TO: University of Toronto Scarborough Academic Committee
SPONSOR: John Scherk, Vice-Dean, Undergraduate
DATE: January 22, 2013
AGENDA ITEM: For approval

ITEM IDENTIFICATION:
Curriculum change proposals from the Department of Computer and Mathematical Sciences:
1. Major Program Modifications Type A:
   • Specialist/Specialist Co-op in Computer Science (Revised)
     o Add a new stream in Health Informatics
   • Specialist/Specialist Co-op in Quantitative Analysis
     o Change program name to Specialist/Specialist Co-op in Statistics
     o Delete streams in Biological and Life Sciences, Physical Sciences, and Social and Health Sciences; Enhance stream in Mathematical Finance, Management and Economics and rename stream as Quantitative Finance; Add a new stream in Machine Learning and Data Mining
     o Associated New Courses
2. Major Program Modifications Type B:
   • New Freestanding Minor in Applied Statistics
     o Associated New Courses
3. Minor Program Modifications:
   • Specialist in Mathematics
   • Specialist Co-op in Mathematics
   • Major in Mathematics
   • Major Co-op in Mathematics
   • Specialist Co-op in Quantitative Analysis
   • Major/Major Co-op in Statistics
   • Major Co-op in Statistics
4. Deleted Courses
5. Other New Courses
6. Significant Course Changes
7. Consent Agenda Course Changes

JURISDICTIONAL INFORMATION:
University of Toronto Scarborough Academic Committee has authority to oversee and approve all curricular and academic matters on which the Committee’s decision is required, including programs, courses, and academic regulations and policies.
SUMMARY:

1. There is great interest among UTSC students in programs in the area of human health. To respond to this interest UTSC is developing a broad suite of programs in health studies/health science. These include existing programs in Mental Health Studies, Human Biology, Paramedicine and Health Studies, together with new areas of study.

In line with this, the Department of Computer and Mathematical Science is proposing to add a new stream in Health Informatics to the Specialist/Specialist Co-op program in Computer Science. This program currently has three streams – Comprehensive, Software Engineering and Information Systems – all of which share a common core. The new stream in Health Informatics will share this common core, and will also expose students to courses in statistics and social sciences, which are useful for a career as a computer scientist in the health sector.

There are no new courses associated with this program change.

The Department is proposing to make a number of changes to the existing Specialist/Specialist Co-op program in Quantitative Analysis so as to refine its focus and strengthen its appeal.

First, the Department proposes to change the name of the program from the Specialist/Specialist Co-op in Quantitative Analysis to the Specialist/Specialist Co-op in Statistics. The term “Quantitative Analysis” is not commonly used, and renaming it as Statistics will better identify its content to students, thereby making it more attractive to students. Major and Minor programs in Statistics already exist and will offer a subset of the revised Specialist program.

Second, the Department proposes to eliminate three existing streams of the program and restructure the remaining stream. The program currently has four streams - Biological and Life Sciences, Physical Sciences, Mathematical Finance, Management and Economics, and Social and Health Sciences – all of which share a common core. The streams in Biological and Life Sciences, Physical Sciences and Social and Health Sciences have not attracted sufficient numbers of students and will be eliminated. The remaining stream in Mathematical Finance, Management and Economics will be enhanced and also renamed as Quantitative Finance. The revised stream will be modified to provide students with a deeper understanding of the theoretical concepts of quantitative finance, and more practice in their application.

Finally, the Department proposes to add a new stream in Machine Learning and Data Mining to the program. Statistical machine learning is a very dynamic, high-demand, and fast-growing field that lies at the intersection of statistics and computational sciences.

There are four new courses associated with these program changes.

2. The Department is proposing a new freestanding Minor program in Applied Statistics targeted at students in non-mathematical disciplines - such as the life sciences and social sciences – who want a more thorough statistical training. Students in these fields, either during their studies or later in their professional careers, are often required to understand,
and even produce, statistical analyses of data relevant to their subject. Unfortunately, many of these students do not have the mathematical background necessary to study statistics at the levels required by other statistics programs at UTSC. The proposed program is targeted at this group of students.

There are two new courses associated with this new program.

3. The Department is revising the requirements of the Specialist and Major programs in Mathematics in response to changes in MATA31H3; the admission and course requirements for the Specialist Co-op in Mathematics, Major Co-op in Mathematics, Specialist Co-op in Quantitative Analysis and Major Co-op in Statistics are being revised to make them consistent with the non co-op versions of the programs; the requirements of the Major and Major Co-op programs in Statistics are being revised to align these programs with other programs in mathematics and statistics.

4. The Department is deleting two redundant courses.

5. The Department is introducing two D-level research opportunities courses in mathematics. In addition it is adding one C-level and four D-level courses in statistics. STAC63H3 will enrich the upper-level electives available to students in all statistics programs. The new D-level courses will provide additional research opportunities to students in statistics programs.

6. The Department is significantly revising the content of MATA31H3 and MATA37H3.

7. The Department is revising the course level, prerequisites, exclusions, and recommended preparation in several courses.

1. MAJOR PROGRAM MODIFICATIONS TYPE A:

Specialist in Computer Science (Revised)
Specialist Co-op in Computer Science (Revised)

Overview:
The Department of Computer and Mathematical Sciences at the University of Toronto Scarborough is proposing to add a new stream to the existing Computer Science Specialist (and its co-op version): this stream is called Health Informatics. The Specialist in Computer Science currently has 3 approved streams: Comprehensive; Software Engineering; and Information Systems. There is no undifferentiated version of the program.

To accommodate this new stream the following specific changes are being made:
- MATB41H, CSCC37H and CSCC63H are being removed from the common core of the program, thus decreasing the total number of required credits from 10.5 to 9.0.
- MATB41H, CSCC37H and CSCC63H are being added to the Comprehensive, Software Engineering, and Information Systems streams. The total number of credits in addition to the core required in the Comprehensive stream increases from 3.0 to 4.5 for a total of 13.5 credits overall. The total number of credits in addition to the core required in the Software Engineering stream increases from 1.5 to 3.0 for a total of 13.5 credits overall. The total number of credits in addition to the core required in the Information Systems stream increases from 4.5 to 6.0 for a total of 15.0 credits overall.
• CSCD11H is replaced by CSCC11H in the Comprehensive, Information Systems and Software Engineering streams of the program. A course change proposal has been submitted for a level change CSCD11H, making it a C-level course.

The overarching objective of the Specialist in Computer Science is to educate computer scientists and give them a broad perspective of the discipline of computer science. The objective of individual streams is to provide exposure to additional subjects. The proposed stream will expose students to subjects including statistics and social sciences, which are useful for a career as a computer scientist in the health sector.

There are no changes to the faculty engaged in delivering the program or to essential physical resources required. The program relies on existing courses in mathematics, computer science, statistics, philosophy, and health studies.

Rationale:
There is great interest among students at the University of Toronto Scarborough (UTSC) in programs in the area of human health. To respond to this interest we are developing a broad suite of programs in health studies/health science. These include existing programs in Mental Health, Human Biology, Paramedicine and Health Studies, together with new areas of study. An essential part of this initiative is the development of strong ties and collaborations with the many units of the University that are part of the health sector in the Toronto area. In particular, these will enable us to expand the experiential elements in the programs.

In line with this, the Department of Computer and Mathematical Sciences is proposing to add a new stream, called Health Informatics, to the existing Computer Science Specialist (and its co-op version). This stream will expose students to subjects that are important for a career in the health sector: more training in statistics than is required in other computer science specialist streams, some aspects of business management, biomedical ethics, and health policy.

The three streams of the existing Specialist in Computer Science share a common core of courses. To accommodate the new stream MATB41H, CSCC37H and CSCC63H will be removed from this common core, as they are not appropriate to the proposed Health Informatics stream, and added to the Comprehensive, Software Engineering, and Information Systems streams of the program as they are appropriate for these streams. This change decreases the total number of credits required in the core from 10.5 to 9.0.

