
Subject: MPHEC Application for Program Modification - Major in Analytics

Prepared by: Shannon Fitzpatrick, Associate Dean, School of Mathematical and Computational Sciences, UPEI

Prepared for: UPEI Senate

Date: February 13, 2026

ISSUE

Approval is requested for major modifications to the Bachelor of Science in Analytics. The application to MPHEC restructures the current program, which requires students to select either the Data Analytics or Business Analytics specialization, into a stand-alone Major in Analytics with optional specializations. In comparison with the original Analytics majors, this update also streamlines requirements and adds Data Science-specific courses.

BACKGROUND

The original Analytics programs included mandatory specializations and a large number of required Mathematics, Statistics, and Computer Science courses, limiting student flexibility and contributing to extended completion times. A review of student data from 2019–2023 showed that only 33% of students remained in the program after two years, due in part to lengthy prerequisite chains and a lack of early Data Science-specific coursework. These constraints also made it difficult for students—particularly international students or those transferring from other institutions—to progress efficiently.

Following a 2021 quality assurance review, the School of Mathematical and Computational Sciences convened a cross-disciplinary committee to redesign the program. Using curriculum guidelines from national bodies (ASA, ACM, SSC) and conducting an outcomes-based gap analysis, the committee identified the need for a clearer Data Science identity and better sequencing of course content. Three new Data Science courses were developed to provide foundational, design, and capstone experiences for students: AMS 1910, AMS 2910, and AMS 4910. These courses, along with foundational courses in Mathematics, Statistics and Computer Science, provide breadth and depth, while reducing barriers to completion.

RECOMMENDATION

We recommend that the Senate approve, in principle, the Bachelor of Science in Analytics as presented.

The Analytics major is a program of strategic importance to the School of Mathematical and Computational Sciences. Its foundational courses form a shared core with the Statistics and Actuarial Science programs, creating a tightly integrated suite of programs. The health and sustainability of all three programs rely on this shared structure; strong enrollment and progression in Analytics supports course viability across the School. We are eager to implement these changes as soon as possible. Once completed, additional specializations will be proposed, and recruitment initiatives will be amplified.

RATIONALE

The redesigned curriculum adds a coherent Data Science pathway from first year through a culminating capstone, strengthening the program's identity and improving recruitment and retention. Reduced mandatory requirements, fewer prerequisite barriers, and increased elective flexibility allow students to personalize their studies and offer more accessible pathways. The proposal responds directly to recommendations from the 2021 external review and aligns with curriculum guidelines. Despite the addition of new courses, no new human resources are required, as advanced courses that were previously required have been made elective. The modified program better prepares graduates for careers in Data Analytics, Business Analytics, and Data Science, as well as quantitative graduate programs.

Application for Program Modification

Submitted by:

Shannon Fitzpatrick, Associate Dean

School of Mathematical and Computational Sciences

Table of Contents

OVERVIEW	2
MPHEC INFORMATION REQUIREMENTS FOR PROGRAM MODIFICATIONS	3
PROGRAM INFORMATION	3
PROGRAM MODIFICATION(S)	5
1) <i>Program Content and Structure</i>	7
2) <i>Student Learning Outcomes and Graduate Outcomes</i>	11
3) <i>Delivery Modes</i>	13
4) <i>Admission, Promotion, and Graduation Requirements</i>	13
5) <i>Human Resources</i>	13
6) <i>Collaborative and Jointly Developed Programs</i>	14
7) <i>Implementation of Truth and Reconciliation Commission (TRC) Calls to Action</i>	14
8) <i>Equity, Diversity, Inclusion and Accessibility (EDIA)</i>	15
9) <i>Additional Information</i>	16
APPENDICES.....	18
APPENDIX 1 CONSULTANT’S REPORT FROM LAST EXTERNAL REVIEW AND THE INSTITUTION’S RESPONSE.....	19
APPENDIX 2 SIDE-BY-SIDE OF PROGRAM REQUIREMENTS AND HYPOTHETICAL STUDENT PROGRESSION	24
APPENDIX 3 ACADEMIC CALENDAR COURSE DESCRIPTIONS	30
<i>The Common Core</i>	31
<i>Other Required Courses</i>	33
<i>Select Electives</i>	36
<i>Full List of SMCS Course Descriptions</i>	36
APPENDIX 4 PROGRAM COMPARISON TABLE	62
APPENDIX 5 STUDENT LEARNING OUTCOMES TABLE	67
APPENDIX 6 FACULTY RESOURCE TABLE.....	71
APPENDIX L LIBRARY INFORMATION	75
APPENDIX S SMCS SELF-ASSESSMENT, MAY 2021	86

Overview

The School of Mathematical and Computational Sciences (SMCS) at UPEI currently has two programs in Analytics: (1) Major in Analytics with a Specialization in Data Analytics and (2) Major in Analytics with a Specialization in Business Analytics. There is no (stand-alone) Major in Analytics. The primary objective of this proposal is to create a Major in Analytics that can be completed without specialization. Students will still have the option of completing a specialization.

Along with this uncoupling of the Major from the Major with Specialization, we are also updating the curriculum to better reflect the state of the field. Analytics and Data Science have advanced significantly since the programs were created in 2015. The new curriculum addresses those advances while still maintaining the core learning objectives.

A new Major in Analytics will allow students to tailor their degree to their interests or pursue an additional major or minor. It also opens the door for the School of Mathematical and Computational Sciences (SMCS) to introduce new specializations, either internally (similar to Data Analytics) or in collaboration with other departments (similar to Business Analytics).

Changes to the program requirements will strengthen its focus on core data science skills. To support this, we have introduced new courses (AMS 1910, AMS 2910 and AMS 4910). Alongside foundational studies in Mathematics, Computer Science, and Statistics, these Data Science-specific courses will provide students with the technical, analytical, and theoretical expertise needed for careers in Data Science, Data Analytics and Business Analytics.

MPHEC Information Requirements for Program Modifications

Note: The MPHEC has developed “tips” intended to assist universities when completing this form. The tips are provided at the end of this document (beginning on page 17) and links are embedded in the information requirements below.

Program Information

- a) Submitting Institution(s): University of Prince Edward Island
- b) Faculty / School / Department: School of Mathematical and Computational Sciences (SMCS)
- c) Credential(s) Granted (as it will appear on the transcript; where applicable, former and proposed; for collaborative programs, note which institution will award each credential, as applicable):

Former: BSc in Analytics, Specialization in Data Analytics; or
BSc in Analytics, Specialization in Business Analytics

Proposed: BSc in Analytics

- d) Program Name^(Tip) (where applicable, former and proposed):

Former Name: Major in Analytics, Specialization in Data Analytics; or
Major in Analytics, Specialization in Business Analytics

Proposed Name: Major in Analytics

- e) Level of Study (undergraduate, post-baccalaureate, graduate): Undergraduate

- f) Program Duration (where applicable, former and proposed):

- | | | |
|------|--|------------------|
| i. | Number of units, credits, or credit hours ¹ required for credential | 120 Credit Hours |
| ii. | Number of expected terms for full-time ² students | 8-13 terms |
| iii. | Number of expected terms for part-time ³ students | 20 terms |

- g) Current / Proposed [Classification of Instructional Program \(CIP\) Code](#): 27.0599

- h) Implementation / Transition plan:

- i. Start date of modified program (factoring in any required approvals, including the MPHEC’s):
September 2026
- ii. If major modifications are proposed, anticipated date of completion of last student enrolled in existing program: May 2029

¹ Universities are able to report credits in the unit they use at their institution. The remainder of this document will refer to “credits” where 6 credits = 6 credit hours = 1.0 unit = 2 term-length courses.

² Full-time and part-time statuses are defined by the reporting post-secondary institution.

³ Full-time and part-time statuses are defined by the reporting post-secondary institution.

- i) Contact Person (should MPHEC staff require additional information during the assessment process)
 - a) Name & Job Title: Rachel Hasan, Quality Assurance and Planning Officer
 - b) Email: rahasan@upei.ca
 - c) Phone Number: +1 902 620 5384

- j) Provide a brief description of the modification(s) to the program (approximately 250 words). **Note: This program description will be made publicly available on the MPHEC's website.**

The current Analytics program requires students to choose between two specializations: Data Analytics or Business Analytics. The proposed change will establish a stand-alone major, where specializations become optional. This flexibility allows students to tailor their degree to their interests or pursue an additional major or minor. It also opens the door for the School of Mathematical and Computational Sciences (SMCS) to introduce new specializations, either internally (similar to Data Analytics) or in collaboration with other departments (similar to Business Analytics).

Changes to the program requirements will strengthen its focus on core data science skills. To support this, we are adding three new courses to the program: AMS 1910 *Introduction to Data Science*, AMS 2910 *Design Thinking with Data*, and AMS 4910 *Capstone Project in Data Science*. Additionally, we have recoded STAT 4660 *Data Visualization and Mining* to STAT 3660 to clearly situate it as the 3rd data science course in the program. We have also updated its name and course description to clarify how it differs from these new courses. Alongside foundational studies in Mathematics, Computer Science, and Statistics, these Data Science-specific courses will provide students with the technical, analytical, and theoretical expertise needed for careers in Data Science, Data Analytics and Business Analytics.

- k) Dates (as applicable).
 - i. Senate (or equivalent) approval of the program modifications:
 - ii. Date of last MPHEC assessment: 2015
 - iii. Date of last external review of the program: May 2021

- a. Identify the name, title, and institution of the external reviewer(s) who assessed the program. Attach as Appendix 1 a copy of the reviewer's report and the institution's response (**Note:** This is **required** if the program has not been previously assessed by the MPHEC).

Stavros Konstantinidis, Professor, Saint Mary's University
Denis Latulippe, Professor, Université Laval
Ying Zhang, Professor, Acadia University

- l) Provide information on anticipated enrolments over the first four years of implementation of the modified program.

With a suite of courses unique to Data Science, the program now has an identity distinct from being an interdisciplinary program in Mathematics, Computer Science, and Statistics. With updated learning outcomes and courses, we will now be able to articulate the program's strengths more effectively and market it accordingly.

While we anticipate an increase in the number of first-year students entering the program, we also expect these changes to enhance retention within the School of Mathematical and Computational Sciences. Based on data collected between 2019 and 2023, only 33% of analytics majors remained in the program after 2 years. With many high-level courses in Mathematics, Statistics, and Computer Science, the curriculum was very demanding, and it was difficult for students to complete their programs within four years. Many 2000-level courses in the program belonged to long prerequisite chains that were only offered once a year. As a result, if a student missed their window of opportunity to take courses such as CS 2910, CS 2920, or STAT 2910, they would add another year to their program.

In addition to improving retention among students who enter the Analytics program in their first year, we view this as a viable option for students who may not succeed in other programs within SMCS. Specifically, we have a large number of Computer Science majors who find much of the CS curriculum to be beyond their capabilities, and the retention rates for the Computer Science program are low. For example, of students who entered the CS program in 2019, the 6-year graduation rate was 41.7%. In comparison, over all Science programs, the rate is 59.9%. Many of these students repeat their CS courses multiple times, yet are successful in other areas of Mathematics and Statistics. This is not to say that courses in Mathematics or Statistics are “easier”, but to acknowledge that the skill sets are different from those required to complete Computer Science.

Currently, it is difficult for Computer Science students to transition to another major after their second year due to course requirements and prerequisite chains. The updated program in Analytics removes many of these barriers. If students complete their Common Core courses (a standard set of first-year courses in SMCS) within their first two years, along with AMS 1910, they can complete the updated Analytics program requirements within the next two years. This flexibility, along with the career opportunities available upon completing an Analytics degree, should make this an attractive option for Computer Science students who might otherwise not complete their degree.

	Year 1		Year 2		Year 3		Year 4	
	FT	PT	FT	PT	FT	PT	FT	PT
New Domestic	4		6		10		12	
New International	6		8		12		14	
Continuing Domestic	5		6		10		12	
Continuing International	21		20		18		20	
Total Student Enrolment Overall	36		40		50		58	

Program Modification(s)

m) Purpose for program modification proposal:

Minor modifications have accumulated over time.

Major modifications are proposed.

n) Indicate below the type of modification(s) to the program, marking all that apply. (For more information, consult the *MPHEC's Proposals for Program Modifications.*)

program content and structure;

delivery mode;

program/credential nomenclature;

admission, promotion, or graduation requirements;

student learning outcomes and/or graduate outcomes;

- faculty resources;
- collaborative or joint programs;
- other.

o) Provide details and a rationale for the modification(s) indicated above. ^(Tip)

With this modification, there are three core objectives: (1) to create a stand-alone major in Analytics with no specialization; (2) to remove required SMCS courses that are not geared toward skills required for Analytics/Data Science; and (3) to add courses that are Data Science-specific and address gaps in student learning.

The Analytics major currently requires students to choose one of two specializations: Business Analytics or Data Analytics. The programs were initially envisioned as being highly specialized to provide students with a breadth and depth of knowledge across Mathematics, Computer Science and Statistics. As a result, the programs have a high number of required courses. When the Data Analytics program was implemented in 2016, it had 107 credits dedicated to required courses and 13 credits of general electives. Similarly, the Business Analytics program had 98 credits of required courses and 22 credits of general electives.

The structure of the programs made recruitment and retention difficult. One issue was the lack of Data Science-specific courses in the first two years of study – students couldn't see how the Analytics programs were distinct from other programs in the School of Mathematical and Computational Sciences. For example, students who were interested in Data Analytics questioned why they shouldn't just take Computer Science. Another issue was that, due to the large number of requirements and long prerequisite chains, students who deviated from a strict advising schedule in any way found it challenging to complete their requirements in a timely manner. This particularly affected international students who pay higher fees and have restrictions on their residency.

A stand-alone Major in Analytics will be a more distinct and accessible option for potential students. With a pared-down list of required courses, students will have the ability to pursue other areas of interest alongside the Analytics major. Initially, we plan to offer two specializations: Business Analytics and Software and Systems (an updated take on Data Analytics) and add new specializations over time. With interest in Data Science skills from many units on campus, there are many opportunities to create specializations across many Departments and Faculties at UPEI.

As part of our 2021 Quality Assurance Review, members of the School of Mathematical and Computational Sciences conducted a Self-Study of several programs, including those in Analytics. In that assessment, we discussed in detail both the opportunities and challenges associated with the Analytics programs. The modifications proposed here were also identified in the Self-Study, including adding courses specific to Data Science that will create a common thread throughout the program, removing unrelated courses, and adding a 4000-level capstone project.

In the report submitted by the review team, the reviewers acknowledged the need for updates to the Analytics program and indicated that there was a plan for updates. More broadly, when commenting on our School's objectives, they said,

"...the review team believes that the School also has a clear and reasonable strategic direction for each of its programs as outlined in its Self-Assessment Report. This is well-served by having the various interrelated programs grouped and harmonized under the direction and leadership of the School allowing it to respond quickly and effectively to any programming needs. This is especially relevant in the context of the "fourth industrial revolution" associated with the emergence of artificial intelligence and

with the financial services industry which is working to develop data analysis capacity and to become much more data-oriented organizations. It is clear from our review that the School is supportive of such important changes and has given careful consideration to its suite of programming to ensure that it remains relevant and desirable.”

Following the review, the School of Mathematical and Computation Sciences struck a committee to redesign the Analytics Major. They developed a comprehensive set of learning outcomes and asked instructors to assess the coverage of each outcome in their courses. In each case, they identified the level of coverage (Introduction, Development, or Mastery). Following this exercise, the committee completed a thorough analysis and identified gaps in the curriculum. As a final piece, SMCS hired new faculty with expertise in the field. This allowed us to develop the introductory course AMS 1910 *Introduction to Data Science* and finalize the updated program requirements. In short, the proposed modification has been part of a long, carefully considered process.

1) Program Content and Structure

All majors in the School of Mathematical and Computational Sciences are required to complete a set of courses referred to as the *Common Core*.

<u>Common Core</u>		Credit hours
MATH 1910	Single Variable Calculus I	4
MATH 1920	Single Variable Calculus II	4
MATH 2610	Linear Algebra	3
CS 1910	Computer Science I	3
STAT 1910	Introduction to Statistics	3
IKE 1040	Indigenous Teaching of Turtle Island	3

In addition to foundational courses in Mathematics, Statistics and Computer Science, students must complete IKE 1040 Indigenous Teachings of Turtle Island, which is required for all UPEI students. We also note that all students at UPEI are required to complete a Writing Intensive course. In the School of Mathematical and Computational Sciences, all students complete MCS 4210: Professional Communication and Practice, which is classified as a Writing Intensive course. Finally, all SMCS programs require students to take at least 15 semester hours of credit in courses outside of the School of Mathematical and Computational Sciences (excluding the UPEI and IKE courses in the common core). Of these 15 semester hours of credit, at least six must be from outside the Faculty of Science.

We note that UPEI has recently removed the requirement that all students take at least one first-year experience course (UPEI 1010, 1020 or 1030). This change will take effect beginning with the 2026-2027 academic year. As reflected in the side-by-side comparison of the 2021 versions of the Analytics programs and the proposed modified program in Appendix 2, this requirement has been removed from the SMCS Common Core and students now have 3 additional credit hours of electives. Over the next year, SMCS will review how some of the skills delivered in these courses (effective use of library resources, for example) can be incorporated into other courses in our programs.

The proposed calendar entry for the Major in Analytics follows, along with two optional specializations: (1) Software and Systems; (2) Business Analytics. These two specializations are updates of the existing Data Analytics and Business Analytics specializations, respectively. Although the specializations are not under the purview of MPHEC, we include them since they are required in the current version of the Analytics major. Note that AMS 2910 and AMS 4910 are proposed courses and the new name of STAT 3660 is also proposed.

ANALYTICS	Credit Hours
The Common Core	20
AMS 1910 Introduction to Data Science	3
CS 1920 Computer Science II	3
STAT 2240 Applied Regression Analysis	3
STAT 2910 Probability and Mathematical Statistics I	3
AMS 2910 Design Thinking with Data	3
STAT 3660 High-Dimensional Data Analytics	3
AMS 4910 Analytics Capstone	3
MCS 4210 Professional Communication and Practice	3
Two SMCS electives at the 2000-level or higher	6
Three SMCS electives at the 3000-level or higher	9
General Electives	61
Total Semester Hours of Credit	120

ANALYTICS, SPECIALIZATION IN SOFTWARE AND SYSTEMS	Credit Hours
The Common Core	20
AMS 1910 Introduction to Data Science	3
CS 1920 Computer Science II	3
CS 2910 Computer Science III	3
CS 2920 Data Structures and Algorithms	3
STAT 2240 Applied Regression Analysis	3
STAT 2910 Probability and Mathematical Statistics I	3
AMS 2910 Design Thinking with Data	3
STAT 3660 High-Dimensional Data Analytics	3

CS 3710 Database Systems	3
Two of	6
CS 3210 User Experience Design	
CS 3610 Analysis, Design of Algorithms	
CS 3620 Software Design, Architecture	
CS 4120 Machine Learning	
CS 4140 Deep Learning	
AMS 4910 Analytics Capstone	3
MCS 4210 Professional Communication and Practice	3
General Electives	61
Total Semester Hours of Credit	120

ANALYTICS, SPECIALIZATION IN BUSINESS ANALYTICS Credit Hours

The Common Core	20
AMS 1910 Introduction to Data Science	3
ACCT 1010 Introduction to Financial Accounting	3
BUS 1410 Marketing	3
BUS 1710 Organizational Behaviour	3
CS 1920 Computer Science II	3
STAT 2240 Applied Regression Analysis	3
STAT 2910 Probability and Mathematical Statistics I	3
AMS 2910 Design Thinking with Data	3
STAT 3660 High-Dimensional Data Analytics	3
One of	3
BUS 2310 Corporate Finance	
BUS 2880 Research and Evidence-Based Management	
BUS 2720 Human Resource Management	
One of	3
BUS 3340 Personal Finance	
BUS 3510 Operations Management	

UNIV 3100 Entrepreneurship Venture Development

UNIV 3200 Entrepreneurship Venture Implementation

CS 3840 Tech Mngmt, Entrepreneurship

One BUSINESS elective at the 3000-level or higher	3
One SMCS elective at the 3000-level or higher	3
AMS 4910 Analytics Capstone	3
MCS 4210 Professional Communication and Practice	3
General Electives	55
Total Semester Hours of Credit	120

- In **Appendix 2**, the table provides the program requirements and a hypothetical student progression through the program, comparing the program as it was last approved by the MPHEC with the modified program.
- In **Appendix 3**, we provide the academic calendar course descriptions for each required course and select electives for the modified program. These descriptions identify any prerequisites and/or co-requisites.
- In **Appendix 4**, the table compares the proposed program to three to five other relevant programs offered in the Maritimes or other Canadian provinces.
- Identify any internal and/or external consultation undertaken that informed the program modification. ^(Tip)

Following the 2021 quality assurance review, the School of Mathematical and Computational Sciences formed a committee to redesign the Analytics program. The membership of the committee drew from all specializations within our School (Mathematics, Statistics, Computer Science, Analytics/Data Science), with about ten faculty members involved. The team proceeded to collaboratively develop program learning outcomes for the Analytics degree, which comprise the core skills that are expected of a graduate from that program. Committee members use the following materials to inform their decisions:

- Buro, K., Peck, R., Horton, N. J., & Gould, R. (2018). *Curriculum guidelines for undergraduate programs in statistics*. American Statistical Association. <https://www.amstat.org/asa/education/Curriculum-Guidelines-for-Undergraduate-Programs-in-Statistical-Science.aspx>
- American Statistical Association. (2016). *Guidelines for assessment and instruction in statistics education (GAISE) college report*. https://www.amstat.org/docs/default-source/amstatdocuments/gaisecollege_full.pdf
- Danyluk, A., & Leidig, J. (2021). *Computing competencies for undergraduate data science curricula*. ACM Data Science Task Force. <https://dl.acm.org/doi/pdf/10.1145/3453538>
- De Veaux, R. D., Agarwal, M., et al (2017). *Curriculum guidelines for undergraduate programs in data science*. *Annual Review of Statistics and Its Application*, 4, 15–30. <https://doi.org/10.1146/annurev-statistics-060116-053930>
- Schwab-McCoy, A., Baumer, B. S., Çetinkaya-Rundel, M., Hardin, J., & Horton, N. J. (2021). Data science in 2020: Computing, curricula, and challenges for the next 10 years. *Journal of Statistics and Data Science Education*, 29(sup1), S1–S11. <https://www.tandfonline.com/doi/epdf/10.1080/10691898.2020.1851159?needAccess=true>

The committee also consulted the recommended curricula from the Statistics Society of Canada, including accreditation criteria (<https://ssc.ca/en/accreditation>).

Committee members had discussions with stakeholders across campus, including those from Business, Applied Communication and Leadership, History, Applied Health Sciences, Psychology, and Climate Change and Adaptation, to discuss the updated major and the potential addition of other specializations.

Committee membership included recent additions to our faculty who have extensive experience working with industry. Particularly, Dr. Dania Tamayo-Vera is a member of Holland College's advisory group for its Data Analytics Post-Graduate Certificate program. She was recruited to serve on the group specifically due to her industry experience.

Committee membership included former Associated Deans and Program Leads in SMCS who have closely advised many students in Analytics, Computer Science, Statistics, and other SMCS programs. They have had numerous discussions with students about the challenges of meeting all the requirements in the current Analytics programs, as well as the difficulties in transitioning out of Computer Science programs after two years.

2) Student Learning Outcomes and Graduate Outcomes

- a) See Appendix 5 for the table identifying the student learning outcomes for the program, how they will be achieved, and changes from the previous version of the program. For context, we provide the following discussion on how the learning outcomes were determined.

Based on the committee analysis of these documents and subsequent meetings, a set of broad learning outcomes was agreed to by the committee for the first stage of the analysis process.

Foundations

- PO1 Mathematical Foundations: Develop an understanding of the fundamental concepts, theories, and practices needed for data science.
- PO2 Statistics Foundations: Apply knowledge of foundational statistical concepts to inform analyses.
- PO3 Computation Foundations: Apply computational thinking and automation through programming languages, algorithms and tools to solve problems involving large and complex data sets.

Data Lifecycle

- PO4 Stakeholders: Engage with stakeholders to elicit, identify and solve data-driven problems in a variety of industries and domains.
- PO5 Study Design: Design and implement research studies to collect and analyze data to inform decision-making.
- PO6 Big Data: Interact with big data technology to access, mine, store and process large and complex data sets.
- PO7 Wrangling: Apply data management techniques to clean, mangle, and process data.
- PO8 Data Analysis: Choose the correct methods and tools to analyze data for a variety of purposes.

Professional Practice

- PO9 Ethics: Describe, identify and address ethical considerations involved in data science, including issues related to privacy, security, and fairness, and apply ethical principles to the collection, analysis, and use of data.

- PO10 Communication: Communicate effectively with both technical and non-technical stakeholders, using data, reports, and presentations.
- P11 Professionalism: Apply professional skills such as teamwork, time management, adaptability and critical thinking to a wide variety of different problem domains and contexts.

Instructors were asked to indicate what learning outcomes were covered in their course. In each case, they were asked to indicate if their coverage of learning outcomes fell into one of the following categories:

- Introduction – Instructors introduced topics that were related to the learning outcomes
- Development – Instructors were taking material that had already been taught, or assumed to have been taught and extending that learning, going in further depth and providing opportunities for practice
- Mastery – Instructors were going into substantial depth, giving students opportunities to practice while also extending the application of their skills and knowledge to problem-solving scenarios.

A gap analysis was conducted to identify learning outcomes that appeared to have limited coverage in the curriculum. These gaps were addressed through the introduction of the courses AMS 1910, AMS 2910 and AMS 4910 into the major program. Additionally, the course description for STAT 3660 was updated to clearly demonstrate how its content and goals differ from those of AMS 1910: *Introduction to Data Science*, AMS 2910: *Design Thinking with Data*, and CS 4120: *Machine Learning*.

b) List the graduate outcomes for the program and indicate if there have been any changes. ^(Tip)

This program is primarily designed to prepare graduates for employment in data-oriented industries. The three key roles students are being prepared for are:

- Data Analysts - People who perform detailed analysis on data, usually for the purposes of reporting requested information. These are positions currently serviced by SMCS, with recent graduates filling roles on the island.
- Business Analysts - People who tend to be trained in business processes and conduct analyses that improve business processes using data. The existing Business Analytics program currently services this route into data-oriented industries.
- Data Scientists - People who perform analysis with the purpose of providing insights and predictions from data, are skilled in machine learning and deep learning, and are skilled at communicating those insights to stakeholders. These are people who have some theoretical knowledge of related degrees, but not the depth of knowledge possessed by computer scientists, mathematicians, statisticians, for example. However, they have depth in applying theory to problems relating to data. This career is the key target for the student pursuing a major in Data Science.

While the primary outcome for this program is not necessarily to pursue graduate studies in the Mathematical and Computational Sciences, there are master's programs with flexible admissions requirements, where the emphasis is on quantitative skills. Examples of two such programs are

Master of Science in Statistics, McMaster University
<https://math.mcmaster.ca/graduate/application-procedure/m-sc-program-in-statistics/>

Master of Management Analytics, Rotman School of Business, University of Toronto
<https://www.rotman.utoronto.ca/programs/specialized-programs/master-of-managementanalytics/admissions-requirements/#criteria>

We also note that there is enough flexibility in the programs to add specific courses that would make students eligible for a broader range of master's programs. In such cases, students are advised to follow the curriculum requirements for our programs in Mathematics, Statistics, or Computer Science.

3) Delivery Modes

For more information on delivery modes, consult the MPHEC's [Guidelines for Institutional Frameworks for Online and Technology-Supported Learning](#). Identify the delivery mode(s) in which the program is designed to be offered (check all that apply): ^(Tip)

X In-person learning – all instruction takes place in an in-person setting

- Online learning – all instruction is fully online and is:
 - Synchronous
 - Asynchronous
 - Both synchronous and asynchronous
- Hybrid learning – a required combination of online (synchronous or asynchronous) and in-person instruction. All students in a hybrid program are expected to undergo the same combination of online and in-person activities. Provide details:
- Hyflex learning – instruction is available simultaneously online (synchronous and/or asynchronous) and in-person. Students can decide which modality to use to access the program components and can make that decision on an ongoing basis.

4) Admission, Promotion, and Graduation Requirements ^(Tip)

a) Describe the program's standard admission, promotion, and graduation requirements and indicate if there have been any changes.

Admission to a Bachelor of Science at UPEI requires successful completion of Grade 12 examinations (academic) in a University Preparatory Program with an overall average of at least 70% (75% for Quebec Secondary V students) in the following subjects:

- Grade 12 Academic English
- Grade 12 Academic Mathematics
- Two Grade 12 Academic Science subjects (acceptable subjects: Chemistry, Biology, Physics, Computer Science, Oceanography, Animal Science, Environmental Science)
- One additional Grade 12 Academic course

There are no additional requirements for admission to programs in the School of Mathematical and Computational Sciences. There have been no changes in these requirements.

5) Human Resources

No new human resources are required for this modification.

Between 2016 and 2025, the School of Mathematical and Computational Sciences added seven full-time faculty members to support new programming and to address the increasing number of students studying Computer Science. The School of Mathematical and Computational Sciences now has 21 fulltime faculty members (tenured or tenure-track) and two faculty members on limited-term appointments.

Sessional instructors and contract faculty are primarily used within SMCS to deliver foundational courses such as MATH 1910, MATH 1920, MATH 2610, and CS 1920, alongside full-time faculty members. Contract faculty provide support for sabbatical, parental and other leaves of absence, and occasionally teach 3000-level and 4000-level courses in their area of expertise.

The programs in Data Analytics and Business Analytics were initially designed to utilize existing courses in Mathematics and Computer Science, with additional Statistics courses being offered as new faculty members were hired. We now have ample capacity to offer all the required MATH, STAT and CS courses. We also note that apart from AMS 1910, AMS 2910, STAT 3660 and AMS 4910, all other courses are required by at least three other SMCS programs, with the Common Core being required by all SMCS programs. Therefore, the only courses specific to the modified Analytics program are AMS 1910, AMS 2910, STAT 3660, and AMS 4910, with the three AMS courses being added since the 2021 review.

Despite the addition of three courses, no new resources are required. This is because many of the required mathematics and statistics courses have been made elective. For example, with the modified program, courses such as MATH 3430 Combinatorics II, AMS 2940 Optimization, and AMS 3770 Combinatorial Optimization could be offered less frequently in response to student demand and instructor availability – we are no longer obligated to offer them annually.

- a) The table identifying all of the faculty members and instructional staff expected to teach required courses in the program is found in **Appendix 6**.
- b) Describe the hiring plan, where applicable,

As stated previously, no new faculty are required for these modifications, so a hiring plan is not included.

- c) Describe how contract faculty (or full-time faculty who will teach in the program on overload) will be used in the delivery of this program (e.g., to replace sabbatical leaves, provide added breadth).

