UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Meeting of Faculty Council

Cycle 3 | February 18, 2022 | 12:10-2:00 pm

https://utoronto.zoom.us/j/81443872158
Meeting ID: 814 4387 2158 | Passcode: 287766

AGENDA

Item		Presenter	Time
1.	**Speaker's Welcome and Approval of Agenda** For approval as a regular motion	J Mostaghimi	12:10-12:14
2.	**Introduction of New Faculty** Ibrahim Ogunsanya (CivMin)	B Sleep	12:14-12:18
3.	**Adoption of Minutes of Previous Meeting *** For approval as a regular motion	J Mostaghimi	12:18-12:20
4.	**Memorial Tributes** Iain Currie (MIE), Frank Hooper (MIE)	M Bussmann	12:20-12:30
5.	**Report of the Dean** For discussion	C Yip	12:30-12:40
6.	**Closure of Minor in Biomedical Engineering and Modifications to Minor in Bioengineering** (Report 3715R) For approval as a regular motion	D Aleman	12:40-12:50
7.	**Proposed Session Dates for the 2022-2023 Academic Year** (Report 3710R) For approval as a regular motion	E Bentz	12:50-12:55
8.	**Major Curriculum Changes for the 2022-2023 Academic Year** (Report 3711) For approval as a regular motion	E Bentz	12:55-1:00
9.	**Information Reports** To receive for information		
	a. **Engineering Graduate Education Committee Information Update** (Report 3714R)	J Audet	1:00-1:10

10.	**Discussion Item** For discussion		
	a. Guidelines for the Assessment of Effectiveness of Teaching in Tenure, Continuing Status and Promotion Decisions	K Tallman	1:10-1:30
11.	**Other Business**	J Mostaghimi	
12.	**Date of Next Meeting**	J Mostaghimi	
13.	**Adjournment**	J Mostaghimi	

*To be distributed.

2/8/2022 12:49 PM

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Memorial Tribute to

IAIN GEORGE CURRIE

Professor Emeritus
Department of Mechanical & Industrial Engineering

February 18, 2022

Be it resolved –

> THAT the Council of the Faculty of Applied Science & Engineering record with deep regret the death on December 25, 2021 of Professor Emeritus Iain George Currie.

Iain George Currie, born March 11, 1936, died peacefully with family by his side on Christmas Day, 2021, at his home in Oakville, at the age of 85.

Iain grew up in Scotland and attended the University of Strathclyde in Glasgow, where he earned a bachelor's degree in mechanical engineering (1960). He then ventured across the ocean for graduate work: a master's degree at the University of British Columbia (1962), and a PhD from the California Institute of Technology (1966). That same year he then joined the Department of Mechanical Engineering at the University of Toronto. Iain retired in 2001, but for many years afterwards remained actively engaged with the Department of MIE as Professor Emeritus. Iain is still well known and fondly remembered by many of us.

Iain's research focused on experimental studies of fluid structure interaction, in particular the use of Laser Doppler Anemometry (LDA) and Particle Image Velocimetry (PIV) to characterize the flow-induced vibration of tube bundles, work that was supported by agencies including Atomic Energy of Canada Limited and Ontario Hydro. Iain also taught fluid mechanics to both undergraduate and graduate students, and was well known as the author of the popular graduate textbook *Fundamental Mechanics of Fluids*, first published in 1993. A fourth edition was released in 2012, and still serves as the textbook for our course in Advanced Fluid Mechanics.

From 1993 to 1998 Iain served as Chair, first of the Department of Mechanical Engineering, and beginning in 1996, of the new Department of Mechanical & Industrial Engineering, the result of a merger that wasn't popular with faculty from either department at the time, but that Iain somehow made work, relying on strong leadership and people skills, plus a dash of good humour. A colleague recalls that Iain at the time had t-shirts printed for everyone that read, "I

survived the MIE merger", or words to that effect. And Iain liked to say that after a bad day, he'd go home and complain to his dog, who would always agree with him. The collegiality of the Department of MIE today is in no small part due to Iain's early leadership.

Iain officially retired in 2001, but remained active within the Department, and was eventually instrumental in establishing and leading an MIE Honours & Awards Committee, organizing many award nominations on behalf of colleagues. That dedication was ultimately recognized in 2017 when Iain was named an Honorary Alumnus of U of T Engineering, one of just a few ever to be so recognized.