In addition to the 9.0 fces of core credits required, the new stream will require 6.0 credits for a total of 15.0 credits overall. This in in line with the Information Systems stream of the Specialist in Computer Science, which also requires the 9.0 fces of core credits, plus an additional 6.0 credits for a total of 15.0 credits. The specific courses chosen for the 6.0 additional credits were very carefully considered for appropriateness by the Department in consultation with faculty in the Health Studies area. There are no hidden pre-requisites.

The proposed stream shares the learning outcomes of the existing Specialist program in Computer Science in addition to an introduction to the Health sector and the applications of computer science and statistics to that sector.
Students in the Co-operative version of the program will do some of their co-op placements in the Health Sector.

Proposed Program Requirements:
SPECIALIST PROGRAM IN COMPUTER SCIENCE (SCIENCE)  
Supervisor of Studies: R. Pancer (416-287-7679) Email: pancer@utsc.utoronto.ca

Program Objectives
This program provides a working knowledge of the foundations of computer science: modern computer software and hardware, theoretical aspects of computer science, and relevant areas of mathematics and statistics. It also imparts an appreciation of the discipline's transformative impact on science and society. The program prepares students for further study and for careers in the computing industry. It comprises three four streams with different emphases:

The Comprehensive Stream provides a broad and balanced exposure to the discipline. It is the stream best-suited for students planning to pursue graduate study in computer science, but it is also suitable for other career paths.

The Software Engineering Stream places a greater emphasis on the engineering side of the discipline, including computer systems and core applications.

The Information Systems Stream has a similar focus as the Software Engineering Stream, but it provides additional exposure to certain aspects of business management. It is of special interest to students wishing to pursue careers in technical management but who have a deep interest in the technology.

The Health Informatics Stream provides a broad perspective of the discipline and exposure to additional subjects, including statistics and social sciences, that are useful for a career as a computer scientist in the health sector.

Program Admission
Each year up to 150 students are admitted directly from high school to the Comprehensive Streams of this program and the Co-operative Specialist Program in Computer Science (see below) on the basis of academic performance. Applicants must have completed Grade 12 Calculus & Vectors and Advanced Functions.

After first year, students may transfer from Comprehensive to other streams. Due to enrolment restrictions in required Management courses, entry to the Information Systems Stream is limited. Selection is based on grades in the program's A-level courses, including the two A-level MGT courses in requirement 6 of the Information Systems Stream below.

An additional number of students may transfer to the program after first year. To be eligible for late entry to a stream of the program, a student must have completed all A-level courses required in that stream. Admission is based on CGPA and grades in computer science, mathematics, and statistics courses that the student has taken. The minimum CGPA for admission is calculated annually.
Program Requirements
To remain in the program, a student must maintain a CGPA of 2 or higher throughout the program. To complete the program, a student must meet the course requirements described below. (One credit is equivalent to two courses). The program requirements comprise a core of 18 courses (9 credits), common to all three streams and additional requirements which depend on the stream, for a total of 27 courses (13.5 credits) for the Comprehensive and Software Engineering Streams, and 30 courses (15 credits) for the Information Systems and Health Informatics Streams.

Note: Many Computer Science courses are offered both at U of T Scarborough and at the St. George campus. When a course is offered at both campuses in a given session, U of T Scarborough students are expected to take that course at U of T Scarborough. The Department of Computer Science at the St. George campus cannot guarantee space for U of T Scarborough students in their courses, especially those offered at both campuses.

Core (9 credits)

1. Writing Requirement (0.5 credit) (*)
(*) It is recommended that this requirement be satisfied by the end of the second year.

2. A-level courses (3 credits)
CSCA08H3 Introduction to Computer Programming
CSCA48H3 Introduction to Computer Science
CSCA67H3 Discrete Mathematics for Computer Scientists
MATA23H3 Linear Algebra I
MATA31H3 Calculus I for Mathematical Sciences
MATA37H3 Calculus II for Mathematical Sciences

3. B-level courses (4 credits)
CSCB07H3 Software Design
CSCB09H3 Software Tools and Systems Programming
CSCB36H3 Introduction to the Theory of Computation
CSCB58H3 Computer Organization
CSCB63H3 Design and Analysis of Data Structures
MATB24H3 Linear Algebra II
MATB41H3 Techniques of the Calculus of Several Variables I
STAB52H3 Introduction to Probability

4. C-level courses (2 credits)
CSGCC37H3 Introduction to Numerical Algorithms for Computational Mathematics
CSGCC43H3 Introduction to Databases
CSGCC63H3 Computability and Computational Complexity
CSGCC69H3 Operating Systems
CSGCC73H3 Algorithm Design and Analysis
5. D-level courses (0.5 credit)

CSCD03H3 Social Impact of Information Technology

A. Comprehensive Stream

This stream requires a total of 27 courses (13.5 credits). In addition to the core requirements 1-5 common to all streams, 6-9 other distinct courses (3-4.5 credits) must be chosen satisfying all of the following requirements:

6. Additional required courses (4 2.5 credits)

MATB41H3 Techniques of the Calculus of Several Variables I
CSCC24H3 Principles of Programming Languages
CSCC37H3 Introduction to Numerical Algorithms for Computational Mathematics
CSCC63H3 Computability and Computational Complexity
CSCD37H3 Analysis of Numerical Algorithms for Computational Mathematics

7. Electives from courses on computers systems and applications (1 credit)

Two of:

CSCC01H3 Introduction to Software Engineering
CSCC09H3 Programming on the Web
CSCD11H3 Introduction to Machine Learning and Data Mining
CSCC85H3 Introduction to Embedded Systems
CSCD01H3 Engineering Large Software Systems
CSCD11H3 Machine Learning and Data Mining
CSCD18H3 Computer Graphics
CSCD27H3 Computer and Network Security
CSCD43H3 Database System Technology
CSCD58H3 Computer Networks
CSCD84H3 Artificial Intelligence
CSC318H Design of Interactive Computational Media
CSC320H Visual Computing
CSC321H Introduction to Neural Networks and Machine Learning
CSC401H Natural Language Computing
CSC469H Operating Systems Design and Implementation
CSC485H Computational Linguistics
CSC488H Compilers and Interpreters

8. Electives from courses related to the theory of computing (0.5 credit)

One of:

MATC09H3 Introduction to Mathematical Logic
MATC16H3 Coding Theory and Cryptography
MATC32H3 Graph Theory and Algorithms for its Applications
MATC44H3 Introduction to Combinatorics
CSC438H Computability and Logic
CSC448H Formal Languages and Automata
CSC465H Formal Methods in Software Design
9. CSC, MAT, or STA elective (0.5 credit)
One of:
Any C- or D-level CSC, MAT, or STA course, excluding MATC82H3, MATC90H3, and STAD29H3.

B. Software Engineering Stream
This stream requires a total of 27 courses (13.5 credits). In addition to the core requirements 1-5 common to all streams, 6-9 other distinct courses (3-4.5 credits) must be chosen satisfying all of the following requirements:

6. Additional required courses (4.5-3 credits)
   MATB41H3 Techniques of the Calculus of Several Variables I
   CSC01H3 Introduction to Software Engineering
   CSC24H3 Principles of Programming Languages
   CSC24H3 Principles of Programming Languages
   CSC37H3 Introduction to Numerical Algorithms for Computational Mathematics
   CSC63H3 Computation and Computational Complexity
   CSD01H3 Engineering Large Software Systems

7. Electives from courses on computer systems and applications (1.5 credits)
Three of:
   CSC09H3 Programming on the Web
   CSD11H3 Introduction to Machine Learning and Data Mining
   CSC85H3 Introduction to Embedded Systems
   CSD14H3 Machine Learning and Data Mining
   CSD18H3 Computer Graphics
   CSD27H3 Computer and Network Security
   CSD43H3 Database System Technology
   CSD58H3 Computer Networks
   CSD84H3 Artificial Intelligence
   CSC318H Design of Interactive Computational Media
   CSC320H Visual Computing
   CSC321H Introduction to Neural Networks and Machine Learning
   CSC401H Natural Language Computing
   CSC469H Operating Systems Design and Implementation
   CSC485H Computational Linguistics
   CSC488H Compilers and Interpreters

