FOR APPROVAL **PUBLIC** **OPEN SESSION**

TO: UTSC Academic Affairs Committee

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DATE: Tuesday, January 10, 2023

AGENDA ITEM: **5**

ITEM IDENTIFICATION:

Minor Modifications: Undergraduate Curriculum Changes –Sciences, UTSC (for approval)*

JURISDICTIONAL INFORMATION:

University of Toronto Scarborough Academic Affairs Committee (AAC) "is concerned with matters affecting the teaching, learning and research functions of the Campus (*AAC Terms of Reference, 2021, Section 4*)." Under section 5.6 of its terms of reference, the Committee is responsible for approval of "Major and minor modifications to existing degree programs." The AAC has responsibility for the approval of Major and Minor modifications to existing programs as defined by the University of Toronto Quality Assurance Process (*UTQAP, Section 3.1*).

GOVERNANCE PATH:

1. **UTSC Academic Affairs Committee [For Approval] (January 10, 2023)**

PREVIOUS ACTION TAKEN:

No previous action in governance has been taken on this item.

HIGHLIGHTS:

This package includes minor modifications to undergraduate curriculum, submitted by the UTSC Sciences academic units identified below, which require governance approval. Minor modifications to curriculum are understood as those that do not have a significant impact on program or course learning outcomes. They require governance approval when they modestly change the nature of a program or course.

- The Department of Computer and Mathematical Sciences (Report: Computer and Mathematical Sciences)
    - 5 new courses
        - MATA34H3: Calculus for Management
        - MATD09H3: Set Theory
        - STAB53H3: Introduction to Applied Probability
        - STAD81H3: Causal Inference
        - STAD91H3: Topics in Statistics

FINANCIAL IMPLICATIONS:

There are no significant financial implications to the campus operating budget.

RECOMMENDATION:

Be It Resolved,

THAT the proposed Sciences undergraduate curriculum changes for the 2023-24 academic year, as detailed in the respective curriculum reports, be approved.

DOCUMENTATION PROVIDED:

1. 2023-24 Curriculum Cycle Undergraduate Minor Curriculum Modifications for Approval Report: Computer and Mathematical Sciences, dated January 10, 2023.

UNIVERSITY OF TORONTO SCARBOROUGH

2023-24 Curriculum Cycle
Undergraduate Minor Curriculum Modifications for Approval
Report: Computer and Mathematical Sciences
January 10, 2023

Computer & Mathematical Sciences (UTSC), Department of

5 New Courses:

MATA34H3: Calculus for Management

Description:

This is a calculus course designed primarily for students in management. The main concepts of calculus of one and several variables are studied with interpretations and applications to business and economics. Systems of linear equations and matrices are covered with applications in business.

Prerequisites: Ontario Grade 12 Calculus and Vectors or approved equivalent.

Exclusions: MATA30H3, MATA31H3, MAT133Y

Note: Students who are pursuing a BBA degree or who are interested in applying to the BBA programs or the Major Program in Economics must take MATA34H3 for credit (i.e., they should not take the course as CR/NCR).

Learning Outcomes:
Students will become proficient in knowing the main concepts in calculus of one and several variables, systems of linear equations, and matrices.
Students will strengthen their overall sense of numeracy/formula/structure and their ability to think logically.
Students will be able to identify problems and examples in business and economics where concepts of calculus, systems of linear equations, and matrices are relevant and applicable.
Students will be able to compute limits and demonstrate understanding of continuity and applications in business and economics.
Students will be able to identify and calculate the tangent line and related interpretations of the derivative concept. They will also be skilled at differentiating standard functions in business and economics of one and several variables.
Students will be proficient at solving small systems of equations and related matrix problems. They will be able to identify problems and examples of matrix concepts in business and economics.
Students will be skilled with basic methods of optimization using one and two-variable methods of calculus. They will be able to identify problems and situations in business and economics where optimization is treated via calculus methods.