Iain Currie was a distinguished teacher and professor, an elegant, generous, gracious, gentle and warm colleague, and a good friend to many of us. He was also a very proud husband, father and grandfather, and will be greatly missed by his beloved wife Catherine, his children Brian, Karen, and the late David, and six beautiful grandchildren: Zander, Izabella, Bisola, Evan, Quinn and Gwynne.

Be it further resolved –

> THAT this tribute to Iain George Currie be inscribed in the minutes of this Council meeting, and that copies be sent to his family as an expression of the respect and gratitude of the members of this Council.

Prepared and presented at Faculty Council by Professor Markus Bussmann, Chair of the Department of Mechanical & Industrial Engineering.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Memorial Tribute to

FRANK CLEMENTS HOOPER

Professor Emeritus
Department of Mechanical & Industrial Engineering

February 18, 2022

Be it resolved –

> THAT the Council of the Faculty of Applied Science & Engineering record with deep regret the passing on May 2nd 2021 of Professor Emeritus Frank Clements Hooper.

Frank Clements Hooper, born in 1924, lived to the ripe old age of 97 years. His first association with the Faculty was in 1942 when he enrolled in Engineering Physics; he graduated four years later in 1946. In 1955, following the completion of post-graduate studies at Imperial College, London, Frank accepted an academic position within the Department of Mechanical Engineering, from which he formally retired in 1989 as Professor Emeritus. It was during his tenure at Imperial College that Frank met the love of his life, Gay Hooper, who sadly passed away in 2016. Frank is survived by their two children, Della and Jeffrey, and three grandchildren.

During his extended academic career from 1955 to 2021, Frank was an active participant on many fronts within the Faculty, and was well respected and appreciated by colleagues across all departments. He chaired or served on numerous Faculty & University committees, and being an effective communicator, was always willing to constructively challenge and debate issues within our Faculty Council, for our collective benefit. Through many years of service Frank demonstrated an unparalleled devotion to the Department, the Faculty and the engineering profession at large.

On the administrative front, Frank first served as the Graduate Secretary in the Department of Mechanical Engineering from 1953 to 1969. Following the revision of the Constitution of Faculty Council in 1972, which transferred the chairship from the Dean to an annually elected Office of the Speaker, Frank Hooper was appointed the first Speaker of Faculty Council; by all accounts he served with distinction until 1976. A year later, Frank was invited to serve as Chair of our prestigious Engineering Science Division, through to 1985.

Frank loved the classroom as much as he did the supporting laboratory experiences in MC120; he enjoyed teaching and the interaction with both undergraduate and graduate students. Students too enjoyed Frank's teaching prowess as he creatively linked the basic fundamentals with real world applications to fully demonstrate the excitement of the practical engineering experience.

In 1970 it was Frank, working with Professor I.W. Smith and the student project leader, Doug Venn, who pioneered and built the very successful and internationally acclaimed U of T Miss Purity entry for the Clean Air Car Race that ran from MIT, Boston to Caltech, Pasadena, powered by an electric/propane hybrid engine! Frank was an inspiring educator, as his infectious enthusiasm and experience encouraged student interest and learning.

Through the years Frank built an enviable research portfolio that earned him broad international accolades and recognition for his contributions in various thermal energy applications, energy production/conservation, and pollution control. Particular career highlights include his Chairmanship of the 6th International Heat Transfer Conference which he hosted in Toronto in 1978; he served as the President of the Assembly of this august body for four years. Frank also had the distinction of serving as the President of the Council of the Royal Canadian Institute in 1981/82.

Frank's research and consulting accomplishments were extensive. He was an early pioneer in the development of the ground source heat pump. He was honored in May 2011 with an award from the Canadian Geo-Exchange Coalition for his pioneering research on ground source heat pump and cooling technology. In the 1980s, his research team installed a mechanized system of solar collectors/receptors on the roof of the Mechanical Building to automatically track and investigate the diffuse component of sky radiation, an initiative that generated the first comprehensive database on the subject. Frank also contributed to heat and mass transfer design for the Orenda engines that powered the Avro Aero, and was intimately involved in the conceptual design of the Toronto District Cooling System that employs deep lake cooling water. In 1991 the significant contributions and varied accomplishments of Frank Hooper were recognized when he was admitted into the Hall of Distinction.