Sessional instructors and contract faculty are used within our School to deliver foundational courses such as MATH 1910, MATH 1920, MATH 2610, and CS 1920, alongside full-time faculty members. Contract faculty provide support for sabbatical, parental and other leaves of absence, and teach courses in their area of expertise. However, 3000 and 4000-level courses in the School of Mathematical and Computational Sciences are almost exclusively taught by full-time faculty members.

6) Collaborative and Jointly Developed Programs **N/A**

7) Implementation of Truth and Reconciliation Commission (TRC) Calls to Action^(Tip)

- a) Describe how the TRC Calls to Action are being addressed and/or implemented within the institution.

At the University of Prince Edward Island (UPEI), the path toward reconciliation is being shaped by a series of thoughtful initiatives that respond to the Truth and Reconciliation Commission (TRC)'s Calls to Action, reflecting a deepening commitment to decolonization and indigenization of our institution.

One of the most impactful steps has been the integration of Indigenous knowledge and perspectives into the university's curriculum. This includes a required Indigenous Teachings course for all incoming students, which introduces the ceremonies, protocols, and traditional cultures of the three distinct groups of Indigenous Peoples recognized in Canada. Beyond this foundational course, UPEI has developed additional programming that encourages students to explore Indigenous histories, cultures, and contemporary issues, fostering a deeper understanding of Canada's colonial legacy and its ongoing impacts. A recently approved Minor in Indigenous Studies, open to all students, further supports this learning and reflection.

Creating welcoming spaces and support systems for Indigenous students is also a priority at UPEI. The Mawi'omi Indigenous Student Centre offers a culturally affirming environment for academic, social, and personal support. It serves as a hub for connection and celebration, helping students feel seen, valued, and supported throughout their academic journey.

To support these initiatives, UPEI has taken meaningful steps to increase Indigenous representation among faculty and staff, recognizing the importance of Indigenous voices in shaping institutional policies and decision-making. This commitment is reflected in the establishment of the Faculty of Indigenous Knowledge, Education, Research, and Applied Studies.

The university's broader governance strategy also reflects its reconciliation goals. The UPEI Action Plan, *Building a Culture of Trust, Safety, and Inclusion*, outlines a five-year roadmap that includes initiatives aimed at advancing reconciliation, improving campus culture, and ensuring institutional accountability.

UPEI hosts workshops, creative sessions, and commemorative events throughout the year, including the annual Mawi'omi gathering on the National Day for Truth and Reconciliation. This event brings together the university and broader community to remember, reflect, and learn together. These activities are designed to increase awareness, foster respectful relationships, and ensure that the stories and experiences of Indigenous Peoples are honoured and understood.

b) Describe how the TRC Calls to Action will be addressed and/or implemented within the modified program.

Across our analytics curriculum, case studies and projects emphasize how data practices can either perpetuate or challenge systemic inequities, directly aligning with TRC goals.

The group projects involved in this program emphasize collaboration, equitable participation, and communication with diverse audiences. These principles align with reconciliation values by encouraging students to approach data analysis with humility, inclusivity, and awareness of diverse perspectives. Students are encouraged to consider whose voices are missing from datasets and how to responsibly engage with communities affected by data-driven decisions before they are implemented.

Courses explicitly cover responsible data practices, privacy, fairness, and ethics, including how bias and unethically sourced data can reinforce historical injustices. This directly responds to TRC Calls to Action that emphasize the need for educational programs to confront legacies of colonialism and systemic inequities. By highlighting how datasets themselves may reflect practices of exclusion, misrepresentation, or exploitation, students learn to critically interrogate the role of data in perpetuating inequity.

8) Equity, Diversity, Inclusion and Accessibility (EDIA)

- a) Describe how equity, diversity, inclusion and accessibility (EDIA) be addressed within the modified program.

Integrated into the curriculum is a human-centered, context-sensitive approach to data analysis and design of solutions. In particular, the chain of courses that form the primary material for the analytics knowledge, abilities and skills, AMS 2910, STAT 3660 and AMS 4910, introduce students to a design thinking framework that is human-centered, and grounded in the perspectives of the people that data is about, the people they are working with in their teams, and reflecting those perspectives, biases and uncertainties in how they communicate their results. This focus on the thoughtful use of data regarding the lived experiences of people that are connected to it is a distinctive feature of this data analytics program in the Atlantic region.

The curriculum is designed to reflect the diverse realities of the world students will engage with. Courses will explore topics such as responsible use of data, bias in data sets, and transparency in reporting, encouraging students to critically examine how data systems can reinforce or challenge social inequities. Through case studies drawn from equity-seeking communities, students will learn to apply data science in ways that are socially responsible and culturally aware. Through lectures and projects, students learn to identify bias within datasets, assess limitations, and evaluate potential harms of analysis. This equips future data scientists with the responsibility to avoid repeating or deepening harms against equity-seeking communities.

To ensure that socio-economic factors do not keep members of the student population from participating in a program that provides routes to opportunities in the new data driven digital economy, the program will use of open platforms, data, resources and open-source tools. This will help ensure that students from all backgrounds can participate fully without financial barriers.

Equity, diversity and inclusion remain a priority for the overall strategic plan for UPEI. As a result, there is a commitment both at the university and within the program that course materials will be designed to be responsive to the accessibility needs of students with disabilities about materials, tools and spaces in which they will learn.

The academic unit offering this program has recently completed several rounds of faculty hiring. Since 2019, we have welcomed a diverse group of new faculty members whose identities are historically underrepresented in science and engineering disciplines, particularly in pathways leading to digital careers. This includes people who bring quite varied lived experiences and perspectives related to gender, race, culture, and disability. As visible role models, they contribute to a more inclusive academic environment and are well-positioned to inspire prospective students by helping them see themselves reflected in this increasingly important discipline and degree program.

9) Additional Information

- i. Provide any other information not covered above that will assist the MPHEC in its understanding and assessment of the modification(s).

We have consulted with the Acting University Librarian Simon Lloyd and our subject-specific librarian, Rosie LeFaive. They indicated that our program modification would not result in any new resources or costs to the library. The library also completed a review of the two new courses proposed for the Analytics Major, AMS 2910 and AMS 4910. These are included in the Appendices (Appendix L).

SMCS's Self-Assessment Document from our 2021 Quality Assurance Review is included in the Appendices (Appendix S).

Feedback on the Information Requirements

The Maritime Provinces Higher Education Commission is committed to the continuous improvement of our program assessment process. We recognize that **clear information requirements** significantly contribute to the ease and efficiency of developing proposals for new and modified programs. To this end, your feedback on the *Information Requirements* you have just completed are greatly appreciated. **We encourage anyone who was involved with the development of this proposal to complete our [online satisfaction survey](#).** Please note that unless you opt to share your name, this survey is anonymous.

APPENDICES

Please ensure that **each of the following is appended/included** when submitting a completed program proposal.

- x A list of the appendices to the program proposal
- x Appendix 1: Consultant's Report from the Last External Review and the Institution's Response (*required if program has not been previously assessed by the MPHEC*)
- x Appendix 2: Side-by-Side of Program Requirements and Hypothetical Student Progression
- x Appendix 3: Academic Calendar Course Descriptions
- x Appendix 4: Program Comparison Table
- x Appendix 5: Student Learning Outcomes Table
- x Appendix 6: Faculty Resource Table
- Appendix 7: Copy of the Revised Inter-institutional Agreement (or Equivalent) for Collaborative Programs (*required if changes have been made to the inter-institutional agreements*).

Other, as applicable:

- A letter of support/approval from the Atlantic Advisory Committee on Health Human Resources (AACHHR) (*required for health-related programs in all three Maritime provinces*)
- A letter of support/approval from the Department of Education and Early Childhood Development (EECD) (*required for education programs in Nova Scotia*)
- Signature (or appended letter) confirming the collaborative submission, and principal applicant
- Any additional information to help the MPHEC assess the quality of the proposed program

Appendices

1. Appendix 1: Consultant's Report from Last External Review and the Institution's Response.
2. Appendix 2: Side-by-Side of Program Requirements and Hypothetical Student Progression
3. Appendix 3: Academic Calendar Course Descriptions
4. Appendix 4: Program Comparison Table
5. Appendix 5: Student Learning Outcomes Table
6. Appendix 6: Faculty Resource Table
7. Appendix L: Library Information
8. Appendix S: School of Mathematical and Computational Sciences Self-Assessment Document , May 2021

Appendix 1

Consultant's Report from Last External Review and the Institution's Response

Report of the Quality Management Review Team
School of Mathematical and Computational Sciences (SMCS)
University of Prince Edward Island (UPEI)
June 22-23, 2021 Review

Team:

- Stavros Konstantinidis, Saint Mary's University
- Denis Latulippe, Université Laval
- Wayne Peters, University of Prince Edward Island
- Ying Zhang, Acadia University

Preamble

A Quality Management review of UPEI's School of Mathematical and Computational Sciences was carried out in June 2021. This review considered the following five programs:

- Actuarial Science (including Pre-Professional Specialization)
- Analytics (including Business Analytics and Data Analytics Specializations)
- Computer Science (including Video Game Specialization, Honours and Minor)
- Financial Mathematics
- Statistics (including Honours and Minor)

This review did not include the Mathematics program which will be reviewed at a later date.

Due to COVID-19 restrictions, this review was conducted virtually using Zoom. In preparation for the review, the team reviewed several documents and online information. During the review, virtual meetings with a number of individuals were held. The following resources and meetings were considered:

- Self-Assessment Report (with appendices) developed by the SMCS
- A virtual tour of the School's facilities in the Cass Science Hall (<https://youtu.be/HXBRfb-CfjQ>)
- Publicly available information on the UPEI website
- Virtual meetings with Kathy Gottschall-Pass, Vice-President Academic and Research (Interim)
- Virtual meetings with Nola Etkin, Dean of Science
- Virtual meetings with Shannon Fitzpatrick, Associate Dean (Interim), SMCS
- Virtual meetings with faculty members in the School's various programs
- Virtual meeting with Rosie Le Faive, Librarian, Robertson Library
- Virtual meeting with SMCS students

Note that this review considered the normal non-COVID operations of the SMCS program. The manner in which it adapted its programs and delivery for the 2020-2021 year in response to COVID restrictions was not considered as part of this review.

The review team's findings are summarized in the following sections, which follow the questions outlined in the *Guidelines for Advisory Teams* (prepared by the Senate Academic Review and Planning Committee as required by Senate policy on Quality Management for Academic Units).

1. Aims and Objectives:

Does the unit have a clear and reasonable strategic direction? Are the aims and objectives of the unit's programs clearly articulated? Are they realistic and achievable? Do they serve the mission of the University and/or the Faculty/School/College?

The School's aims and objectives are clearly articulated in its mission statement which includes delivering quality programs, preparing students for relevant careers or graduate studies, contributing to knowledge through research, and providing relevant foundational skills to all UPEI students. Each of these specific objectives directly contributes to the University's overall mission. These aims and objectives arise from an internal review and restructuring in 2016 that created new and comprehensive programming in the mathematical and computational sciences.

In light of this, the review team believes that the School also has a clear and reasonable strategic direction for each of its programs as outlined in its Self-Assessment Report. This is well-served by having the various inter-related programs grouped and harmonized under the direction and leadership of the School allowing it to respond quickly and effectively to any programming needs. This is especially relevant in the context of the "fourth industrial revolution" associated with the emergence of artificial intelligence and with the financial services industry which is working to develop data analysis capacity and to become much more data-oriented organizations. It is clear from our review that the School is supportive of such important changes and has given careful consideration to its suite of programming to ensure that it remains relevant and desirable.

2. Curriculum and teaching:

a. Are the unit's strategic directions and plans appropriate and realistic?

The strategic directions and plans are appropriate but ambitious considering the available resources, especially the number of faculty members. The programs were adapted to new realities in the last years, and they are now well aligned with the students and society needs. Moreover, the School offers a coherent set of programs and courses covering the major fields related to mathematical and computational sciences. In this context, the additional requested resources should not be seen to grow new programs; they are tied to the unit's need to maintain a reasonable quality of programming for existing programs and commitments.

Existing alliances with other faculties, such as Economics and Business faculties for actuarial science and financial mathematics, are certainly appropriate and realistic. As discussed below, reinforcing cross-sectional teaching between programs and even developing new alliances with other universities for some specific matters could also be considered, along with a proper mix of in-person and on-line teaching.

b. Is the curriculum coherent and up-to-date?

There have been some significant curriculum changes in the past years to update the programs and related service/cross program courses so that the overall curriculum seems to be coherent and up-to-date. There is the possible exception of Analytics (to be renamed as Data Science) which is a new and evolving field. The Analytics faculty are already proposing ways to update the curriculum. The introduction of analytics will also be an opportunity to update other programs, such as statistics and actuarial science, where there is growing demand and need for analytics specialization.

There seems to be an issue with the offering of elective courses, especially considering the fact that they are often offered only once every two years. Moreover, we would have appreciated a more global assessment of the situation in the self-assessment report: The situation of each program is presented separately. This leads us to think that there could be a more integrated approach to the course offering, especially elective courses.

At a more micro level, we have a few minor comments about the computing component with a few courses (such as Stat 1910), and possible overlap between MSC 4210 and Stat 4550. As stated in the self-assessment report, the former concern can be addressed by requiring the R-course in the early time, or introducing a lab session into Stat 1910 with R.

- c. *Does the curriculum contain the necessary basic courses? Is the level of the basic courses satisfactory?*

Yes. In actuarial science, accreditation by professional bodies make it more challenging. All universities have to cope with these requirements that are especially important for UPEI, as a new program. In the coming years, the Canadian Institute of Actuaries (CIA) will be moving from course accreditation to program accreditation. It should be seen as an opportunity and the director of actuarial science should be involved with the CIA to influence coming developments and make sure that the realities of smaller universities are properly considered.

- d. *Does the academic unit make the most effective use of appropriate and available distance learning modalities?*

The Covid-19 pandemic forced the reinforcement of distance learning. The School faculty members should build on this new reality in the context of flexible and hybrid approaches best suited to the UPEI situation. It should contribute to reducing the teaching load of the faculty members involved (for instance having material available on the Internet), increase flexibility for students, and even reinforce interactions in a context of active learning.

Like all of us, though, implementing the plans and tools to do this for this past year was likely done somewhat quickly and probably without enough forward thinking as we tried to respond to an abrupt change. Going forward, we expect there will be much more thoughtful consideration given to how we do these things and that the University will

contribute to the emergence of this new reality, by providing adequate and prompt support (support personnel and equipment/platforms).

It should be done with care and discernment as close human relationships is a student's expectation and a UPEI strength.

The Self-Assessment outlined the issue of lack of TA resources and lab space as well as scheduling issues that may be addressed partially by remotely teaching and online assignment system.

e. Are degree requirements appropriate?

Yes, although as discussed below, the number of elective courses varies a lot between programs.

f. Is the supply of elective courses satisfactory?

It varies program by program. There is only 1 elective course required to complete a major in Computer Science. Other programs have a large elective course space. For example Statistics has 52 electives while Analytics Business Specialization has 13.

We did hear from faculty and a bit from students about the lack of availability of elective courses. It seems a problem that 3rd or 4th year program specific courses are offered in alternate years.

Cross-listed courses between programs increases the supply of elective courses. As mentioned in b) , thought should be given to have a more integrated set of elective courses for the different programs.

g. Are admission requirements appropriate? Are there appropriate procedures and mechanisms for assessing applicants?

These subjects are outside the responsibilities of the unit. However, after our meeting with the Vice-President Academic and Research, we feel that admission requirements and procedures for assessing applicants are indeed appropriate.

In fact, the admission processes at UPEI are typically handled fully by the Registrar's Office in terms of confirming entry requirements. They would reach out to the unit directly for recommendations where transfer credits are to be considered. The entry requirements for students coming right out of high school are consistent with those for other science/engineering programs. These processes are fairly standard across almost all programs at UPEI.

The challenge regarding admission has probably more to do with the assessment of the prerequisite of international students, especially for computer science where there is a large number of applicants.

h. Does the unit provide appropriate academic advisement to students?

On paper, the structure for supporting student advisement seems appropriate. Each program has an identified individual who is student-facing for this. Student advising is provided by the Director of Actuarial Science & Financial Mathematics and the three Program Leads: in Mathematics and Statistics, in Computer Science, and in Analytics (to be renamed as Data Science). Generally, students seem satisfied with the advising they get and with the overall dedication of their professors.

Nonetheless, as stated in the self-assessment report, integration and cohesion among students seem to remain an issue. More effort may be needed to provide support to international students to help them transition from the past to the current. A person who is familiar with the situation (either faculty/staff/senior student) in the program can be designated into the advisement team, considering the size of the international students.

i. Are the core required learning outcomes (e.g., communication, including literacy and numeracy, the ability to carry out research, problem solving, critical thinking, selfdirectedness and experiential learning) across the curriculum clearly laid out for students and linked to required courses?

We did not find much about this in the provided documents. Two courses were added to the curriculum, namely Communication in the Mathematical Sciences (MATH401 - 3 credits) and Tutoring in the Mathematical Sciences (MATH401 - 1 credit).

This could be a challenge for the School to deal within the next few years. It usually involves defining a set of possible (high level) learning outcomes and then making a table specifying, for each required course and for each outcome, the score (e.g., 1 to 5) of the course content towards the learning outcome. Based on what we see in other universities, the UPEI administration would need to provide infrastructure for this task, normally via skilled administrative assistants.

j. Are the methods of evaluating student academic achievement appropriate and are various methods of evaluating student achievement mixed in appropriate proportions?

Yes, as confirmed by checking through course outline and exam files.

k. Are the experiential education components (if any) of the curriculum appropriately designed? Is there an appropriate procedure in place to administer and evaluate the experiential education components?

Co-op work is encouraged in some programs such as Computer Science and Actuarial Science. The students then have an opportunity to work with employers on different projects and submit a report for evaluation for each project. There is also involvement of some students in capstone projects (e.g., in courses led by Professor LeBlanc). On the

other hand, the students we met indicated that the courses of the last two years (3rd and 4th) should be more project-based.

In this context, and based on the information we got, we consider that there could be an assessment of the co-op experience to ensure consistency and appropriateness across programs, and see how it could play a role in evaluating the students. This should also be taken into account in assessing the goal of the academic portion of the programs.

l. Is the student work load appropriate?

The results presented in the Self-Assessment Report are positive overall. No concern was expressed by the students during the interview, except for Actuarial Science students who stated that preparation for the professional exams is an extra-load. Nonetheless, they mentioned that professors do cover the exams material and preparation even if not obliged to. It should help promote professional qualifications

3. Research:

a. Is the pattern of scholarly research and/or creative activity within the Department, School, or Faculty appropriate?

Yes. We feel that the pattern of research and creative activity in the unit is clearly appropriate. In the past two years, they had produced about 43 refereed journal publications and 24 conference presentations, and 10 faculty members have received external research grants from multiple national/regional grant agencies (such as NSERC, CIHR, AARMS and MITACS) as PI or co-investigator. We also note the organization of two international conferences in the past 5 years, one of which (CIAA 2019) published proceedings in the well-known series LNCS. The unit had also hosted the AARMS Summer School in 2017, 2018, and 2019. Those records clearly show the active HQP training activities (3 of students co-authorships in the past two years). They also highlight the healthy collaboration of researchers across SMCS programs and outside of SMCS and the industry engagement.

b. Does the Department, School, or Faculty show potential for continued scholarly research and creative activity?

Yes. With multiple existing programs, the interdisciplinary research collaboration is a strength in SMCS. The recently added Masters of Science in Mathematical and Computational Sciences provides an effective platform for faculty members to further focus on those collaborative projects and allow students to access broad expertises and funding resources. In addition to the current Honours research programs, the School has proposed new Honours programs in Actuarial Science and Financial Mathematics, and has the potential for future research investment in data analysis and processing for crosscampus collaboration with “data science adjacent” research areas.

4. Service:

- a. *Are the goals and objectives of the unit with respect to professional and/or community service clearly laid out?*

Yes. The individual faculty member CVs show that all faculty members contribute to service at the school level. SMCS has a strong presence in the university committees and activities. There have been significant outreach activities including Math Camp (that has been conducted over the past two decades), PEI Math Leagues organized in the recent years, and various activities initiated/performed by the individual faculty members (such as high school teacher programming training, high school student mentorship, integrating the statistical reasoning course from Census at School into the existing PEI curriculum). All these help promote mathematical and computer sciences and encourage high school students to continue their mathematical and computer studies at university.

- b. *Is the level and quality of service being provided to the University, the profession and the community appropriate?*

Yes. In spite of the full teaching and research load, faculty members have provided substantial services to the University, the profession and community.

5. Balance:

- Is there an appropriate balance in the Department, Faculty or School among scholarly research, teaching and professional or community service that would allow the Department to fulfill its mission?*

The overall view is that, for several faculty members, the balance of responsibilities is more heavily weighted toward teaching than it should be.

The standard teaching load of five courses per year is at the high end when compared to other universities, but it is the same as in universities of comparable size. Teaching three courses in one semester leaves very little room for meaningful research during that semester. While there is relief for newcomers who want to establish themselves in research or for those receiving their first research grants, there should be a simple mechanism for established faculty with externally funded research to get a one course release for research. Such a simple mechanism exists, for instance, at Saint Mary's University, where 10 months before the beginning of an academic year, faculty with external funding state in writing their wish for a one course release and the Chairperson and Dean simply confirm the authenticity of the external funding. The existing mechanism of accumulating small points for HQP supervision toward research release should still be available at least for those with no external funding.

With the existing faculty complement, it is a challenge to deliver all scheduled courses and programming expectations, in Actuarial Science, in Computer Science and in Statistics. Sabbatical and other leaves cannot always be filled with qualified sessionals, so faculty take overloads out of necessity. The existing pool of sessionals is not always sufficient to cover the teaching needs and, in any case, increasing the number of sessionals is not always a good solution as these individuals make no, or little, research/service contributions.

There is also an issue with equitable distribution of faculty workload. Faculty in areas with student growth teach larger classes compared to faculty in other areas. One solution is that the former faculty should have a reduced service duty, provided that the latter faculty have sufficient capacity to fulfill the internal service expectations.

6. Facilities and Resources:

Does the University have a sufficient supply of the following facilities and resources?

- a. *office, teaching, research, and study areas;*
- b. *equipment of various sorts, including audio-visual, computer, and multi-media;* c. *library resources.*

Faculty are happy with the available library resources, and they raised no issues about needing more equipment. There is a growing need for data sets, but this does not seem to be an issue. Faculty members can access open data sets or use data developed for their own research.

It seems that in the near future, the current building will not be able to accommodate office space for all faculty members.

The most serious issue is limited computer lab space. There is one lab with 40 computers and this lab is non-configurable. While this was possibly sufficient 10 years ago, there is a need for, either a larger-and-configurable lab, or for a second lab, due to the rapidly growing student population and the need for computer lab space in several courses. A second lab would allow lab classes to take place in parallel. In any case, a solution should be given to the limited computer lab space.

7. Faculty:

- a. *Does the Department, School, or Faculty have enough members with the appropriate areas of specialization?*

The short answer is no. For example, there are (significantly) more than two specialization areas in Statistics and (significantly) more than six specialization areas in Computer Science. Of course, in a small university the limited number of faculty members makes it a challenge to cover all areas of specialization. The possibility to increase collaboration with industry experts or faculty in other universities should be

considered, keeping in mind that relying too much on such people is not a good solution as these individuals make no research or service contributions.

- b. *Does the Department, School, or Faculty make adequate provision for faculty members to be able to pursue research programs as well as teaching and administrative activities? Is the balance among teaching, research, and service appropriately struck?*

Regarding the "balance" part of this question, we refer the reader to the section "Balance" discussed above. In that section, we suggested that a simple mechanism should be in place for course releases for faculty holding external grants and we noted that for several faculty the balance of responsibilities is more heavily weighted toward teaching, out of necessity to meet the teaching needs of the unit. It is a challenge to deliver all scheduled courses and programming expectations, and to make more available course sections for students to take--with the rapid student increase, there are more and more students who cannot take a course that is offered only once in a year or once in two years. It is clear that there is an issue with the low number of faculty members. Students pointed this out directly or indirectly: only two full-time statistics faculty and a limited choice of CS elective courses which is due to the low count of CS faculty. The last CIPS accreditation report in 2012 concluded that "there was an urgent need for hiring a minimum of 1 person to avoid fragility of the (CS) program". In the last few years, with the creation of the unit there has been a rapid growth in student population. While the new position in "Data Science-and-Computer Science" will cover some of the pre-2016 needs, it will not be sufficient to mitigate the challenges with the post-2016 growth in student population. It is also evident that the School needs additional Statistics faculty to reach a higher quality and meet the expertise demand from Actuarial and Data Sciences. In addition, as indicated in the Self-Assessment, the lack of lab/tutorial support to Stat 1910/Stat 1210 can be a serious quality issue. Note that the Statistics program at Acadia University with 4.5 faculty members and one full-time lab instructor does not have an official Statistics major. The limited number of faculty members in actuarial science also make it precarious to achieve the evolving requirements of professional accreditation, which are increasingly recognized as a necessary standard.

- c. *Is the student/faculty ratio appropriate?*

Assuming the ratio refers to the number of majors divided by the number of faculty, the Computer Science program has a high ratio: about 280/6. This is nearly 3 times higher than the ratio in the CS program at Saint Mary's University (Halifax). Considering also service and cross-platform courses, the ratio must be very high in the Statistics program.

8. Quality Assurance:

Does the Department, School, or Faculty adequately measure the effectiveness of their activities?

It is assumed that this is the first review of these SMCS programs since they were first created in 2016. As such, this current review is certainly timely, following five years of delivery. While there was no information provided in the documents or during our virtual meetings regarding this item, the review team believes that it is important for the SMCS to develop appropriate measures that can be used to monitor its ongoing effectiveness in meeting its established program delivery goals.

9. Graduate Programs (if applicable):

- a. *Is the level of scholarship within the Department, School, or Faculty (as shown by scientific, scholarly, and professional publications or by appropriate creative activity) satisfactory for a graduate program?*

Yes. After reviewing the research publications and external funding records as well as the current faculty member research profiles, we believe the level of scholarship is satisfactory for a graduate program. The program is under the direction of the Faculty of Science. So the strong interdisciplinary nature of the SMCS programs will ensure a wide range of research options and resources to future students. Noting that UPEI is the only university on the Island, the graduate program will provide a unique opportunity for both UPEI students and beyond.

- b. *Does the program satisfy the normal expectations of a graduate program?*

Yes. In spite of the research funding limitation (which is common in most primary undergraduate universities in Canada), through our interviewing with faculty members, the Vice-President Academic and Research and the Dean of Science, we have confirmed that the program can satisfy the normal expectations of a graduate program by following a similar model used by other similar size universities. In addition, we observed that SMCS has a strong record in faculty member collaboration. The collective effort such as cosupervision and creative funding formula will provide a satisfied research environment for graduate students.

10. Advice:

Taking into account fiscal constraints, what are the two or three most important things that the academic unit could do to improve the quality of its programs?

- Consider a more integrated and flexible approach to offering elective courses among the various different programs in order to maximize course availability and options for students while optimizing the use of available teaching capacity.
- Identify/provide additional space to support the delivery of the labs in the Computer Science program.
- A need for additional faculty and lab instructor positions has been identified in the SMCS Self-Assessment report to better support the requirements of the different programs, to facilitate a more equitable distribution of teaching loads among faculty, and to maintain the overall quality of existing programming. Unfortunately, these needs were presented separately for individual programs rather than being coordinated and prioritized in any overall School plan.

Based on its review, the review team believes that justification does exist to support a request for some additional faculty and lab instructor positions. However, in order to better justify the recommended human resources support, the SMCS is strongly encouraged to develop a more coordinated and integrated staffing plan which considers a phased-in approach to hiring and identifies ways in which teaching capacity can be shared among programs.



October 12, 2021

Dear Dr. Gottschall-Pass,

Please find attached the School of Mathematical and Computational Sciences (SMCS) response to the Report of the Quality Management Review Team. The reviewers provided a comprehensive report on the following programs, including all associated specializations and honours programs:

- Actuarial Science
- Analytics
- Computer Science
- Financial Mathematics
- Statistics

The faculty and staff of SMCS thank the review team for the time and effort they dedicated to this extensive review. We were glad to see many favourable comments from the reviewers, endorsing our overall vision for education in the mathematical and computational sciences at UPEI and acknowledging our members' efforts to deliver quality programs to our students. We appreciate their commentary on the challenges we face, as well as their advice and recommendations.

We look forward to working with you and other members of the administration to address the challenges identified in the reviewers' report and implement suggested changes.

Sincerely,

A handwritten signature in cursive script, appearing to read "S Fitzpatrick".

Shannon Fitzpatrick, Interim Associate Dean
School of Mathematical and Computational Sciences

SCHOOL OF MATHEMATICAL AND COMPUTATIONAL SCIENCES

550 University Avenue, Charlottetown, Prince Edward Island, Canada C1A 4P3

T 902 628-4349 F 902 566-0466 upei.ca/mathcompsci

School of Mathematical and Computational Sciences'
Response to the Report of the Quality Management Review Team
October 2021

The following is the response from the School of Mathematical and Computational Sciences (SMCS) to the Report of the Quality Management Review Team. In their report, the reviewers' comments fall under 10 categories. Our responses to their comments are similarly categorized. In general, the reviewers identify issues and challenges that were also identified by SMCS in the self-study. As such, we largely agree with their observations and recommendations. Their time and dedication to this comprehensive review are very much appreciated.

1. Aims and Objectives

The reviewers were very supportive of SMCS's objectives and how they fit within UPEI's overall mission. They were also supportive of the School's administrative structure in that it allows us to "*respond quickly and effectively to any programming needs*" within our interrelated programs. We appreciate this endorsement from the reviewers.

2. Curriculum and Teaching

The reviewers state that "*the additional requested resources should not be seen to grow new programs; they are tied to the unit's need to maintain a reasonable quality of programming for existing programs and commitments.*" We agree with this assessment. All requested resources are tied to ensuring quality programming by (1) providing experiential learning in the classroom, (2) expanding elective offerings in critical areas, and (3) ensuring we have qualified faculty delivering these programs.

To prepare students for their place in the "*fourth industrial revolution*," we need to incorporate more active learning in the classroom. This demand is coming from both faculty and students, with the reviewers noting that "the students we met indicated that the courses of the last two years (3rd and 4th) should be more project-based."

Instructors require computer workstations in the classroom to provide students with hands-on learning opportunities, whether it be data analysis, mathematical modelling, or live coding. With a single 40-person computer lab (CSH 104), we cannot currently add these active learning components to our classes. In fact, we are going in the opposite direction. With increases in enrolments, many Computer Science classes that were once held in CSH 104 can no longer be accommodated by that room. As a result, our ability to include active

learning activities in lectures is decreasing. Expanded computing facilities and having access to "smart" classrooms are a high priority for SMCS. This will be discussed further in Section 6. Facilities and Resources.

To expand elective offerings, the reviewers suggest that "*there could be a more integrated approach to the course offering, especially elective courses.*" Such opportunities exist within Statistics, Analytics and Actuarial Science. Statistical Modelling and Predictive Analytics courses required for Actuarial Science are good elective options for Statistics and Analytics majors. Once we have faculty who can deliver these courses regularly, we will promote them more extensively across programs.

