, in a majority of pursuits, will require good mathematics and computer skills. Additionally, and perhaps idealistically, there will be required an enhanced culture of innovation based upon competence in and sufficient exposure to more sophisticated tools (for example meaningful mathematical models and computer simulations). One of the most successful recent Canadian initiatives in this regard is the Canadian research network MITACS (Mathematics of Information Technology and Complex Systems). Using its research and training programs, MITACS aims to develop the next generation of innovators with scientific and business skills.

The urgency for training of future generations of innovators is captured in the following excerpt from *The Globe and Mail*, 1 July, 2009:

> "Barring an extension of the workweek - Canadians already put in more hours than Americans and are virtual workaholics compared with Europeans - innovation is the only sure way for Canada to be more productive. It is the key to maintaining our standard of living and providing increasingly costly public services for an aging population."

Assessment of the needs of the program

The need for a shift from recruitment into a generic B.Sc. Major in Mathematics degree toward a degree better emphasizing and more supportive of applications, namely the B.Sc. Major in Applied Mathematics, is a direct response to observed expressions of student interest as well as visible and widely acknowledged market forces and strategic pressures.

Relationship between the proposal and the Framework for Planning approved by Council (1998)

The University's Integrated Plan includes the strategic initiatives in Health, Science and Technology and Environment. In all these subjects modelling plays a prominent role from cellular processes through large scale properties of entire populations, image acquisition and data processing. The proposed degrees in Applied Mathematics feature, as perhaps their most novel (in the U of S context) elements, the involvement in and emphasis upon *mathematical modelling*.

The proposal vis a vis the University's goals and objectives

Because of its supportive role in relation to other programs the present proposal will increase the value of existing B.Sc. and B.A. degrees if chosen in conjunction with and complementary to them. It provides an attractive option for non-traditional students seeking to upgrade their preparations for a career.

Is the proposed program appropriate to a university?

Yes! Indeed, programs similar to this are available at such leading Canadian universities as: McGill, Toronto, Waterloo, Western Ontario, Alberta, British Columbia, among others.

Relationship of the proposed program to other programs offered by the sponsoring unit

The only relatively comparable program is the B.Sc. Honours in Mathematical Physics. That program specifically targets a select group of students interested both in Mathematics and Physics and provides them with additional training in Mathematics. The majority of students in that program continue to graduate schools, many of them in Mathematics.

In contrast, the proposed program in Applied Mathematics is designed to help students in Mathematics and other disciplines by giving them more career choices. It is not expected that the graduates of this program will necessarily go on to graduate schools in Mathematics.

The program encompasses and replaces the existing B.Sc. Honours in Mathematics - Concentration in Applied Mathematics.

Relation to the current College academic plan

Applied Mathematics is, by its very nature, interdisciplinary, and has already made contributions in the Social Sciences (particularly in Economics, but also in Psychology and Sociology), the Natural Sciences, Engineering, and Medicine.

The proposal is based on the recognition that the interdisciplinary character of Applied Mathematics, in its supportive role, is ideally suited to enhance the existing B.Sc. and B.A. degrees and also to better prepare students for their further professional careers.

Is the proposed program similar to others available at the University? Within the Province?

No. We believe that the program will be unique within the Province.

Is another program going to be deleted by the sponsoring unit as part of this proposal?

Yes, the B.Sc. Honours in Mathematics - Concentration in Applied Mathematics will be deleted.

Does the sponsoring unit have the required budget to support the program?

No. There will be some support required to mount two new courses in Mathematical Modelling - the most novel and exciting elements manifest in the program.

Additional resources needed to run the program

The program culminates with two new modelling courses for the B.Sc. 4-year and B.Sc. Honours degrees, the first of which is also required for B.Sc. 3-year degree and the Minor. These two courses are essential in that they provide students with an opportunity to work on practical problems (population dynamics, biological modelling, financial mathematics, etc). These two courses will require additional resources.

Will additional resources by required by other units on campus (e.g. Library, Educational Media Access and Production, Information Technology Services, Facilities Management)?

No.

Letters of Support

Biology - 08 March 2012

As Acting Head of the Department of Biology, I enthusiastically support the proposed program in Applied Mathematics.