Frank was an exceptional role model and a friendly and respected senior statesman within the Faculty, with a keen sense of humour and wit. He was always willing to go the extra mile to welcome and support new faculty with their teaching and research and to offer sincere advice or a few words of wisdom, as required. He will be remembered fondly by his many colleagues and students over the years for his positive attitude and smile, willingness to listen and assist, and extensive engineering experience and know-how.

Thank you, Frank and Gay. Rest in Peace. Together we enjoyed years of memorable times. For many this included an enjoyable afternoon sail on the lake followed by a beer at the RCYC.

Be it further resolved –

> THAT this tribute to Professor Frank Clements Hooper be inscribed in the minutes of this Council meeting, and that copies be sent to his family as an expression of the respect and gratitude of the members of this Council.

Prepared by Professor Emeritus Ron Venter with input from Professor Emeritus James S. Wallace. Presented at Faculty Council by Professor Markus Bussmann, Chair of the Department of Mechanical & Industrial Engineering.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3715 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (February 1, 2022)
Faculty Council (February 18, 2022)

From: Professor Dionne Aleman
Associate Dean, Cross-Disciplinary Programs

Date: January 17, 2022; revised February 4, 2022

Re: **Closure of Minor in Biomedical Engineering and Modifications to Minor in Bioengineering**

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a regular motion (requiring a simple majority of members present and voting to carry).

BACKGROUND

The overlap between the Minor in Bioengineering and the Minor in Biomedical Engineering has caused challenges since they were created in 2006 and 2014 respectively, as students participating in these minors often take similar classes and have similar learning outcomes. In addition, students enrolled in the Biomedical Engineering minor have a lower level of completion than those in the Bioengineering minor.

It is therefore proposed that the Minor in Biomedical Engineering be closed and its requirements and courses be integrated into the Minor in Bioengineering. It is further proposed that the Minor in Bioengineering be modified to include a requirement for a laboratory or hands-on experience, and outline optional pathways and themes for students to focus their electives. The Biomedical Engineering pathway outlines themes on molecular engineering, cell and tissue engineering and clinical engineering. The Bioprocess Engineering pathway outlines themes on biomolecular and microbial engineering, and bioprocess engineering.

PROCESS AND CONSULTATION

The proposed changes have been discussed by and/or received feedback from the IBME Undergraduate Curriculum Committee, Advisory Committee and faculty; the Cross-Disciplinary Programs Office; the Department of Chemical Engineering & Applied Chemistry; the Edward S. Rogers Sr. Department of Electrical & Computer Engineering; students currently enrolled in the two minors

and in CHE353, CHE354 and BME331 (the foundational courses of both minors); the FASE Undergraduate Curriculum Committee; and department chairs and the director of Engineering Science.

RECOMMENDATIONS FOR COUNCIL

THAT the Minor in Biomedical Engineering be closed and its requirements and courses be integrated into the Minor in Bioengineering, as described in Report 3715 Revised. Administrative suspension of enrolment in the program will be effective April 30, 2022 and full closure of the minor will be effective June 30, 2026.

THAT the Minor in Bioengineering be modified to include a laboratory or hands-on course requirement and optional pathways and themes, as described in Report 3715 Revised. Administrative suspension of enrolment in current program requirements will be effective April 30, 2022 and, for students newly enrolled in the minor, new program requirements will be effective May 1, 2022.

Appendix 1 to Report 3715R

University of Toronto
Major Modification Proposal

Modifications to Freestanding Minors Where There is No Existing Specialist or Major