Finally, the reviewers noted challenges related to the preparedness of students entering SMCS programs. "*Challenge regarding admission has probably more to do with the assessment of the prerequisite of international students, especially for computer science where there is a large number of applicants.*"

SMCS faculty have noted a variation of preparedness among international students in particular. Many students admitted into SMCS are not sufficiently prepared for their introductory courses of Math 1910, Stat 1910 and CS 1910. Current admission requirements into the Faculty of Science do not consider the variation of high school mathematics programming on a global scale.

In Computer Science, many majors repeat courses at the 1000 and 2000 levels numerous times. Despite limited success, these students are dedicated to remaining in the program until all options are exhausted. Given the growth rate of Computer Science, enrollment management is a necessity. SMCS looks forward to working with the Dean of Science, Registrar's Office, and the International Office to address these issues.

3. Research

We agree with the reviewers that "*interdisciplinary research collaboration is a strength in SMCS.*" There are opportunities to expand on this by recruiting faculty who align with UPEI's strategic plan and research goals. By building research capacity in Machine Learning, Deep Learning, Big Data Analysis, and Risk Analysis and Management, SMCS will be wellpositioned to contribute to a wider variety of research initiatives both on the UPEI campus and within the broader community.

4. Service

The reviewers noted that SMCS faculty members have "*provided substantial services to the University, the profession and community.*" While much of our service to the community has been curtailed over the last 18 months, we look forward to returning to our regular outreach initiatives when it is safe to do so.

5. Balance

The reviewers note that "the balance of responsibilities is more heavily weighted towards teaching than it should be." They advocate for a mechanism for faculty who receive external funding to receive teaching release for research. They note that researchers who do not have external funding should continue to access the system of accumulating teaching credits for student supervision.

SMCS faculty support this recommendation. We point to a previous program out of the Office of the Vice President Academic and Research, which provided teaching release for the duration of a faculty member's first Tri-Council grant. While this did not fully address the issues around teaching-research balance, it allowed new faculty to firmly establish their research profile, incentivized faculty to apply for NSERC funding during a time when the success rates had drastically decreased and served as a vital recruiting tool for new faculty.

6. Facilities and Resources

Facilities

The reviewers highlight our need for additional space. They note that with the growth of SMCS, "*the current building will not be able to accommodate office space for all faculty members.*" We agree that Cass Science Hall does not provide adequate space for SMCS. Given our current faculty and staff complement, Cass Science Hall can accommodate at most two additional faculty members.

In addition to office space, we have outgrown most other faculty and student spaces in Cass Science Hall. For example, before COVID, our student lounge was frequently at maximum capacity, occupied by the same subset of students. In addition, events held in Cass Science Hall such as new student orientation, information sessions and social events could only accommodate small numbers of students. SMCS students require space to gather and build community. This is especially important given that both women and international students in SMCS have expressed concerns around inclusiveness.

As another example, there is only one research space in Cass Science Hall, which also serves as a service centre for equipment maintenance and repair. As a result, the current research space can accommodate at most one researcher. That is woefully inadequate for our research-active faculty. Researchers within SMCS require dedicated space to house equipment, conduct testing, develop prototypes, and collaborate with colleagues.

In planning for a new space for SMCS, we should anticipate further growth in our student numbers, as well as our faculty and staff complement. We, therefore, cite the following non-teaching space requirements:

- Associate Dean's Office

- Reception Area/Office Space for two administrative staff members
- Office space for 25 Faculty Members
- Office space for 3-4 Lab Instructors
- Sessional office
- Visitors' office
- Research space
- Board Room
- Faculty Lounge
- SMCS Help Centre
- Graduate Student Office Space
- Student Lounge

When it comes to teaching, the reviewers recognize that one of the most pressing issues is the limited computer lab space. Expanded facilities are required to maintain our current Computer Science lab components in courses such as CS 1910, CS 1920, and CS 2910. They are also needed to provide experiential learning opportunities across SMCS disciplines, as discussed in Section 2.

Given the growth in our programs, we have identified the following as priorities:

- Total lab capacity of 200. These 200 seats would ideally be divided into four spaces with a capacity of 50 students each, with removable partitions, so that they could be configured as two large labs, each with 100 seats.
- Two 60-person "smart" classrooms that can be configured for group work. The space would require appropriate power and internet access for students using laptops, and multiple large monitors so group members can share code, data sets and visualizations, etc. There would also need to be a limited number of workstations to accommodate students who do not have their own equipment.

The additional lab capacity would satisfy the growing demand for lab sections in CS 1910, 1920, and 2910. It would also allow us to convert the Stat 1910 tutorial into a laboratory for statistical analysis in R. These facilities would also be used for existing labs in AMS 4600, AMS 4610 and Stat 3250, as well for lectures where instructors are incorporating active learning.

These facilities would also allow instructors to include live coding and data analysis as part of the examination process. With the necessity of online learning in 2020-2021, instructors took advantage of the benefits of these evaluation methods. While academic integrity issues went along with at-home examinations, the ability to write and test code in an exam setting was highly beneficial for both students and instructors. Instructors would like to continue to test in this manner in a controlled in-person examination setting.

The smart classrooms described above would be similar to facilities found in the Faculty of Engineering. Such facilities are necessary to move to more project-based learning.

Resources

According to the original proposal for SMCS, a half-time administrative assistant was to be added to the SMCS core budget by 2018. Several factors were cited at that time, such as

- An increase in the number of majors due to new programming.
- An increase in general inquiries from students from other programs who access our courses (driven by increased enrolments in Science and Engineering).
- A School mandate to deliver outreach programming to PEI schools and the community at large.
- Initiatives such as conferences, workshops, and summer schools, which contribute to a thriving research environment and raise the profile of SMCS.

We have managed the need for this half-time administrative position through a number of casual and contract positions, but stable funding for a permanent position is needed.

SMCS currently has two staff members who serve as lab instructors - Chris Vessey (PA 7) and Justin Gulati (MTS 6). We also note that Chris Vessey's duties are described as 50% lab instruction and 50% system administrator. SMCS requires an additional lab instructor to deliver our programs. We point to the following:

- Increased enrolments in CS 1910 and CS 1920
- The need for a dedicated lab instructor for CS 2910. Faculty are currently responsible for delivering labs and taking on overload to do so.
- The need for a dedicated lab instructor for Stat 1910. This would be required for the Stat 1910 tutorial to transition to a lab.
- Increasing enrolments in our 1-credit communications course MCS 3050. This course will require an additional section in 2022-2023. (MCS 3050 and our 1credit technology labs are delivered by staff.)

We propose that a new MTS 6 position be created as a 9-month recurring contract. The applicant could have a background in Mathematics, Statistics or Computer Science, provided they had strong programming skills, knowledge of statistical techniques, and experience with R and Python platforms. Given these criteria, we feel confident we could recruit a good candidate.

7. Faculty

In the section on balance, the reviewers note that "*With the existing faculty complement, it is a challenge to deliver all scheduled courses and programming expectations in Actuarial Science, in Computer Science and Statistics.*" They also state that "*The limited number of*

faculty members in Actuarial Science also make it precarious to achieve the evolving requirements of professional accreditation, which are increasingly recognized as a necessary standard."

While faculty are needed across many specializations, our top priorities are to add a tenure-track position in Actuarial Science and a tenure-track position in Computer Science. Again, while these are the top two priorities, this by no means addresses the full scope of faculty needs within SMCS or even within those two programs.

Currently, we have two faculty members dedicated to the Actuarial Science program. Of the 31 required courses in the Major in Actuarial Science, 10 (AMS prefixed) courses and their associated labs require instructors with specialized expertise in Actuarial Science. Two faculty members cannot deliver all of these courses and labs on a regular basis. It is even more challenging to deliver the Major in Actuarial Science with Pre-professional Specialization, which is designed for students who plan to complete the full suite of exams required to apply for Associate status from the Canadian Institute of Actuaries (CIA), the Society of Actuaries (SOA), or the Casualty Actuarial Society (CAS). There are 13 courses and associated labs in the Pre-professional Specialization that are aligned directly with the professional exams and require specialized instructors. This year, faculty members from other programs such as Financial Mathematics and Analytics have taken on overload teaching to help deliver that specialization. Going forward, a third faculty member dedicated to the Actuarial Science program is required to deliver both the Major and the Pre-Professional Specialization.

Three faculty dedicated to the Actuarial Science program are the bare minimum required to achieve CIA accreditation. However, now that the program is in its sixth year, faculty members associated with the program are beginning to apply for sabbatical leave. We have no capacity to back-fill for any type of leave of absence for our two current Actuarial Science specialists. We do not have faculty or sessional instructors who can take over these courses. Even the addition of a third faculty member will not remedy the situation, as their expertise within the Actuarial Science program will differ from the two other faculty. Therefore, another faculty member would be required (tenure track or term) in those situations. However, given the demand for Actuarial Science professionals in both industry and academia, we have little confidence that a term faculty member could be recruited.

Although we have concerns about the fragility of our Actuarial Science Program, there are many reasons to celebrate this program. UPEI is the only university in Atlantic Canada offering an advanced curriculum for all six professional exams and three Validation by Educational Experience (VEE) subjects. In 2020, our program was designated as a UCAP–Advanced Curriculum program by the Society of Actuaries. Accordingly, our program is now comparable to the best programs offered across the country and internationally. This designation is a powerful marketing tool, and we expect the number of majors in Actuarial Science to double within the next three years.

As student numbers grow, so should the faculty complement. A total of five specialists in Actuarial Science would allow us to deliver our program comfortably. We could regularly offer all of the required courses, back-fill for sabbatical and other leaves of absence, provide teaching release for faculty who accumulate credits through student supervision, and effectively react to changes in accreditation requirements. Since Actuarial Science specialists have extensive training in mathematics, statistics and analytics, additional specialists in this area will also give us more flexibility and help address growing numbers in courses across SMCS.

We now turn our attention to Computer Science. In discussing student/faculty ratios, the reviewers note that "*the Computer Science Program has a high ratio: about 280/6. This is nearly 3 times higher than the ratio in the CS program at Saint Mary's University.*" This ratio was based on 2019 data. Currently, there are 335 CS majors registered at UPEI, and we consider the CS faculty complement to be 6.5 (Dr. Gurjit Randhawa was hired in July 2021 to serve both the CS and Analytics programs). Therefore, the previous ratio of approximately 47 students per faculty member in Computer Science has increased to approximately 52 majors per faculty member.

From our students' perspective, the main issues in Computer Science are growing class sizes, lack of electives, and lack of experiential learning opportunities. The first two issues cannot be addressed without additional CS faculty.

Growing class sizes have translated into increased workload for faculty, as the reviewers have pointed out when discussing balance. We have also reached a point where additional sections of CS courses need to be introduced for reasons outside of workload. As the reviewers point out, "*with the rapid student increase, there are more and more students who cannot take a course that is offered only once in a year or once in two years.*" There are also issues around the availability of large classrooms on campus.

Given the demand for Computer Science professionals, our ability to recruit additional sessional instructors or contract faculty members is practically non-existent. In fact, we cannot even recruit strong fourth-year CS students to serve as markers or lab assistants in our courses because they prefer to work in the local industry. As a result, the typical routes of providing TA and marking support for large upper-year classes are not effective solutions for growing class sizes.

Due to these enrolment pressures, the diversity of CS electives has decreased over the years. In a given year, we offer one 2000-level CS course and two 3000+-level CS courses that are purely elective. While CS students can use other courses within SMCS to fulfil elective requirements, such courses do not provide breadth within Computer Science. Given the number of students enrolled in Computer Science, we should be providing more opportunities for students to customize their program through their choice of electives.

When Computer Science was last reviewed in 2012, the CIPS accreditation report stated an urgent need to add at least one faculty member. This was to deliver the minimum program requirements. Nine years and almost 250 Computer Science majors later, we have added 0.5 faculty. This growth warrants the addition of multiple faculty positions. We argue that three additional faculty members in CS are needed to ensure the quality of that program.

While the fragility of the Actuarial Science program and the growth of the Computer Science program put focus on those two disciplines, this does not discount the need for additional Statistics and Mathematics faculty in SMCS. The reviewers state that "*It is also evident that the School needs additional Statistics faculty to reach a higher quality and meet the expertise demanded from Actuarial and Data Science.*"

Dr. Paul Sheridan will be joining SMCS in May 2022 (he was recruited in Spring 2021 but deferred his appointment). While he will contribute to both Analytics and Statistics, this increase to 2.5 Statistics faculty is not sufficient to deliver the full suite of required Statistics courses across our majors. (In 2021-2022, we are offering 15 sections of Statistics courses.) The reviewers point out that Acadia University, which does not offer major programs in Statistics or Actuarial Science, has 4.5 dedicated statistics faculty.

Although Mathematics was not explicitly included in this review, it cannot be separated from the other programs in SMCS, given both the administrative structure of SMCS and the Mathematics requirements across all of our majors. Mathematics is seeing similar issues related to growing numbers and the need for additional course sections. We also had a Mathematics specialist, Dr. Ken Sulston, retire in 2021. This is significant because he was replaced by Dr. Gurjit Randhawa, a specialist in Computer Science and Analytics. We made this strategic choice to address urgent needs in those programs, but it has nonetheless made delivery of our mathematics courses even more difficult.

It is also important to note that, as well as serving the majors within SMCS, Math and Stats faculty support programming across the UPEI campus. Increasing enrollments in not only SMCS but in the Faculties of Science and Engineering affect the workload of those faculty members. Enrollment pressures have resulted in a heavy reliance on sessional instructors to deliver mathematics and statistics service courses. (SMCS offers 14 Math and Stats course sections per year, with an average enrollment of 100, purely in service to other programs on campus.)

While additional faculty members will go a long way to addressing program sustainability in SMCS, we also have the opportunity to build research capacity that aligns with UPEI's research goals. For example, over the last decade, the impact of climate change has become a significant focus area for researchers in Actuarial Science. Actuaries have unique expertise in assessing and managing risk, and climate-related risk has become a pressing issue for government, regulatory bodies, the insurance industry, and others. With UPEI's new Centre for Climate Change, we have a unique opportunity to build research capacity in this area. We are currently seeing research collaboration between Dr. Kai Liu and Professor

Louis Doiron (Actuarial Science, SMCS) with researchers in the School of Climate Change and Adaptation. By recruiting an additional faculty member in Actuarial Science who can collaborate with researchers in Climate Science, we have the opportunity to become a research leader when it comes to Climate-Related Risk.

8. Quality Assurance

The reviewers are correct in assuming that this is the first review for SMCS programs introduced in 2016. While information about the timelines of the introduction of programming in Actuarial Science, Analytics, Financial Math, and Statistics was included in the appendices of the self-assessment document, this fact was not explicitly stated. As noted by the reviewers, the Computer Science program was last reviewed as part of CIPS accreditation in 2012. All SMCS programs will continue to be subject to UPEI's quality assurance procedures.

9. Graduate Programs

We introduced an MSc program in Mathematical and Computational Sciences in September 2021. As such, it was not part of this review. We are appreciative of the reviewers' comments in support of this new initiative.

10. Advice

The three important issues highlighted by the reviewers closely align with those in the SMCS self-assessment and were previously discussed in this document. Again, we address their specific recommendations:

- Consider a more integrated and flexible approach to offering elective courses among the various programs.

We will investigate such opportunities. While additional electives have been raised as an issue, particularly in Computer Science, our priorities lie with the ability to reliably offer required courses across programs with class sizes that are both manageable and feasible when it comes to available space.

- Identify/provide additional space to support the delivery of the labs in the Computer Science program.

This is a top priority. However, we argue that this goes beyond lab delivery in Computer Science. Giving SMCS students access to computer workstations in both lecture and lab environments is a requirement of a modern university. By limiting instructors to static lectures and unrealistic exercises (a necessity if computational work is done by hand), we are not adequately preparing our students for their future careers or studies. **New space for labs should be identified immediately, and it**

should be part of a larger plan to relocate SMCS to a larger facility that can meet its growing needs.

- A need for additional faculty and lab instructor positions.

This is a top priority. Given the scope of this assessment (5 Majors, along with various Honours and Specializations), we understand the reviewers' concerns that SMCS had not coordinated or prioritized its needs. While there is much overlap in certain SMCS programs, the two programs most in need of resources – Actuarial Science and Computer Science – do not have a lot of commonalities when it comes to teaching requirements.

As previously argued, a faculty member in Actuarial Science will improve our ability to deliver both that program but also Analytics, Financial Mathematics, and Statistics. Furthermore, if we recruit a Computer Scientist whose specialization is data science adjacent, this will also support to our Analytics program. Both positions will contribute to UPEI's research goals.

Obviously, there are budget implications for these new staff and faculty positions. We argue that the tuition and lab fees generated by enrollment growth since 2015 should fund these positions.

When the School of Mathematical and Computational Sciences was proposed in 2015, the goal was to add 240 majors by 2021, with an additional faculty member (above our current complement) to be added once 195 students were added. The business plan presented at that time clearly demonstrated that tuition alone would more than fund all faculty and staff positions proposed at that time (lab fees and international student fees were not included). **An additional position in Actuarial Science should be funded based on that business plan.**

As previously discussed, the 2015 business plan also included the addition of a halftime administrative position. **An additional 0.5 administrative position should be funded based on that business plan.**

We have since exceeded the expectations of that business plan, adding approximately 300 majors since 2015. Those students contribute almost \$2 million annually in tuition revenue, while the business plan was based on \$1.6 million. If we conservatively estimate that 40% of SMCS majors are international students, that is another \$1 million collected annually in international fees. On a smaller but still significant scale, enrollments in Computer Science labs have increased by approximately 200 seats since 2015. There are also approximately 150 lab seats associated with courses in Actuarial Science that were not projected when the program was created. Therefore, we are already generating more than \$26,000 per year in additional lab fees compared with 2015. If the Stat 1910 tutorial were to be

converted to a lab, that would add a minimum of 200 lab seats or \$15,000 in annual lab fees. These additional fees (tuition, international and lab) constitute approximately \$1.5 million in annual revenue that was not accounted for in the original School proposal. **An additional faculty position in CS and lab instructor position should be funded immediately based on these numbers. Another four faculty positions should be committed to SMCS over the next five years to support SMCS programming.**

We argue that it would best serve SMCS and UPEI to conduct a hiring round with multiple positions explicitly dedicated to non-male applicants. Currently, the Associate Dean is the only female faculty member in SMCS; all other faculty are male. In recent faculty searches in Computer Science and Analytics, there have been few non-male applicants, and only male candidates have been interviewed in the final round. By hiring a cohort of women and non-binary faculty, we would create a community within SMCS of non-male faculty who could support each other and our students.

Conclusion

This is an exciting time for the School of Mathematical and Computational Sciences. While the rapid growth of SMCS has made for challenges, we recognize the opportunities it has provided us to advance the Mathematical and Computational Sciences on PEI. With the proper resources, we can continue this mission to advance undergraduate education in these fields, as well as provide leadership and expertise to our university and community partners.

Appendix 2

Side-by-Side of Program Requirements and Hypothetical Student Progression

Appendix 2: Side-by-Side of Program Requirements and Hypothetical Student Progression

The following table should be used to present the program requirements and student progression. On the left, include the program as it was last approved by the MPHEC; on the right, include the modified program. Programs that have not been previously assessed by the MPHEC but have had an external cyclical review within the last ten years may use the version of the program when the review took place as the reference point for the side-by-side comparison. ***If no changes have been made or are proposed to the program requirements and student progression, the right side may be left blank with a note confirming the requirements on the left remain in effect.***

Note: Not all sections may apply.

	Program as Last Approved by the MPHEC <i>or</i> as it was Assessed through an External Review		Modified Program	
	Course Number, Title, and Credit Value ⁴	Status (new, modified, existing)	Course Number, Title, and Credit Value	Status (new, modified, existing)
YEAR 1				

⁴ Cross-level course refers to offering two courses, one undergraduate and one graduate, in the same time and place, with the same instructor. For cross-level courses, provide both undergraduate and graduate course numbers and titles, e.g., PSYC 4015/6005 Advanced Research Methods. If non-credit, indicate 0 for credit value. See section 1.4.7 of the *Assessment Standards and Criteria* for parameters for cross-level courses.

Required Courses ⁵	Math 1910 Single Variable Calculus 1	4cr	Math 1910 Single Variable Calculus 1	4cr	existing
	Math 1920 Single Variable Calculus 2	4cr	Math 1920 Single Variable Calculus 2	4cr	existing
	CS 1910 Computer Science 1	3cr	CS 1910 Computer Science 1	3cr	existing
	CS 1920 Computer Science 2	3cr	CS 1920 Computer Science 2	3cr	existing
	Stat 1910 Intro to Probability and Statistics	3cr	Stat 1910 Introduction to Statistics	3cr	modified
			AMS 1910 Intro to Data Science	3cr	existing
	One of	3cr			
	UPEI 1010 Writing Studies		IKE 1040 Indigenous Teachings of Turtle Island	3cr	existing
	UPEI 1020 Inquire Studies				
	UPEI 1030 University Studies				

Select Electives ⁶					
Special Requirements ⁷					
Other Degree or Distribution Requirements ⁸	Electives. 12 credit hours		Electives. 6 credit hours		
Credits	32 credit hours		29 credit hours		
YEAR 2					
Required Courses	MATH 2910 Multivariable, Vector Calculus	4cr	AMS 2910 Design Thinking With Data	3cr	New

⁵ Required courses are courses that contribute directly to the program's focus and credit total and will be identified within the academic calendar as such. (For a major in a 4-year undergraduate degree, list subject-area courses that every student enrolled in the proposed major must take, and that count toward the credit total for that major.)

⁶ Select electives are courses chosen from a predetermined list of courses either in the same field or in a field that directly contributes to the program's focus. Lists can be included in the table or in an attachment if necessary.

⁷ Special requirements may include a thesis, capstone, work-integrated learning, etc.

⁸ Other requirements outside of the subject area. E.g. For a major in a 120-credit (or equivalent) undergraduate degree, include all other breadth or distribution requirements needed for graduation that fall outside of the focus of the major. All possible general or open electives are not required to be listed; instead, describe the source of the elective (e.g., humanities courses at the 1000-2000 level - 18 credits).

	MATH 2420 Combinatorics 1 MATH 2610 Linear Algebra 1 MATH 2620 Linear Algebra 2 MATH 2720 Mathematical Reasoning CS 2910 Computer Science 3 CS 2920 Data Structures and Algorithms STAT 2910 Probability, Math. Statistics I. AMS 2940 Optimization One of MCS 2010 Tech Lab in MAPLE MCS 2020 Tech Lab in MATLAB MCS 2030 Tech Lab in R	3cr 3cr 3cr 3cr 3cr 3cr 3cr 3cr 1cr	existing existing existing existing existing existing existing modified existing existing	STAT 2240 Applied Regression Analysis STAT 2910 Probability, Math. Statistics I	3cr 3cr	Modified Modified
Select Electives				Two electives from the School of Mathematical and Computational Sciences at the 2000-level or higher. 6cr One elective from outside the Faculty of Science. 3 cr		

				One elective from outside the School of Mathematical and Computational Sciences 3cr	
Special Requirements					
Other Degree or Distribution Requirements				General Electives 10 credit hours	
Credits	29 credit hours			31 credit hours	
YEAR 3					
Required Courses		Existing		STAT 3660 High-Dimensional Data Analytics 3cr	Modified

Select Electives	MATH 3010 Differential Equations	3cr	Existing		
	MATH 3430 Combinatorics II	3cr	Existing		
	MATH 3610 Group Theory	3cr	Existing		
	AMS 3770 Combinatorial Optimization	3cr	Existing		
	STAT 3910 Probability, Math. Statistics II	3cr	Modified		
	STAT 3240 Applied Regression	3cr	Existing		
	CS 3610 Analysis, Design of Algorithms	3cr	Existing		
	CS 3710 Database Systems	3cr	Existing		
	MCS 3050 Tutoring in Math, CS	1cr			
Special Requirements				Three electives from the School of Mathematical and Computational Sciences at the 3000-level or higher. 9cr	
				One elective from outside the Faculty of Science. 3 cr	
				One elective from outside the School of Mathematical and Computational Sciences 3cr	
Other Degree or Distribution Requirements	Electives 4 credit hours			General Electives 12 credit hours	
Credits	29 credit hours			30 credit hours	
YEAR 4	AMS 3910 Mathematical Modeling		Existing	AMS 4910 Capstone in Analytics. 3cr	Existing
	STAT 4550 Data Analysis and Inference		Existing	MCS 4210 Professional Communications and Practice. 3cr	Existing
	STAT 4660 Data Visualization and Mining		Modified		
	CS 4210 Machine Learning		Modified		
	CS 4440 Data Science		Existing		
	MCS 4210 Professional Communications and Practice		Existing		
Required Courses					
Select Electives	Two electives from the School of Mathematical and Computational Sciences at the 2000-level or higher. 6cr			One elective from outside the School of Mathematical and Computational Sciences 3cr	
Special Requirements					

Other Degree or Distribution Requirements	Electives 6 credit hours		General Electives 21 credit hours	
Credits	30 credit credit hours		30 credit hours	
TOTAL PROGRAM CREDITS	120 credit hours		120 credit hours	

Appendix 3

Academic Calendar Course Descriptions

Appendix 3: Academic Calendar Course Descriptions

The Common Core

MATH 1910 SINGLE VARIABLE CALCULUS I

This course is an introduction to differential and integral calculus of functions of a single variable. The course is intended primarily for majors in the Mathematical and Computational Sciences, Engineering and the Physical Sciences, as well as those planning to continue with further Mathematics courses. The concepts of limits, continuity and derivatives are introduced and explored numerically, graphically and analytically. The tools of differential calculus are applied to problems in: related rates; velocity and acceleration; extrema of functions; optimization; curve sketching; and indeterminate forms. The concepts of definite and indefinite integrals are introduced, and the relation between the two integrals is discovered via the Fundamental Theorem of Calculus.

PREREQUISITE: Grade XII academic Mathematics

Four lecture hours and one tutorial hour per week

Semester hours of credit: 4

NOTE: Credit will not be given jointly for this course and MATH 1120.

MATH 1920 SINGLE VARIABLE CALCULUS II

This course is a continuation of integral calculus of functions of a single variable and an introduction to sequences and series. Techniques of integration are studied, including improper integrals and numerical integration, and the tools of integral calculus are used to compute areas, volumes and arc lengths; and are applied to problems in physics and differential equations. Sequences, series, tests for convergence, Taylor series and Taylor polynomials are studied.

PREREQUISITE: MATH 1910

Four lecture hours and one tutorial hour per week Semester

hours of credit: 4

MATH 2610 LINEAR ALGEBRA I

This course introduces some of the basic concepts and techniques of linear algebra to students of any major. The emphasis is on the interpretation and development of computational tools. Theory is explained mainly on the basis of two or three-dimensional models. Topics covered are: matrices; determinants; systems of equations; vectors in two and three-dimensional space including dot and cross products, lines, and planes; concepts of linear independence, basis, and dimension explained with examples; linear transformations and their matrices; eigenvectors and eigenvalues.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours per week Semester
hours of credit: 3

STAT 1910 INTRODUCTION TO STATISTICS

This course introduces students to statistical reasoning and data analysis using R. Emphasizing modern computational approaches, students will learn to summarize and visualize data, apply inferential techniques (e.g., confidence intervals, hypothesis tests, and ANOVA), and model relationships (e.g., regression). Core statistical concepts, including randomization tests, boot- strapping, and the Central Limit Theorem, will be explored through theoretical and applied perspectives. Designed for students with a strong foundation in grade 12 mathematics, this course focuses on interpreting results, making data-driven decisions, and preparing for advanced studies in statistics. PREREQUISITE: Grade XII academic Mathematics.

Three lecture hours plus a 1.5 hour lab per week Semester
hours of credit: 3

CS 1910 COMPUTER SCIENCE I

Students will be introduced to computational thinking. They will learn how abstraction and decomposition can be used to solve problems and how to create, analyse and trace their own algorithmic solutions. They will iterate and improve their solutions through pseudocode and through implementation in the procedural programming paradigm. They will learn the following programming constructs: data structures and types, decision structures, repetition structures, functions, exception handling, and ways to represent data in lists and strings. They will learn to test their code ensuring correctness of their programs. PREREQUISITE: Grade XII academic Mathematics

Three lecture hours and 1.5 hours lab per week Semester
hours of credit: 3

IKE 1040 INDIGENOUS TEACHINGS OF TURTLE ISLAND

With respect to the traditional and unceded territory of Epekwitk (PEI) and Mi'kma'ki, this course is an introduction to the three groups of Indigenous peoples recognized in Canada. Anchored in Indigenous knowledges, students will learn about ceremonies, protocols, traditions and cultures. This course further introduces Canada's history of colonization and cultural assimilation policies. These will help to begin fostering an understanding of Indigenous worldviews and fulfill the University of Prince Edward Island's commitment to the Truth and Reconciliation Commission's Calls to Action.

REQUISITES: none

Semester hours of credit: 3

Other Required Courses

AMS 1910 Introduction to Data Science

This course provides an introduction to data analysis, artificial intelligence and business intelligence tools, equipping students with the skills to explore, analyze, and communicate data-driven insights effectively. Students will learn to manipulate datasets, perform basic exploratory data analysis, and build interactive dashboards using widely available platforms. The course emphasizes hands-on practice with real-world datasets, focusing on data cleaning, visualization, and predictive modelling. Students will develop the ability to tell compelling stories with data, create professional-grade reports, and communicate actionable insights to diverse audiences. No prior coding experience is required.

PREREQUISITES: Admission to a major in the School of Mathematical and Computational Sciences, or permission of the instructor.

Three hours a week

Semester hours of credit: 3

CS 1920 COMPUTER SCIENCE II

Students will learn and apply the object-oriented paradigm of programming to reinforce and extend their knowledge in computational thinking, data representation and algorithms. They will learn how encapsulation can be used to create robust programs that perform a well-defined set of tasks, and how to extend and reuse this code through inheritance and polymorphism. They will learn searching and sorting algorithms, how to apply recursion, and objects for organizing data such as linked lists, stacks and queues.

PREREQUISITE: CS 1910

Three lecture hours and 1.5 hours lab per week Semester hours of credit: 3

STAT 2240 APPLIED REGRESSION ANALYSIS

This course builds upon the basis of inference studied in Statistics 1910 and provides students with an advanced knowledge of regression techniques. Topics covered are simple and multiple linear regression techniques, matrix notation, the design matrix, model building techniques, residual analysis, and non-linear regression.

PREREQUISITE: STAT 1910

COREQUISITE: MATH 2610 must be completed or taken concurrently.

Three lecture hours per week Semester hours of credit: 3

STAT 2910 PROBABILITY AND MATHEMATICAL STATISTICS I (proposed update to pre-req)

This course is an introduction to the theoretical basis of statistics for students who have completed STAT 1910. The study concentrates on the mathematical tools required to develop statistical methodology. Topics covered include: probability, continuous and discrete random variables, moment generating functions, multivariate probability distributions and functions of random variables.