C. Information Systems Stream
This stream requires a total of 30 courses (15 credits). In addition to the core requirements 1-5 common to all streams, 9-12 other distinct courses (4.5-6 credits) must be chosen satisfying all of the following requirements:

6. Required management courses (2 credits)
   MGTA03H3 Introduction to Management I
   MGTA04H3 Introduction to Management II
   MGTB23H3 Managing People in Organizations
MGTB29H3 Managing Groups and Organizations

7. **Additional required mathematics and computer science courses (4.5 credits)**
   - MATB41H3 Techniques of the Calculus of Several Variables I
   - CSCC01H3 Introduction to Software Engineering
   - CSCC37H3 Introduction to Numerical Algorithms for Computational Mathematics
   - CSCC63H3 Computability and Computational Complexity
   - CSCD01H3 Engineering Large Software Systems
   - CSCD43H3 Database System Technology

8. **Electives from courses on computer systems and applications (1 credit)**
   Two of:
   - CSCC09H3 Programming on the Web
   - CSCDC11H3 Introduction to Machine Learning and Data Mining
   - CSCC85H3 Introduction to Embedded Systems
   - CSCD11H3 Machine Learning and Data Mining
   - CSCD18H3 Computer Graphics
   - CSCD27H3 Computer and Network Security
   - CSCD58H3 Computer Networks
   - CSCD84H3 Artificial Intelligence
   - CSC318H Design of Interactive Computational Media
   - CSC320H Visual Computing
   - CSC321H Introduction to Neural Networks and Machine Learning
   - CSC401H Natural Language Computing
   - CSC469H Operating Systems Design and Implementation
   - CSC485H Computational Linguistics
   - CSC488H Compilers and Interpreters

D. **Health Informatics Stream**
   This stream requires a total of 30 courses (15 credits). In addition to the core requirements 1-5 common to all streams, 12 other distinct courses (6 credits) must be chosen satisfying all of the following requirements:

6. **Additional courses related to health studies (2 credits)**
   - PHLB09H3 Biomedical Ethics
   - MGTA06H3 Introduction to Health Management*
   (*) This course has prerequisites not included in this program’s requirements

   **One of:** (courses on health policy and politics)
   - HLTB16H3 Introduction to Public Health
   - HLTB17H3 Conceptual Models of Health
   - HLTB40H3 Health Policy and Health Systems
   - HLTC40H3 Introduction to Health Economics

   **One of:** (other courses on health studies)
   - HLTB22H3 Biological Determinants of Health
   - HLTC05H3 Social Determinants of Health*
   (*) This course has prerequisites not included in this program’s requirements
7. Additional required Computer Science and Statistics courses (1.5 credit)
CSCC01H3 Introduction to Software Engineering
STAB57H3 Introduction to Statistics
STAC50H3 Data Collection

8. Additional CSC, MAT and STA courses (2.5 credits)
MATB41H3 Techniques of the Calculus of Several Variables I
Four of: any other C- or D-level CSC or STA courses, excluding STAD29H3 **, †
Of the five courses taken to satisfy this requirement, at least one must be a D-level course, and at least three must be CSC courses.

** Some C- and D-level CSC and STA courses have prerequisites that are not included among the required courses for this stream. Review the prerequisites carefully before selecting courses for this requirement. One or more courses taken to satisfy this requirement can be prerequisites for other courses also taken to satisfy this requirement.

† Among the CSC courses that can be used to satisfy this requirement there are two categories of courses that are particularly well aligned with the goals of the Health Informatics stream: software engineering and systems, and computer science applications. Courses in the category of software engineering and systems include: CSCC09H3, CSCC85H3, CSCD01H3, CSCD43H3, and CSCD58H3. Courses in the category of computer science applications include: CSCC11H3, CSCD18H3, and CSCD84H3.

SPECIALIST (CO-OPERATIVE) PROGRAM IN COMPUTER SCIENCE (SCIENCE)
Supervisor of Studies: R. Pancer (416-287-7679) Email: pancer@utsc.utoronto.ca
Co-op Contact: askcoop@utsc.utoronto.ca

Program Objectives
This program combines the coursework of the Specialist Program in Computer Science described above with paid work terms in public and private enterprises. It shares the goals and structure of the Specialist Program in Computer Science, including all its streams (Comprehensive, Software Engineering, and Information Systems, and Health Informatics), but complements study of the subject with considerable work experience.

Program Admission
Refer to the Program Admission requirements for the Specialist Program in Computer Science described above and the Co-operative Programs section in this Calendar. Students entering this program after first year must have a CGPA of at least 2.75.

Program Requirements
To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

Work Term Requirements
Students must successfully complete three work terms, at most one of which can be during the summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker...
panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

**Course Requirements**
The Co-operative Program can be taken in conjunction with any of the streams in the Specialist Program in Computer Science. For the course requirements of each stream, please refer to the description of the Specialist Program in Computer Science.

**Specialist in Quantitative Analysis**
**Specialist Co-op in Quantitative Analysis**

*Overview:
The Department of Computer and Mathematical Sciences currently offers a Specialist Program in Quantitative Analysis, which has four streams: Biological and Life Sciences; Physical Sciences; Mathematical Finance, Management and Economics; and Social and Health Sciences. Of these streams, Mathematical Finance, Management and Economics has been the most successful at attracting many excellent students. This proposal brings forward a number of changes to this existing program to refine its focus, and strengthen its appeal.

Specifically, we propose to:
1. Rename the program as Specialist in Statistics*.
2. Restructure the program:
   • Eliminate the Biological and Life Sciences; Physical Sciences; and Social and Health Sciences streams because they have not attracted sufficient numbers of students.
   • Introduce significant enhancements to the existing Mathematical Finance, Management and Economics stream; rename this stream as Quantitative Finance.
   • Introduce a new stream to the program: Machine Learning and Data Mining.
   • Structure the program such that both streams of the program (Quantitative Finance and Machine Learning and Data Mining) share a common core of courses. Students will continue to choose a stream in their second year of study.
   • CSCA67H and MATB44H will move from the common core to the Quantitative Finance stream.
   • CSCB07H, CSCB63H and CSCB63H will move from the common core to the Machine Learning and Data Mining stream.
   • Add the following courses (as either requirements or options) to the common core: MATA30H, MATA36H, MATB61H, CSCC37H, STAC62H, STAC67H and STAD37H.
   • Apply these changes to the Co-op analog of this program.

*Note: The existing Major and Minor programs in Statistics will offer a subset of the common core of the Specialist program.

These changes are line with recommendations from the Fall 2011 External Review of the Department, which highlighted a need to address concerns associated with the current Quantitative Analysis Specialist program, and which also suggested we introduce a program in Machine Learning and Data Mining. Both streams of the revised program are targeted at fields that are in high-demand areas by industry, and also lead to further study at the graduate level.
The learning outcomes of the revised program are described below:

1. In addition to providing a sound understanding of modern statistical theory and methodology, the Quantitative Finance stream will give students a sound theoretical understanding of the core concepts of quantitative finance. In ACTB40H3 [Fundamentals of Investment and Credit] students will study the concept of the time value of money and its various applications. In the new course STAB41H3 [Financial Derivatives] the no arbitrage principle and its consequences for risk-neutral pricing in the binomial pricing model will be studied. STAC70H3 [Statistics and Finance] will extend this to a rigorous development of stochastic calculus and its application to risk-neutral pricing to obtain, for example, the Black-Scholes result. In STAD70H3 [Statistics and Finance II] portfolio theory, the capital asset pricing model and value-at-risk measures will be developed. In all these courses practical and computational aspects of the concepts will be emphasized so that students graduate ready to apply their skills.