Programs being modified:	Minor in Bioengineering & Minor in Biomedical Engineering
Proposed major modification:	Minor in Bioengineering: • Modify to integrate Biomedical Engineering courses and requirements • Organize courses into two main pathways, including (1) Biomedical Engineering, and (2) Bioprocess Engineering Minor in Biomedical Engineering: • Close as a result of this minor being merged with the Bioengineering minor
Department/unit (if applicable):	Cross-Disciplinary Programs Office (CDPO)
Faculty/academic division:	Faculty of Applied Science and Engineering (FASE)
Dean's Office contact:	Caroline Ziegler, Faculty Governance & Programs Officer (governance.fase@utoronto.ca)
Proponent:	Prof. Dionne Aleman, Associate Dean, Cross-Disciplinary Programs (aleman.mie@utoronto.ca) Prof. Warren Chan, Director, Institute of Biomedical Engineering (warren.chan@utoronto.ca) Prof. Emma Master, Chemical Engineering and Applied Chemistry (emma.master@utoronto.ca)
Version Date:	February 4, 2022

1. Summary

The Faculty of Applied Science and Engineering's (FASE) Minor in Bioengineering was originally created in 2006 and aside from some elective additions, has retained the same structure as when it was created. The Minor in Biomedical Engineering was launched in 2014 as a specialized sub-set of courses that provided an ideal background for the newly created Biomedical MEng program. The overlap between these two minors, and the specificity of the course requirements for the Minor in Biomedical Engineering, has caused challenges over the years.

It is proposed to merge the courses of the Minor in Biomedical Engineering into the Minor in Bioengineering, and close the Minor in Biomedical Engineering. The program requirements of the updated Bioengineering minor will be restructured and it will add a requirement for a lab course, or bio-related capstone/thesis experience to ensure students get a hands-on component in the minor. The calendar listing for the minor will also include recommendations for pathways to help students navigate the range of electives available. The proposal also takes the opportunity to formally articiulate the learning outcomes of the minor.

2. Effective Date

Minor in Bioengineering:

- Administrative suspension of enrolment in current program requirements: April 30, 2022
- New program requirements effective May 1, 2022 for students newly enrolled in the minor

Minor in Biomedical Engineering:

- Administrative suspension of enrolment in the program: April 30, 2022
- Closure of minor with full effect: June 30, 2026

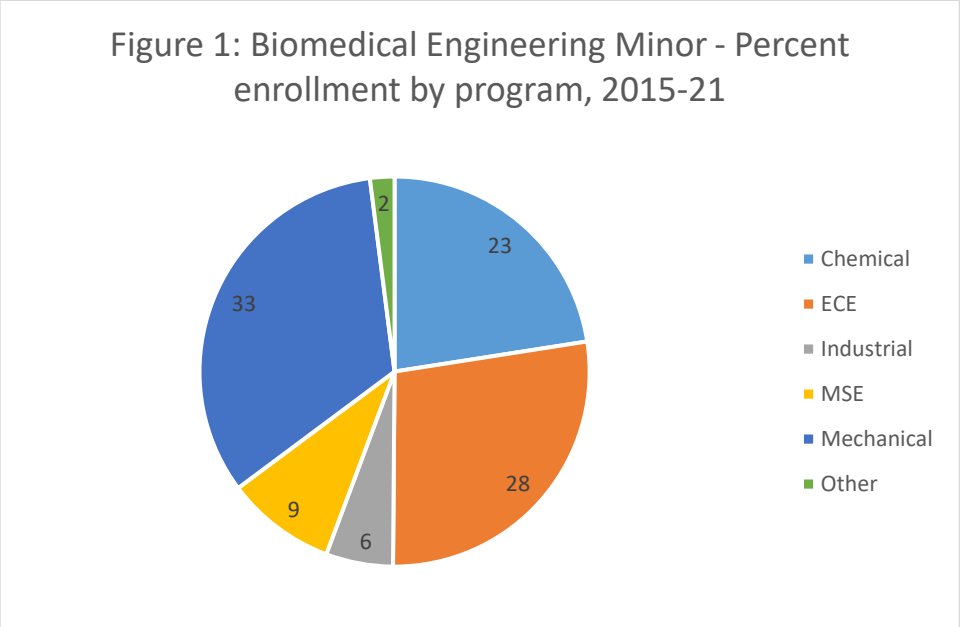
Students enrolled in either program prior to May 1, 2022 will be allowed to complete the old requirements of either minor or switch to the new Bioengineering minor requirements.