PREREQUISITE: STAT 1910 and MATH 1920

Three lecture hours per week Semester

hours of credit: 3

AMS 2910 DESIGN THINKING WITH DATA (proposed new course)

This course builds on the foundational data skills introduced AMS 1910 such as data wrangling, exploratory analysis, and visualization and develops them to inform problem framing and solution specification within a human-centered design thinking framework. Students learn to engage key parties to identify meaningful problems, co-create ideas, and iteratively refine solutions through testing and feedback. Students are introduced to new techniques such as collecting and evaluating data from surveys, interviews, and observation; recognizing and addressing issues of data quality, bias, and uncertainty; and transforming insights into clear narratives and prototypes that support decision-making. Through case studies and hands-on projects, students will integrate technical analysis with human-centered insights to design data-driven solutions that are both actionable and contextually relevant. Optional extensions are available for students with programming experience.

PREREQUISITE: AMS 1910 and one of STAT 1210, STAT 1910, BUS 2510, PSY 2700 PSY 2710, PSY 2750, ENGN 2130, SOC 3320, or EDU 4810.

Three lecture hours per week Semester

hours of credit: 3

STAT 3660 HIGH-DIMENSIONAL DATA ANALYTICS (proposed update to STAT 3660)

This course trains students to critically apply statistical and computational techniques to real-world data analysis problems, with an emphasis on high-dimensional data. Building on foundations from earlier courses, students will deepen their understanding of how to frame analytical objectives, preprocess complex datasets, and apply appropriate modeling approaches. Topics include exploratory data analysis (i.e., data acquisition, data

preprocessing, data cleaning, visualization techniques, numerical summaries, data exploration), dimension reduction methods (e.g., principal component analysis, multidimensional scaling, t-SNE, UMAP, K-means, neural embeddings) for simplifying and interpreting high-dimensional datasets, and supervised and unsupervised learning of both continuous and categorical outcomes. Algorithms could include (clustering algorithms, multiple linear regression, logistic regression, decision trees, neural networks and pretrained models). The course emphasizes not only technical skills but also critical reasoning about model assumptions, generalization, and the implications of statistical learning in applied contexts.

PREREQUISITES: CS 1910, STAT 2240 and STAT 2910 Semester
hours of credit: 3

AMS 4910 ANALYTICS CAPSTONE (proposed new course)

This capstone course challenges students to synthesize their knowledge of data science, design thinking, and statistical learning into a substantial applied project. Working with real or hypothesized users, students will define a complex, decision-oriented problem and deliver a validated data product or insight-driven solution. Emphasis is placed on integrating the full data science pipeline, from framing objectives and gathering data to cleaning, modelling, evaluating, and communicating findings. Students will apply methods from prior coursework in data wrangling, visualization, predictive modelling, and human-centred design, while tailoring advanced approaches to domain-specific challenges. The course further trains students in professional skills, including iterative project management, documentation, reproducibility, and communication of results to both technical and non-technical audiences. Culminating in a public presentation and professional-grade report, the course provides students with an opportunity to demonstrate readiness to translate data science expertise into real-world impact.

PREREQUISITES: AMS 2910 and STAT 3660 Semester
hours of credit: 3

4210 PROFESSIONAL COMMUNICATION AND PRACTICE

This course aims to build students' oral and written communications skills, and to prepare students to think critically about essential and potentially controversial issues in the Mathematical and Computational Sciences, with the goal of preparing students for a professional environment. Using examples from their discipline, students will focus on such aspects as description of processes, presentation of data, extended abstracts, correct use of terminology, and sensitivity to language and tone. Discussions of topics

relevant to the professional Mathematical and Computational Scientist, such as: ethics; security; privacy and civil liberties; risk and liability; intellectual property; and certification standards are also a key part of the course.

PREREQUISITE: At least 36 semester hours of credit completed in courses in the School of Mathematical and Computational Sciences

Three hours per week

Semester hours of credit: 3

Select Electives

In the Analytics major, at least two elective courses at the 2000-level or higher and at least three at the 3000-level or higher are required from the School of Mathematical and Computational Science (SMCS). SMCS courses refer to any course with the prefix MATH, STAT, CS, AMS or MCS in the academic calendar. The full list of courses follows.

Full List of SMCS Course Descriptions

MATHEMATICS COURSES (MATH PREFIX)

1010 ELEMENTS OF MATHEMATICS

This course provides an introduction to several mathematical topics at the university level, and is intended for students majoring in a discipline other than Mathematical and Computational Sciences, or the Natural Sciences. The course consists of four modules: (1) Sets and Logic, (2) Number Theory, (3) Geometry, (4) Mathematical Systems.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours a week

NOTE: Credit will not be given jointly for this course and any other 1000-level Mathematics course.

1110 FINITE MATHEMATICS

This course introduces students to finite mathematical techniques and to mathematical models in business, life and the social sciences. The course begins with an introduction to mathematical models, types of models, and conversion of verbal models to mathematical models. Topics covered include systems of linear equations and matrices, linear inequalities and linear programming, sets, counting and probability.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours a week

NOTE: Credit for Mathematics 1110 will not be allowed if taken concurrent with or subsequent to Mathematics 2610.

1120 CALCULUS FOR THE MANAGERIAL, SOCIAL AND LIFE SCIENCES

This course provides an introduction to calculus for students in the managerial, social and life sciences. The main emphasis of the course is the development of techniques of differentiation and integration of algebraic, exponential and logarithmic functions. Applications of derivatives and integrals are also discussed.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours a week

NOTE: Credit will not be given jointly for this course and MATH 1910.

1910 SINGLE VARIABLE CALCULUS I

This course is an introduction to differential and integral calculus of functions of a single variable. The course is intended primarily for majors in the Mathematical and Computational Sciences, Engineering and the Physical Sciences, as well as those planning to continue with further Mathematics courses. The concepts of limits, continuity and derivatives are introduced and explored numerically, graphically and analytically. The tools of differential calculus are applied to problems in: related rates; velocity and acceleration; extrema of functions; optimization; curve sketching; and indeterminate forms. The concepts of definite and indefinite integrals are introduced, and the relation between the two integrals is discovered via the Fundamental Theorem of Calculus.

PREREQUISITE: Grade XII academic Mathematics

Four lecture hours and one tutorial hour per week

Semester hours of credit: 4

NOTE: Credit will not be given jointly for this course and MATH 1120.

1920 SINGLE VARIABLE CALCULUS II

This course is a continuation of integral calculus of functions of a single variable and an introduction to sequences and series. Techniques of integration are studied, including improper integrals and numerical integration, and the tools of integral calculus are used to compute areas, volumes and arc lengths; and are applied to problems in physics and differential equations. Sequences, series, tests for convergence, Taylor series and Taylor polynomials are studied.

PREREQUISITE: MATH 1910

Four lecture hours and one tutorial hour per week

Semester hours of credit: 4

2420 COMBINATORICS I

This course offers a survey of topics in combinatorics that are essential for students majoring in the Mathematical or Computational Sciences. Topics include: logic, proof techniques such as mathematical induction, recursion, counting methods, and introductory graph theory. PREREQUISITE: MATH 1920

Three lecture hours per week

2610 LINEAR ALGEBRA I

This course introduces some of the basic concepts and techniques of linear algebra to students of any major. The emphasis is on the interpretation and development of computational tools. Theory is explained mainly on the basis of two or three-dimensional models. Topics covered are: matrices; determinants; systems of equations; vectors in two and three-dimensional space including dot and cross products, lines, and planes; concepts of linear independence, basis, and dimension explained with examples; linear transformations and their matrices; eigenvectors and eigenvalues.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours per week

2620 LINEAR ALGEBRA II

This course continues MATH 261 with further concepts and theory of linear algebra. Topics include real and complex vector spaces, orthogonality, Gram-Schmidt Process, canonical forms, spectral decompositions, inner product spaces and the projection theorem.

PREREQUISITE: MATH 1910, MATH 2610 Three

lecture hours a week

2720 MATHEMATICAL REASONING

This course provides students with experience in writing mathematical arguments. It covers first-order logic, set theory, relations, and functions. The ideas and proof techniques are considered in the context of various mathematical structures such as partial orders, graphs, number systems, and finite groups.

PREREQUISITE: None

Three lecture hours per week

2810 FOUNDATIONS OF GEOMETRY

This course presents an axiomatic base for Euclidean geometry and an insight into the interdependence of the various theorems and axioms of that geometry and non-Euclidean geometries. Topics include: incidence and separation properties for points, lines, planes and space; congruence properties; geometric inequalities; similarity properties; and geometric constructions.

PREREQUISITE: Six semester hours of First Year Mathematics Three

lecture hours per week

2820 MATHEMATICAL PHYSICS (See [Physics 2820](#)).

PREREQUISITE: MATH 2910 and either PHYS 1120 or PHYS 1220

2910 MULTIVARIABLE AND VECTOR CALCULUS

This course continues from Math 1920 and is an introduction to multivariable differentiation and integration and vector calculus. Topics include parametric representation of curves; polar coordinates; vectors; dot and cross products; curves and surfaces in space; calculus of vector-valued functions; functions of several variables;

partial differentiation; directional derivatives; tangent planes; local and constrained maxima and minima; double and triple integrals; changes of variables in multiple integrals; vector fields; line and surface integrals; gradient, divergence and curl; Green's, Stokes' and Divergence Theorems.

PREREQUISITE: MATH 1920

Four lecture hours per week Semester
hours of credit: 4

3010 DIFFERENTIAL EQUATIONS

This course introduces the basic theory of differential equations, considers various techniques for their solution, and provides elementary applications. Topics include linear equations; separable equations; linear independence and Wronskian; second-order equations with constant coefficients; nonhomogeneous equations; applications of first- and second-order equations; Laplace and inverse Laplace transforms, and their application to initial-value problems; series solutions about ordinary and singular points; and Fourier series.

PREREQUISITE: MATH 1920

Three lecture hours per week

3310 COMPLEX VARIABLES

This is a first course in complex variables. The aim is to acquaint students with the elementary complex functions, their properties and derivatives, and with methods of integration. Topics covered include: definition and development of complex numbers as ordered pairs; geometric representation; basic formulas and inequalities involving argument and conjugates; roots of complex numbers, limit, continuity, and derivative; Cauchy Riemann conditions; harmonic functions; properties of trigonometric, hyperbolic, logarithmic, exponential, and inverse trigonometric functions; bilinear transformation; integration; Cauchy Integral Theorem and Formula; residues and poles; Laurent and Taylor's series; and improper integrals.

PREREQUISITE: MATH 2910

Three lecture hours per week

3420 NUMBER THEORY

This first course in number theory will include the following topics: equivalence of the principles of induction and the well-ordering principle; division algorithm; positional notation and repeating decimals; greatest common divisor; Euclidean Algorithm; Fundamental Theorem of Arithmetic; Pythagorean Triplets; Prime Numbers Theorem; Mersenne and Fermat Numbers; congruences; Euler's Phi-function; Chinese Remainder Theorem; Diophantine Equations; Theorems of Lagrange and Wilson; Quadratic Reciprocity Law of Gauss; Legendre symbol and primitive roots; perfect numbers; multiplicative number-theoretic functions; Moebius inversion.

PREREQUISITE: Six semester hours of Mathematics at the 2000 level or higher Three lecture hours per week

3430 COMBINATORICS II

This course continues MATH 2420, with the examination of advanced counting techniques, binomial coefficients, and generating functions. Other topics include relations, partial orders, and Steiner Triple systems.

PREREQUISITE: MATH 2420

Three lecture hours per week

3510 REAL ANALYSIS

This is a first course in real analysis. Topics include: the reals as a complete ordered field; closed and open sets; Bolzano-Weierstrass and Heine-Borel Theorems; Cauchy Sequences; limits and continuity; derivative; Mean Value Theorem; Riemann Integral; and the Fundamental Theorem of Calculus. PREREQUISITE: MATH 1920 and MATH 2720

Three lecture hours per week

3610 GROUP THEORY

An introduction to group theory, including: cyclic groups, symmetric groups, subgroups and normal subgroups, Lagrange's theorem, quotient groups and homomorphisms, isomorphism theorems, group actions, Sylow's theorem, simple groups, direct and semidirect products, fundamental theorem on finitely generated Abelian groups.

PREREQUISITE: MATH 2720

Three lecture hours per week

3710 GRAPH THEORY

This course is an introduction to the ideas, methods, and applications of graph theory. Topics include graph connectivity, graph factors and factorizations, planar graphs, and colourings.

PREREQUISITE: MATH 2420 or MATH 2720

Three lecture hours per week

4020 POINT-SET TOPOLOGY

A first course in topology, covering some review of set theory; cardinal numbers; binary relations; metric spaces, convergence and continuity in metric spaces; topological spaces, bases, sub-spaces; continuity in general; homeomorphism; product spaces; separation axioms; compactness; connectedness.

PREREQUISITE: MATH 3510

Three lecture hours per week

4520 MEASURE THEORY AND INTEGRATION

A first course in measure theory, covering measure as a generalization of length, outer measure, sigma-algebras, measurability, construction of measures, Lebesgue measure on the real line, measurable functions and the Lebesgue integral. Additional topics may include and convergence theorems, product measures and Fubini Theorem.

PREREQUISITE: MATH 3510

Three lecture hours per week

4530 FUNCTIONAL ANALYSIS

This first course in functional analysis covers topics like: metric spaces, Banach spaces, function spaces, Hilbert spaces, generalized Fourier series and linear operators.

PREREQUISITE: MATH 2620 and MATH 3510

Three lecture hours per week

4620 RING AND FIELD THEORY

Introduction to ring and field theory, including: polynomial rings, matrix rings, ideals and homomorphisms, quotient rings, Chinese remainder theorem, Euclidean domains, principal ideal domains, unique factorization domains, introduction to module theory, basic theory of field extensions, splitting fields and algebraic closures, finite fields, introduction to Galois theory.

PREREQUISITE: MATH 3610

Three lecture hours per week

4710 PARTIAL DIFFERENTIAL EQUATIONS

This course is an introduction to the theory and application of partial differential equations. Topics include: first-order equations and characteristic curves; classification of second order equations as parabolic, hyperbolic or elliptic; Laplace, wave and diffusion equations, and their physical origins; solution using Fourier series; and separation of variables.

PREREQUISITE: MATH 2910 and MATH 3010

Three lecture hours per week

4720 DYNAMICAL SYSTEMS

This course is a study of the long-term qualitative behaviour of solutions of systems of differential or difference equations. Topics include: non-linear systems, linearization, numerical and graphical methods, equilibria, phase space, stability, bifurcations, strange attractors, and chaos. Applications to physics, biology and other sciences are studied.

PREREQUISITE: MATH 2610, MATH 2910 and MATH 3010

Three lecture hours per week

STATISTICS COURSES (STAT PREFIX)

1210 INTRODUCTION TO STATISTICS FOR THE LIFE AND SOCIAL SCIENCES

The main objective of this course is to introduce the basic concepts of descriptive statistics, and statistical inference, to students outside of SMCS. Topics include frequency distributions, descriptive statistics, rules of probability, discrete and continuous probability distributions, random sampling and sampling distributions, confidence intervals, one- and two-tail tests of hypotheses, and correlation and linear regression.

PREREQUISITE: Grade XII academic Mathematics.

Three lecture hours per week

NOTE: Credit will not be allowed for Statistics 1210 if a student has received credit for any of the following courses: Business 2510, Education 4810, Psychology 2710 and Sociology 3320. Credit for Statistics 1210 will not be allowed if taken concurrent with or subsequent to Statistics 1910.

1910 INTRODUCTION TO STATISTICS

This course introduces students to statistical reasoning and data analysis using R. Emphasizing modern computational approaches, students will learn to summarize and visualize data, apply inferential techniques (e.g., confidence intervals, hypothesis tests, and ANOVA), and model relationships (e.g., regression). Core statistical concepts, including randomization tests, boot- strapping, and the Central Limit Theorem, will be explored through theoretical and applied perspectives. Designed for students with a strong foundation in grade 12 mathematics, this course focuses on interpreting results, making data-driven decisions, and preparing for advanced studies in statistics. PREREQUISITE: Grade XII academic Mathematics. Three lecture hours plus a 1.5 hour lab per week

2240 (Previously 3240) APPLIED REGRESSION ANALYSIS

This course builds upon the basis of inference studied in Statistics 1910 and provides students with an advanced knowledge of regression techniques. Topics covered are simple and multiple linear regression techniques, matrix notation, the design matrix, model building techniques, residual analysis, and non-linear regression.

PREREQUISITE: STAT 1910

COREQUISITE: MATH 2610 must be completed or taken concurrently.

Three lecture hours per week

2910 PROBABILITY AND MATHEMATICAL STATISTICS I

This course is an introduction to the theoretical basis of statistics for students who have completed STAT 1910. The study concentrates on the mathematical tools required to develop statistical methodology. Topics covered include: probability, continuous and discrete random variables, moment generating functions, multivariate probability distributions and functions of random variables.

PREREQUISITE: STAT 1910

COREQUISITE: MATH 2910 must be completed or taken concurrently. Three lecture hours per week

3330 (Previously 4330) TIME SERIES I

This course is an introduction to Time Series methods, including: stationary models, trends and seasonality, stochastic Time Series models, autoregressive and moving average processes and an introduction to Time Series forecasting. ARIMA models. Seasonal Time Series and Spectral Analysis are also covered.

PREREQUISITE: STAT 2240 (Previously STAT 3240)

Three lecture hours per week

3660 (Previously 4660) DATA VISUALIZATION AND MINING

This course explores methods for visualizing and interpreting high-dimensional and multimodal data. Topics include working with feature and embedding spaces, clustering, and interactive visualizations, alongside best practices in design, principles of visual perception, and ethical considerations like avoiding bias and misleading representations. Through projects and case studies, students will develop practical skills using visualization tools and libraries.

PREREQUISITE: CS 1910, MATH 2910 and STAT 2910

Three lecture hours per week

PREREQUISITE: MATH 2620, MATH 2910 and STAT 2910 Three lecture hours per week

3910 PROBABILITY AND MATHEMATICAL STATISTICS II

This course builds on the mathematical foundation developed in Statistics 2910 and introduces the student to the theory of statistical inference. Topics covered include: sampling distributions and central limit theory, methods of estimation, hypothesis testing, least squares estimation of linear models, and an introduction to Bayesian inference.

PREREQUISITE: STAT 2910

Three lecture hours per week

4110 STATISTICAL SIMULATION

This course introduces statistical simulation, and its use as a tool to investigate stochastic phenomena and statistical methods. Topics include the building and validation of stochastic simulation models useful in computing, operations research, engineering and science; related design and estimation problems; variance reduction; and the implementation and the analysis of the results.

PREREQUISITE: STAT 3910

Three lecture hours per week

3340 (Previously 4240) EXPERIMENTAL DESIGN

This course builds upon the basis of inference studied in Statistics 1210 and Statistics 3240 to include statistical techniques commonly used in experimental studies. Students will study topics such as analysis of variance models, hypothesis testing in ANOVA models, randomization, and blocking techniques. PREREQUISITE: STAT 2240 (Previously STAT 3240)

Three lecture hours per week

4280 GENERALIZED LINEAR MODELS

This course covers the basic theory, methodology and applications of generalized linear models. Topics include logistic regression, probit regression, binomial regression, Poisson regression, overdispersion, quasi-likelihood, and the exponential family.

PREREQUISITE: STAT 3240 and STAT 3910

Three lecture hours per week

4340 TIME SERIES II

This course includes topics from Time Series Econometrics, including Maximum Likelihood and Least Squares Estimation of ARIMA Models and GARCH Models, Wavelets and Financial Models. Non-stationary Time Series, multivariate Time Series and panel cointegration analysis are also covered.

PREREQUISITE: STAT 4330

Three lecture hours per week

4410 STOCHASTIC PROCESSES

This course is an introduction to the branch of probability theory that deals with the analysis of systems that evolve over time. Topics include random walks, Markov chains, Poisson processes, continuous time Markov chains, birth and death processes, exponential models, and applications of Markov chains.

PREREQUISITE: STAT 3910

Three lecture hours per week

4550 DATA ANALYSIS AND INFERENCE

This course is an introduction to data analysis with a focus on regression. Topics include: initial examination of data, correlation, and simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals, diagnostics and remedial measures interactions and dummy variables, variable selection, least squares estimation and inference for non-linear regression will also be discussed.

PREREQUISITE: STAT 3240

Three lecture hours per week

4740 MULTIVARIATE ANALYSIS

This course deals with the statistics of observation and analysis of more than one output variable. Topics include estimation and hypothesis testing for multivariate normal data, principal component analysis and factor analysis, discriminant analysis, cluster analysis, and correspondence analysis. PREREQUISITE: STAT 3240

Three lecture hours per week

COMPUTER SCIENCE COURSES (CS PREFIX)

1610 DIGITAL SYSTEMS

This course provides an introduction to digital systems, beginning with elementary components such as logic gates, from which are constructed components such as adders and comparators, and progressing to more complex systems such as programmable logic devices, memory and processor units. Students acquire skills in the design and analysis of combinational and sequential digital systems, CAD design and simulation tools for complex systems, and construction of digital systems based upon a modular methodology.

PREREQUISITE: CS 1910 or ENGN 1310, and three semester hours of Mathematics

Three lecture hours and a three-hour laboratory session per week

1910 COMPUTER SCIENCE I

Students will be introduced to computational thinking. They will learn how abstraction and decomposition can be used to solve problems and how to create, analyse and trace their own algorithmic solutions. They will iterate and improve their solutions through pseudocode and through implementation in the procedural programming paradigm. They will learn the following programming constructs: data structures and types, decision structures, repetition structures, functions, exception handling, and ways to represent data in lists and strings. They will learn to test their code ensuring correctness of their programs.

PREREQUISITE: Grade XII academic Mathematics

Three lecture hours and 1.5 hours lab per week

1920 COMPUTER SCIENCE II

Students will learn and apply the object-oriented paradigm of programming to reinforce and extend their knowledge in computational thinking, data representation and algorithms. They will learn how encapsulation can be used to create robust programs that perform a well-defined set of tasks, and how to extend and reuse this code through inheritance and polymorphism. They will learn searching and sorting algorithms, how to apply recursion, and objects for organizing data such as linked lists, stacks and queues.

PREREQUISITE: CS 1910

Three lecture hours and 1.5 hours lab per week

2060 WEB DEVELOPMENT AND PROGRAMMING

In this course, students learn to create websites that involve server-side scripting and database operations. While one specific scripting language is used to acquire web development and programming skills, students are exposed to a spectrum of scripting languages, enabling them to easily adapt to others.

PREREQUISITES: CS 1910

Three hours per week

2520 COMPUTER ORGANIZATION AND ARCHITECTURE

This course provides a basic understanding of the organization and architecture of modern computer systems. It examines the function and design of major hardware components both from a designer's perspective and through assembly language programming. Topics include components and their interconnection, internal/external memory, input/output subsystems, processors, computer arithmetic, instruction sets, addressing modes, and pipelining.

PREREQUISITE: CS 1920

Three hours per week

2620 COMPARATIVE PROGRAMMING LANGUAGES

This course examines the principal features of major types of programming languages, including procedural, logical, functional and object-oriented languages. Features include parameter-passing mechanisms, control structures, scope, and binding rules. Each language type is illustrated by considering a specific language.

PREREQUISITE: CS 1920

Three lecture hours per week

2710 PRACTICAL EMBEDDED SYSTEMS

This course introduces students to the concept of embedded systems architectures, the interconnection of sensors and actuators to such systems, and the usage of such platforms for data acquisition and control of automated systems. Popular microcontroller units and system-on-chip platforms will be examined. PREREQUISITES: CS 1210 or CS 1410 or CS 1910 or ENGN 1310 Three lecture hours per week

2820 PROGRAMMING PRACTICES

This course introduces the student to development in the Unix/Linux environment. Topics include development tools, shell programming, common utility programs, processes, file/directory management, IDEs, testing/debugging, version control, and an introduction to software engineering.

PREREQUISITE: CS 1920 or permission of the instructor (based on completion of CS 1910 with first class standing) Three lecture hours per week

2910 COMPUTER SCIENCE III

Students will learn and apply advanced programming concepts in an object-oriented language. They will be introduced to software engineering with test-driven design and the use of version control to maintain their codebase. Students will gain mastery of an object-oriented language and design and implement data structures. Students will be introduced to the functional programming paradigm and multi-threaded programs.

PREREQUISITE: CS 1920 and six credit hours of Mathematics

Three lecture hours and 1.5 hours lab per week

2920 DATA STRUCTURES AND ALGORITHMS

This course continues the study of data structures, recursive algorithms, searching and sorting techniques, and general strategies for problem solving. It also introduces complexity analysis and complexity classes.

PREREQUISITE: CS 2910 and six semester hours of Mathematics Three lecture hours per week

3110 VIDEO GAME DESIGN

This course focuses on the process from initial idea to final design of a video game. Students will craft a game document from an original concept of their own creation and create a prototype of the game based on that document.

PREREQUISITE: CS 2910 and CS 2920

Three lecture hours per week

3130 MOBILE DEVICE DEVELOPMENT – ANDROID

This course introduces the student to programming for mobile devices that use the Android platform. The course will present a study of the architecture, operating system and programming language of these devices.

PREREQUISITE: CS 2910 and CS 2920 Three lecture hours per week

3210 USER EXPERIENCE DESIGN

This course introduces students to the processes and techniques for creating interactive technologies. Students will learn about a variety of topics relating to user centred design including: elicitation techniques, needs analysis, conceptual design, and prototyping. Students will learn how to evaluate their own designs through expert methods and with users. Students will be introduced to a variety of different qualities of interactive technologies including usability and user experience.

PREREQUISITES: CS 1920

Three lecture hours per week

3220 INTRODUCTION TO BIOINFORMATICS

This course is an introduction to bioinformatics, with a focus on a practical guide to the analysis of data on genes and proteins. It familiarizes students with the tools and principles of contemporary bioinformatics. Students acquire a working knowledge of a variety of publicly available data and computational tools important in bioinformatics, and a grasp of the underlying principles enabling them to evaluate and use novel techniques as they arise in the future.

Cross-listed with Biology 3220.

Cross-level listed with VPM 8850 and Human Biology 8850.

PREREQUISITE: CS 2920 or BIO 2230 or permission of instructor. If taken as VPM 8850 or HB 8850 – Admission to the graduate program and permission of the instructor.

Three lecture hours and a one-hour laboratory session per week

Note: No student can be awarded more than one course credit among HB 8850, VPM 8850, CS 3220 and BIO 3220.

3420 COMPUTER COMMUNICATIONS

This course introduces the basic principles of modern computer communication: protocols, architectures and standards. Topics include layered architectures, data transmission, error and flow control, medium access, routing, congestion control and common internet application protocols.

PREREQUISITE: CS 2520 and CS 2820

Three lecture hours per week

3520 OPERATING SYSTEMS

This course introduces the student to the major concepts of modern operating systems. Topics covered include: process management, memory management, file systems, device management and security.

PREREQUISITE: CS 2520, CS 2620, CS 2820, CS 2910 and CS 2920 Three lecture hours per week

3610 ANALYSIS AND DESIGN OF ALGORITHMS

This course, which introduces the study of algorithm design and measures of efficiency, is a continuation of CS 2920 Topics include algorithm complexity and analysis; techniques such as divide and conquer, greedy and dynamic programming; searching and sorting algorithms; graph algorithms; text processing; efficient algorithms for several common computer science problems and NP-completeness.

PREREQUISITE: CS 2910, CS 2920 and MATH 2420
Three lecture hours per week

3620 SOFTWARE DESIGN

This course examines the principles and best practices in object-oriented (OO) software design. Topics include a review of foundational OO concepts, OO design principles, and design patterns for good software design.

PREREQUISITE: CS 2910 and CS 2920
Three lecture hours per week

3710 DATABASE SYSTEMS

This course introduces the fundamental concepts necessary for the design, use and implementation of database systems. Topics discussed include logical and physical organization of data, database models, design theory, data definition and manipulation languages, constraints, views, and embedding database languages in general programming languages.

PREREQUISITES: CS 2910 and CS 2920
Three lecture hours per week

3840 TECHNOLOGY MANAGEMENT & ENTREPRENEURSHIP

This course provides an overview on how to start and sustain a technology-oriented company. Topics discussed will include the role of technology in society, intellectual property, patents, business plans, financial planning, sources of capital, business structure, liability, tax implications, sales, marketing, operational and human resource management. This course will be taught using problem-based and experiential learning strategies with involvement from real life entrepreneurs as motivators and facilitators. Cross-listed with Engineering 4230.

PREREQUISITE: CS 2520, CS 2620 and CS 2820
Three lecture hours per week

4060 CLOUD COMPUTING

This course examines: the critical technology trends that are enabling cloud computing, the architecture and the design of existing deployments, the services and the applications they offer, and the challenges that need to be addressed to help cloud computing to reach its full potential. The format of this course will be a mix of lectures, seminar-style discussions, and student presentations.

PREREQUISITE: CS 2060

Three lecture hours per week

4110 ARTIFICIAL INTELLIGENCE AND AUTOMATED REASONING

This course introduces general problem-solving methods associated with automated reasoning and simulated intelligence. Topics include problem abstraction, state space heuristic search theory, pathfinding, flocking behaviour, knowledge representation, propositional logic, reasoning with uncertainty, machine learning and connectionism.

PREREQUISITE: CS 2910 and CS 2920

Three lecture hours per week

4120 MACHINE LEARNING

Machine learning is the study of mechanisms for acquiring knowledge from large data sets. This course examines techniques for detecting patterns in sets of uncategorized data. Supervised and unsupervised learning techniques are studied, with particular application to real-world data.

PREREQUISITE: CS 1920 and STAT 1910

Three lecture hours per week

4140 Deep Learning

This course explores the theoretical foundations and practical applications of deep learning in artificial intelligence (AI). Students will gain hands-on experience with neural network architectures, from basic feedforward networks to sophisticated transformer models, and will explore the concept of transfer learning to leverage pre-trained models for specialized tasks. Through project-based learning, students will design and conduct deep learning experiments, analyze results, and present findings in a conference-paper format. Emphasis is placed on understanding AI limitations, ethical considerations, and risk mitigation strategies. By course completion, students will be equipped to implement, evaluate, and critically assess deep learning solutions for real-world applications.

PREREQUISITE: CS 4120

Three lecture hours per week

4350 COMPUTER GRAPHICS PROGRAMMING

This course introduces the student to the principles and tools of applied graphics programming including graphical systems, input and interaction, object modeling, transformations, hidden surface removal, and shading and lighting models. Languages, graphics libraries and toolkits, and video game engines are introduced, as well as relevant graphics standards.

PREREQUISITE: CS 2620, CS 2910, MCS 2050 and MATH 2610 Three lecture hours per week

4360 ADVANCED COMPUTER GRAPHICS PROGRAMMING

This course builds on the computer graphics programming concepts introduced in CS 435. Students are given a deeper understanding of the components of the 3D graphics pipeline, and how they are used in modern graphical applications. Topics include advanced texture mapping, practical uses of vertex and pixel shaders, screen post-processing, particle systems, and graphics engine design.