Topics Covered:
1. Limits and continuity: limits at a point, infinite limits/limits at infinity, continuity
2. Differentiation: the derivative and tangent line concepts, differentiation rules, interpretation of the derivative in economics/business, the marginal concept. Some additional topics in differentiation: derivatives of logarithm and exponential functions.
3. Differentiation (cont'd)
4. Applications of derivatives and curve sketching: monotonicity, extrema, extrema on a closed interval, applications in economics, concavity, derivative tests, asymptotes, curve sketching
5. Applications of derivatives and curve sketching (cont'd)
6. Matrices, basic matrix operations, terminology, systems of equations, applications. Yes (from MATA33)
7. Matrix inverse, inverse calculations, solving systems of equations using matrix inverse. Yes (from MATA33)

8. Partial Derivatives, Applications of partial derivatives, implicit partial differentiation Yes (from MATA33)
9. Higher-order partial differentiation, chain rule for partial derivatives, second derivative test (identify the maximum & minimum) Yes (from MATA33)
10. Lagrange multipliers: overview, technique for functions of 2 and 3 variables, multiple constraints, applications. Yes (from MATA33)
11. Integration: the indefinite integral, integration with initial conditions, applications in economics, elementary techniques of integration
12. Integration: the indefinite integral, integration with initial conditions, applications in economics, elementary techniques of integration.

Methods of Assessment:
A beginning test, two midterm tests, and one final exam.
The Beginning Test will give students an opportunity to demonstrate their prerequisite mathematics and provide feedback on their readiness to move forward in MATA34.
The two midterm tests and final exams will provide students with opportunities to demonstrate knowledge of limits, continuity, derivatives, differentiation, and calculus applications in business and economics. The two tests and exam will also give students opportunities to show knowledge of concepts and methods of solving systems of equations and matrix concepts. The beginning test and the two midterm tests will be returned to students upon grading, hence they will provide valuable feedback to students in the form of their grades and comments on said tests.

Mode of Delivery: In Class

Breadth Requirements: Quantitative Reasoning

Rationale:
This course is being proposed to satisfy the request of the Management department to have a single calculus/mathematics course that will meet the needs of students studying business or economics. MATA34H3 will replace the combination MATA32H3+MATA33H3. In consultation with the department of Management, it is understood that a one-term calculus course for their students will meet the demands of Management programs in mathematically sound and efficient ways.

Consultation:
DCC Approval: October 3, 2022.
RO Approval: Sept 19, 2022.

Resources: The course will be taught by a regular faculty member. The course will replace MATA32H3 & MATA33H3, therefore, no additional resources are required for the single-semester MATA34H3.

MATD09H3: Set Theory

Description:

This course is an introduction to axiomatic set theory and its methods. Set theory is a foundation for practically every other area of mathematics and is a deep, rich subject in its own right. The course will begin with the Zermelo-Fraenkel axioms and general set constructions. Then the natural numbers and their arithmetic are developed axiomatically. The central concepts of cardinality, cardinal numbers, and the Cantor-Bernstein theorem are studied, as are ordinal numbers and transfinite induction. The Axiom of Choice and its equivalents are presented along with applications.

Prerequisites: MATB43H3 and [MATC09H3 or MATC27H3 or MATC37H3].

Exclusions: MAT409H1

Learning Outcomes:
This course enables students to explore and understand axiomatic set theory. By the end of this course, students will be able to:

- describe and use the Zermelo-Fraenkel axioms.
- demonstrate knowledge and understanding of core concepts, theorems, and applications in axiomatic set theory.
- demonstrate the ability to write correct mathematical proofs.
- communicate mathematical thinking through the writing of mathematical proofs.
- demonstrate the ability to understand and question abstract and foundational mathematics
- appreciate and demonstrate an understanding of the role and methods of set theory in other areas of mathematics.

Topics Covered:

The Zermelo-Fraenkel axioms for set theory, general set constructions.
Relations, functions, orderings, ordered sets
Inductive sets, axiomatic development of the natural numbers, recursion.
Cardinality, cardinal numbers and their arithmetic, Cantor-Bernstein theorem, finite sets, countable sets, uncountable sets, applications, linearly ordered sets, completion, the real numbers as a complete linearly ordered set.
Well-ordered sets, transitive sets, ordinal numbers and their arithmetic, transfinite induction.
Axiom of choice and some of its equivalents, applications to other areas of mathematics.