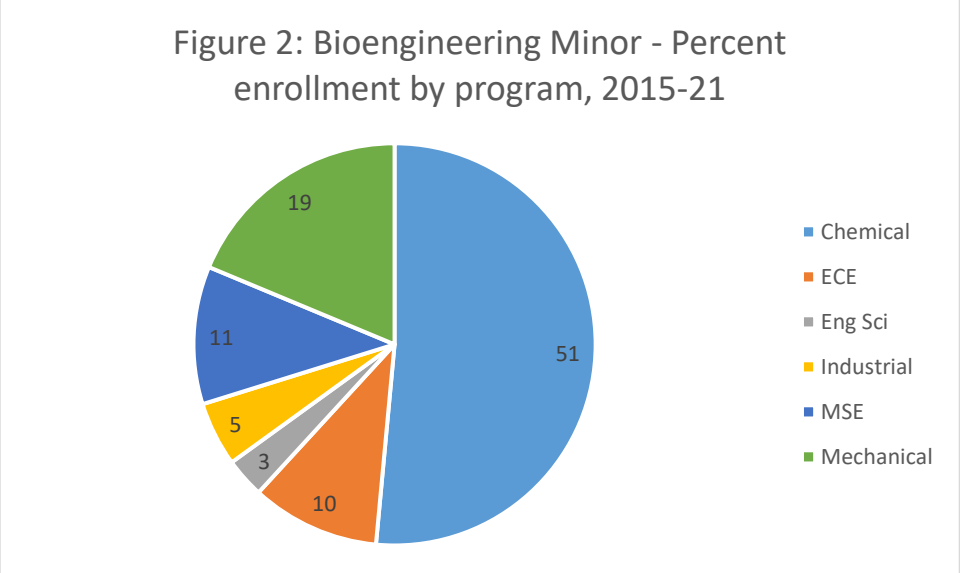
3. Academic Rationale

The Bioengineering minor, introduced in 2006, was the first ever minor in FASE and it was intended for engineering undergraduates interested in learning more about biology and its application to engineering. The term 'bioengineering' is very broad, referring to all areas where engineering and biology intersect. By contrast, the Biomedical Engineering (BME) minor, launched in 2014, is more specific and was designed for those specifically wanting to apply their engineering knowledge to applications in the health care sector. Although the Biomedical Engineering minor is currently a separate minor, there is significant overlap between the two; in their current structures, students that participate in these minors often take similar classes and have similar learning outcomes. As a result, continuing to have two separate minors is redundant and may be confusing to students. Originally there was also a co-curricular Mentorship Program and a seminar series associated with the BME minor which have since been discontinued by the Institute of Biomedical Engineering (IBME).

Students in the minors come from a variety of programs, but primarily from Chemical, ECE and Mechanical Engineering (Figure 1 and 2). Note that some programs (Civil, Mineral, Industrial), do not have a path to completing the minors without taking on considerable extra courses. A small number of students in those programs – particularly those who might be considering applying for med schools in the future – start off in one of the programs, but usually drop it by 3rd or 4th year.

Engineering Science students are not eligible to enroll in the BME minor, but can enroll in Bioengineering, so long as they are not in the Biomedical Systems major.





In its current state, the Biomedical Engineering minor has been struggling with low completion rates (Table 1). Although enrollment numbers have been high and have increased since the program's initial introduction, many students who sign up for the program do not successfully complete the program.

From 2014 to 2021, (7 academic years), 136 students enrolled in the Biomedical Engineering minor program but only 52 students have successfully completed the program. In contrast, during the same period, the Bioengineering minor saw an enrolment of 341 and 265 completions. Annecdotally, the primary reason given for abandoning or switching out of the BME minor was the timetable challenges of fitting the specific, lab intensive courses. Of the 84 students who dropped the Biomedical Engineering minor over this period, 31 (from CHE, MSE

and MEC) switched to the to the more flexible Bioengineering minor, and of those students who switched, 27 have completed or are still actively enrolled in this minor. The Institute of Biomedical Engineering had wanted to add more courses and restructure the Biomedical Engineering minor to increase program flexibility, thereby hopefully improving program completion. However, restructuring the minor to accomplish this has been difficult because of its high similarity to the Bioengineering minor. The key differentiator between the two had been the very focused subset of courses for the Biomedical Engineering Minor. Adding courses would have blurred this distinction.