2. In addition to providing a sound understanding of modern statistical theory and methodology, the Statistical Machine Learning and Data Mining stream will train students in the core concepts of machine learning through the courses CSCC11H3 [Introduction to Machine Learning and Data Mining] and the new course STAD68H3 [Advanced Machine Learning and Data Mining]. Through these courses, together with the additional Statistics and some Computer Science courses, students will develop a deep understanding of the latest concepts in machine learning and the ability to implement these in contexts of practical importance.

There will be no essential differences to the physical resources being used to deliver the revised program. The faculty complement of Statistics at UTSC was recently increased, and the revised program has been designed to be delivered with the existing faculty resources.

*Rationale:*
The Department of Computer and Mathematical Sciences at the University of Toronto Scarborough currently offers a Specialist program in Quantitative Analysis, which has four streams: Biological and Life Sciences; Physical Sciences; Mathematical Finance, Management and Economics; and Social and Health Sciences. Of these streams, that in Mathematical Finance, Management and Economics has been the most successful at attracting many excellent students. This proposal brings forward a number of changes to the existing program to refine its focus and strengthen its appeal to students.

The proposed changes effectively address recommendations made in the 2011 External Review of the Department, which highlighted a need to address concerns associated with the current Quantitative Analysis Specialist program, and which also suggested we introduce a program in Machine Learning and Data Mining. Both streams of the revised program are targeted at fields that are in high-demand areas by industry, and also lead to further study at the graduate level.

First, this proposal seeks approval to change the name of the program from Specialist in Quantitative Analysis to Specialist in Statistics. The term “Quantitative Analysis” is not commonly used, so by renaming the program we will better identify its content to students, and consequently be better positioned to attract more students. Major and Minor program in Statistics already exist. These programs will offer a subset of the common core of the revised Specialist program in Statistics.

The revised program will consist of two streams: Quantitative Finance, which corresponds to the existing Mathematical Finance, Management and Economics stream; and Machine Learning and
Data Mining, which is an exciting and innovative new area of study on the cutting-edge area of statistics.

The Quantitative Finance stream will serve the type of student attracted to the Mathematical Finance, Management and Economics stream of the existing Specialist in Quantitative Analysis. This revised and renamed stream has been substantially enriched in comparison to the existing stream, and modified to better serve the needs of students interested in this subject. In particular, the existing Mathematical Finance, Management and Economics stream has only two courses that can properly be said to be concerned with quantitative finance. The revised Quantitative Finance stream, however, will have four such courses: These courses will provide students with a deeper understanding of theoretical concepts, and more practice in their application. The depth of this stream with respect to its requirements in computing, mathematics, statistics and quantitative finance will substantially enhance its attractiveness to prospective students in this area. This stream differs from similar streams within existing programs in Statistics offered at U of T and other institutions as it provides more of the mathematical, statistical, and computer science background that underlies the concepts of quantitative finance.

The Statistical Machine Learning and Data Mining stream offers a coherent and sustained focus on an exciting new area of statistics that has attracted significant attention. (See, for example, the following articles: Big Data’s Impact in the World, New York Times, February 11, 2012 and Big Data, Big Impact: New Possibilities for International Development, Davos World Economic Forum 2012.) Statistical machine learning is a very dynamic, high-demand, and fast-growing field that lies at the intersection of statistics and computational sciences. It is driven by applied problems in science and technology, where data streams are increasingly large-scale, high-dimensional and heterogeneous. This stream of the program will be quite distinctive as we are not aware of any similar programs currently being offered elsewhere. Employment prospects for graduates in this field are excellent, and so we expect this stream or program of study to be attractive to excellent students.

Proposed Program Requirements:

SPECIALIST PROGRAM IN STATISTICS (SCIENCE)
Supervisor of Studies: Sotirios Damouras (416-287-7679) Email: sdamouras@utsc.utoronto.ca

Program Objectives
This program provides training in the discipline of Statistics. Students are given a thorough grounding in the theory underlying statistical reasoning and learn the methodologies associated with current applications. A full set of courses on the theory and methodology of the discipline represent the core of the program. In addition students select one of two streams each of which provides immediately useful, job-related skills. The program also prepares students for further study in Statistics and related fields.

The Quantitative Finance Stream focuses on teaching the computational, mathematical and statistical techniques associated with modern day finance. Students acquire a thorough understanding of the mathematical models that underlie financial modeling and the ability to implement these models in practical settings. This stream prepares students to work as quantitative analysts in the financial industry, and for further study in Quantitative Finance.

Academic Committee. 22 January 2013.
The Statistical Machine Learning and Data Mining Stream focuses on applications of statistical theory and concepts to the discovery (or “learning”) of patterns in massive data sets. This field is a recent development in statistics with wide applications in science and technology including computer vision, image understanding, natural language processing, medical diagnosis, and stock market analysis. This stream prepares students for direct employment in industry and government, and further study in Statistical Machine Learning.

Program Requirements
To complete the program, a student must meet the course requirements described below. (One credit is equivalent to two courses.)

The first year requirements of the two streams are almost identical, except that the Quantitative Finance stream requires ECMA04H3 while the Statistical Machine Learning and Data Mining stream requires CSCA67H; these courses need not be taken in the first year. In the second year the two streams have considerable overlap. This structure makes it relatively easy for students to switch between the two streams as their interests in Statistics become better defined.

Note: There are courses on the St. George campus that can be taken to satisfy some of the requirements of the program. STAB52H3, STAB57H3 and STAC67H3, however, must be taken at the University of Toronto Scarborough; no substitutes are permitted without permission of the program supervisor.

CORE (7.5 credits)

1. Writing Requirement (0.5 credit) *
   (*) It is recommended that this requirement be satisfied by the end of the second year.

2. A-level courses (2.5 credits)
   CSCA08H3 Introduction to Computer Programming
   CSCA48H3 Introduction to Computer Science
   MATB24H3 Linear Algebra II
   One of:
     MATA31H3* Calculus I for Mathematical Sciences
     MATA30H3 Calculus I for Biological or Physical Sciences
   One of:
     MATA37H3* Calculus II for Mathematical Sciences
     MATA36H Calculus II for Physical Sciences
   (*) MATA31H3 and MATA37H3 are recommended; the latter requires the former.

3. B-level courses (2.5 credits)
   MATB41H3 Techniques of the Calculus of Several Variables I
   MATB61H3 Linear Programming and Optimization
   STAB52H3 Introduction to Probability

Academic Committee. 22 January 2013.
STAB57H3 Introduction to Statistics

4. C-level courses (1.5 credits)
   CSCC37H3 Introduction to Numerical Algorithms for Computational Mathematics
   STAC62H3 Stochastic Processes
   STAC67H3 Regression Analysis

5. D-level course (0.5 credits)
   STAD37H3 Multivariate Analysis

A. Quantitative Finance Stream
   This stream requires a total of 26 courses (13 credits). In addition to the core requirements, 11 other courses (5.5 credits) must be taken satisfying all of the following requirements:

6. Additional A-level course (0.5 credit)
   ECMA04H3 Introduction to Microeconomics: A Mathematical Approach

7. Additional B-level courses (2.0 credits)
   ACTB40H3 Fundamentals of Investment and Credit
   MATB42H3 Techniques of Calculus of Several Variables II
   MATB44H3 Differential Equations I
   STAB41H3 Financial Derivatives

8. Additional upper-level courses (3.0 credits)
   MATC46H3 Differential Equations II
   STAC70H3 Statistics and Finance I
   STAD57H3 Time Series Analysis
   STAD70H3 Statistics and Finance II (new)
   Two of:
   APM462H1 Nonlinear Optimization
   CSCC11H3 Introduction to Machine Learning and Data Mining
   MATC37H3 Introduction to Real Analysis
   STAC51H3 Categorical Data Analysis (new)
   STAC58H3 Statistical Inference* (new)
   STAC63H3 Probability Models (new)
   STAD68H3 Advanced Machine Learning and Data Mining (new)
   STAD94H3 Statistics Project
   (*) Especially recommended for students planning to pursue graduate study in statistics

B. Statistical Machine Learning and Data Mining Stream
   This stream requires a total of 26 courses (13 credits). In addition to the core requirements 11 other courses (5.5 credits) must be taken satisfying all of the following requirements:

6. Additional A-level course (0.5 credit)
   CSCA67H3 Discrete Mathematics for Computer Scientists
7. Additional B-level courses (1.0 credit)
Two of:
- CSCB07H3 Software Design
- CSCB20H3 Introduction to Databases and Web Applications
- CSCB36H3 Introduction to the Theory of Computation
- CSCB63H3 Design and Analysis of Data Structures

8. Additional upper-level courses (4.0 credits)
- CSCC11H3 Introduction to Machine Learning and Data Mining
- STAC58H3 Statistical Inference (new)
- STAD68H3 Advanced Machine Learning and Data Mining (new)

Five of: *
- C or D-level CSC, MAT or STA courses (excluding STAD29H3), three of which must be STA courses.