PREREQUISITE: CS 4350

Three lecture hours per week

4440 DATA SCIENCE

Data science is an interdisciplinary and emerging field where techniques from several areas are used to solve problems using data. This course provides an overview and hands on training in data science, where students will learn to combine tools and techniques from computer science, statistics, data visualization and the social sciences. The course will focus on: 1) the process of moving from data collection to product, 2) tools for preparing, manipulating and analyzing data sets (big and small), 3) statistical modelling and machine learning, and 4) real world challenges.

PREREQUISITE: CS 2910, CS 2920 and STAT 1910

Three lecture hours per week

4610 WIRELESS SENSOR NETWORKS

This course is an introduction to Wireless Sensor Networks. It includes the following topics: single-node architecture, wireless sensor network architecture, physical layer, MAC protocols, link-layer protocols, naming and addressing, time synchronization, localization and positioning, topology control, routing protocols, transport layer, and quality of service.

PREREQUISITE: CS 2520, CS 2910 and CS 2920

Three lecture hours per week

4650 VIDEO-GAME ARCHITECTURE

This programming-driven course aims to explore the various systems that comprise a typical video-game project, including event systems, state machines, rendering, scripting and AI programming. Students will implement these components throughout the course with the end goal of building a small game.

PREREQUISITE: CS 4350

CO-REQUISITE: CS 4360 (must be taken previously or concurrently) Three lecture hours per week

4720 COMPILER DESIGN

This is a first course in compiler design. The course covers: compilation phases, lexical analysis, parsing, scope rules, block structure, symbol tables, run-time heap and stack

management, code generation, pre-processing, compiler-compilers, and translation systems.

PREREQUISITE: CS 3320

Three lecture hours per week

4810 SOFTWARE ENGINEERING

This course emphasizes the theory, methods and tools employed in developing medium to large-scale software which is usable, efficient, maintainable, and dependable. Project planning and management are major foci. Topics include requirements modelling/specification, project costing, scheduling, software design, software architecture, traditional and agile process models, team management, and re-engineering. Students will develop a project plan for a major project to be undertaken in CS 4820 or CS 4830.

PREREQUISITE: CS 3620

Three lecture hours per week

4820 SOFTWARE SYSTEMS DEVELOPMENT PROJECT

In this course, students work in groups to complete and present a significant software project based on a project plan developed in CS 4810.

PREREQUISITE: CS 4810

One lecture hour per week plus significant project development time

4830 VIDEO GAME PROGRAMMING PROJECT

In this course, students work as a group to develop a single design into a fully functioning video game. This course applies the project management skills learned in CS 4810 to the development of a professional quality video game based upon the students' design.

Restricted to students enrolled in the Major in Computer Science with a Specialization in Video Game Programming.

PREREQUISITE: A minimum grade of 70% in CS 4360, 4650 and 4810 One lecture hour per week plus significant project time.

Semester hours of credit: 6

APPLIED MATHEMATICAL SCIENCE COURSES (AMS PREFIX)

1910 Introduction to Data Science

This course provides an introduction to data analysis, artificial intelligence and business intelligence tools, equipping students with the skills to explore, analyze, and communicate data-driven insights effectively. Students will learn to manipulate datasets, perform basic exploratory data analysis, and build interactive dashboards using widely available platforms. The course emphasizes hands-on practice with real-world datasets, focusing on data cleaning, visualization, and predictive modelling. Students will develop the ability to

tell compelling stories with data, create professional-grade reports, and communicate actionable insights to diverse audiences. No prior coding experience is required.
PREREQUISITES: Admission to a major in the School of Mathematical and Computational Sciences, or permission of the instructor. Three hours a week

2030 INTERMEDIATE MICROECONOMICS I

Initial reading will be provided to cover for some of the material normally covered in Economics 1010. The theories of consumer and producer behaviour are elaborated upon through the application of classical utility and indifference curve and production isoquant approaches. Choice under uncertainty and competitive market outcomes are also examined.

Cross-listed with Economics 2030.

PREREQUISITES: Enrolled in Bachelor of Science in Actuarial Science or Financial Mathematics

Three hours a week

2040 INTERMEDIATE MACROECONOMICS I

Initial reading will be provided to cover for some of the material normally covered in Economics 1020. This course explores the national economy in terms of the determination of national output, the general price level, the rate of interest, and employment. It then analyzes the effectiveness of monetary and fiscal policy in achieving specific goals and combination of goals.

Cross-listed with Economics 2040.

PREREQUISITES: Enrolled in Bachelor of Science in Actuarial Science or Financial Mathematics

Three hours a week

2160 FINANCIAL MATHEMATICS I

This first course in financial mathematics includes topics such as measurement of interest; the growth of money; annuities and perpetuities; loan repayment; bonds; common and preferred stocks; the term structure of interest rates; interest rate sensitivity; using duration and convexity to approximate change in present value; interest rate swaps; and determinants of interest rates.

PREREQUISITE: MATH 1910

Three lecture hours plus a two hour lab per week

2410 FINANCIAL ECONOMICS I

Introduction to mathematical techniques used to price and hedge derivative securities in modern finance. Modelling, analysis and computations for financial derivative products, including exotic options and swaps in all asset classes. Applications of derivatives in practice will also be discussed.

PREREQUISITE: AMS 2160

Three lecture hours a week plus a two hour lab per week

2510 LONG TERM ACTUARIAL MATHEMATICS I

This course will explore the future lifetime random variable, probability and survival functions, force of mortality; complete and curtate expectation of life, and Makeham and Gompertz mortality laws. Other topics will include: Life tables, characteristics of population and insurance life tables, selection, and fractional age assumptions. Life insurance payments and annuity payments: Present value random variables; expected present values; higher moments; actuarial notation, annual, monthly and continuous cases, relationships between insurance and annuity functions. Premiums, expense loadings, present value of future loss random variables and distribution, net and gross cases, the equivalence principle and portfolio percentile principle will also be discussed.

PREREQUISITE: AMS 2160

Three lecture hours a week plus a two hour lab per week

2940 OPTIMIZATION

An introduction to the methods and applications of linear programming. Topics include linear programming formulations, the simplex method, duality and sensitivity analysis, and integer programming basics. Applications to transportation, resource allocation and scheduling problems will be examined. Software will be used to illustrate topics and applications.

PREREQUISITE: MATH 2610

Three lecture hours per week

3040 INTRODUCTION TO GGY AXIS

An introduction to the software package GGY AXIS. Topics include the basic functions and commands, programming and problem-solving using GGY AXIS.

PREREQUISITE: AMS 2510

Two lab hours per week for 6 weeks Semester
hours of credit: 1

3140 PROBABILITY FOR ACTUARIES

The purpose of this course is to prepare students for the Probability professional exam by bringing together topics such as probability, continuous and discrete univariate random variables (including binomial, negative binomial, geometric, hypergeometric, Poisson, uniform, exponential, gamma, normal), probability generating functions, moment generating functions, multivariate random variables (including the bivariate normal), joint distributions, conditional distributions, marginal distributions, functions of random variables. In addition, the following topics are introduced: Central Limit Theorem, risk and insurance applications, and probability applications in actuarial science (including discrete and continuous time Markov chains with application to insurance).

PREREQUISITE: STAT 2910

Three lecture hours per week plus one-hour lab per week

3160 GAME THEORY

The course covers the fundamentals of game theory and its applications its applications to the modeling of competition and cooperation in business, economics, biology and society. Two-person games in strategic form and Nash equilibria. Extensive form games, including multi-stage games, coalition games and the core Bayesian games, mechanism design and auctions.

PREREQUISITE: MATH 1920, MATH 2420 and STAT 1910

Three lecture hours per week

3310 ADVANCED CORPORATE FINANCE

This course covers various advanced topics in corporate finance, and covers topics such as fundamentals of capital budgeting; valuing stocks, capital markets and the pricing of risks; optimal portfolio choice and the capital asset; estimating the cost of capital; investment behavior and capital market efficiency; capital structure in a perfect market; debt and taxes; financial distress, managerial incentives, and information; real options; raising equity capital; debt financing; and supplementary material for investments and finance: measures of investment risk, Monte Carlo simulation, and empirical evidence on the efficient market hypothesis. Where suitable, topics are treated from a mathematical and quantitative perspective.

PREREQUISITE: BUS 2310

Three lecture hours per week plus a two hour lab per week

3410 FINANCIAL ECONOMICS II

This course will discuss advanced mathematical techniques used to price and hedge derivative securities in modern finance. Topics include: modelling, analysis and computations for financial derivative products, including exotic options and swaps in all asset classes. Students will also have the opportunity to apply these derivatives in practice.

PREREQUISITE: AMS 2410

Three lecture hours per week plus a two hour lab per week

3420 INTRODUCTION TO FINANCIAL DERIVATIVES

Introduction to mathematical techniques used to price and hedge derivative securities in modern finance. Topics include: modelling, analysis and computations for basic options and forwards on different class assets, general properties of options including put-call parity relationship, pricing and hedging of European and American options using the binomial model, Black-Scholes formulas for calls and puts, option Greeks, Delta-hedging, exotic options including Asian and barrier options.

PREREQUISITE: AMS 2160

Three lecture hours per week plus a one hour lab per week

3510 LONG TERM ACTUARIAL MATHEMATICS II

This course will discuss: policy values, annual, monthly and continuous cases, Thiele's equation, policy alterations, modified policies and multiple state models. Other topics will

include applications in life contingencies, assumptions, Kolmogorov equations, premiums, policy values, multiple decrement models, Joint Life Models, Valuation of insurance benefits on joint lives, and dependent and independent cases.

PREREQUISITE: AMS 2510

Three lecture hours per week plus a two hour lab per week

3770 COMBINATORIAL OPTIMIZATION

In this course, various algorithms will be considered, including minimum spanning tree, shortest path, maximum flow, and maximum matching. The links with linear and integer programming will also be considered, with particular attention to duality.

PREREQUISITES: MATH 2420

Three lecture hours per week

3910 MATHEMATICAL MODELLING

This course studies the process of mathematical modeling, namely, formulating a “realworld” problem in mathematical terms, solving the resulting mathematical problem, and interpreting the solution. Major topics include the modelling process, proportionality, geometric similarity, model fitting, graphical models, dimensional analysis, and deterministic and probabilistic dynamical processes (with models formulated as differential and difference equations). Applications are taken from science, business and other areas, according to class interest.

PREREQUISITE: MATH 2610 and MATH 3010; a statistics course is recommended. Three lecture hours per week

4040 ADVANCED GGY AXIS

This course covers advanced applications of the software package GGY AXIS in the form of actuarial case studies in pricing and reserving.

PREREQUISITES: AMS 3040, AMS 3510, and AMS 4540 Three lecture hours a week

4080 FINANCIAL MATHEMATICS II

This course explores foundational notions and models in financial mathematics. Topics include attainable payoffs, arbitrage, completeness, the law of one price, first and second Fundamental Theorems of Asset Pricing, introduction to discrete-time stochastic calculus, conditional expectations, risk-neutral martingale measures, dynamic replication in the binomial model for European, American and exotic options, general multi-asset multiperiod models.

PREREQUISITE: MATH 2610 and AMS 2410 or AMS 3420, and STAT 2910 Three lecture hours per week

4090 FINANCIAL MATHEMATICS III

This course explores continuous-time models in financial mathematics. Topics include

Brownian motion, geometric Brownian motion, quadratic variation, Riemann-Stieltjes and Ito integrals, Ito's formula, replication and risk-neutral pricing under the Black-Scholes economy, Black-Scholes partial differential equation, delta-hedging for multi asset derivatives, and valuation of cross currency options.

PREREQUISITE: AMS 4080

Three lecture hours per week

4450 STATISTICS FOR RISK MODELING

The purpose of this course is to prepare for the Statistics for Risk Modeling professional exam by bringing together topics such as the key concepts of statistical learning and regression modelling with applications; linear models; time series models; principal components analysis; decision trees; and cluster analysis with their applications.

PREREQUISITE: STAT 2910, STAT 3240, and MCS 2030.

Three lecture hours per week plus two hours lab per week

4540 LOSS MODELS I

This course explores models for loss severity, parametric models, effect of policy modifications, and tail behaviour. Topics also include: models for loss frequency: $(a, b, 0)$, $(a, b, 1)$, mixed Poisson models; compound Poisson models, Aggregate claims models: moments and moment generating function: recursion and Classical ruin theory.

PREREQUISITE: AMS 3510 and STAT 3910

Three lecture hours per week plus a one hour lab per week

4550 LOSS MODELS II

This course is a study of the mathematics of survival models and includes some examples of parametric survival models. Topics include: tabular survival models, estimates from complete and incomplete data samples, parametric survival models, and determining the optimal parameters. Maximum likelihood estimators, derivation and properties, product limit estimators, Kaplan-Meier and Nelson-Aalen, credibility theory: limited fluctuation; Bayesian; Buhlmann; Buhlmann-Straub; empirical Bayes parameter estimation; statistical inference for loss models; maximum likelihood estimation; the effect of policy modifications; and model selection will also be discussed.

PREREQUISITE: AMS 4540

Three lecture hours per week plus a one-hour lab per week

4580 CREDIBILITY THEORY

This course is an introduction to credibility theory and will provide the ability to understand and estimate losses using credibility procedures as well as to apply and critique limited fluctuation (classical) credibility, explain and apply Bayesian credibility, apply conjugate priors in Bayesian credibility, apply Buhlmann and Buhlmann-Straub models and understand their relationship to Bayesian models, and explain and apply empirical Bayesian method in the nonparametric and semiparametric cases.

PREREQUISITE: STAT 3910

Three lecture hours plus a one-hour lab per week

4600 PREDICTIVE ANALYTICS I

This course is an introduction to topics such as predictive model building process in R; problem definition, data visualization, exploratory data analysis, identification of data issues and resolution, and initial model selection; model selection; model validation; communication of results and uncertainties; sample project and report.

PREREQUISITE: STAT 3250 and STAT 4280

Three lecture hours per week plus a one-hour lab per week

4610 PREDICTIVE ANALYTICS II

This course builds on AMS 4600 and covers more advanced topics of the predictive model building process in R including a project and final report.

PREREQUISITES: AMS 4600

Three lecture hours per week plus a one-hour lab per week

4680 NONLINEAR OPTIMIZATION

This course is a study of unconstrained optimization, optimality conditions (necessary, sufficient and Karush-Kuhn-Tucker), penalty functions, convex functions, and convex programming.

PREREQUISITE: MATH 2910 and AMS 2940

Three lecture hours per week

4700 SHORT TERM INSURANCE PRICING AND RESERVING

This course covers the basic methods to calculate premiums and reserves for short-term insurance coverages; the role of rating factors and exposure; the different forms of experience rating; the description and application techniques for estimating unpaid losses from a run-off triangle; the following methods: Chain ladder, Average cost per claim, Bornhuetter Ferguson; and the underlying statistical models for these methods; as well as premiums calculation using the pure premium and loss ratio methods.

PREREQUISITES: AMS 2510

Three lecture hours per week plus a one-hour lab per week

4780 QUANTITATIVE RISK MANAGEMENT

This course is an introduction to financial risk management. Topics include: risk measures, modeling for multivariate distributions and copulas, market, credit and operational risk. Advanced topics in quantitative risk management will also be discussed.

PREREQUISITE: AMS 3310

Three lecture hours per week

MATHEMATICAL AND COMPUTATIONAL SCIENCES COURSES (MCS PREFIX)

2010 MAPLE TECHNOLOGY LAB

An introduction to the software package MAPLE. Topics include the basic functions and commands, programming and problem-solving using MAPLE.

PREREQUISITE: CS 1910 and MATH 1920

Two lab hours per week for 6 weeks Semester
hours of credit: 1

2020 MATLAB TECHNOLOGY LAB

An introduction to the software package Matlab. Topics include the basic functions and commands, programming and problem-solving using Matlab.

PREREQUISITE: CS 1910 and MATH 2610

Two lab hours per week for 6 weeks
Semester hours of credit: 1

2030 R TECHNOLOGY LAB

An introduction to the software package R. Topics include the basic functions and commands, programming and problem-solving using R.

PREREQUISITE: CS 1910 and STAT 1910

Two lab hours per week for 6 weeks
Semester hours of credit: 1

2040 VISUAL BASIC IN EXCEL TECHNOLOGY LAB

An introduction to the software package Excel and Visual Basic in the Excel environment. Topics include the basic functions and commands, programming and problem-solving using Excel and Visual Basic.

PREREQUISITE: CS 1910 and AMS 2400

Two lab hours per week for 6 weeks Semester
hours of credit: 1

2050 C++ TECHNOLOGY LAB

An introduction to C++ for java programmers. Topics include basic terminology, pointers, memory management, classes, operator overloading, heap versus stack variables and the C++ standard template library.

PREREQUISITE: CS 1920

Two lab hours per week for 6 weeks.

3050 TUTORING IN MATHEMATICAL AND COMPUTATIONAL SCIENCES

Students are introduced to techniques for facilitating learning in the Mathematical and Computational Sciences, and then put these techniques into practice by mediating student group learning either in introductory Mathematical and Computational Sciences

courses, Mathematical and Computational Science Help Centre or in outreach programs to High Schools. Students are assessed on a pass/fail basis.

PREREQUISITE: At least 36 semester hours of credit completed in courses in the School of Mathematical and Computational Sciences

One lecture hour per week plus practical tutoring

Semester hours of credit: 1

3320 THEORY OF COMPUTING

This course introduces automata theory, formal languages and computability. Topics include: finite automata; regular expressions; regular, context-free, and context-sensitive languages; computability models; algorithmic decidable and undecidable problems.

PREREQUISITE: CS 2910, CS 2920 and MATH 2420

Three lecture hours per week

3500 QUANTUM INFORMATION

This course is an introduction to quantum information science; the field of studying, storing, processing and communicating information using quantum systems. Topics include: quantum mechanics for Qubit Systems, foundations of Quantum Computing, algorithms, communication and cryptography.

PREREQUISITE: MATH 2620

Three lecture hours per week

3920 NUMERICAL ANALYSIS

Approximate solution of equations, various interpolative or iterative methods, especially Newton's; convergence tests and rates of convergence; roundoff and truncation errors; propagation of error in calculations; interpolating polynomials; Gauss-Jordan and other methods for simultaneous linear equations; inversion of matrices; determinants and eigenvalues; simultaneous nonlinear equations; evaluation of definite integrals; approximate derivatives; initial-value ordinary differential equations; least-squares curve fitting.

PREREQUISITE: MATH 3010 and CS 1910 or equivalent

Three lecture hours per week

3950 SPECIAL TOPICS IN MATHEMATICAL AND COMPUTATIONAL SCIENCES

This course provides students with an opportunity to pursue special topics in Mathematical and Computational Science. Content varies from year to year.

PREREQUISITE: Permission of the instructor

Three lecture hours per week

4210 PROFESSIONAL COMMUNICATION AND PRACTICE

This course aims to build students' oral and written communications skills, and to prepare students to think critically about essential and potentially controversial issues in the Mathematical and Computational Sciences, with the goal of preparing students for a

professional environment. Using examples from their discipline, students will focus on such aspects as description of processes, presentation of data, extended abstracts, correct use of terminology, and sensitivity to language and tone. Discussions of topics relevant to the professional Mathematical and Computational Scientist, such as: ethics; security; privacy and civil liberties; risk and liability; intellectual property; and certification standards are also a key part of the course.

PREREQUISITE: At least 36 semester hours of credit completed in courses in the School of Mathematical and Computational Sciences

Three hours per week

4420 CRYPTOGRAPHY AND CODES

This course is a study of encoding and encryption algorithms and their applications. Linear codes, error detection, and error-correcting codes, are introduced. Symmetric and asymmetric key encryption algorithms are studied and analyzed. Other topics include confidentiality, message authentication, public and private keys, digital signatures, and security.

PREREQUISITE: MATH 2420, MATH 2610 and CS 1920

Three lecture hours per week

4901 HONOURS PROJECT I

The objective of this course is to provide research experience for the student who intends to pursue further studies at the graduate level, or who is planning a career where research experience in the Mathematical and Computational Sciences would be an asset. A research project is done under a faculty supervisor

PREREQUISITE: Acceptance into an Honours program in SMCS Semester hours of credit: 3

4902 HONOURS PROJECT II: THESIS

The objective of this course is to provide research thesis experience for the student who intends to pursue further studies at the graduate level, or who is planning a career where research experience in the Mathematical and Computational Sciences would be an asset. The research project results from MCS 4901 are further analysed as needed under a faculty supervisor, reported in a thesis format, and presented and defended at a seminar.

PREREQUISITE: MCS 4901

Semester hours of credit: 3

4910 DIRECTED STUDIES IN MATHEMATICAL AND COMPUTATIONAL SCIENCES

These courses are designed and recommended for students in the Mathematical and Computational Sciences to encourage independent initiative and study. Reading and research will be conducted in one or more specialized areas. (See [Academic Regulation 9](#) for Regulations Governing Directed Studies.)

PREREQUISITE: Permission of the instructor

One, two, or three hours credit

4950 ADVANCED TOPICS IN MATHEMATICAL AND COMPUTATIONAL SCIENCES

This course provides students with an opportunity to pursue advanced topics in the Mathematical and Computational Sciences Content varies from year to year but is always at a fourth-year level. Prospective students should contact the School of Mathematical and Computational Sciences for a more detailed description of any particular year's offering.

PREREQUISITE: Permission of the instructor

Three lecture hours per week

Appendix 4

Program Comparison Table

4: Program Comparison Table

Using the following table, compare the proposed program to three to five other relevant programs offered at other institutions in Canada (international programs may be considered only if there are no comparable Canadian programs). Comment on similarities as well as differences.

Program Name	Institution	Website	Similarities with Modified Program	Differences Compared to Modified Program	Other Notes
BSc. Math with Data Analytics	Acadia	https://math.acadiau.ca/linked-pages/bscmath-stats-with-dataanalytics-option.html	Includes regression, time series, statistical learning. Strong mathematics / statistics foundations	Mathematics centric identity with data as a secondary outcome No dedicated capstone project No explicit domain agnostic problem analysis and design thinking course sequence.	
Bachelors Computer Science with Data Science Specialization	Dalhousie	https://www.dal.ca/study/program-sites/digitalinnovation/programdetails/datascience.html	Includes programming, statistics, and data science concepts. Offers capstone	Computer Science centric identity, more emphasis on skills that lean towards data engineering careers as opposed broadly applicable crossdomain data analytics skills. No explicit domain agnostic problem analysis and design	Software and Systems specialization provides students seeking more technical skills or a data engineering career path.

				thinking course sequence.	
Certificate in Data Analytics	UNB	https://www.unb.ca/academics/calendar/undergraduate/current/saintjohnprograms/certificateindataanalytics.html	Provides a variety of statistics and computer science courses covering wide variety of topics relevant to data analytics	Only a certificate program, not a degree. Small number of courses, with only 1 required data analytics course.	Software and Systems specialization provides students seeking more technical skills or a data engineering career path.

				Majority of courses are computer science courses leaning the degree towards data engineering careers as opposed to broadly applicable cross-domain data analytics skills. No explicit domain agnostic problem analysis and design thinking course sequence.	
Data Science (Honours Spec./Major/Minor/Certificate)	Western University	https://www.uwo.ca/sci/datascience/undergraduate/programs.html	Blends math, statistics, and computer science; Includes a fourth-year capstone in the Honours stream.	More math/algorithms intensive; No explicit business specialization path. No explicit domain agnostic problem analysis and design thinking course sequence.	Multiple modular pathways (major/minor/certificate) similar to new UPEI program structure to offer flexibility.
Data Science (BMath/BSc)	University of Waterloo	https://uwaterloo.ca/future-students/programs/data-science	Blends math, statistics, and computer science; applied data analysis; ML and distributed analytics options. Experiential/co-op options	Math centric identity; No explicit domain agnostic problem analysis and design thinking course sequence. Capstone availability varies by stream.	Co-op availability is similar to our program.
Mathematics (BA/BSc) / BSc in Mathematics & Data Analytics	Wilfrid Laurier University	https://www.wlu.ca/programs/science/undergraduate/mathematics-ba-orbsc/index.html	Blends math, statistics, and computer science; Experiential/co-op options	Math-centric identity No explicit capstone project. No explicit business analytics or data engineering path.	

				No explicit domain agnostic problem analysis and design thinking course sequence.	
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Appendix 5

Student Learning Outcomes Table

Appendix 5: Student Learning Outcomes Table

Using the following table, identify the student learning outcomes for the modified program. For each student learning outcome, indicate the courses where this outcome will be developed and/or assessed. Aspects of courses, specific assessments, and/or pedagogical approaches that will contribute to the development of the outcomes can be listed in Approaches and Assessments.

Student Learning Outcomes Outcomes should follow the stem “By the end of the program, students will be able to...”	Related Courses and Program Components List the courses and/or program components that will contribute to students’ achievement of the learning outcomes	Approaches and Assessments Describe how the learning outcomes will be achieved and/or assessed within the program	Overview of Changes, if any (since previous MPHEC assessment or last external review)
Apply fundamental mathematical concepts, theories, and reasoning to formulate, analyze, and solve data science problems. (Mathematical Foundations)	MATH 1910, MATH 1920, MATH 2610, STAT 2910, STAT 2240, STAT 3660, AMS 4910	Problem sets, midterms/finals (proofs & applications), modelling labs, capstone modelling component	Only Mathematics courses that are required for Data Science remain as required courses. Advanced mathematics courses in Group Theory, Differential Equations and Optimization have been made elective.
Apply foundational statistical concepts to design, analyze, and interpret data analyses that inform sound conclusions. (Statistical Foundations)	STAT 1910, STAT 2910, STAT 2240, STAT 3660, AMS 4910	Labs, inference projects, regression project, HD analytics project, capstone analysis	Advanced courses in Statistics not related to Data Science have been removed. New Data Science-specific courses AMS 1910, AMS 2910 and AMS 4910 were added to support this outcome. A lab component in R has been added to STAT 1910.

Design and implement algorithms and software solutions to acquire, process, and analyze large and complex datasets using contemporary programming languages and tools. (Computational Foundations)	CS 1910, CS 1920, STAT 1910, AMS 2910, STAT 3660, AMS 4910 (Software and Systems Reinforcement and Extensions: CS 2910, CS 2920, CS 3710, CS 3610/3620/4120/4140)	Programming assignments, code reviews, data pipeline labs, ML notebooks, capstone code repo	Advanced computer science courses related to software have been made elective. This outcome is supported through the introduction of courses AMS 1910, AMS 2910 and AMS 4910.
Engage diverse parties to elicit requirements, frame data-driven questions, and co-design feasible analytic solutions across industries and domains (Problem Analysis)	AMS 2910, AMS 4910, MCS 4210 (Business Analytics Reinforcement and Extensions: BUS 1410, BUS 1710, BUS 2880/3510/UNIV 3100/3200)	Stakeholder interviews, design briefs, requirements docs, presentations	Previously, STAT 3660 (formerly STAT 4660) and CS 4440 Data Science supported this outcome. Now, students are introduced to this in their first year of study and build throughout their program. The introduction of AMS 4910 makes CS 4440 redundant.
Design studies and experiments to answer questions efficiently and draw valid and reproducible conclusions. (Study Design)	AMS 2910, STAT 2240, STAT 1910, STAT 2910, AMS 4910 (Business Analytics Reinforcement and Extensions: BUS 2880)	Study protocols, IRB-ready materials, survey instruments, experiment plans, qualitative analysis summaries and reports, case studies	Human centered design thinking chain throughout the degree with AMS1910, AMS2910, AMS4910
Explain the characteristics and challenges of big data, evaluate appropriate storage and processing strategies, and apply best practices for security, privacy, and governance. (Big Data Governance)	STAT 3660, AMS 2910, AMS 4910 (Software and Systems Reinforcement and Extensions: CS 3710; CS 4120/4140)	Assignments, Case/platform evaluations; governance plans; individual projects	Data governance skills throughout AMS1910, AMS2910, AMS4910
Clean, transform, integrate, and document datasets to ensure quality, reproducibility, and readiness for analysis. (Wrangling)	AMS 1910, STAT 1910, STAT 2240, AMS2910, STAT 3660, AMS 4910	Modelling projects with diagnostics, cross-validation studies, optimization labs, capstone results	Specific increases in coverage and detail of knowledge from STAT1910 and STAT3660, skills and abilities in AMS1910, AMS2910 and AMS4910 chain

<p>Select, implement, and evaluate appropriate analytical, statistical, and machine-learning methods to discover patterns, make predictions, and optimize decisions. (Data Analysis)</p>	<p>STAT 3660, AMS 4910 (Software and Systems Reinforcement and Extensions: CS 4120/4140)</p>	<p>Ethics case analyses, bias audits, accessibility checks, governance plan in capstone</p>	<p>Methods are taught in STAT3660 and AMS4910 from a theoretical and technical perspective. Extensions for machine learning and algorithmic approaches in specialization.</p>
<p>Identify, evaluate, and address ethical, legal, and social implications of data science—including privacy, security, fairness, and accessibility—and integrate ethical principles throughout the data lifecycle. (Ethics)</p>	<p>AMS1910, AMS 2910, MCS 4210, AMS 4910, STAT 3660 (bias/limitations), (Software and Systems Reinforcement and Extensions: CS3210)</p>	<p>Ethics case analyses, bias audits, accessibility checks, governance plan in capstone</p>	<p>Ethics is now touched on throughout all years of study within curriculum. Software and systems extends to user experience testing and inclusive design.</p>
<p>Communicate complex technical findings clearly and appropriately to technical and non-technical audiences using written reports, presentations, and data visualizations. (Communication)</p>	<p>MCS 4210, AMS1910, AMS 2910, AMS 4910, STAT 2240, STAT 1910</p>	<p>Technical reports, executive summaries, slide decks, data stories/dashboards</p>	<p>Requirements are throughout the program, beginning in first year. Student must communicate choices made, justification of choices and results.</p>
<p>Demonstrate professional behaviours—including teamwork, project management, adaptability, and critical thinking—across diverse domains and contexts. (Professionalism)</p>	<p>MCS 4210, AMS 2910, AMS 4910</p>	<p>Team peer assessments, project plans, retrospectives, professionalism reflection</p>	<p>Extensions of working with clients and other end-users in AMS2910 and AMS4910.</p>

Appendix 6

Faculty Resource Table

Appendix 6: Faculty Resource Table Using the following table, identify all the faculty and instructional staff expected to teach required courses and select electives in the modified program.¹⁰ Be sure to identify any new administrative or other duties and/or roles faculty members will hold within the modified program (can be included under rank). If new faculty hires are required to support the program, provide the same information to the extent possible (e.g. status, desired areas of expertise, list of courses expected to be taught), in addition to the anticipated hire date.