Modern biological science is becoming increasingly quantitative and continues to use modeling tools to test hypotheses of biological principles. As a department, we recognize that students with a strong mathematical foundation are better prepared to succeed in senior Biology undergraduate and graduate courses. A program in applied mathematics would provide the students with an opportunity to develop this foundation. Indeed, the proposed program demonstrates a mechanism for students to build strength across disciplines. The modeling courses in the program could become very important for students with interdisciplinary interests.

Please use this message as a demonstration of support for the program.

I wish you success.

Regards

Jack Gray, Ph.D.
Acting Head and Associate Professor
Department of Biology

Computer Science - 10 March 2012

On behalf of the Department of Computer Science, I'd like to express support for the proposed Applied Mathematics Program.

Many areas of mathematics play a large role in Computer Science. Indeed, each era of computer science can be seen as looking heavily to mathematics for answers. Historically, numerical analysis and discrete mathematics (set theory and logic) played a foundational role in the discipline, as stability of numerical algorithms (related to roundoff error) was an early challenge. Discrete mathematics formed a theoretical basis for the idea of computation, and led to the establishment of several areas of mathematics (theory of algorithms, search algorithms) based heavily on those concepts. It also provideda formal basis for the design and implementation of programming languages, and the validation of software.

Probability and statistics are valuable to all disciplines - indeed, some people see statistics as a significant service industry to all of science. Among other things, probability and statistics, in the early days of computing, provided the basis for understanding the management of multiple processes and traffic flow in networks and for understanding of performance issues in general. More recently, these disciplines have formed the basis for practical theories of testing.

In the last 20 years, computers have been used extensively for modelling, perhaps most spectacularly in computer graphics, where mathematics related to physics (the behaviour and interaction of light with surfaces, animation, mechanics) has been used to produce realistic images and movies. Doing simulations that in effect directly imitate the behaviour of light are intractable, and the models succeed by both understanding the actual mathematics of processes, and how approximations may produce desired effects effectively.

I could go on. It seems to me that a good applied mathematics program would be very valuable to many of our undergraduates seeking to find interdisciplinary applications of computing.

Eric Neufeld,
Professor and Head
Department of Computer Science

Geological Sciences - 9 March 2012

Thank you for the opportunity to review your new program proposal in Applied Mathematics.
As you know, I am a strong supporter for more mathematics in all of our programs.

Geophysics students currently take math 110,116, 266, 225 and 226 (honours do 238, 276 instead of 225, 226 and add 338.6), and so a minor may be an attractive option for some of them. We should work towards this. The geophysics program is rather heavily prescribed so there are not many opportunities for our students to take another mathematics class as an elective, but I do recommend numerical analysis, and\or a statistics class, if a student should seek advice as to electives. I am pleased to see that both are in the program.

Sam Butler is developing a graduate class in finite element modeling. I can see the Applied Mathematics program meshing very well with this so your graduates might consider that as an option if they stay for a graduate degree.

I have a minor quibble with the paragraph that addresses about the need for Canada to transition from a resource based economy to a knowledge based economy. The exploration side of the resource economy is intensely knowledge based, which of course explains why we require as much mathematics in the geophysics program as we do.

Best wishes with your proposal.
Jim Merriam

Physics and Engineering Physics - 9 March 2012

First, I would like to congratulate you and your colleagues for this program which is quite long over due. I have been aware that you were on this task for quite some time and it is good to see a well finished project.

At the physics and engineering physics department, mathematics is our language and thus we cannot overemphasize its importance in every thing we do. We have been collaborating with you for several years on the mathematical physics program, which attracted high caliber students who went on to attain high academic laurels at institutions of high repute.

While the mathematical physics program attracts abstract thinkers who intend to pursue theoretical physics programs, the applied mathematics will be useful and appealing to several disciplines in engineering, social sciences and medicine etc.

The way you have allowed for 3 yr, 4yr and also minors in this area caters to students of diverse interests and strengths.

I find the categorization into discrete and continuous modeling very appealing. It allows a student or a researcher to focus on their domain of application such as digital computer related topics or the fluid dynamics problem and see the relevance of applied mathematics to their specialization.

Already some of our bright students pursue double degree programs in Engineering Physics and 3 or 4 year math programs. They will find the applied mathematics program even more attractive. We will be recommending this program to them.

Regards

Chary

Dr. Chary Rangacharyulu
Professor and Head

Physics and Engineering Physics

Economics - 29 November 2011

The Department of Economics would like to be included among the enthusiastic supporters of the proposed program in Applied Mathematics.