(*) Some of the courses on this list have prerequisites that are not included in this program; in choosing courses to satisfy this requirement, check the prerequisites carefully and plan accordingly.

SPECIALIST (CO-OPERATIVE) PROGRAM IN STATISTICS
Supervisor of Studies: Sotirios Damouras (416-287-7679) Email: sdamouras@utsc.utoronto.ca
Co-op Contact: askcoop@utsc.utoronto.ca

Program Objectives
This program combines the coursework of the Specialist Program in Statistics described above with paid work terms in public and private enterprises. It shares the goals and structure of the Specialist Program in Statistics, including its two streams (Quantitative Finance and Statistical Machine Learning and Data Mining), but complements study of the subject with considerable work experience.

Program Admission
Refer to the Program Admission requirements for the Co-operative Programs section in this Calendar.

Program Requirements
To remain in the program, a student must maintain a cumulative GPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

Work Term Requirements
Students must successfully complete three work terms, only one of which can be during the summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

Course Requirements
The Co-operative Program can be taken in conjunction with any of the streams in the Specialist Program in Statistics. For the course requirements of each stream, please refer to the description of the Specialist Program in Statistics.
Associated New Courses:

**STAB41H3  Financial Derivatives**

A study of the most important types of financial derivatives, including forwards, futures, swaps and options (European, American, exotic, etc). The course illustrates their properties and applications through examples, and introduces the theory of derivatives pricing with the use of the no-arbitrage principle and binomial tree models.
Prerequisite: ACTB40H3
Exclusion: MGTC71H3
Breadth Requirement: Quantitative Reasoning

**STAC58H3  Statistical Inference**

Principles of statistical reasoning and theories of statistical analysis. Topics include: statistical models, likelihood theory, repeated sampling theories of inference, prior elicitation, Bayesian theories of inference, decision theory, asymptotic theory, model checking, and checking for prior-data conflict. Advantages and disadvantages of the different theories.
Prerequisite: STAC62H3
Exclusion: STA352Y, STA422H
Breadth Requirement: Quantitative Reasoning

**STAD68H3  Advanced Machine Learning and Data Mining**

Statistical aspects of supervised learning: regression, regularization methods, parametric and nonparametric classification methods, including Gaussian processes for regression and support vector machines for classification, model averaging, model selection, and mixture models for unsupervised learning. Some advanced methods will include Bayesian networks and graphical models.
Prerequisite: STAC58H3 and STAC67H3
Exclusion: None
Breadth Requirement: Quantitative Reasoning

**STAD70H3  Statistics and Finance II**

A survey of statistical techniques used in finance. Topics include mean-variance and multi-factor analysis, simulation methods for option pricing, Value-at-Risk and related risk-management methods, and statistical arbitrage. A computer package will be used to illustrate the techniques using real financial data.
Prerequisite: STAC70H3 and STAD37H3
Co-requisite: STAD57H3
Breadth Requirement: Quantitative Reasoning
2. **MAJOR PROGRAM MODIFICATIONS TYPE B:**

Minor in Applied Statistics

*Overview:*
The Department proposes a new freestanding Minor program in Applied Statistics. The program is targeted at students in non-mathematical disciplines, for example in the life sciences or social sciences, who want, or need, a more thorough statistical training. The proposed program contains a suite of courses that are primarily application oriented. The courses in the program are focused on methods and interpretation as opposed to mathematics or theory. The skills imparted by the program will allow students to conduct statistical studies and properly analyse data relevant to their fields.

*Rationale:*
Statistical training is important to an increasing number of fields, especially in the life sciences and the social sciences (including management). Students in these fields, either during their studies or later in their professional careers, are often required to understand and even produce statistical analyses of data relevant to their subject. Unfortunately, many of these students do not have the mathematical background necessary to study statistics at the level that Specialist and Major programs (or even our existing Statistics Minor program) require. Yet, equipped with suitable courses, it is possible to teach such students to follow and even conduct statistical studies. The proposed freestanding Minor is targeted at this group of students.

Notably, the proposed program does not require calculus. It requires an elementary course on computer programming (increasingly a key skill for statistical analyses), a two-course sequence on basic principles of statistics (using either generic courses offered by the Department of Computer and Mathematical Sciences, or discipline-specific statistics courses offered by other Departments), three new courses (a case-based course in which students learn to write statistical reports, a course on the principles underlying the proper collection of data, and a course addressing more advanced statistical techniques such as regression and factor analysis), and electives from a broad collection of relevant courses. The skills imparted through these courses will allow students in the life sciences, social sciences, and management to properly analyse data relevant to their fields.

Currently approximately one thousand students take STAB22H each year but only a few of them go on to take follow-up statistics courses. In part this is because the subsequent statistics courses offered to these students are not part of any program. For this reason we are proposing to offer a freestanding Minor program targeted at these students.

The mode of delivery will be through traditional classes. One of the proposed courses designed in part to support this program is case-oriented.

*Admission/Eligibility Requirements:*
Students can enter the program after completing STAB27H. There is no enrolment limit.
Program Requirements:
MINOR PROGRAM IN APPLIED STATISTICS (SCIENCE)

This program requires a total of 4.0 credits as follows:

One (0.5 credits) of:
- CSCA08H  Introduction to Computer Programming
- CSCA20H  Computer Science for the Sciences

One (0.5 credits) of:
- STAB22H  Statistics I
- ECMB11H  Quantitative Methods in Economics I
- PSYB07H  Data Analysis in Psychology

One (0.5 credits) of:
- STAB27H  Statistics II
- ECMB12H  Quantitative Methods in Economics II
- PSYC08H  Advanced Data Analysis in Psychology

All of the following (1.5 credits):
- STAC32H  Applications of Statistical Methods (new)
- STAC50H  Data Collection (new)
- STAD29H  Statistics for Life and Social Scientists

Two (1.0 credits) of:
- any ACT, CSC, MAT, STA course
- ECMA04, ECMA06H, ECMB02H, ECMB06H, ECMC11H, ECMD10H, ECMD70H
- GGRB02H
- HLTB15H, HLTC15H
- MGTB09H, MGTC71H, MGTHC74H, MGTD07H, MGTD30H
- POLB11H

Associated New Courses:

STAC32H3  Applications of Statistical Methods

A case-study based course, aimed at developing students’ applied statistical skills beyond the basic techniques. Students will be required to write statistical reports. Statistical software, such as SAS and R, will be taught and used for all statistical analyses.
Prerequisite: STAB27H3 or STAB57H3 or equivalents
Breadth Requirement: Quantitative Reasoning

STAC50H3  Data Collection

The principles of proper collection of data for statistical analysis, and techniques to adjust statistical analyses when these principles cannot be implemented. Topics include: relationships among variables, causal relationships, confounding, random sampling, experimental designs, observational studies, experiments, causal inference, meta-analysis. Statistical analyses using SAS or R.
Prerequisite: STAB27H3 or STAB57H3 or equivalents
Breadth Requirement: Quantitative Reasoning
3. MINOR PROGRAM MODIFICATIONS:

Specialist in Mathematics

Overview of Changes:
- Add CSCA67H3 to requirement 2.
- Increase the total fces in the core of the program from 7.0 to 7.5.