Methods of Assessment:
Written assignments: they will give students the opportunity to demonstrate their ability to formulate proofs and answer questions about set theory and receive feedback on their work. They are an assessment item that will cause students to engage with the ideas and concepts of set theory on a progressively deeper level.
Midterm Test and Final Exam: These will give students the opportunities to formalize and consolidate their learning of set theory and communicate that learning on paper. The test and exam will also encourage a progressively deeper study of, and multiple reviews of, the ideas and concepts in set theory.
Written Report: This will give students the opportunity to informally research a topic of choice in set theory. It will also provide a substantial opportunity to formally write mathematics in a style seen in mathematical literature and papers. The written report will necessitate students' curiosity, deeper thinking about set theory, independent learning, and organization in careful writing.

Mode of Delivery: In Class

Breadth Requirements: Quantitative Reasoning

Rationale:
This course is being proposed in response to students' expressed interest in having a course taught in set theory and to increase the CMS Department offerings in foundations of mathematics. The course is designed for both the Specialist and Major programs in mathematics, but it could also be of interest to students in Computer Science, Statistics, Philosophy, or Physics.

Consultation:
RO Approval: Sept 26, 2022.
DCC Approval: October 3, 2022.

Resources: The course will be taught by a regular faculty member. No additional resources are required.

STAB53H3: Introduction to Applied Probability

Description:

An introduction to probability theory with an emphasis on applications in statistics and the sciences. Topics covered include probability spaces, random variables, discrete and continuous probability distributions, expectation, conditional probability, limit theorems, and computer simulation.

Prerequisites: [MATA22H3 or MATA23H3] and [MATA35H3 or MATA36H3 or MATA37H3]

Exclusions: STAB52H3, PSYB07H3, STA107H, STA237H1, STA247H1, STA257H, STA246H5, STA256H5

Learning Outcomes:
Upon completion of the course, students will be able to:
- Comprehend and employ basic concepts and techniques of Probability Theory
- Translate real-world settings into probability models using random variables
- Employ common discrete and continuous distributions
- Model probabilistic relationships with conditioning and independence
- Calculate and interpret probabilities, distributions, and expectations
- Understand the major limiting results of probability and their applications in Statistics

The course will provide an accessible and practical introduction to Probability Theory, geared towards non-CMS students, e.g. students in Physical, Health, or Social Sciences who want to learn probability and/or complete a Statistics Major or Minor. Statistics Specialist or CMS students will have to complete STAB52H3. STAB53H3 will cover similar topics to STAB52H3, but the emphasis will be placed on concepts and applications, rather than mathematical rigour.
STAB53H3 will serve as a program requirement (alternate for STAB52H3) for the Major and Minor in Statistics. It will lay

the probabilistic foundation for the development of B/C/D-level methodological courses in Statistics, according to the programs' learning outcomes, namely "Apply probability theory for describing random phenomena and quantifying uncertainty in common statistical applications".

Topics Covered:
- Probability Model and Basic Rules
- Conditional Probabilities & Independence
- Random Variables and Transformations
- Common Discrete and Continuous Distributions
- Expectation and Variance
- Multivariate and Conditional Distributions
- Inequalities and Limiting Results

Methods of Assessment:
Methods of assessment will consist of
- Weekly Quizzes
- 1 or 2 Midterms
- Final Exam

These parallel STAB52H3 and are typical for B-level CMS courses.

Mode of Delivery: In Class

Breadth Requirements: Quantitative Reasoning

Rationale:
The department's current introductory probability course, STAB52H3, serves diverse students, ranging from Minors to Specialists. This makes it difficult to satisfy the demands of the various programs and courses that it serves. The department, therefore, is creating two versions of the course, a theoretical one in STAB52H3, and an applied one in the proposed STAB53H3. STAB52H3 will be geared toward Statistics Specialists and CMS students, whereas STAB53H3 will be geared toward Statistics Majors, Minors, and non-CMS students. The proposed STAB53H3 will allow students to complete the Statistics Minor and Major, by serving as a prerequisite to STAB57H3 and subsequent C/D level methodological courses in Statistics and help fill a curriculum-related gap.

Consultation:
DCC Approval: October 3, 2022.
RO Approval: Sep 26, 2022.
Consultations with the impacted units of Management (Aug 25, 2022) and Physical & Environmental Sciences (Aug 25, 2022).

Resources:
The course will be taught by regular faculty. The course will require TA support which the unit's existing budget will cover. No additional support or equipment will be required.