Name	Rank ¹¹	Status (Tenure, Tenure-Track, Contract [specify planned length])	Highest Degree or Professional Designation Held	Areas of Expertise	Number of Courses Expected to be Taught in this Program per Year	List of required Courses and Select Electives ¹² Faculty Can Teach in this Program (course names and numbers)	Anticipated Hire Date (if applicable)
CURRENT FACULTY							
Paul Sheridan	Assistant Professor	Tenure Track	PhD	Statistics, Data Science	2	STAT 1910 STAT 2910 STAT 2240 STAT 3660 AMS 4910	
Michael McIssac	Professor	Tenured	PhD	Statistics	2	STAT 1910 STAT 2910 STAT 2240 STAT 3660	
Kristina Kupferschmidt	Assistant Professor	TenureTrack	PhD	Data Science	3	STAT 1910 AMS 1910 AMS 2910 AMS 4910 MCS 4210	

¹⁰ Only faculty who directly support the program should be included in the table, i.e., those who teach courses directly related to the program of study, including cross-listed faculty. It is not required to list faculty who teach required courses that satisfy general degree requirements (i.e., distribution or breadth courses), particularly if those courses are existing and offered by departments outside of those which house this program. E.g., If students in a new in Major in Theatre are required to take a general survey course taken by all Bachelor of Arts students, faculty who teach that course need not be included in the table. However, an introductory chemistry course would directly contribute to the program of study for a new Major in Biochemistry; faculty who teach that course should therefore be included in the table. For collaborative programs, do not include faculty from non-university partners.

¹¹ Rank refers to job title (e.g. professor, assistant professor, senior lecturer, sessional instructor).

¹² The requirement to list all select electives taught may be omitted for programs with a large number of select elective courses that are taught by faculty outside of the academic unit or core faculty group (e.g., highly interdisciplinary programs).

Andrew Godbout	Associate Professor	Tenured	PhD	Computer Science	1	CS 1910 CS 1920	
Shafiqul Islam	Professor	Tenured	PhD	Mathematics	1	MATH 1910 MATH 1920 MATH 2610	
Soudabeh Asadi Dezaki	Assistant Professor	Tenure Track	PhD	Mathematics	1	MATH 1910 MATH 1920 MATH 2610	
Antonio Bolufe-Rohler	Associate Professor	Tenured	PhD	Computer Science	1	CS 1910 CS 1920	
David Horrocks	Associate Professor	Tenured	PhD	Mathematics	1	MATH 1910 MATH 1920 MATH 3610	
Dania Tamayo-Vera	Assistant Professor	Tenure Track	PhD	Computer Science	1	AMS 1910 CS 1910 CS 1920	
Christopher Power	Professor	Tenured	PhD	Computer Science	1	AMS 1910 AMS 2910 CS 1910 CS 1920 MCS 4210	
Sami Khedhiri	Professor	Tenured	PhD	Statistics	2	STAT 1910 STAT 2910 STAT 2240	
Shannon Fitzpatrick	Professor	Tenured	PhD	Mathematics	1	MATH 1910 MATH 1920 MATH 2610 MCS 4210	
Pouya Faroughi	Assistant Professor	Contract (2.5 years)	PhD	Statistics Actuarial Science	1	STAT 1910 STAT 2910	
Justin Gulati	Sessional and Lab Instructor	Full time lab instructor	Masters	Mathematics	1	MATH 1910 MATH 1920	

Taif Al Musabe	Sessional and Lab Instructor	Full time lab instructor	Masters	Computer Science	1	AMS 1910 STAT 1910 Lab CS 1910 Lab	
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Note: The MPHEC reserves the right to request CVs for faculty teaching in the program.

Appendix L

Library Information

- Curriculum forms for the two proposed new courses, AMS 2910 and AMS 4910, which include library reports.

NEW COURSE PROPOSAL

Motion #

Faculty/School: **Science**

Department/Program(s): **School of Mathematical and Computational Sciences**

MOTION: That the proposed course AMS 2910 Design Thinking with Data be approved as presented.

Course Number and Title	AMS 2910 Design Thinking with Data
Description	This course builds on the foundational data skills introduced AMS 1910 such as data wrangling, exploratory analysis, and visualization and develops them to inform problem framing and solution specification within a human-centered design thinking framework. Students learn to engage key parties to identify meaningful problems, co-create ideas, and iteratively refine solutions through testing and feedback. Students are introduced to new techniques such as collecting and evaluating data from surveys, interviews, and observation; recognizing and addressing issues of data quality, bias, and uncertainty; and transforming insights into clear narratives and prototypes that support decision-making. Through case studies and hands-on projects, students will integrate technical analysis with human-centered insights to design data-driven solutions that are both actionable and contextually relevant. Optional extensions are available for students with programming experience
Cross-Listing	Click here to enter text.
Prerequisite/Co-Requisite	Prerequisite: AMS 1910 and one of STAT 1210, STAT 1910, BUS 2510, PSY 2700, PSY 2710, PSY 2750, ENGN 2130, SOC 3320, EDU 4810
Credit(s)	3
Notation	Click here to enter text.

This is: A Core Course

Grade Mode: Numeric (Standard)

Anticipated Enrolment: 40

Is there an Enrolment Cap: No

If there is an enrolment limit, please explain. [Click here to enter text.](#)

Rationale for New Course: In the 2021 quality assurance review of SMCS programs, it was recommended that courses specific to Data Science should be added to the Analytics Programs so that such a course was available at every level. This is the second such course to be introduced, following AMS 1910 Introduction to Data Science. The course contributes to accreditation-style graduate attributes (design, communication, ethics, teamwork), and develops in-demand skills identified in Canadian labour

market studies (problem framing, communication, stakeholder engagement, domain knowledge development, data storytelling, bias/uncertainty reasoning).

Effective Term: Fall 2026 [Select a Term.](#)

Implications for Other Programs: None

Impact on Students Currently Enrolled: None

Resources Required: None. We will deliver this course with existing resources.

In offering this course will UPEI require facilities or staff at other institutions: No
If yes, please explain. [Click here to enter text.](#)

Authorization	Date:
Departmental Approval: Shannon Fitzpatrick	October 3, 2025
Faculty/School Approval: Nola Etkin	October 27, 2025
Faculty Dean's Approval:	
Graduate Studies Dean's Approval: Click here to enter name of approver.	Click here to select approval date.
Registrar's Office Approval: Click here to enter name of approver.	Click here to select approval date.

Form Version: September 2023



NEW COURSE PROPOSAL

Motion #

LIBRARY RESOURCE REQUIREMENTS FOR A NEW COURSE PROPOSAL

[Click here to enter text.](#)

To be completed by the liaison and/or collections librarian.

Note that the submitting program is required to allow the library staff two weeks to complete this.

Existing resources:

- Collections – Print books, Ebooks, other physical media, other online media, subscriptions, other
 - OneSearch returns 3750 available book/chapter results (print and e) for “design thinking”, 94 of which are within the O’Reilly platform (likely focused on tech/data/comp sci/math).
 - OneSearch returns over 16k available book/chapter results (print and e) for “data science”
 - OneSearch returns only 8 results for available books/chapters with keywords “design thinking” and “data science”
- Interdisciplinary packages that include content that support this course
 - Springer Nature eBooks
 - Scopus
 - De Gruyter Brill Online
 - ProjectMUSE
- Physical Space in Library (other than collections, explain) - none
- Library Administrative/Research Support – **Rosie Le Faive, liaison to SMCS, is available for consultation.**

New resources needed to support this proposal:

- Collections:
 - Monographs – some recommended data science books can be purchased.
 - Subscriptions/Databases - none
 - Other including potential Open Educational Resources (OERs) - none
- Physical Space in Library (other than collections, explain) - none
- Library Administrative/Research Support - none
- Other One-Time or Ongoing Library expenses (e.g. software licenses, explain) - none

Summary of additional budget allocation required:

- First year startup: \$ __0__ in first fiscal year the course/program is offered
- Additional startup years: \$ __0__ in second year, \$ __0__ in third year....
- Annual: \$ __0__ in addition to the startup figure(s) above starting in the fiscal year AFTER the year the course is first offered
 - Per-year percentage increase in annual: __0__

Note that if future budget constraints require the Library to cancel interdisciplinary packages listed above, there may be a loss of resources needed for this course.

Date Received by Liaison/Collections Librarian	October 6, 2025
Name of Librarian to be Contacted with Questions	Rosie Le Faive

Approved by University Librarian or Designate	Simon Lloyd
Date Approved by UL or Designate	October 14, 2025

NEW COURSE PROPOSAL

Motion #

Faculty/School: **Science**

Department/Program(s): **School of Mathematical and Computational Sciences**

MOTION: That the proposed course AMS 4910 Analytics Capstone be approved as presented.

Course Number and Title	AMS 4910 Analytics Capstone
Description	This capstone course challenges students to synthesize their knowledge of data science, design thinking, and statistical learning into a substantial applied project. Working with real or hypothesized users, students will define a complex, decision-oriented problem and deliver a validated data product or insight-driven solution. Emphasis is placed on integrating the full data science pipeline, from framing objectives and gathering data to cleaning, modeling, evaluating, and communicating findings. Students will apply methods from prior coursework in data wrangling, visualization, predictive modeling, and human-centered design, while tailoring advanced approaches to domain-specific challenges. The course further trains students in professional skills including iterative project management, documentation, reproducibility, and communication of results to both technical and non-technical audiences. Culminating in a public presentation and professional-grade report, the course provides students with an opportunity to demonstrate readiness to translate data science expertise into real-world impact.
Cross-Listing	Click here to enter text.
Prerequisite/Co-Requisite	AMS 2910 and STAT 3660
Credit(s)	3
Notation	Click here to enter text.

This is: A Core Course

Grade Mode: Numeric (Standard)

Anticipated Enrolment: 20

Is there an Enrolment Cap: No

If there is an enrolment limit, please explain. [Click here to enter text.](#)

Rationale for New Course: In the 2021 quality assurance review of SMCS programs, it was recommended that courses specific to Data Science should be added to the Analytics Programs and that one of those courses should be a capstone project. This is the fourth course in Data Science, following

AMS 1910 Introduction to Data Science, AMS 2910 Design Thinking with Data, and STAT 3660 High-Dimensional Data Analytics.



NEW COURSE PROPOSAL

Motion #

Effective Term: Fall 2026 [Select a Term.](#)

Implications for Other Programs: None

Impact on Students Currently Enrolled: None

Resources Required: None. We will deliver this course with existing resources.

In offering this course will UPEI require facilities or staff at other institutions: No

If yes, please explain. [Click here to enter text.](#)

Authorization	Date:
Departmental Approval: Shannon Fitzpatrick	October 3, 2025
Faculty/School Approval: Nola Etkin	October 27, 2025
Faculty Dean's Approval:	
Graduate Studies Dean's Approval: Click here to enter name of approver.	Click here to select approval date.
Registrar's Office Approval: Click here to enter name of approver.	Click here to select approval date.

LIBRARY RESOURCE REQUIREMENTS FOR A NEW COURSE PROPOSAL

[Click here to enter text.](#)

To be completed by the liaison and/or collections librarian.

Note that the submitting program is required to allow the library staff two weeks to complete this.

Existing resources:

- Collections – Print books, Ebooks, other physical media, other online media, subscriptions, other
 - OneSearch returns 3750 available book/chapter results (print and e) for “design thinking”, 94 of which are within the O’Reilly platform (likely focused on tech/data/comp sci/math).
 - OneSearch returns over 16k available book/chapter results (print and e) for “data science”
 - OneSearch returns over 448,000 available book/chapter results for “statistic*”.
 - O’Reilly (package) contains over 35,000 ebooks that would support many facets of this project-based course, from data science and analysis to individual technical tools and solutions.
- Interdisciplinary packages that include content that support this course
 - Springer Nature eBooks
 - Scopus
 - De Gruyter Brill Online
 - ProjectMUSE
- Physical Space in Library (other than collections, explain) - **none**
- Library Administrative/Research Support – **Rosie Le Faive, liaison to SMCS, is available for consultation.**

New resources needed to support this proposal:

- Collections:
 - Monographs – none.
 - Subscriptions/Databases - none
 - Other including potential Open Educational Resources (OERs) - none
- Physical Space in Library (other than collections, explain) - none
- Library Administrative/Research Support - none
- Other One-Time or Ongoing Library expenses (e.g. software licenses, explain) - none

Summary of additional budget allocation required:

- First year startup: \$ __0__ in first fiscal year the course/program is offered
- Additional startup years: \$ __0__ in second year, \$ __0__ in third year....
- Annual: \$ __0__ in addition to the startup figure(s) above starting in the fiscal year AFTER the year the course is first offered
 - Per-year percentage increase in annual: __0__

Note that if future budget constraints require the Library to cancel interdisciplinary packages listed above, there may be a loss of resources needed for this course.

Date Received by Liaison/Collections Librarian	October 6, 2025
Name of Librarian to be Contacted with Questions	Rosie Le Faive
Approved by University Librarian or Designate	Simon Lloyd
Date Approved by UL or Designate	October 14, 2025



UNIVERSITY
of Prince Edward
ISLAND

Academic Planning and Curriculum Committee

[Click here to enter a date.](#)

NEW COURSE PROPOSAL

Motion #

Appendix S

SMCS Self-Assessment, May 2021

School of Mathematical and Computational Sciences Self-Assessment Document

May 2021

Report Context	4
About the School of Mathematical and Computational Sciences	4
Mission Statement of the School of Mathematical and Computational Sciences	5
Teaching Review	6
School of Mathematical and Computational Sciences	6
Goals of the School	6
School Enrolment	6
Overview of Common Courses	6
Delivery of Programs within the School	7
Strengths of the School	7
Opportunities for the School	8
Challenges for the School	8
Student Satisfaction	10
Actuarial Science	10
Goals of the program	10
Overview of Current Enrollment	11
Overview of Curriculum	11
Strengths of the Program	11
Opportunities in the Program	12
Challenges for the Program	12
Proposed Actions	13
Analytics	13
Goals of the program	13
Overview of Current Enrollment	14
Overview of Curriculum	14

Strengths of the Program	14
Opportunities in the Program	14
Challenges for the Program	15
Proposed Actions	16
Computer Science	17
Goals of the program	17
Overview of Current Enrollment	17
Overview of Curriculum	17
Strengths of the Program	18
Opportunities in the Program	19
Challenges for the Program	19
Proposed Actions	20
Financial Mathematics	20
Goals of the program	20
Overview of Current Enrollment	20
Overview of Curriculum	20
Strengths of the Program	20
Challenges for the Program	21
Proposed Actions	21
Statistics	21
Goals of the program	21
Overview of Current Enrolment	21
Overview of Curriculum	21
Strengths of the Program	22
Opportunities in the Program	22
Challenges for the Program	23
Proposed actions	24
Research and Creative Activity	25
Overall research vision for SMCS	25
Highlighted Research Collaborations	25
External Funding	27
Highlighted Industrial Engagement	27
Event Organization	28
Future Research Investment	29
Service	30
Overview of service contributions	30
Service to the School of Mathematical and Computational Sciences	30
Service to the Broader University Community	30

Outreach	30
Balance of Roles and Responsibilities	32
Current Situation	32
Proposed Actions	32
Infrastructure and Support	34
Staffing Levels	34
Current Situation	34
Proposed Actions	34
Sessional lecturers	35
Current Situation	35
Proposed Actions	36
Facilities	36
Current Situation	36
Challenges	36
Proposed Actions	37
Library Support	37
Non-Salary Budget	37
Relationship to Broader Context	38
Budget Implications of Proposed Actions	39
New Tuition	39
New Costs	40
Lab Fees and Student Assistants	41

Report Context

This report provides a review of teaching and research in the School of Mathematical and Computational Sciences (SMCS)

For purposes of reviewing curriculum and teaching, the report begins with an overview of the School of Mathematical and Computational Sciences. What follows is a more detailed description of the following programs:

- Actuarial Science (including Pre-Professional Specialization)
- Analytics (including Business Analytics and Data Analytics Specializations)
- Computer Science (including Video Game Specialization, Honours and Minor)
- Financial Mathematics
- Statistics (including Honours and Minor)

Note that the Mathematics curriculum is not included in this particular review. Due to the already wide scope, Mathematics will be reviewed at a later date.

Following the examination of teaching and curriculum, the remainder of the report will consider SMCS as a whole. With common facilities, budget, and other resources, this seemed a reasonable approach.

About the School of Mathematical and Computational Sciences

The School of Mathematical and Computational Sciences is a non-departmentalized School, with the administrative head being the Associate Dean. It is housed within the Faculty of Science, with the Associate Dean reporting to the Dean of Science.

Within the School there is a Director of Actuarial Science and Financial Mathematics, as well as three Program Leads in each of Mathematics and Statistics, Computer Science, and Analytics. The Program Leads are appointed by the Associate Dean. Their duties include advising students and reviewing degree audits, acting as Co-op coordinator for their respective programs, and advising the Associate Dean on program specific issues apart from curriculum development.

The Director of Actuarial Science and Financial Mathematics assumes the responsibilities of the Program Lead for those majors, but also provides a leadership role when it comes to curriculum development and bringing the Actuarial Science requirements in line with professional accreditation standards.

We consider our regular faculty complement to be 18, with any additional positions discussed in the document to be above and beyond those 18. However, we currently have 16 active faculty members, including the Associate Dean. (Note that the budget information in Appendix A.3 indicates 19, but that is due to an unfilled contract position in Computer Science.)

We are in the process of filling two tenure-track positions in Data Science. One position is a reposting of a search that was suspended in March 2020 due to COVID-19. The other resulted from a recent retirement in Mathematics which has been reallocated toward Data Science. If successful, we hope to recruit faculty members with differing skills within Data Science - one with a very strong background in Statistics and one with a very strong Computer Science background.

For the 2021-2022 academic year, we are also advertising 10-month contract positions in Mathematics and Statistics. This is to partially offset parental and sabbatical leaves, as well as the previously mentioned retirement.

Mission Statement of the School of Mathematical and Computational Sciences

The mission of SMCS is to:

- Deliver quality programs in the Mathematical and Computational Sciences.
- Prepare students for careers in applied fields such as Actuarial Science, Analytics, Computer Science, Financial Mathematics and Statistics.
- Prepare students for graduate studies in the Mathematical and Computational Sciences.
- Impart a strong foundation of quantitative skills to all students at UPEI.
- Advance the Mathematical and Computational Sciences by contributing to the body of knowledge through research.

Teaching Review

School of Mathematical and Computational Sciences

Goals of the School

The School of Mathematical and Computational Sciences (SMCS) at UPEI was founded in 2016 with the goal of offering a comprehensive suite of programming in the mathematical and computational sciences. Realizing the need for graduates who could move into careers requiring strong quantitative skills, areas of applied mathematics and statistics were the focus when we looked to expand our programming. As a result, new programs in Actuarial Science, Analytics, Financial Mathematics, and Statistics were added to our existing programs in Mathematics and Computer Science.

SMCS also has a mandate to promote the mathematical and computational sciences across PEI and especially in the K-12 school system. Through various activities, our goal is to provide resources to schools to promote numeracy, data literacy, problem solving skills, coding skills and algorithmic thinking.

The original calendar entry for the School of Mathematical and Computational Sciences can be found in Appendix B.1.b. The current calendar entry can be found in Appendix E.

School Enrolment

SMCS currently has over 400 majors enrolled in our various programs. In comparison, there were about 150 majors in the existing programs when SMCS was established in the Winter of 2016. The most significant growth has been in Computer Science and Actuarial Science. In Computer Science, the number of majors has increased approximately 140% since 2016, with over 70% of the majors in the SMCS choosing Computer Science. Actuarial Science has been growing steadily since it was introduced in 2016 and now has over 50 majors.

One decrease to note is in the number of Minors in Mathematics. This can be mainly attributed to the fact that our former introductory course in statistics, Stat 2210, could be used as a mathematics elective toward the minor requirements. Therefore, students who were required to take Stat 2210, which then included Engineering students, could more easily achieve the minor requirements.

For additional information regarding enrolments, please see Appendix A.1. Program Statistics.

Overview of Common Courses

All students enrolled in a major in the School of Mathematical and Computational Sciences complete a set of courses that we refer to the Common Core. The courses are as follows:

Math 1910 and 1920	Single Variable Calculus I and II
CS 1910 and 1920	Computer Science I and II
Stat 1910	Introduction to Probability and Statistics
Math 2610	Linear Algebra
MCS 3050	Tutoring in the Mathematical and Computational Sciences

MCS 4210 Professional Communications and Practice

Note that MCS 3050 is a 1-credit course (typical courses are 3-credit) where students gain experience through either tutoring in our Help Centres or acting as teaching assistants in a 1000-level course within our common core. The course MCS 4210 is designated as a Writing Intensive Course at UPEI. Each student at UPEI is required to complete at least one Writing Intensive Course. These two courses are focused on developing students' communication skills. It is recommended that they be taken in 3rd and 4th years, respectively.

All students entering a program in SMCS are strongly encouraged to complete their Common Core courses within their first 3 terms. By doing so, students will have the flexibility to transfer into any of our programs in their second year of study without losing step with their cohort.

Delivery of Programs within the School

The majority of courses in SMCS are delivered in a lecture format. Our first-year core courses each include either a laboratory or tutorial in addition to their lectures. Prior to COVID-19, these were all delivered in-person. Course outlines and samples of assessment materials can be found in Appendix F. Since the online learning that occurred in 2020-2021 was atypical for SMCS, the course outlines and assessment materials that are provided in Appendix F have been chosen from the 2019-2020 academic year. The exception to this is CS 1910 and CS 1920 which have undergone a major revision this year. Information from 2021-2022 is included for those courses.

Strengths of the School

SMCS offers a broad selection of programs in the mathematical and computational sciences. This includes applied programs which prepare students to enter the workforce directly, as well as preparing students for graduate and other professional programs. While new programs have given UPEI students additional opportunities, students in the traditional areas of Mathematics and Computer Science have also benefited from having a broad range of electives available to them.

SMCS provides academic advising to all students. We have four program leads responsible for various cohorts of students: Mathematics and Statistics; Computer Science; Analytics; and Actuarial Science and Financial Mathematics.

SMCS has an active student society and supports a number of activities that add to student experience. Examples include:

- Problem Solving and Competitive Programming clubs
- Sponsored travel, accommodation and registration for student conferences such as the Science Atlantic conference and the Actuarial Students' National Association (ASNA) conference
- Annual Integration Tournament and Trivia Challenge

SMCS promotes the mathematical and computational sciences within the broader community. Examples include:

- Holding an annual 3-day Math Camp for grade 10 and 11 students

- Hosting the PEI Math League, which is a series of team problem solving competitions
- Sponsoring a specialty prize at the annual PEI Science Fair

Unfortunately, most of our regular activities were cancelled for 2020-2021 due to COVID-19. However, we intend to resume activities as soon as it is feasible to do so safely, adhering to the directives of the Chief Public Health Officer (CPHO) of PEI.

Opportunities for the School

SMCS has recently seen the addition of an MSc in Mathematical and Computational Sciences. This is a two-year thesis-based Masters program. While some faculty have supervised MSc students in other streams of the MSc program, there hasn't been a wide-spread opportunity to supervise graduate students. With the addition of the Mathematical and Computational Sciences specialization, we look forward to recruiting graduate students.

All indications are that the SMCS student population will continue to increase. The LinkedIn 2020 Canada Emerging Jobs Report (https://business.linkedin.com/content/dam/me/business/en-us/talent-solutions/emerging-jobs-report/Emerging-Jobs-Report-Canada_2019.pdf) was "dominated by tech" and indicated that "data science specifically is an area that has seen explosive growth over the last 5 years and is a role we anticipate to keep a spot on this list for years to come". The top emerging job trend was Artificial Intelligence Specialist, with knowledge of machine learning and deep learning listed as unique skills to the job. Also highlighted in the report were the digital transformation of the banking industry, advances in computer gaming, and the e-learning industry. In fact, core skills in the mathematical and computational sciences were highlighted in 13 of the top 15 emerging jobs.

We also point to the Nova Scotia government's recent investment of \$16.8 million to support computer science programming in its universities. In a news release they stated, "Digital skills drive the start-up economy and COVID-19 has accelerated digital adaptation and increased its importance. The digital future is here, and digital skills are essential to creating the jobs of today."

With the proper resources, SMCS can continue to grow and offer unique programming. Specific opportunities in individual programs will be outlined later in this report.

Challenges for the School

The Common Core was initially developed to provide students with an introductory suite of courses that would allow them to move into any SMCS program after their first year. This was extended to include two courses, MCS 3050 and MCS 4210, as part of an advanced common core. These courses are intended to develop the communication skills of our majors. In order to maximize available resources, MCS 4210 has been team taught, with students receiving $\frac{2}{3}$ of the course content as one large class. The remainder of the course is delivered by three instructors, each responsible for a smaller group who have been cohorted according to their program (Actuarial Science and Financial Math; Computer Science and Analytics; Mathematics and Statistics). Some challenges that have arisen with this course are:

- with growing numbers, it is difficult to provide students with meaningful feedback on written assignments.

- in attempting to serve all SMCS programs, some students comment that the material does not seem relevant to their major.
- cohorts differ greatly in number, so workload is not distributed equitably in the third of the course that is delivered as a team.

With current enrolments, most of our upper-level Stats courses must be accessible to Statistics, Actuarial Science and Analytics majors. It is often a challenge to meet the needs of students in these various cohorts. For example, in order for our Actuarial Science program to meet CIA accreditation standards, no less than 80% of course marks must come from substantive tests and exams. This may not be pedagogically in line with what instructors see as necessary for other students in those courses. As another example, the courses Stat 3250 Statistical Learning and Modelling, AMS 4600 Predictive Analytics I and AMS 4610 Predictive Analytics II have been previously seen as useful electives for our Statistics and Analytics majors. However, with lab components that focus on problems Actuarial Science students would encounter in professional examinations, there are challenges in satisfying these diverse audiences.

With many programs requiring a variety of Math, Stats and CS courses, scheduling is a challenge. Beyond first year, most courses are only offered once per year in a single time slot. As a result, timetables are built on the assumption that students are taking their required courses according to year-by-year advising guides. As a result, students who deviate from these plans often find it difficult to schedule their courses due to time-conflicts and prerequisite chains.

Dedicated teaching space in SMCS is restricted to one 40-person computer lab and one 20-person classroom. The computer lab is non-configurable. Therefore, instructors who would like to incorporate active learning where students could work in groups and do real-time coding, data analysis or modelling do not have facilities to do so.

Finding adequate TA support for many courses is a significant issue. We have primarily relied on 3rd and 4th year students as both TAs in our 1000-level labs and tutorials, and as markers for all larger courses. In terms of labs and tutorials, there are issues with putting student assistants to work in a timely manner. In general, the time required to process student employment information means that students cannot begin work until 2-3 weeks into term. When it comes to marking, there is difficulty in finding students both qualified and interested in marking upper-level courses. Attempts have been made to rectify these issues such as advertising outside of UPEI, but we still struggle to find long-term solutions.

Equitable distribution of teaching loads among faculty is currently a challenge for SMCS. With rapid growth in the number of CS majors, our CS faculty have seen an increase in workload, particularly related to grading. In contrast, faculty who are teaching exclusively, or almost exclusively, within new programs have significantly lower average enrolments. This is not surprising and would be typical in any new program. However, these inequities can cause morale issues among faculty.

Student Satisfaction

Surveys regarding student satisfaction among both current students and graduates can be found in Appendix C.

In the undergraduate survey, 52 students responded. In questions regarding quality of teaching, access to faculty members, and class size, the majority of students reported they were either satisfied or very satisfied. The majority of those students were also satisfied that their program was worth the investment. When questioned about the development of skills such as critical thinking, ability to do research, and communication skills, the majority of students were satisfied.

Unfortunately, only 14 former students participated in the survey of graduates. Again, we see the majority of students reporting that they were either satisfied or very satisfied with quality of teaching, class size, etc, as well as the core skills.

Among both groups, there were positive comments regarding small class size and interactions with faculty. There were comments that indicate students want to see more practical applications to what they are learning and get a better sense of how it will benefit them in their future careers. There is also evidence that we, as a School, need to improve when it comes to making all students feel welcome and included in our programs.

In UPEI's strategic plan *An Inclusive Campus Culture* was highlighted as a priority. SMCS needs to address the fact that not all of our students find it to be a welcoming and inclusive environment. Two groups of particular concern are (1) international students new to SMCS and (2) students identifying as female who do not see themselves reflected in the make-up of SMCS. In 2018, a peer-mentoring initiative was attempted within SMCS to address some of these issues, but unfortunately, we did not have a sufficient number of students willing to serve as mentors. We also had a *Women in SMCS* group for a short period of time. This was a student initiative which died out after its champions graduated from our programs. There are currently no specific initiatives to address these issues.

Actions for SMCS: To investigate new initiatives to promote diversity and inclusion within SMCS; to promote EDI education and training opportunities for faculty and staff.

Actuarial Science

Goals of the program

The Major in Actuarial Science provides students with a comprehensive quality education in Actuarial Science and prepares students to write the early professional exams required to eventually become an Actuary. The Major in Actuarial Science with the Pre-Professional Specialization is designed for students who plan to complete the full suite of exams required to apply for Associate status from the Canadian Institute of Actuaries (CIA), the Society of Actuaries (SOA), or the Casualty Actuarial Society (CAS).

Overview of Current Enrollment

There are approximately 50 Actuarial Science majors currently active in our program. Eight of these students are currently in their 4th year of study. Enrollment in Actuarial Science has seen a steady increase since it was established in 2016.

Overview of Curriculum

The Actuarial Science curriculum is designed to prepare students to become professional actuaries, and the courses are aligned with the seven professional actuarial accreditation exams at the Associateship level. Each of the exams together with the UPEI courses are as follows

1. Probability (P): Stat 1910, Stat 2910, Stat 3910
2. Financial Mathematics (FM): AMS 2160
3. Investments and Financial Markets (IFM): AMS 3310, AMS 2410, AMS 3410
4. Long Term Actuarial Mathematics (Life Insurance and Pensions) (LTAM): AMS 2510, AMS 3510
5. Short Term Actuarial Mathematics (Health and Dental Insurance, Property and Casualty Insurance, and Loss Models) (STAM): AMS 4700, AMS 4580, AMS 4540, AMS 4550
6. Statistics for Risk Modeling (SRM): STAT 3240, Stat 3250, Stat 4280, Stat 4330, MCS 2030
7. Predictive Analytics (PA): AMS 4600, AMS 4610

The Major in Actuarial Science includes all courses aligned with the first five exams in the list, while the Pre-Professional Specialization includes courses aligned with all seven exams.

The program has also been accredited by the SOA for the three required VEEs (Validation by Educational Experience). An Actuarial Science student who achieves 70 per cent or above in each of these courses will receive accreditation for the associated VEE. The three VEEs, together with the UPEI courses satisfying the criteria, are as follows:

1. Accounting and Finance: ACCT 1010, BUS 2310
2. Economics: AMS 2030, AMS 2040
3. Mathematical Statistics: STAT 3910

The program has also been recognized by the Society of Actuaries (SOA) as being a university offering an actuarial program with an advanced curriculum for all six exams currently part of that review and assessment process. The program is now designated as a UCAP–Advanced Curriculum program (UCAP-AC). UPEI is the only university in Atlantic Canada to have been recognized for six professional exams.