Proposed Program Requirements:
SPECIALIST PROGRAM IN MATHEMATICS (SCIENCE)
Supervisor of Studies: E. Moore (416-287-7267) Email: emoore@utsc.utoronto.ca

Program Objectives
This program provides the student with a sound foundation in the main areas of mathematics, and some exposure to computer programming and statistics. It comprises four streams: Comprehensive, Statistics, Teaching, and Design-Your-Own, each serving a more specific goal.

The Comprehensive Stream provides a broad and deep knowledge of mathematics at the undergraduate level. It is the recommended program for students who plan to pursue graduate study in mathematics, but it is also suitable for other career paths.

The Statistics Stream provides greater exposure to statistics, and the areas of mathematics most closely associated with it. This stream prepares students for careers in industry, or for graduate study in certain mathematically-oriented subjects, including statistics and financial mathematics.

The Teaching Stream is intended for students with a serious interest in mathematics but whose career objectives lie in mathematics education at the elementary or secondary level.

The Design-Your-Own Stream allows students to tailor their studies in mathematics to specific interests, with guidance from (and approval of) the program supervisor.

Program Requirements
The Program requirements consist of a core 14 courses (7.5 credits), common to all four streams, and additional requirements that depend on the stream, for a total of 25-27 courses (12.5-13.5 credits).

The structure of the programs allows for easy switching between streams until relatively late. Consequently, these programs should not be viewed as rigidly separated channel's feeding students to different career paths, but as a flexible structure that provides guidance to students in their course selection based on their broad (but possibly fluid) interests.

Core (7.5 credits)

1. Writing Requirement (0.5 credit)(*)
PHLA10H3, WSTA01H3.
(*) It is recommended that this requirement be satisfied by the end of the second year.

2. A-level courses (2.5 credits)
CSCA67H3 Discrete Mathematics for Computer Scientists
MATA23H3 Linear Algebra I
MATA31H3 Calculus I for Mathematical Sciences
MATA37H3 Calculus II for Mathematical Sciences
CSCA08H3 Introduction to Computer Programming

3. B-level courses (3.5 credits)
MATB24H3 Linear Algebra II
MATB41H3 Techniques of the Calculus of Several Variables I
MATB42H3 Techniques of the Calculus of Several Variables II
MATB43H3 Introductions to Analysis
MATB44H3 Differential Equations I
STAB52H3 Introduction to Probability (**) 
STAB57H3 Introduction to Statistics (**)  
(**) This course may be taken after second year, except for the Statistics stream.

4. C-level courses (1 credit)
MATC01H3 Groups and Symmetry
MATC34H3 Complex Variables

A. Comprehensive Stream
This stream requires a total of 27 28 courses (13.5 14 credits)  
In addition to the core requirements 1-4 common to all streams, 13 other distinct courses must be chosen satisfying all of the following requirements:

5. Elementary courses in closely related disciplines (1.5 credits): (***)
CSCA48H3 Introduction to Computer Science
PHYA10H3 Introduction to Physics IA
PHYA21H3 Introduction to Physics IIA
(***) It is recommended that these be taken in first year.

6. Additional courses in analysis and algebra (1.5 credits):
MATC37H3 Introduction to Real Analysis
MATC46H3 Differential Equations II
MATD01H3 Fields and Groups

7. Courses in key areas of mathematics (1.5 credits):
Three of:
MATC15H3 Introduction to Number Theory
MATC27H3 Introduction to Topology
MATD02H3 Classical Plane Geometries and their Transformations
MATD34H3 Complex Variables II

Academic Committee. 22 January 2013.
8. Mathematics of computation (0.5 credit):
One of:
- MATC09H3 Introduction to Mathematical Logic
- MATC32H3 Graph Theory and Algorithms for its Applications
- MATC44H3 Introduction to Combinatorics
- CSCC37H3 Introduction to Numerical Algorithms for Computational Mathematics
- CSCC63H3 Computability and Computational Complexity

9. Electives (1.5 credits):
Three of:
- C- or D-level MAT courses, excluding MATC82H3 and MATC90H3

B. Statistics Stream
This stream requires a total of 25 courses (42.5 credits).
In addition to the core requirements 1-4 common to all streams, 11 other distinct courses must be chosen, satisfying all of the following requirements (in choosing courses to satisfy requirements 7-9, students must select at least one D-level course).

5. Algebra and Analysis (1.5 credits):
- MATB61H3 Linear Programming and Optimization
- MATC46H3 Differential Equations II
- MATD01H3 Fields and Groups

6. Regression Analysis (0.5 credit):
- STAC67H3 Regression Analysis

7. Discrete mathematics and geometry (0.5 credit):
One of:
- MATC32H3 Graph Theory and Algorithms for its Applications
- MATC44H3 Introduction to Combinatorics
- MATD02H3 Classical Plane Geometries and their Transformations

8. Upper-level MAT electives (1 credit):
Two of:
- Any C- or D-level MAT courses (*)
(*) For students wishing to pursue graduate studies in Mathematics or Statistics it is recommended that MATC37H3 be chosen as one of these two courses.

9. Upper-level STA electives (2 credits):
Four of:
- ACTB47H3 Introductory Life Contingencies
- Any C- or D-level STA course, excluding STAD29H3
C. Teaching Stream
This stream requires a total of 25 courses (42.5 credits).
In addition to the core requirements 1-4 common to all streams, 11 other distinct courses must be
chosen, satisfying all of the following requirements:
5. Algebra, analysis, and geometry (2 credits):
   MATC15H3 Introduction to Number Theory
   MATC82H3 Mathematics for Teachers
   MATD01H3 Fields and Groups
   MATD02H3 Classical Plane Geometries and their Transformations

6. Discrete mathematics (0.5 credit):
   One of:
   - MATC32H3 Graph Theory and Algorithms for its Applications
   - MATC44H3 Introduction to Combinatorics

7. MAT electives (1.5 credits):
   Three of:
   - C- or D-level MAT courses

8. MAT/STA/CSC electives (1.5 credits):
   Three of:
   - C- or D-level MAT, STA, CSC courses, excluding STAD29H3

D. Design-Your-Own-Stream
This stream requires a total of 25 courses (42.5 credits).
In addition to the core requirements 1-4 common to all streams, 11 other distinct courses must be
chosen, satisfying the following requirement:
5. Electives (5.5 credits):
   11 courses approved by the program supervisor. The core courses together with the approved
electives must satisfy the degree requirement so that they include at least 12 courses (6 credits) at
the C- or D-level, of which at least two (one credit) are at the D-level.

Specialist Co-op in Mathematics

Overview of Changes:
- Revise Admission, Program and Course Requirements sections to fully align co-op version
  of program with non-co-op version.

Proposed Program Requirements:
SPECIALIST (CO-OPERATIVE) PROGRAM IN MATHEMATICS (SCIENCE)
Supervisor of Studies: E. Moore (416-287-7267) Email: emoore@utsc.utoronto.ca
Co-op Contact: askcoop@utsc.utoronto.ca

Program Objectives
This program combines the coursework of the Specialist Program in Mathematics described above
with paid work terms in public and private enterprises. It shares the goals and structure of the
Specialist Program in Mathematics, including its four streams (Comprehensive, Statistics, Teaching, and Design-Your-Own), but complements study of the subject with considerable work experience.

**Admission and Program Requirements**

Students entering this program after first year must have 4.0 full credits including **CSCA08H3, CSCA48H3, CSCA67H3, MATA23H3, MATA30H3, MATA31H3 & MATA37H3, PHYA10H3 & PHYA21H3** plus a cumulative GPA of at least 2.5. The Comprehensive Stream also requires **CSCA48H3, PHYA10H3 & PHYA21H3**. Also refer to the Program Admission requirements in the Co-operative Programs section in this Calendar. To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below. Refer to the Program Admission requirements for the Specialist Program in Mathematics described above and the Co-operative Programs section in this Calendar. Students entering this program must have a CGPA of at least 2.5.