STAD81H3: Causal Inference

Description:

Correlation does not imply causation. Then, how can we make causal claims? To answer this question, this course introduces theoretical foundations and modern statistical and graphical tools for making causal inference. Topics include potential outcomes and counterfactuals, measures of treatment effects, causal graphical models, confounding adjustment, instrumental variables, principal stratification, mediation and interference.

Prerequisites: STAC50H3 and STAC58H3 and STAC67H3

Enrolment Limits: 40

Learning Outcomes:
By the end of the term, the students will have learned:
1.To rigorously define causal effect contrasts using potential outcomes
2.To express assumptions using causal graphs
3.To formulate strategies for identification and estimation of causal effects
4. To identify assumptions necessary to make a statistical estimand causally interpretable

One of the program objectives for the Statistical Science Stream specialists is to acquire expertise in the … methods used to analyze data to answer scientific questions of interest, and the theory that underlies these activities. The fundamental question at the core of many scientific inquiries is causal, and this course will better prepare students for answering such questions.

Topics Covered:
- Potential outcomes and counterfactuals
- Causal graphical models: Directed Acyclic Graphs (DAGs), d-separation, Single World Intervention Graph (SWIG)
- Confounding adjustment: propensity score, doubly robust methods
- Instrumental variables
- Principal stratification, mediation and interference

Methods of Assessment:
Assignments — practice applying specific causal inference methods to datasets and problems
Exam — test knowledge of concepts in a more controlled setting
Course Project — apply causal inference pipeline to a specific problem on a real-world dataset

Mode of Delivery: In Class

Breadth Requirements: Quantitative Reasoning

Rationale:
The proposed course aims to bridge this curriculum gap and will be the first one in UTSC devoted to causal inference. Similar courses have existed or been recently developed in many peer institutions such as Stanford, Berkeley and Cornell. A similar course also exists in the graduate department of Statistical Sciences at UTSG (STA4517H – Foundations & Trends in Causal Inference). The course is going to serve students in the Specialist and Major programs in Statistics.

Consultation:
DCC Approval: October 3, 2022.
RO Approval: September 26, 2022.

Resources:
The course will be taught by regular faculty and will require TA support which will be covered by the unit's existing budget. It will not require additional equipment or laboratory fees.

STAD91H3: Topics in Statistics

Description:

Topics of interest in Statistics, as selected by the instructor. The exact topics can vary from year to year. Enrolment is by permission of the instructor only.

Prerequisites: Permission from the instructor is required. This will typically require the completion of specific courses which can vary from year to year.

Learning Outcomes:
STAD91H3 will support Statistics programs by expanding the selection of upper-level courses, and by engaging students in advanced Statistical theory and practice.
Students interested in graduate studies will benefit in particular, as they will have the opportunity to take such a course at UTSC.

Topics Covered:
The topics covered in STAD91H3 will be determined by the specific instructor and will build on current offerings and the strengths of the faculty.
The course will focus on advanced topics of current interest in statistical research, for example, functional/nonparametric regression, robust statistics, and network data.

Methods of Assessment:
The methods of assessment will be determined by the instructor and will be comparable to those for D-level courses in Statistics. Methods of assessment will consist of a mix of
- Assignments
- Project(s)

- Midterm(s)
- Final Exam

Mode of Delivery: In Class

Breadth Requirements: Quantitative Reasoning

Rationale:
The reason this course is being proposed is to allow Statistics faculty to offer courses on advanced topics of current interest or related to their research, without having to introduce a new course every time. Similar topics courses are offered by Mathematics (MATD10H3 and MATD10H3) and Computer Science (CSCD71H3) at CMS. The content and prerequisites will be determined by the instructor and published in the timetable prior to offering the course. Another use of this topics course is to allow CMS to try out new upper-level STA course offerings for fine-tuning new course curriculum proposals. The proposed STAD91H3 will be different than the current reading (STAD92H3 and STAD93H3) & project (STAD94H3 and STAD95H3) courses, in that it will have larger enrollment and carry teaching credit. Because of that, the Department Chair and Associate Chair for Statistics will have to approve any STAD91H3 course offering, and the course will only be taught by regular faculty. STAD91H3 will serve as an upper-level STA elective in the Statistics Specialist, Major and Minor programs.

Consultation:
DCC Approval: October 3, 2022.
RO Approval: October 12, 2022.

Resources: The course will only be taught by regular faculty. If TA support is required, it will be covered by the unit's existing budget. No additional support or equipment will be required.