Since economics is, in many respects, a form of applied mathematics, this is very much the sort of foundation that strong honours and prospective graduate students in economics are well advised to have studied. We have already discussed this with you and among ourselves, and plan to have a recommended economics specific course sequences identified shortly after you get the general structure approved. (As you know, we are already advising some of our top students to take your new Mathematical Modelling courses.)

Since I am not sure that I can appear at this afternoon's meeting (the timing conflicts with a seminar in Bioresource Policy Business and Economics), I would be pleased to have this email included in support your proposal.

Good luck with this.

Don Gilchrist, Head
Department of Economics

College of Engineering - 8 March 2012

I've looked through the material that you sent to me. I have not had the opportunity to vet your proposal through our Academic Programs and Standards Committee or our Faculty Council, but I am happy to provide the following comments which reflect my own observations and thoughts on the Applied Mathematics program:

I can certainly see that there would be a handful of students interested in some acknowledgement of the math skills that they developed within an engineering program through some sort of Dual Degree in Engineering and Applied Mathematics or, perhaps through an Applied Mathematics Option/Minor. Both of these, of course, would require the students to take extra courses above their regular engineering degree. However, without surveying the students, I can not give you specific numbers on student demand. And without surveying the employers of our students, I can not make a judgement on the employer demand for more applied mathematics skills within our grads.

It is important for me to state that adding either a Minor in Applied Mathematics or an option in applied mathematics to our B.Sc. in Engineering degrees would require the Canadian Engineering Accreditation Board to be informed of the change and likely require a review of the modified degree (either through an accreditation visit or through an extensive report to the Board).

A dual degree (B.Sc. in Engineering + 3 year B.Sc. in Applied Mathematics for example) would not result in such a review.

I strongly support the notion of closer ties between the College of Engineering and the Department of Mathematics and Statistics because of our strong need for excellent instruction in the areas of Applied Mathematics. Thus, I am very happy to see the Department of Mathematics and Statistics putting more emphasis on their Applied Mathematics area. I can see that by removing the Honours in Mathematics, Stream in Applied Mathematics and replacing it with a more agile set of Applied Mathematics degrees, minors and/or options, students will have more flexibility to shape their undergraduate experience to suit their interests and receive institutional recognition for their efforts and success in Applied Mathematics.

I am very interesting in continuing the conversations about applied mathematics and the relationship between your Department and our College. Please let me know if there is more specific information you need from the College of Engineering as you move your proposal forward.

Regards,
Aaron Phoenix

Dr. Aaron Phoenix, P.Eng.
Assistant Dean - Undergraduate Administration
Engineering Student Centre

Medical Imaging, College of Medicine - 29 February 2012

I wish you the best of luck with this initiative.
Please use my comments as you may wish.
I am in broad support of the initiative to develop a new Bachelor of Science program in Applied Mathematics. Developing further expertise and recognizing this expertise with a Bachelor of Science in Applied Mathematics will be an excellent complement to the current program on campus. In particular I can envisage these students working on related undergraduate research projects that will benefit medical imaging with potential applications to medical image signal analysis and modelling of cancer imaging strategies.

Paul Babyn
<Paul.Babyn@saskatoonhealthregion.ca>

Testimonial

18 January 2013 *To Whom It May Concern*

My name is Ilona Vashchyshyn, and I'm a third year student in the Honours Mathematics program. I began my studies in Engineering, but after taking several mathematics courses in my first and second years, I realized that mathematics was my passion. Part of what captivated me was the pervasiveness of mathematics in daily life – indeed, nearly every discipline relies on it in some way: from the differential equations at the heart of quantum mechanics, to statistics in climate modeling, to the linear algebra behind Google's search engine, mathematics helps us understand and improve the world around us. I was therefore especially interested in an Applied Mathematics program: while mathematics in itself is beautiful, to me it really comes alive when I can see it "under the hood", so to speak, of everyday life. I really enjoyed Math 398, a course where we discussed various economic and biological mathematical models; I would be very interested in taking more courses like this in the future. I also think that math skills are especially relevant in today's information and technology economy, and therefore that any students graduating with an Applied Mathematics degree would have an advantage. I would be very happy to see such a program established at the University of Saskatchewan.

Thank you,

Ilona Vashchyshyn, #11099719