**Program Requirements**

To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

**Work Term Requirements**

Students must successfully complete three work terms, at most one of which can be during the summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

**Course Requirements**

The Co-operative Program can be taken in conjunction with any of the streams in the Specialist Program in Mathematics. For the course requirements of each stream, please refer to the description of the Specialist Program in Mathematics. The course requirements of the Co-operative Specialist Program in Mathematics are identical to those of the Specialist Program in Mathematics described above.

**Major in Mathematics**

*Overview of Changes:*
- Add CSCA67H3 to requirement 1 of the program.
- Increase the total fees to complete the program from 8.0 to 8.5.

*Proposed Program Requirements:*

**MAJOR PROGRAM IN MATHEMATICS (SCIENCE)**

*Supervisor of Studies:* N. Cheredeko (416-287-7226) *Email:* n.cheredeko@utoronto.ca

**Program Objectives**

This program provides a solid foundation in basic areas of mathematics, especially those with applications in other disciplines. This program is intended to be combined with other programs, typically a major program in another discipline.
Program Requirements

This stream requires a total of 16 distinct courses or (8.5 credits), chosen so as to satisfy all of the following requirements:

1. Foundational courses (5.5 credits)
CSCA67H3 Discrete Mathematics for Computer Scientists
MATA23H3 Linear Algebra I
One of:
   - MATA30H3 Calculus I for Biological and Physical Sciences
   - MATA31H3 Calculus I for Mathematical Sciences
One of:
   - MATA36H3 Calculus II for Physical Sciences
   - MATA37H3 Calculus II for Mathematical Sciences (*)
CSCA08H3 Introduction to Computer Programming
MATB24H3 Linear Algebra II
MATB41H3 Techniques of the Calculus of Several Variables I
MATB42H3 Techniques of the Calculus of Several Variables II
MATB44H3 Differential Equations I
STAB52H3 Introduction to Probability
One of:
   - MATC01H3 Groups and Symmetry
   - MATC15H3 Introduction to Number Theory

(*) MATA31H3 is required for MATA37H3

2. Further analysis courses (1 credit)
Two of:
   - MATB43H3 Introduction to Analysis
   - MATC27H3 Introduction to Topology
   - MATC34H3 Complex Variables
   - MATC35H3 Chaos, Fractals, and Dynamics
   - MATC37H3 Introduction to Real Analysis
   - MATC46H3 Differential Equations II
   - MATD34H3 Complex Variables II

3. Further algebra geometry, and discrete mathematics courses (1 credit)
Two of:
   - MATC01H3 Groups and Symmetry
   - MATC09H3 Introduction to Mathematical Logic
   - MATC15H3 Introduction to Number Theory
   - MATC32H3 Graph Theory and Algorithms for its Applications
   - MATC44H3 Introduction to Combinatorics
   - MATC63H3 Differential Geometry
   - MATD01H3 Fields and Groups
   - MATD02H3 Classical Plane Geometries and their Transformations
4. Electives (1 credit)
Two of:
   MATB61H3 Linear Programming and Optimization
   STAB57H3 Introduction to Statistics
any C- or D-level MAT, STA, or CSC course, excludin STAD29H3

Recommended Writing Course: Students are urged to take a course from the following list of courses by the end of their second year.

Major Co-op in Mathematics

Overview of Changes:
   • Revise Admission, Program and Course Requirements sections to fully align co-op version of program with non co-op version.

Proposed Program Requirements:
MAJOR (CO-OPERATIVE) PROGRAM IN MATHEMATICS (SCIENCE)
Supervisor of Studies: N. Cheredeko (416-287-7226) Email: n.cheredeko@utoronto.ca
Co-op Contact: askcoop@utsc.utoronto.ca

Program Objectives
This program combines the coursework of the Major Program in Mathematics described above with paid work terms in public and private enterprises. It shares the goals and structure of the Major Program in Mathematics, but complements study of the subject with considerable work experience.

Admission and Program Requirements
Students entering this program after first year must have 4.0 full credits including CSCA08H3, [CSCA48H3 or PSCB57H3], MATA23H3, [MATA30H3 or MATA31H3] & [MATA36H3 or MATA37H3] plus a cumulative GPA of at least 2.5. Also refer to the Program Admission requirements in the Co-operative Programs section in this Calendar. To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below. Refer to the Program Admission requirements for the Major Program in Mathematics described above and the Co-operative Programs section in this Calendar. Students entering this program must have a CGPA of at least 2.5.

Program Requirements
To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

Work Term Requirements
Students must successfully complete three work terms, at most one of which can be during the
summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

Course Requirements
For the course requirements, please refer to the description of the Major Program in Mathematics. The course requirements of the Co-operative Major Program in Mathematics are identical to those of the Major Program in Mathematics described above.

Specialist Co-op in Quantitative Analysis

Overview of Changes:
- Revise Admission, Program and Course Requirements sections to fully align co-op version of program with non co-op version.

Proposed Program Requirements:
SPECIALIST (CO-OPERATIVE) PROGRAM IN QUANTITATIVE ANALYSIS (SCIENCE)
Supervisor of Studies: S. Damouras (416-208-4794) Email: sotirios.damouras@utoronto.ca
Co-op Contact: askcoop@utsc.utoronto.ca

Program Objectives
This program combines the coursework of the Specialist Program in Quantitative Analysis described above with paid work terms in public and private enterprises. It shares the goals and structure of the Specialist Program in Quantitative Analysis, but complements study of the subject with considerable work experience.

Admission and Program Requirements
Students entering this program after first year must have 4.0 full credits including CSCA08H3, CSCA48H3, CSCA67H3, (CSCA65H3), MATA23H3, [MATA30H3 or MATA31H3] & [MATA36H3 or MATA37H3] plus a cumulative GPA of at least 2.5. Also refer to the Program Admission requirements in the Co-operative Programs section in this Calendar. To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below. Refer to the Program Admission requirements for the Specialist Program in Quantitative Analysis described above and the Co-operative Programs section in this Calendar. Students entering this program must have a CGPA of at least 2.5.

Program Requirements
To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

Work Term Requirements
Students must successfully complete three work terms, at most one of which can be during the summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker...
panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

**Course Requirements**

For the course requirements, please refer to the description of the Specialist Program in Quantitative Analysis. The course requirements of the Co-operative Specialist Program in Quantitative Analysis are identical to those of the Specialist Program in Statistics described above.

**Major in Statistics**

**Major Co-op in Statistics**

**Overview of Changes:**

- Delete CSCA48H3 or PSCB57H3 from First Year requirements.
- Add CSCA08H3 to First Year requirements.

**Proposed Program Requirements:**

**MAJOR PROGRAM IN STATISTICS (SCIENCE)**

*Supervisor of Studies: M. Samarakoon  Email: mahinda@utsc.utoronto.ca*

**Recommended Writing Course:** Students are urged to take a course from the following list of courses by the end of their second year.


**Program Requirements**

This program requires 8.0 full credits.

**First Year 1. A-level courses**

[CSCA48H3 Introduction to Computer Science or PSCB57 Introduction to Scientific Computing] CSCA08H3 Introduction to Computer Programming

**MATB24H3 Linear Algebra II**

**MATB41H3 Techniques of the Calculus of Several Variables I**

**MATB42H3 Techniques of the Calculus of Several Variables II**

**STAB52H3 An Introduction to Probability**

**Second Year 2. B-level courses**

**MATB24H3 Linear Algebra II**

**MATB41H3 Techniques of the Calculus of Several Variables I**

**MATB42H3 Techniques of the Calculus of Several Variables II**

**STAB52H3 An Introduction to Probability**

(*) Note: The sequence MATA31H3 and **MATA37H3** is recommended. **MATA31H3** is the prerequisite for **MATA37H3**.