Strengths of the Program

The Actuarial Science Program was fully endorsed by the Society of Actuaries (SOA) in 2020 for six professional exams and three Validation by Educational Experience (VEE) subjects. Accordingly, it is the most complete Actuarial Science Program in Atlantic Canada offering a full coverage of the Associateship professional exams and VEE's and is comparable to the best programs offered across the country and internationally.

The Director of Actuarial Science and Financial Mathematics, Professor Louis Doiron, is a fully qualified Actuary (FCIA, FSA, MAAA) with extensive professional experience. Professor Doiron is responsible for overseeing the curriculum for the Actuarial Science Program and ensuring that it aligns with the professional accreditation curriculum requirements of the CIA, SOA, and CAS. Professor Doiron is also closely connected with the industry and serves on several Committees and Boards of the professional associations (CIA, SOA, CAS, IAA, AFC) in Canada, the U.S., and internationally. There are two other faculty members who primarily serve the Actuarial Science and Financial Mathematics programs, one of whom is an Associate of both the CIA and the SOA. Both maintain active research programs in Actuarial Science and Quantitative Finance, respectively.

Several of our students have already passed professional actuarial exams, current students have been successful in finding co-op work placements, and recent graduates are working in the field.

Opportunities in the Program

The Actuarial Science program offers good opportunities for growth and development. The program is well positioned to apply for accreditation from the Canadian Institute of Actuaries (CIA), as evidenced by the SOA's recognition. Accreditation allows students to earn Actuarial Professional Exam credits by excelling in the corresponding courses. Currently, there are no accredited programs in Atlantic Canada, so obtaining accreditation at UPEI would give us a competitive advantage in recruiting new students.

As student numbers grow, there is an interest in developing Honours degrees in Actuarial Science and Financial Mathematics. Currently, students interested in completing a research project in one of these areas would have to do so under either an Honours in Mathematics or Honours in Statistics program, each of which has additional course requirements.

The development of a Professional Master's Degree in Actuarial Science is seen as an attractive growth opportunity. This graduate degree would be aimed at students who completed their undergraduate degree in mathematics, statistics, or another related field, but do not have specific training in actuarial science. There is significant demand for professional Master's degrees, especially among international students, and there are currently no such programs in Atlantic Canada.

Challenges for the Program

The greatest challenge for the Actuarial Science program lies in offering all of the required courses on a regular basis. Currently, there is a subset of courses that are not offered every year. Given that Actuarial Science students have few electives and there are often long prerequisite chains for required courses, offering courses biannually can make it difficult for some students to complete all of their requirements in the standard four years.

CIA accreditation has always been a goal for this program. It would be a distinction that sets UPEI apart from all other Atlantic Canadian Universities. However, there have been setbacks in the timelines originally set out for achieving accreditation. The Major in Actuarial Science was originally designed to satisfy CIA accreditation requirements. Soon after, CIA accreditation requirements were updated to include additional courses such as Predictive Analytics. These requirements led to the creation of the Pre-Professional Specialization, which is the program now aligned with CIA requirements. Obviously,

the teaching resources required to deliver the Pre-Professional Specialization are greater than those for the original major program.

Another accreditation issue arises with the Statistics courses required within the Actuarial Science program. In order to meet the CIA standards, both curriculum and assessment requirements must be imposed upon specific courses within the Actuarial Science program. This is manageable for courses that are specific to the program. However, most of the required Statistics courses are also required by other majors in SMCS. As a result, both instructors and non-Actuarial Science students enrolled in such courses are unhappy with the restrictions put on curriculum and assessment.

Proposed Actions

It is highly recommended that a new Faculty member is added who has expertise to teach within the Actuarial Science and Financial Mathematics programs. An addition of such a faculty member would allow courses such as AMS 4600 & 4610 (Predictive Analytics I & II), AMS 4580 (Credibility Theory) and AMS 4700 (Short-term Insurance Pricing and Reserving) to be offered more regularly. It would also allow SMCS to handle sabbaticals and other leaves of absence, as well as course release gained from student supervision and other duties, without having to hire term faculty members. This is important, as we anticipate difficulties in finding term faculty with this expertise. With this addition, faculty members could also contribute to teaching within our common core or from our set of service courses.

In terms of programming, we would like to add an Honours in Actuarial Science. We would also like to investigate adding either a Professional Masters or a Post-Degree Diploma in Actuarial Science. While a Professional Masters would attract students, particularly international students, there are resource implications since stand-alone graduate courses would be required. A Post-Degree Diploma would be less resource intensive, but perhaps not as attractive to international students. In either case, entrance requirements would have to be carefully considered so that students could complete the programs in an acceptable time frame. This type of initiative goes beyond the scope of this review of undergraduate programming. So, while we would like to investigate these opportunities, the budget implications are not addressed in this document.

Action for Administration: Add an additional faculty position in Actuarial Science.

Action for SMCS: Develop an Honours Stream in Actuarial Science; investigate the opportunities for Graduate Programming.

Analytics

Goals of the program

Analytics is situated at the confluence of statistics, computer science and mathematics all centered on finding, interpreting and presenting meaningful patterns in data. All graduates have a wide variety of skills in mathematics, statistics and computer science, with the ability to analyze data in a wide variety of domains.

Overview of Current Enrollment

There are currently 18 students registered as Analytics Majors. Six are Business Analytics Majors, while 12 are registered in Data Analytics. Given that most of the required courses in the Analytics program are either required for Math, Stats or Computer Science Majors, or attractive electives, overall course enrollments are healthy.

Overview of Curriculum

As with all programs in SMCS, Analytics students complete courses in the Common Core. Analytics students receive a depth in Mathematics (Group Theory, Differential Equations, Optimization), Computer Science (Data Structures, Database Systems) and Statistics (Probability and Mathematical Statistics, Applied Regression) through a set of courses common to both specializations. For the Data Analytics specialization, students take three additional CS courses: Data Science, Machine Learning and Analysis of Algorithms. For the Business Analytics specialization students take 15 credits from the School of Business which closely align with their Certificate in Business. This removes some optionality from the Business Analytics program.

Strengths of the Program

Data science and data-oriented industries represent a major economic opportunity for the Maritime provinces and for PEI in particular. Current students enjoy a range of different courses from across all aspects of SMCS, with a variety of core and optional courses.

Opportunities in the Program

On the UPEI campus, there is extensive opportunity for collaboration. For example, researchers in the Atlantic Veterinary College (AVC), Climate Change and Adaptation, Environmental Studies, Engineering, Physics, Chemistry, Biology and Applied Human Sciences, already work with large data sets. While in the Social Sciences (e.g. Sociology, Psychology) and Arts (e.g. History, Music, Diversity and Social Justice), there are opportunities for supporting arguments made through traditional methods with data from a variety of sources. Students across all of these disciplines would benefit from strong analytics-related programs and potentially specializations offered to their degree programs.

Several existing companies in biotechnology, procurement and government all have a demand for students who are fluent in data and the methodologies for analyzing them. These employment opportunities extend to both graduates of the program and current students through co-operative education. Currently job opportunities outnumber graduates. We see this trend continuing, especially in a post-COVID world, where remote work will be abundant in the data-oriented industries due to the ability of its workers to conduct their analyses from a distance. This represents a major opportunity for growth on the Island.

There are several broad career paths supported in data-oriented industries:

- Data Engineers/Architect- People who develop and maintain the infrastructure for big data analysis. These include people who build things like pipelines for data feeding to various custom

applications (e.g. IBM Analytics division). These are developers who have skills related to our CS degree.

- Data Analysts - People who perform detailed analysis on data, usually for purposes of reporting requested information. These are positions that are currently serviced by our Stats and Math degrees, with recent graduates populating roles on the island.
- Data Scientists - People who perform analysis with the purpose of providing insights and predictions from data, are skilled in machine learning and deep learning, and are skilled at communicating those insights to stakeholders. These are people who have some theoretical knowledge of related degrees, but not the depth of knowledge possessed by computer scientists, mathematicians, statisticians, for example. However, they have depth in applying theory to problems relating to data. This career route should be the key target for the Analytics degree.
- Business Analysts - People who tend to be trained in business processes, and conduct analyses that improve business processes using data. This route into data-oriented industries is currently serviced by the existing analytics program and should be retained.

There is an opportunity for the Analytics degree to target these last two career paths, and other non-traditional routes into data industries (e.g. green economy, blue economy, travel and tourism). These data scientists and business analysts are also professionals who need robust skill sets in working with data holders to understand the data available, data engineers to understand the pipelines available to identify gaps, and domain experts to understand what questions need to be addressed through data and how to communicate to other stakeholders. Discussions with Innovation PEI identifies these professionals as essential to the current Island context especially in areas around agriculture, health, and the blue economy.

Challenges for the Program

The program has not recruited the number of students anticipated. Currently there are fewer than 20 students in the Analytics program. Reasons for struggling recruitment are unclear, but anecdotal evidence suggests it is a combination of several things:

- Despite marketing initiatives, students do not really know what Analytics is or why they would do it. It may be that the name is not in line with current societal discourses around data and data science. Data science is now the dominant phrase in the media.
- Students currently studying Mathematics or Statistics have not been attracted to the program due to a lack of interest in the deep Computer Science courses, while students currently studying Computer Science are deterred by the depth of math that is needed in later years.
- The goals of the program are unclear in terms of the skills data-oriented industries require from graduates.

The program may also suffer from the fact that it has no courses that are distinctive and support learning of a unique set of skills in comparison to the other degrees from the school. The program has good courses from a variety of programs, but there is no single through-line to pull them together.

Currently, when comparing Data Analytics and Business Analytics, there are only a handful of required courses unique to the Data Analytics Specialization, including Data Science and Machine Learning courses. Given that these courses are now necessary to be effective in all data-oriented industries and

that the Business Analytics students possess the necessary prerequisites, it makes sense for these to be required in both specializations.

There have been challenges in hiring a tenure-track faculty member within this field. As a result, there are courses in the program that have not been offered consistently.

Proposed Actions

Due to the shift in language and industry, the Analytics program should be renamed Data Science. The program should be refocused to produce data scientists (as defined above), making it distinctive within SMCS. The following potential changes have been identified:

- There should be a Major in Data Science containing a subset of courses common to both of the current specializations, with Machine Learning added as a required course. (Currently there are two Specializations, but no stand-alone Major in Analytics.) Specializations could then build on top of that major program.
- Introduce courses specific to Data Science that will create a common thread throughout the program. (An Introduction to Data Science course has also been identified as being needed in the Statistics program.) These courses should build analytical skills, but also include discussion on ethical issues related to data and understanding the needs of stakeholders.
- CS courses geared towards software engineering and data architecture should be made elective courses. (For example, CS2910, CS2920, CS3710, and CS3610.) These could be used to create a new specialization route geared towards data engineering, along with other systems courses.
- Mathematics and Statistics courses that are not geared towards specific skills for data science should be made elective courses (For example, MATH2720, MATH3430, MATH3610, STAT 3910.)
- The existing R Technology Lab should be a mandatory second year course for all Analytics students
- Existing courses should be examined for redundancies and rationalized. (For example, STAT3240, STAT4550, STAT4660, CS4120.)
- Machine Learning should be a mandatory course for all Analytics students. It is currently only required for the Data Analytics Specialization.
- A 4000-level capstone project course should be introduced.

Action for SMCS: Rebrand Analytics as Data Science and update the program as described above.

Computer Science

Goals of the program

Students in the Computer Science program gain a solid foundation in the principles and practice of computer science. This includes skills in programming, mathematics, and computational thinking, allowing students to engage with and solve complex problems. They gain breadth through electives that expose them to a wide range of different theories, systems and applied computing. They have the opportunity to apply their skills in both individual and group settings throughout the degree program, developing transferable skills that make them ready to participate in design and development teams. Students in the Video Game Programming Specialization gain specific skills in the core technologies in creating video games, in particular advanced topics in game design, graphics and game engine programming.

Overview of Current Enrollment

Computer Science has 277 majors enrolled across all its programs (Major, Honours and Specialization). There are approximately 95, 80, 50 and 50 students in first through fourth years, respectively. In the Video Game Programming Specialization, there are approximately 49 students across all years.

Computer Science has seen tremendous growth over the last five to ten years. In the 2012 Computer Science program review, there were 25, 26 and 25 students in second through fourth years, respectively. (At that time, UPEI students were not required to declare a major in first year.)

Overview of Curriculum

The Computer Science (CS) program has pivoted in the last 18 months to teach introductory computer science using the newest conceptualizations around computational thinking that have come out of CS education research and practice. In 2020-2021, CS1910 and CS1920 were revamped to better serve the diversity of students we have in SMCS, with a focus on computational thinking and problem-solving and using this as a gateway to programming being a means of automating problem-solving. This emphasis on the key aspects of computational thinking, specifically algorithms, abstraction/decomposition, logic and pattern recognition are intended to support all students in SMCS in improving their problem-solving skills and support them in their program goals. Further, the first-year program has shifted to using Python as an introductory language, which is a more practical skill for future careers in statistics, actuarial science and analytics. We believe that this makes the program one of the most progressive in the region for creating well-rounded students coming out of the first year and helps support the goals of the common core to allow flexibility to change programs within SMCS. From these first-year courses, the CS program has a spiral of learning that continues into the second year, providing CS students with skills in algorithms and data structures as well as introducing more advanced techniques such as functional programming in the Java programming language and multi-threading of processes.

The program provides different skills through sets of required and elective courses.

- Programming Stream: encompasses the fundamentals of automation of problem-solving, the construction of programming languages, and the basis for the creation of software systems used in other themes. Students learn Python in the first year as a primary language, transitioning to Java in the second year. Several different languages are taught throughout the second to fourth

year. Required courses give expertise in C (CS2820), SQL (CS3710) and a course on comparative programming languages (CS2620).

- Algorithms Stream: the fundamentals of computational thinking in terms of how we represent and solve problems. Students receive a number of required courses in data structures and algorithms in the first year (CS1910, CS1920), second-year (CS2920) through to the third year (CS3610), with elective courses in Data Science (CS4440) Machine Learning (CS4120), AI (CS4110), and Bioinformatics (CS3220) on offer.
- Software Systems Stream: Beginning in the second year and following through the fourth year, students learn about the infrastructure of computing systems. There are several required and elective courses that expose students to a variety of different pieces of technology including computer architecture (CS2520), databases (CS3710), operating systems (CS3520), networks (CS3420). Advanced courses in cloud computing and networking provide opportunities for extension.
- Software Engineering Stream: Students learn the key techniques in creating robust and reliable software, as well as the processes for managing large scale software projects. The curriculum begins with testing, deployment and source management tools in the first and second year (CS1910, CS1920, CS2910, CS2920), design patterns in the third year (CS3620), with software architecture and software engineering processes in the fourth year (CS4810) leading to the capstone team project (CS4820).
- Platform-Based Systems: Students learn how to build multi-tiered systems, usually with a user-facing front-end. These courses include a fundamental set of skills around web development (CS2060), mobile application development (CS3130), and user experience design (CS3210).
- Video Game Specialization: Students learn the fundamentals of game development, including game design (CS3110), graphics (CS4350, CS4360), and game engine development (CS4650). Students on this specialization have a separate capstone project focused on game development (CS4830).

Strengths of the Program

The curriculum supports a spiral of learning through various streams of courses. When compared against the ACM Curriculum, our program shows broad coverage of core materials, including approximately 90% coverage of Tier 1 core and over 80% coverage of Tier 2 core. This indicates very strong coverage of key theory and practice in computer science.

In the recent revamp of the first year the degree has adopted the newest ways of presenting computational thinking, focusing on core skills of abstraction, decomposition, algorithms and logic. Updates to our introductory programming courses CS 1910 and 1920 include a focus on computational thinking for all programs and a switch to Python. This change of focus was influenced by the desire to be more relevant for other programs in SMCS including Statistics, Actuarial Science and Analytics, as well as other units across campus.

Students are provided opportunities to participate in team-based activities, developing communication and teamwork skills. Group projects are present in each year of the program, so these skills are

reinforced as students progress through the program.

Opportunities in the Program

Given the growth in the number of students, we should be offering more opportunities for students to customize their outcomes via electives. With the addition of Analytics and the accompanying faculty position, we have been able to offer courses such as Machine Learning and Data Science on a regular basis. However, there are gaps in other areas of expertise including cybersecurity, parallel and distributed computing, and high-performance computing.

There are many opportunities to collaborate with other units on campus that have projects suitable for Honours and Master's students. There is also potential to work with the Faculty of Engineering, as many of their student design projects could benefit from collaboration with CS students.

Challenges for the Program

In order to capitalize on the opportunities in Computer Science, teaching capacity must increase. Despite substantial growth, the faculty complement for CS specialists has remained constant over the past decade, with new hires only for replacement purposes.

In a review conducted in 2012 for the Canadian Information Processing Society (CIPS), the reviewers concluded that there was an urgent need for hiring a minimum of 1 person to avoid fragility of the program. The reviewers also noted that the CS program relied heavily on the goodwill of faculty to take on overload and be flexible in teaching well outside of specialty areas. This remains true in 2021.

The addition of teaching resources remains the number one priority for the program. An estimated three additional faculty members are needed to ensure delivery of a wide variety of courses as well as to ensure that fragility does not occur in staffing for unplanned absences, career breaks or sabbaticals. There is also insufficient staff for running labs effectively. The number of required lab sections in the CS 1910, 1920, 2910 stream has grown with no change to the 0.5 full-time equivalent staff position supporting those labs.

Student spaces for teaching and learning limit how faculty can deliver their courses. In order to shift to active learning in many classes, reconfigurable spaces where students can work in groups with computer resources are needed. In addition, increased enrollment means that our 40-person computer lab is insufficient for students working on campus, running interactive classes, or running examinations using live coding questions.

The current teaching assistant model is insufficient to support students with the current growth profile. Without a large pool of graduate students, alternatives must be found to provide sufficient TA support for faculty.

Proposed Actions

Hiring of CS faculty and staff is needed as soon as possible. This must be done before other significant actions such as addressing gaps in the curriculum or addition of lab components to courses can begin. If SMCS is successful in recruiting faculty members in Data Science, one of whom has a strong Computer Science background, then two additional CS faculty members would be sufficient.

The addition of a large lab space is also of urgent importance. Our current 40-person facility is insufficient for teaching and assessment needs. Further, with the shape of teaching changing with many instructors moving to much more interactive ways of teaching and learning, such as small group teaching within classes, there is a need to expand purpose-built teaching spaces and communal areas where student breakout groups can form and work.

Action for Administration: Add two additional faculty positions in Computer Science to address growing numbers and gaps in expertise; add a lab instructor position; allocate space for a large teaching lab.

Financial Mathematics

Goals of the program

1. To provide a comprehensive program in Financial Mathematics
2. To prepare students for careers or graduate studies
3. To provide research opportunities to our students.

Overview of Current Enrollment

There are currently five Financial Mathematics Majors. While the number of majors is low, the vast majority of required courses are common to other programs. Therefore, growth across all programs will support Financial Mathematics offerings.

Overview of Curriculum

The Financial Mathematics requirements include the Common Core, a breadth of courses across Mathematics and Statistics, courses from Business and Economics, as well as advanced courses in Financial Mathematics and Financial Economics. Many of those specialized courses are shared with the Actuarial Science program, but there are two courses, AMS 4080 and 4090 (Financial Mathematics II and III) which are specifically designed for Financial Mathematics majors.

The curriculum in the Financial Mathematics program is quite comprehensive and rigorous for an undergraduate program. Our students get a solid preparation for an entry level in the industry or to attend graduate school.

Strengths of the Program

The wide scope of the course offerings in the Financial Mathematics program is showing to be an asset for our students applying to graduate school in this area. There is a small but meaningful sample of

students (including Mathematics students) who have taken some of these courses that have been accepted in top graduate programs. There are also increasing opportunities for student research in this area.

Challenges for the Program

Currently, Financial Mathematics is attracting fewer majors than expected. As a result, two courses required exclusively for Financial Mathematics, AMS 4080 Financial Mathematics II and AMS 4090 Financial Mathematics III, have not been offered on a regular basis. Since all other course requirements in Financial Mathematics are also requirements for other programs, low numbers of majors do not have a significant impact from a resource perspective. However, we would like to see more students taking advantage of this program.

Proposed Actions

It is suggested that an Honours degree in Financial Mathematics be added. Students interested in doing research in this area currently have to do so under the Honours in Mathematics or Honours in Statistics programs.

Action for SMCS: Develop an Honours program in Financial Mathematics.

Statistics

Goals of the program

1. To provide a quality Major and Honours in Statistics;
2. To serve the needs of students in other programs, both within SMCS and other units;
3. To provide research opportunities to students.

Overview of Current Enrolment

The Statistics Major is new and consequently current numbers are fairly small, about 10 declared majors across all years. Overall numbers of course enrolments are, however, much higher. Lower-level courses serve the needs and interests of students from many disciplines, both inside and outside SMCS, while upper-level courses attract students from related programs such as Math, Financial Math, Analytics and Actuarial Science. As a consequence, enrollment numbers are very healthy.

Overview of Curriculum

The current Statistics curriculum aligns fairly closely with what was originally proposed when the major was introduced in 2016. The main change to the major has been the replacement of two courses, Stat 2210 and Stat 2220 with a single course, Stat 1910. The course Stat 2210 has been renamed Stat 1210 and serves many non-SMCS students as a one-term introduction to Statistics.

Stat 1910 is the entry course for all SMCS majors and others who will engage in further upper-year statistics courses. The courses Stat 2910 (Probability and Mathematical Statistics I) and Stat 3910

(Probability and Mathematical Statistics II) provide the pathway to the upper years with a rich variety of offerings.

As we consider modifications and improvements to the program, we keep in mind the recommendations of the ASA- endorsed Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report of 2016, which are:

- Teach statistical thinking. Teach statistics as an investigative process of problem-solving and decision-making. Give students experience with multivariable thinking.
- Focus on conceptual understanding.
- Integrate real data with a context and purpose.
- Foster active learning.
- Use technology to explore concepts and analyze data.
- Use assessments to improve and evaluate student learning.

Strengths of the Program

We view the overall design of the current program to be its greatest strength. It serves Statistics majors well, and offers them the opportunity to take courses in financial math, analytics, etc, which complement their statistical education. Likewise, many upper-level statistics courses are required courses for Actuarial Science and Analytics students. Students in those related disciplines are also taking advantage of the opportunities afforded by the Statistics program by incorporating other Statistics electives into their programs, evidenced by the good numbers of those students in upper-year Statistics courses.

Opportunities in the Program

As a relatively new program in an expanding discipline, there are plenty of varied opportunities for our program. One of these relates to the growth of Data Science which, as a combination of Statistics and Computer Science, positions SMCS well to take advantage.

Statistics students are very much in demand by industry and government. Provincially, we have seen much interest from the Department of Veterans Affairs, who have much “data” to deal with, so closer ties with this government agency are of particular interest.

Expanded research opportunities for undergraduate students are another area of interest. Although the Honours program in Statistics is on the books, to date it has attracted no students. The recently introduced MSc. in Mathematical and Computational Sciences may aid in the effort of recruiting Honours students, as undergraduates will have more exposure to opportunities for research and future graduate studies.

Another potential opportunity lies with the accreditation program run by the Statistical Society of Canada (SSC). Graduates of an accredited undergraduate Statistics program can apply to the SSC for the professional designation A.Stat. Although not currently required in order to gain employment as a statistician, it provides a small “stamp” of approval. It may become more important in the future, if a major employer (e.g. Statistics Canada) decides to require it of their hires, so we intend to look further

into this opportunity. In looking over the SSC requirements for program accreditation, it appears that we are well-positioned to pursue it, if we choose to do so.

Challenges for the Program

The greatest challenge for the program lies in offering the curriculum (core courses, electives, service course Stat 1210) with two full-time Statistics faculty.

With growing numbers in SMCS and Stat 1910 being in the common core, demand for Stat 1910 has increased accordingly. At least one additional section of Stat 1910 should be added as soon as possible, both to improve scheduling options as well as to bring the enrollment in line with those for both Math 1910 and CS 1910. There is also a need for additional tutorial sections. With tutorial enrollment growing to 90 students in a single section, the ability for the instructor to assist students is diminished. This is also not consistent with the sizes of Math 1910 tutorials and CS 1910 labs, which are capped at 50 and 40 students, respectively.

There is also a strong case for the Stat 1910 tutorials to be reclassified as laboratories. This is a workload issue given that each hour of tutorial is only equivalent to 0.33 lecture hours while each lab hour is equivalent to 0.5 lecture hours. The structure of the Stat 1910 tutorials is more akin to the labs attached to Computer Science courses, and they should be designated as such with the appropriate teaching credit.

In the current curriculum, some 4th-year courses required by Statistics majors or other disciplines are not offered every year. In addition, the core curriculum is rather “top heavy” at the 3rd and 4th-year level. This makes it difficult for majors to schedule these rotating courses.

This situation might be partially alleviated by some streamlining of the upper years of the curriculum. The starting point to doing so would be to download some of the more basic material into a new course, Introduction to Data Science (IDS), offered at the 2nd-year level. Such a course would serve the needs not only of Statistics majors, but also of Analytics, Computer Science and other SMCS majors. As the course is interdisciplinary, with components from both Statistics and Computer Science, we’ll confine ourselves here to what, from the Statistics side, would be desirable within the course. Referring to the SSC’s endorsed curriculum guidelines, the following learning objectives could be met by such a course:

- Store and retrieve data of various types and formats, and manipulate them efficiently.
- Write efficient and well-documented code that supports reproducible research, including writing algorithms and conducting simulations.
- Clearly communicate concepts, methods and results to diverse audiences orally, and in writing.
- Function effectively in a collaborative and/or interdisciplinary environment.
- Demonstrate ethical practice in the conduct of data collection, data handling, statistical analysis and reporting.

This would meet outcomes under the SSC’s categories of “Computing with Data” and “Statistical Practice”. As an IDS course would serve several of the majors within SMCS and allow for streamlining in both the Statistics and Analytics programs, there are no resource implications in adding such a course.

We also recognize that Statistics majors need better computing skills and to learn to use appropriate software. The main computational tool of the program is R, which is used in a number of courses.

However, MCS 2030 (R Technology Lab) is not always listed as a prerequisite, leaving the instructor to feed students the R code as needed. It would be useful to ensure that students have taken this course early in their studies.

Developing communications skills is another issue of concern. Although Statistics majors must take MCS 4210 (Professional Communication and Practice) along with other SMCS majors, that course is in need of some rethinking or revision. Alternatively, we can examine whether writing and presenting should be built into certain Statistics courses, be part of a capstone project course, be developed via consulting, or other means.

The calendar descriptions for 3000- and 4000-level courses have not been updated since the Statistics program was established in 2016. Thus, these calendar entries do need some fine-tuning to reflect current practice. Doing so also provides the opportunity to explicitly identify courses that develop skills such as statistical thinking, computing with R, writing, and speaking.

We now mention the SSC-endorsed Curriculum Guidelines for Canadian Undergraduate Programs in Statistics. While it is clear that we are currently teaching the core areas of “Statistical Methodology” and “Theoretical Foundations” well, but may not be fully teaching the core areas of “Computing with Data” and “Statistical Practice”. The changes outlined above go some way to addressing this issue.

Proposed actions

Additional teaching capacity is urgently required. A faculty member with expertise in Statistics should be added as soon as possible. A part-time lab instructor should also be added to teach the proposed Stat 1910 labs.

An update to the Statistics curriculum is in order. The addition of a new 2nd-year course, Introduction to Data Science, is proposed, with subsequent streamlining of some upper-year course offerings. Next, the R technology lab should be added as a prerequisite to Stat 3240 and Stat 4110, which ensures that students take it early in their degree. Finally, calendar entries for upper-year courses should be updated to reflect current practice and to highlight which courses develop particular skill sets, such as computational, written and oral communications.

In reviewing or revising the program, the curriculum guidelines set out by the Statistical Society of Canada in 2018, as well as GAISE (2016), will be observed.

Any of the suggested course additions will be offset by streamlining the 4th year of the program. Therefore, the total number of courses offered on an annual basis will not increase.

Action for Administration: Add a faculty member in Statistics and a part-time lab instructor.

Action for SMCS: Update program requirements as described above to add a course in Data Science, require R earlier in the program, and ensure the program reflects current industry practices; investigate SSC accreditation.

Research and Creative Activity

Overall research vision for SMCS

SMCS has decided not to specialize in any particular area of research within the various disciplines. Rather, we have aimed to cover a variety of research areas. The main reason for this is to provide our students with high-quality instruction in our upper-level courses and allow them significant choice when it comes to Honours projects and other research opportunities. We will continue to support faculty who pursue a wide range of research interests.

That being said, our recently added Masters of Science in Mathematical and Computational Sciences focusses on projects that are interdisciplinary in nature and allow students to access tools in Mathematics, Statistics and Computer Science. As a result, it is anticipated that this type of research will come to the forefront in the future.

The past year has slowed some research activity, with faculty unable to collaborate in the usual ways and many conferences being cancelled in 2020. Instead, let us consider successes over 2019 and 2020

- Faculty produced over 40 publications over those two years. Three of those involved collaboration with current or former students. Six of those involved collaboration with UPEI researchers outside of SMCS.
- Faculty gave 15 conference presentations in 2019.

More information on research contributions can be found in Appendix B.2. Scholarly Activities and in the individual cvs found in Appendix D.

Highlighted Research Collaborations

Volume Preservation within Deep Neural Networks - Dr. A. Godbout and Dr. G. MacDonald

Training deep neural networks with back propagation can be challenging because of vanishing gradients (or similar exploding gradients). This difficulty controlling the magnitude of the error gradient makes it difficult to update and improve a deep neural network while training. The goal of this project is to solve the vanishing gradient problem by preserving volume within a deep neural network.

As part of the project, the researchers developed a volume-preserving neural network (VPNN) that preserves volume within the weight matrices and activation functions of a neural network. The researchers have also developed a volume-preserving recurrent neural network (VPRNN) that outperforms many of the top orthogonal and unitary recurrent neural network architectures on common and challenging datasets. (The vanishing and exploding gradient problem is especially prevalent within recurrent neural networks, which are often targeted towards sequential datasets and natural language processing tasks that require especially deep networks.) Their VPRNN architecture uses volume-preserving orthogonal operations and is quite efficient, requiring a small number of parameters (and thus a small memory footprint) to produce state of the art performance.

The project has thus far produced four BSc Honours projects (two of those Honours students have continued with or have been accepted into MSc graduate studies), three of those students are co-

authors on peer-reviewed publications of the work and two are listed as inventors on a patent application to protect the intellectual property around the research. Those outcomes are listed below, with student researcher highlighted with an *.