**Academic Committee. 22 January 2013.**
STAB57H3 An Introduction to Statistics*

Third and Fourth Year **Upper-level courses**

STAC67H3 Regression Analysis*

2.0 full credits from **Four of:**

any C- or D- (or 300-400 on St. George) level courses in STA courses, except STAD29H3

1.0 full credit from **Two of:**

ACTB40H3, ACTB47H3 or any C- or D- (or 300-400 on St. George) level courses in CSC, MAT or STA courses

*STAB52H3, STAB57H3, STAC67H3 - These courses must be taken at UTSC. No substitutes are allowed without permission of the program supervisor.

**Major Co-op in Statistics**

**Overview of Changes:**

- Revise Admission, Program and Course Requirements sections to fully align co-op version of program with non co-op version.

**Proposed Program Requirements:**

**MAJOR (CO-OPERATIVE) PROGRAM IN STATISTICS (SCIENCE)**

*Supervisor of Studies: M. Samarakoon (416-208-4748) Email: mahinda@utsc.utoronto.ca*

*Co-op Contact: askcoop@utsc.utoronto.ca*

**Program Objectives**

This program combines the coursework of the Major Program in Statistics described above with paid work terms in public and private enterprises. It shares the goals and structure of the Major Program in Statistics, but complements study of the subject with considerable work experience.

**Admission and Program Requirements**

Students entering this program after first year must have 4.0 full credits including CSCA08H3, CSCA48H3, MATA23H3, [MATA30H3 or MATA31H3] & [MATA36H3 or MATA37H3] plus a cumulative GPA of at least 2.5. Also refer to the Program Admission requirements in the Co-operative Programs section in this Calendar. To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below. Refer to the Program Admission requirements for the Major Program in Statistics described above and the Co-operative Programs section in this Calendar. Students entering this program must have a CGPA of at least 2.5.

**Program Requirements**

To remain in the program, a student must maintain a CGPA of 2.5 or higher throughout the program. To complete the program, a student must meet the work term and course requirements described below.

**Work Term Requirements**

Students must successfully complete three work terms, at most one of which can be during the summer. In addition, prior to their first work term, students must successfully complete the Arts & Science Co-op Work Term Preparation Activities. These include networking sessions, speaker
panels and industry tours along with seminars covering resumes, cover letters, job interviews and work term expectations.

**Course Requirements**

For the course requirements, please refer to the description of the Major Program in Statistics. The course requirements of the Co-operative Major Program in Statistics are identical to those of the Major Program in Statistics described above.

4. **DELETED COURSES:**

   - ACTB47H3 Introductory Life Contingencies
     - The course is redundant
   - STAC52H3 Experimental Design
     - The course is redundant

5. **OTHER NEW COURSES**

**MATD92H3 Mathematics Project**

A significant project in any area of mathematics. The project may be undertaken individually or in small groups. This course is offered by arrangement with a mathematics faculty member. This course may be taken in any session and the project must be completed by the last day of classes in the session in which it is taken.

Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course.

Breadth Requirement: Quantitative Reasoning

**MATD93H3 Mathematics Project**

A significant project in any area of mathematics. The project may be undertaken individually or in small groups. This course is offered by arrangement with a mathematics faculty member. This course may be taken in any session and the project must be completed by the last day of classes in the session in which it is taken.

Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course.

Breadth Requirement: Quantitative Reasoning

**STAC63H3 Probability Models**

This course continues the development of probability theory begun in STAB52H3. Probability models covered include branching processes, birth and death processes, renewal processes, Poisson processes, queuing theory, random walks and Brownian motion.

Prerequisite: STAB52H3

Breadth Requirement: Quantitative Reasoning
STAD92H3  Readings in Statistics

This course is offered by arrangement with a statistics faculty member. This course may be taken in any session and must be completed by the last day of classes in the session in which it is taken. Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course. Breadth Requirement: Quantitative Reasoning

STAD93H3  Readings in Statistics

This course is offered by arrangement with a statistics faculty member. This course may be taken in any session and must be completed by the last day of classes in the session in which it is taken. Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course. Breadth Requirement: Quantitative Reasoning

STAD95H3  Statistics Project

A significant project in any area of statistics. The project may be undertaken individually or in small groups. This course is offered by arrangement with a statistics faculty member. This course may be taken in any session and the project must be completed by the last day of classes in the session in which it is taken. Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course. Breadth Requirement: Quantitative Reasoning

6.  SIGNIFICANT COURSE CHANGES:

MATA31H3  Calculus I for Mathematical Sciences
  •  Revise course content and description

MATA31H3 Calculus I for Mathematical Sciences
Basic techniques of Calculus. Elementary functions including exponential, logarithm and trigonometric functions; limits and continuity; differentiation; indeterminate forms and L'Hopital's rule; optimization and other applications of derivatives; Riemann sums and integration; techniques of integration; improper integrals, applications of integration including areas, volumes, and arc length.
A theoretical course in calculus emphasizing proofs and techniques, as well as the intuition behind them. Axioms and basic properties of real numbers. Functions, including transcendentals. Limits and continuity.
Least upper bounds, extreme and intermediate value theorems. Derivatives and applications. Integrals and the fundamental theorem of calculus.
Prerequisite: Grade 12 Calculus and Vectors
Breadth Requirement: Quantitative Reasoning

Academic Committee. 22 January 2013.
**Rationale:**
The content of MATA31H3 was originally designed as a proof-based introductory Calculus course, the purpose of which was to prepare students for the rigorous mathematics they will meet in later courses. This approach proved problematic for several reasons. First the audience is quite diverse with some of the students lacking the necessary prior exposure to the techniques of Calculus. Second many students encountered enormous difficulties with the material and as a consequence there has been a high attrition rate in MATA31.
To address these issues we have redesigned the course content to provide more emphasis on the techniques of Calculus. In addition, to replace the exposure to mathematical proof that was previously provided in MATA31, those students who are pursuing higher level MAT courses such as MATA37H3 will also required to take CSCA67H3 (as a gentler introduction to proof). Finally, the changes proposed will solve a problem noted by the Department of Physical and Environmental Sciences, i.e., that physics students taking MATA31 do not receive enough instruction on techniques of integration that are necessary for first year physics courses. The new syllabus for MATA31 will contain the required integration techniques.

**MATA37H3 Calculus II for Mathematical Sciences**
- Revise course content and description
- Revise Prerequisites:

**MATA37H3 Calculus II for Mathematical Sciences**
A theoretical course in calculus emphasizing proofs and techniques, as well as the intuition behind them. Axioms and basic properties of real numbers; theorems concerning differentiation and integration; fundamental theorem of calculus; numerical integration; sequences and series; Taylor polynomials and remainder; uniform convergence and power series.
A continuation of MATA31H3, emphasizing proofs and techniques, as well as the intuition behind them. Transcendental functions revisited, Techniques and applications of integration. Taylor polynomials and remainder term, Sequences and series. Uniform convergence and power series.
Prerequisite: MATA31H3, CSCA67H3
Breadth Requirement: Quantitative Reasoning

**Rationale:**
With the change in MATA31H3 (proposed concurrently this this change) it is necessary to an additional required course that provides students with more prior exposure to mathematical proof techniques. Thus, CSCA67H3 is now a prerequisite for MATA37. Further, some topics from the old MATA31H3 must be moved into MATA37H3.

7. **CONSENT AGENDA COURSE CHANGES:**
- CSCD11H3 Machine Learning and Data Mining
  - Course level to C – this will become the introductory course to machine learning and data mining
  - Revise Prerequisite
  - Revise Exclusion
• MATA32H3  Calculus for Management I
  o  Revise Exclusion
• MATC01H3  Groups and Symmetry
  o  Revise Prerequisite
• MATC46H3  Differential Equations II
  o  Revise Prerequisite
• STAC62H3  Stochastic Processes
  o  Revise Prerequisite
• STAC70H3  Statistics and Finance
  o  Revise Prerequisite
  o  Add Corequisite and Exclusion
• STAD29H3  Statistics for Life & Social Scientists
  o  Revise Prerequisite and Exclusion