- MacDonald G, Godbout A, *Gillcash B**, *Cairns S**. Volume-preserving Neural Networks. In 2021 International Joint Conference on Neural Networks, IJCNN 2021 2021. Institute of Electrical and Electronics Engineers (IEEE). (Accepted to Appear July 2021)
- *Taylor-Melanson W**, MacDonald G, Godbout A. Volume-preserving Recurrent Neural Networks (VPRNN). In 2021 International Joint Conference on Neural Networks, IJCNN 2021 2021. Institute of Electrical and Electronics Engineers (IEEE). (Accepted to Appear July 2021)
- MacDonald G, Godbout A, *Gillcash B**, *Cairns S**. Volume preserving neural network architecture and system and method for building a volume preserving neural network, US Patent Application No. 17/096,425

Finally in 2020, Dr. Gordon MacDonald and Dr. Andrew Godbout were invited to give the keynote Blundon Lecture at the Science Atlantic Mathematics, Statistics and Computer Science Conference on the topic of Deep Learning and Volume-preserving Neural Networks:

MacDonald G, and Godbout A. Volume Preserving Neural Networks. Blundon Keynote Lecture, Science Atlantic Mathematics, Statistics and Computer Science, 2020.

The next steps in the project involve the continued development of solutions involving volume preservation within deep neural networks, and an exploration of applications of the architecture to challenging datasets including natural language processing and time series processing.

Computational Aspects in Finance and Insurance - Dr. K. Liu, Dr. A. Alvarez and Dr. S. Islam

Dr. Liu, Dr. Alvarez and Dr. Islam, along with S. Chen (Cape Breton University) and M.T. Hasan (University of New Brunswick), are supported under an AARMS Collaborative Research Grant. Their focus is on numerical approximations and computational methods to solve complex problems that appear in financial and insurance applications. They bring together techniques and theories from several areas such as Stochastic Processes, Statistics, Dynamical Systems and other areas including insurance, finance, economics, science and technology, engineering and so on to develop a sound scientific basis for quantitative analysis.

The research has a strong Data Analytics component. Complex big data sets lying in multidimensional spaces are increasingly important in insurance, finance, economics, and science. Big data is believed to be the key to the next wave of management innovation, productivity and growth. However, there is still a shortage of professionals who can draw meaningful insights from data and turn them into effective decision-making. Therefore, it is an important goal for the group to inspire students to be interested in quantitative analytics research, train students in different approaches to quantitative analytics research, and to expand collaboration in both academia and industry.

Group members have supervised a number of UPEI student projects in this area, which are listed below.

- Junshi Dong, MSc Student, Jan 2020 – Present, M. Sc. Thesis project: Biogeographical Modelling of Coronavirus Dispersal

- Jiaying Liu, Undergraduate Summer Research Student, May 2020 – August 2020. Research project: Some Remarks on the Black-Scholes Equation
- Jingfan Zhang, Undergraduate Summer Research Student, May 2020 – August 2020. Research project: Numerical Approximations for the Pricing of Multivariate Derivatives
- Ben Wang, Undergraduate Summer Research Student, May 2019- August 2019. Research project: Portfolio Selection using Fundamental Analysis.

The group also holds a regular seminar series where these students have presented their research.

Some recent publications are listed below.

- **A. Alvarez**, A. Assadi and **K. Liu** (2021). Closed-form Approximated Pricing of Multivariate Derivatives Under Switching Regime Models with Multiple States of the Markov Chain. *Applied Stochastic Models in Business and Industry*, accepted
- **A. Alvarez** (2021) “Financial modelling with multivariate mixed fractional Brownian motion”, *Revista Investigación Operacional*, 42(2): 127-136.
- H. Liu, **K. Liu**, D. Li and Y. Li (2020), “Fund Managers’ Association Networks, Information Sharing and Fund Performance”, *Applied Economics Letters*, 27(10): 841-847.
- B. Porth, L. Porth, W. Zhu, M. Boyd, K.S. Tan, and **K. Liu** (2020). Remote Sensing Applications for Insurance: A predictive Model for Pasture Yield in the Presence of Systemic Weather. *North American Actuarial Journal*, 24(2): 333-354.
- **K. Liu** and K.S. Tan (2020), “Real-time Valuation of Large Variable Annuity Portfolios: A Green Mesh Approach”, *North American Actuarial Journal*, DOI:10.1080/10920277.2019.1697707.
- **K. Liu** and M. Feng (2020), “Path Generation Methods on Valuation of Large Variable Annuities Portfolio”, *Proceedings of the 2020 Winter Simulation Conference*, IEEE Press, 481-491.

External Funding

Currently, faculty members Alexander Alvarez, Antonio Bolufe-Rohler, Maxim Burke, Shafiqul Islam, Michael Mclsaac, Christopher Power and Nasser Saad hold NSERC research grants. Michael Mclsaac is a co-investigator on two CIHR grants. Alexander Alvarez, Kai Liu and Shafiqul Islam are currently among five researchers who have been awarded an AARMS collaborative research grant. Kai Liu holds a MITACS Elevate grant, a MITACS Accelerate grant as well as a Health PEI Research Grant.

In addition to research grants, other examples of funding include Dr. Kai Liu’s research services agreement with Stopping Time Big Data & Technology Company to design a mobile retail recommendation system based on Machine Learning Technology, and Dr. Andrew Godbout’s award from the Springboard Technology Development Program Award to build a prototype and pursue commercialization options of his research on gait analysis and feedback systems.

Further details can be found in Appendix A.2, as well as in the faculty cvs found in Appendix D.

Highlighted Industrial Engagement

Dr. Christopher Power’s research program in accessible game design has had an international impact across the gaming industry through his collaboration with The AbleGamers Charity. His research has been realized in the Accessible Player Experiences Design Pattern Language, a data-driven research design tool is used heavily in the commercial game industry, with a deck of design cards and its

accompanying website (accessible.games/apx) being on over 2000 developer desks throughout the US, Canada and Europe. Additionally, Dr. Power has trained nearly 200 developers from Square Enix Montreal, Eidos Montreal, Blizzard/Activision/King, Avalanche, Microsoft Xbox, Gearbox and several other studios in the use of these patterns to create more inclusive games. As of fall 2021, AbleGamers will be offering scholarships to UPEI students in their 3rd and 4th year to attend training alongside commercial game developers for the enhancement of their CVs.

Several projects are being driven by Dr. Power and AbleGamers here at UPEI. For example, research assistants working with Dr. Power have developed prototypes for control remapping in the Unity Game engine, conducted environment scans of VR research and its barriers to people with disabilities, and in the future will be working with Dr. Bolufé-Röhler to develop recommender systems to help people find solutions for their own accessibility needs in gaming. Dr. Power is working with the Faculty of Sustainable Design Engineering on several projects for AbleGamers, with 2021 being the planned launch of a new project to design a device for players who cannot lift or pull standard controllers.

Event Organization

In the summers of 2017, 2018 and 2019, the School of Mathematical and Computational Sciences hosted the annual AARMS Summer School. The themes of the summer schools were, respectively, Financial Mathematics and Actuarial Sciences; Data Analytics; and Dynamical Systems, Differential Equations and Special Functions. The summer schools each offered four graduate-level courses delivered by internationally renowned experts. Students from all over the world are selected to attend and are provided tuition and accommodations at no charge.

In 2018, the School of Mathematical and Computational Sciences at UPEI hosted the 23rd International Conference on Implementation and Applications of Automata, a conference focused on all aspects of implementation and application of automata and related structures, including theoretical aspects. Dr. Cezar Campeanu was the chair of both the program committee and organizing committee of the conference. The conference attracted approximately 50 attendees from all over the world. Conference highlights included four invited talks, and the Sheng Yu award for the best paper of the conference. The proceedings of the conference were published in the Springer LNCS series volume 10977. Selected papers from the conference were published in World Scientific journal, International Journal of Foundations of Computer Science Vol. 31, No. 08, (2020).

In 2015, the School of Mathematical and Computational Sciences at UPEI hosted the Canadian Mathematical Society Summer Meeting. Dr. Shannon Fitzpatrick and Dr. Gordon MacDonald acted as the Scientific Directors of the conference. The conference attracted approximately 250 attendees from across Canada and the world. Conference highlights included five plenary lectures, three prize lectures and a public lecture. There were also 17 scientific sessions, an education session and a student poster session.

In 2016, SMCS hosted DEWCOM 2016, a conference on Dew Computing. Dr. Yingwei Wang acted as Program Committee Chair and Organizing Committee Chair.

Future Research Investment

Continued investment in data analysis and processing has value for cross-campus collaboration, the offering of new program options, and supporting the Island industry. We could also look at specialists in “data science adjacent” areas such as

- Image processing (applicable to climate science, engineering, AVC),
- Autonomous systems (applicable to climate science, agriculture, engineering (robotics, autonomous vehicles, satellites))
- High performance computing (applicable to anything involving big data, engineering, AVC)
- Bioinformatics (Biology, AVC)

There are also benefits to adding a specialist in Embedded Systems. This is a growing area and such expertise would support local interests such as the biotechnology sector.

Service

Overview of service contributions

For a complete list of service contributions please see Appendix B.3. as well as the faculty cvs found in Appendix D.

Service to the School of Mathematical and Computational Sciences

All faculty members contribute to service on the school level. The School has a number of standing committees such as the Program Committee, Awards Committee and Outreach Working Group. Faculty are also engaged when it comes to hiring decisions and tenure and promotion through various Hiring Committees and the Departmental Review Committee, respectively. There are also other service roles such as organizing our annual Math Camp and PEI Math League competitions, coaching our Mathematics Problem Solving Group and our Programming Teams, and writing our quarterly newsletter, among others.

Service to the Broader University Community

On the whole, SMCS has a strong presence when it comes to service to the University. For example, we have representatives on the UPEI Senate, the University Review Committee (tenure and promotion), and the Faculty of Science Graduate Studies Committee. Faculty have participated in hiring committees for other units on campus such as the School of Climate Change and Adaptation, the Faculty of Business, and the Faculty of Sustainable Design Engineering. SMCS members were also quite active with newly formed Faculty of Science committees related to teaching and research during the COVID-19 pandemic.

Outreach

Our primary outreach activity over the past two decades has been our annual 3-day Math Camp for grade 10 and 11 students. It is typically held for a weekend in early May, and sees a group of approximately 20 students invited to campus. (Unfortunately, the camp has not run since 2019 due to COVID-19 and CPHO restrictions.) The goal of the camp is to give some of PEI's best students an opportunity to broaden their mathematical horizons beyond what they see in their course work, and to encourage them to continue their math studies at university. They participate in a variety of math-related activities, such as group problem solving, math relays, math trivia and faculty sessions. The student feedback to the Camp has been very positive. Math Camp is a national initiative of the Canadian Mathematical Society, which provides about half the budget of approximately \$2600 (the other half coming from the Dean of Science and the School).

In the 2018-2019 and 2019-2020 academic years, our School hosted the PEI Math League. In our inaugural year, we had 40 students participate, representing five different PEI high schools. The students worked in teams of four to complete a number of challenging math problems, which were provided by organizers of the Nova Scotia Math League. After three local competitions, our top three teams were invited to compete at the finals in Nova Scotia, where a PEI team won the competition. We were looking forward to another successful year in 2019-2020, but unfortunately, we could not complete the four competitions due to COVID-19.

Faculty members also contribute to the community through various high school presentations, engagement with the PEI Science Fair, administration of the Canadian Open Mathematics Challenge on PEI, and administration of the Canadian Math Kangaroo Contest on PEI.

Our Lab Instructor Chris Vessey engaged in teacher training for 6 high school teachers in embedded systems. This included learning Arduino technology and programming. This led to those teachers revamping the CMP521 curriculum to include aspects of what was taught in this training.

In 2017, Dr. Godbout received a grant from the Google IgniteCS program to train junior high school students, involving several of our undergraduate students as mentors to young people to get interested in computing (<https://www.saltwire.com/prince-edward-island/news/local/google-upei-hope-to-get-junior-high-students-interested-in-computer-science-104089/>). The camp was held in the spring and attracted 30 students. The students learned about computational thinking and wrote computer programs using various languages. Local industry representatives also came to give presentations about their work as professional computer scientists. In 2018 the camp was held again, extending enrollment to include grades 5 and 6.

During the summer of 2020, Dr. Michael McIsaac and Dr. Christopher Power supervised 2 senior undergraduate students in integrating the statistical reasoning course from Census at Schools into the existing PEI curriculum. Our goal with this project on the Outreach Committee at the School of Mathematical and Computational Sciences at UPEI is to support the teaching of Statistics and Probability in PEI classrooms. We are hoping to accomplish this by taking advantage of Census@School (<https://censusatschool.ca/about/>), an international classroom project designed to engage students aged 8 to 18 in statistical reasoning, using data collected about themselves and about participating students from around the world. The Canadian component of Census@School was developed by Statistics Canada and is maintained by the Statistical Society of Canada, which has the mission of promoting the highest possible standards for statistical education and practice in Canada.

By making it easy for Island teachers to use real student data in their instruction (data from students in the class, across Canada, or around the world), we might be able to provide additional opportunities for engagement of certain students. In addition, the introduction to Census@School could allow teachers to introduce more student-driven work that could align nicely with some of the PEI curriculums' Communication and Information Technology objectives.

As a first step, we have worked with a summer student to examine the Data Analysis unit plans in the existing (non-Covid) curriculum guides and determine where problems could be modified to instead examine Census@School data. At its simplest, teachers could—as described in the linked document—replace some of their usual practice problems with those based on Census@School data, in the hope of making the lessons more engaging for students by using real, student-derived data. Additionally, interested teachers could take these exercises further by using technology to explore Census@School data live in their classroom in response to student interest, or by allowing students to use technology to explore existing data on their own according to their own interests, or by registering with Census@School, surveying their own class through the Census@School website, and using their students' own data in these lessons.

Currently there are a variety of directions that may be pursued in Outreach. Building on the Census@School work, the committee is pursuing, with collaboration across campus, a PromoScience bid

that would uplift the Island's data literacy and computational thinking skills. Initial discussions have shown interest from the Faculty of Engineering to pursue this bid in the future.

Alongside this is a desire to provide opportunities to increase equality, diversity and inclusion in our programs in SMCS. This could include programs such as promoting young women into STEM, in particular Math, Stats and CS. This could include code clubs aimed specifically at young women, run by young women from our undergrad programs, either as volunteers or paid. There is good evidence that role models in the classroom is one of the most important aspects of keeping young women engaged past the age of 16 in STEM careers. There are opportunities to work with STEAM PEI on these types of initiatives. STEAM PEI (steampei.com) has run camps and in-school workshops on PEI for a number of years, including camps for girls aged 10-15 and camps that include digital and coding components.

Balance of Roles and Responsibilities

Current Situation

The regular teaching load for faculty is five courses per year, typically with three courses in one term and two in the other. Currently, faculty in program-lead positions receive one course release per year. New faculty members receive one course release per year for their first two years. We have two faculty members utilizing a program that provides course-release of one course per year for the duration of their first tri-council grant.

For certain faculty members within our School, the balance of responsibilities is more heavily weighted toward teaching than it should be.

Given the current faculty complement, it is a challenge to deliver all of our courses, particularly in Computer Science. With various leaves of absence (sabbatical, parental leave, etc.), faculty have taken on overload due to necessity. For example, during the 2020-2021 academic year, a faculty member was on parental leave and we were unable to find a term replacement. In order to deliver required courses in Computer Science, two faculty members took an overload of one course each. In other programs, many faculty members have taken on small overloads in order to provide directed studies courses to students whose schedules are not in sync with courses that are offered on a rotational basis. We also have faculty doing small overloads of one-third to one-half of a course since they are supervising the associated labs for the courses.

Equitable distribution of workload among faculty is currently a challenge for SMCS. With rapid growth in the number of CS majors, our CS faculty have seen an increase in workload, particularly related to grading. In contrast, faculty who are teaching exclusively, or almost exclusively, within new programs have significantly lower average enrolments. This is not surprising and would be typical in any new program. However, these inequities can cause morale issues among faculty.

For more information on class sizes and trends, please see Appendix A.1. Program Statistics.

Proposed Actions

We propose that five new faculty positions be added to SMCS as soon as possible. One of these positions was budgeted for when SMCS was created and they were tied to enrollment targets. Those

targets have been exceeded. The second position was agreed upon shortly after the School's formation when updated SOA accreditation requirements made it clear that an additional faculty member was required in Actuarial Science. The funding of three additional positions is addressed later in this document (under Budget Implications of Proposed Actions).

Additional faculty members in Computer Science are required to address increasing numbers of students and the limited number of electives available. When adding additional faculty in Computer Science, the teaching gaps in the areas of cybersecurity, parallel and distributed computing, and high-performance computing would be prioritized.

With the retirement of a faculty member in Mathematics, and reallocating that position to support the Analytics and Computer Science programs, we now have a deficit when it comes to Mathematics teaching. A faculty member in Mathematics is required to support that program and the large service component in Mathematics.

Another high priority would be a new faculty member who specializes in Actuarial Science. With this expertise, we would be able to regularly offer the complete suite of AMS courses in the Actuarial Science Pre-Professional Specialization. We would also be better equipped to accommodate sabbaticals and other leaves of absence. Finally, when we have the full complement of faculty who primarily teach within the Actuarial Science and Financial Mathematics programs, we would be able to have those faculty members teach some other introductory courses such as Math 1910, 1920 and Stat 1910. This would lead to a more balanced workload among faculty within SMCS.

The final priority is to hire an additional Statistics specialist. With the large number of Statistics courses required for the Statistics, Actuarial Science, Financial Mathematics and Analytics majors, along with the high service component, there are challenges to deliver all of these courses with only two dedicated Statisticians. With growing numbers of students enrolled in Stat 1910, we will also need to add additional sections to both bring the workload in line with that of our other 1910 courses and allow for the scheduling issues among the various majors.

Action for Administration: To allocate a total of five new faculty positions to SMCS.

Infrastructure and Support

Staffing Levels

Current Situation

The School of Mathematical and Computational Sciences currently has four staff members, two in administrative support positions and two in technical positions.

Administrative support consists of one full-time permanent position funded through the core budget and one contract half-time position.

We have a System Administrator who also acts as our sole lab instructor in Computer Science. In his capacity as lab instructor, he acts as the instructor for five lab sections during each of the fall and winter semesters. He also co-teaches the 1-credit course MCS 3050 Tutoring in the Mathematical and Computational Sciences which is offered in both the fall and winter semesters. Finally, he manages the student tutors in the Computer Science Help Centre and student lab assistants in CS 1910 and CS 1920. This is a full-time position, with his student-facing duties defined as 50% of his position.

Finally, we have a second lab instructor who teaches a number of 1-credit, stand-alone, labs in Maple, Matlab, R and Visual Basic in Excel. He also co-teaches the 1-credit course MCS 3050 Tutoring in the Mathematical and Computational Sciences which is offered in both the fall and winter semesters. Finally, he manages the student tutors in the Math Help Centre and in the courses Math 1910, Math 1920 and Stat 1910. This is a 10-month renewable contract.

Proposed Actions

According to the original proposal for a School of Mathematical Sciences, found in Appendix B.1.a., a half-time administrative assistant was to be added to the School's core budget by 2018. There are a number of factors contributing to our need for additional administrative support such as

- The number of SMCS majors has increased from just over 100 in Fall 2015 to current numbers over 400. Our service to other departments has also increased due to growth within the Faculty of Sustainable Design Engineering and general increases within the Faculty of Science. These have all contributed to the general number of requests and inquiries for our administrative staff.
- A School mandate to deliver outreach programming to PEI schools and the community at large.
- Initiatives such as conferences, workshops, and summer schools that are necessary for a thriving research environment and raise the profile of SMCS.

We have managed this need through a number of casual and contract positions, but stable funding for a permanent position is needed.

With an increase in the number of students, we also need additional technical staff. Another lab instructor in Computer Science is required. The reasons for this include

- The number of students enrolled in each of the 1000-level CS courses has increased by 50% in the past 5 years. As a result, the number of lab sections has increased from 3 lab sections to 5 lab sections per term.
- With growth within SMCS as a whole, MCS 3050 has moved from being offered only in the fall to being offered in both the fall and winter semesters.
- The number of students working as tutors in the Computer Science Help Centre and as lab assistants in CS 1910 and 1920 has grown substantially.
- CS 2910 labs are currently taught by faculty members. Given increasing numbers, we anticipate having to move from two lab sections to three lab sections for this course in Fall 2021. It would be a better use of faculty resources to assign these courses to a lab instructor.

A part-time lab instructor is also required for Statistics.

- Enrollment in Stat 1910 has increased from 110 students when the course was introduced in 2018-2019 to approximately 180 students in 2020-2021. As a result, the number of tutorials should increase from 1 per semester to 2 per semester.
- All Stat 1910 tutorials are currently being delivered by faculty members. It would be a better use of faculty resources to assign these courses to a lab instructor. This will be particularly true if the tutorials are re-coded as laboratories to properly reflect the workload.
- A second section of the 1-credit course MCS 2030 R Technology Lab will require a second section to be added in 2022, due to the 40-seat capacity of our computer lab. A part-time lab instructor could take on duties related to this course.

The funding of these additional positions is addressed later in this document (under Budget Implications of Proposed Actions).

Action for Administration: To allocate 1.5 new lab instructor positions to SMCS ; to add the current 0.5 administrative position into SMCS's core budget.

Sessional lecturers

Current Situation

We currently have a pool of regular sessionals who teach a number of service courses in Mathematics and Statistics. We also have sessional instructors regularly teaching sections of courses such as Math 1910 Calculus I, Math 1920 Calculus II, Math 2610 Linear Algebra, AMS 2940 Optimization, CS 1910 Introduction to Programming I, and CS 1920 Introduction to Programming II. We also rely on local industry professionals who deliver courses in our Video Game Programming Specialization as sessionals.

While we have consistent sessional support for many of our introductory and service courses, it can be challenging to find sessionals to help deliver 1000 or 2000-level CS courses. As a result, outside of the Video Game Specialization courses, we try to minimize the number of CS courses that are advertised to sessional instructors.

Proposed Actions

Action for Administration: Allocate additional faculty to SMCS to reduce our reliance on sessional instructors.

Facilities

Current Situation

The School of Mathematical and Computational Sciences currently occupies the Cass Science Hall.

Facilities available in Cass include:

- Administrative office and Reception area
- Dedicated Computer Lab (with 40 workstations)
- SMCS Help Centre
- Seminar Room
- Board Room
- Office space for the Associate Dean, 18 Faculty Members, and 2 Lab Instructors
- Spare office currently occupied by a research consultant for ACENET.
- Sessional office
- Visitors' office
- Research room
- Graduate Student space
- Student Lounge
- Faculty Lounge

Challenges

SMCS has outgrown the Cass Science Hall. In terms of faculty offices, we currently have one available office space, which temporarily houses a research consultant for ACENET. Our visitor's office is very small and not suitable for a regular faculty member. Our sessional office is a former seminar room and is mainly utilized for office hours.

We currently have one dedicated computer lab, CSH 104, with capacity for 40 students. In addition to the lab sections, a handful of classes are taught in this room. The number of CS courses with fewer than 40 registered students is decreasing, so the room is used less and less for lectures. As a result, there is little opportunity for active learning during regular lecture times or for running in-person examinations using live coding questions. Furthermore, with CSH 104 used for classes and labs for the majority of the day, there is no opportunity for students to access the lab outside of class time.

Our seminar room CSH 101, which holds approximately 20 people, is regularly used for small classes. It is a bookable space on campus, which means it is not a dedicated SMCS space.

We have only one small dedicated research space, which has only been utilized by a small number of CS faculty. It is not large enough to house multiple researchers, so the faculty member most in need of space has been given exclusive access. While many researchers in SMCS do not require lab spaces per se, they do require dedicated spaces in order to meet and collaborate with their students and

colleagues. This will only become more of an issue with the launch of our MSc in Mathematical and Computational Sciences in Fall 2021.

Proposed Actions

The university should work toward finding a new dedicated space for SMCS. This space should include a large teaching lab, ample office and research space, and expanded student space. With demand for computer scientists and data scientists steadily increasing, all trends indicate that our student numbers will continue to grow.

Action for Administration: Allocate space to accommodate growth in SMCS including additional teaching, research and lab space.

Library Support

Faculty members in SMCS report that they are happy with the library holdings and services. The library staff have been supportive and responsive to our needs. A report from the library will be available to reviewers prior to the site visit.

Non-Salary Budget

The School of Mathematical and Computational Sciences has a discretionary budget of approximately \$60,000/year. Included in our discretionary budget are funds associated with lab fees. With the increased enrollments in SMCS, we have spent approximately \$40,000 per year toward student assistants in each of the last two fiscal years. The remainder of the budget has typically been spent on upgrading office computers for faculty and purchasing equipment for student spaces. With increasing enrollment, our costs related to student markers, tutors and lab assistants will continue to increase.

Many other activities in SMCS have been subsidized through a sizable donation from TD bank in 2016. This donation has allowed us to offer student awards for summer research, fund travel to undergraduate conferences such as Science Atlantic and Actuarial Students' National Association Conference (ASNA). It has also funded outreach events such as the PEI math league. Those funds will be spent by 2022, so an increase to discretionary funds is in order.

Action for Administration: To increase the School's discretionary budget to fund markers, tutors, student activities and outreach.

Relationship to Broader Context

As previously mentioned, *An Inclusive Campus Culture* was highlighted as a priority in UPEI's strategic plan, and SMCS has fallen short in providing that to some of our female students. While EDI training for faculty and staff is one way to address this issue, at the heart of the problem is a lack of community among our female students. This problem is not unique to SMCS; women are extremely underrepresented in the mathematical and computational sciences across Canada. According to [Stats Canada](#), of the post-secondary students who were enrolled in mathematics and computer science programs across Canada in the 2018-2019 academic year, only 28 percent were women. On PEI, only 17% were women. This underrepresentation is also seen among the SMCS faculty, with only one female faculty member among the usual complement of 18. Although there are challenges, SMCS and UPEI need to make a strong effort to recruit additional female faculty members. Having female mentors for our students can go a long way in building community among current students and attracting new female students to SMCS.

One of the five priorities listed in UPEI's current strategic plan is *Education for a Connected World*. As part of this priority, the need for more interdisciplinary opportunities was highlighted. Our programs in Actuarial Science, Financial Mathematics and Business Analytics were specifically introduced to increase interdisciplinary opportunities for students. We wanted to give students who had strong mathematics skills options for study that were outside of the traditional paths within science and engineering. These interdisciplinary opportunities also extended to research, with SMCS faculty members collaborating with faculty in many units on campus, including the Department of Economics, School of Climate Change and Adaptation, Faculty of Engineering, and the Atlantic Veterinary College.

When the School of Mathematical and Computational Sciences was formed in 2016, we discussed how "big data" was becoming ubiquitous and how analytics was revolutionizing many industries. We now have faculty engaged in research at the forefront of this revolution and are training students to work in high-demand fields. While recent faculty additions to SMCS have been categorized according to programs such as Actuarial Science or Computer Science, we see that their research is more wide-ranging, often lying in the intersections of Mathematics, Statistics and Computer Science (which is at the heart of the analytics). By strategically expanding the faculty complement to promote this type of interdisciplinary research and investing in state-of-the-art facilities, SMCS can continue to build on its successes of the past five years.

Budget Implications of Proposed Actions

As part of the 2015 proposal to form a School of Mathematical Sciences, the budget included the addition of four new faculty positions (see Appendix B.1.a). These positions were to be added over time, as enrollment goals were achieved. Three of those positions have been allocated so far. All four were to be in place once 195 new majors joined SMCS. The enrollment goal of 195 new majors was achieved in the 2019-2020 academic year. In 2017, it was recognized by administration that an additional (fifth) new faculty member was required in order for the SMCS program in Actuarial Science to meet accreditation standards. So, while we are now proposing five faculty positions, bringing our faculty complement to 23, only three of those are “new” and based on growth since 2019. We also note that the addition of a 0.5 administrative assistant to our core budget was also included in the 2015 School proposal, so we do not consider that to be a new cost.

Since the School was established, we have added approximately 240 new majors. We expect the growth in Computer Science and Actuarial Science to continue to be strong, and changes to the Analytics specializations will draw additional students. We will also be accepting our first MSc students this fall.

Below are the projected new enrollments (full-time equivalent) since 2019, accounting for attrition and graduation rates. We consider these to be conservative estimates. Since tuition rates for 2021-2022 were unavailable, we assumed a freeze on tuition for 2021-2022 and 2% increases for the following years.

New Tuition

	2021-2022		2022-2023		2023-2024		2024-2025		2025-2026	
	FTE (#)	Tuition	FTE (#)	Tuition	FTE (#)	Tuition	FTE (#)	Tuition	FTE (#)	Tuition
New Majors since 2019	80	\$511,200	110	\$717,000	140	\$930,700	160	\$1,085,000	170	\$1,175,800
Graduate Students	4	\$17,200	8	\$35,200	9	\$40,300	9	\$41,200	10	\$46,500
New Revenue from Tuition		\$528,400		\$752,200		\$971,000		\$1,126,200		\$1,222,300
Overhead (20% of Tuition)		-\$105,700		-\$150,400		-\$194,200		-\$225,200		-\$244,500
Annual Balance		\$422,700		\$601,800		\$776,800		\$901,000		\$977,800

New Costs

To address growth since 2019, we consider three new faculty positions, as discussed above, 1.5 new lab instructors and an increase to the discretionary budget. An increase to the discretionary budget is required to support student and outreach activities, as previously discussed, as well as address the increasing costs of hiring student tutors for our help centers and Math 1910 and 1920 tutorials. (Costs for undergraduate and graduate student assistants working in labs are considered later since those are funded through laboratory fees.)

Costs	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026
Two new faculty members (salary and benefits)		\$210,800	\$224,000	\$237,800	\$261,400
One new faculty member (salary and benefits)			\$107,500	\$114,200	\$121,300
1.5 full time lab instructors (salary and benefits)		\$109,800	\$112,000	\$114,200	\$116,500
Discretionary Budget		\$20,000	\$22,000	\$24,000	\$25,000
Total costs		\$340,600	\$465,500	\$490,200	\$524,200

Based on the tuition revenue described above, these costs would result in the following annual and cumulative surpluses.

Surplus	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026
Annual	\$422,700	\$261,200	\$311,300	\$410,800	\$453,600
Cumulative	\$422,700	\$683,900	\$995,200	1,406,000	\$1,859,600

We would also see a savings in sessional stipends by adding additional faculty members. While additional teaching capacity in Computer Science would be used to add new courses and additional sections of existing courses, new faculty members in Actuarial Science and Statistics would reduce our reliance on sessional instructors by 8-10 courses per year. As of July 2021, a sessional instructor at Step 2 receives \$6,579 for a 3-credit course. So, there is an annual savings of over \$52,000 per year on sessional instructors that has not been factored into the above surplus.

Lab Fees and Student Assistants

In the 2020-2021 academic year, we had 590 registrations in courses that collected a lab fee of \$75 per registration. When 20% is taken off for overhead, this leaves a balance of approximately \$35,400 for 2020-2021. This would be sufficient to cover costs of student assistants working in such courses. If Stat 1910 were to convert its tutorial to a lab, which better reflects workload, there would be a projected increase of approximately 200 lab registrations per year. This would bring annual lab fees (minus 20% overhead) to at least \$48,000 (based on current numbers), which should be allocated directly to SMCS.

With this change, and proposed increase to the discretionary budget of \$20,000 in 2023, this would be sufficient to support student lab assistants, tutors, as well as other School initiatives.