Table 1: Students graduating with completed minor

	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	Total
BME								
Chemical	1	4	1	4	2	0	3	15
ECE	0	0	1	3	5	12	1	22
MSE	0	0	0	1	0	0	0	1
Mechanical	0	0	1	3	5	1	4	14
Total								52
BIO								
Chemical	8	14	17	29	24	24	33	149
ECE	4	11	6	1	2	0	1	25
Eng Sci	2	0	1	0	0	2	1	6
Industrial	3	1	0	2	1	0	0	7
MSE	3	3	4	5	6	2	5	28
Mechanical	9	5	8	2	8	7	11	50
Total								265

In contrast, the Bioengineering minor is broadly accessible, including a wide variety of courses, but lacks any required exposure to a laboratory component beyond the 12.8P in BME331 or CHE354. The proposed changes are expected to increase the number of students who complete a hands-on component in the minor (e.g., a bio-related capstone/thesis experience), providing practical experiences that help more students convert ideas into real-world applications. The calendar listing for the Bioengineering minor will also include recommendations for pathways to help students navigate the range of electives available.

Given these points, integrating the two minors into a single minor is much more feasible and sensible. Merging the two ultimately allows students to derive full benefit of all the course options rather than trying to divide up courses between minors to make them distinct from each other. It will also avoid confusion among students between two programs that appear very similar. The possibility of a merger has been discussed among core members of both programs and support for this change is very strong.

4. Description of the Proposed Major Modification(s)

We propose the closure of the Biomedical Engineering minor and merger of its requirements and courses into the Bioengineering minor. The single resulting program would be named Bioengineering because the Bioengineering name is broader. Thus, Bioengineering would include Biomedical Engineering. While the Cross-Disciplinary Programs Office (CDPO) will manage the overall activities (e.g., enrollment, tracking completions, calendar, etc.), IBME and CHE will be the initial lead units from September 2022 to August 2024, working in collaboration with other partner units (ECE, MSE, MIE, CIV) in advising students, curriculum design, and management of courses and activities. Co-leadership will ensure a smooth transition of the program as it goes through this merger. Beginning September 2024, BME will be the lead unit and an advisor appointed by CHE (or other unit as appropriate) will remain on to provide vital perspectives and input as it pertains to the Bioprocess pathway.

We propose to recommend (but do not require) that students structure their minor course selections around two pathways in this program:

(1) Biomedical Engineering;
(2) Bioprocess Engineering

These two pathways encapsulate the major learning concepts of the bioengineering field and provide a depth of knowledge relating to molecular and cell scale engineering, manufacturing of biosystems, biochemicals and devices, and the translation of technologies for environmental sustainability and patient care.

Under this restructured program, students will be able to:

- Understand how bioengineering concepts can be applied to address grand challenges facing human and environmental health.
- Understand the relevance of biological systems to the discovery of new medicines, development of sustainable processes, increased food security, and generation of renewable fuels and chemicals.
- Gain greater insights into leading edge approaches used to model and engineer biomolecular and cellular processes.
- Gain hands-on experience with analytical and molecular bio-techniques, solving practical bioengineering problems.

Program Requirements:

Enrollment Requirements: The Bioengineering minor is open to all undergraduate students except for those enrolled in Engineering Science's major in Biomedical Systems Engineering.

General Program Requirements for a Minor: 3.0 full course equivalents (FCE), where no more than 0.5 credits can be a core course in the student's degree program. Departmental capstone and thesis courses are exempt from the core course credit limit.

Completion Requirements:

1. CHE353H1F: Engineering Biology or BME205H1S (for Engineering Science students) (0.5 FCE)

2. Choose at least 1 course (0.5 FCE):
   BME412H1F: Intro to Biomolecular Engineering (recommended for *Biomedical Engineering pathway*)
   BME455H1F: Cellular and Molecular Bioengineering II* (recommended for *both pathways*)
   BME331H1S: Physiological Control Systems (recommended for *Biomedical Engineering pathway*)
   CHE354H1S: Cell and Molecular Biology (recommended for *Bioprocess Engineering pathway*)
   * In order to take BME455 students must complete CHE354 as a pre-requisite.

   Although students are required to only complete 1 out the 4 courses listed above, it is highly recommended to complete 2 of the above courses if scheduling permits.

3. Choose at least 1 course (0.5-1.0 FCE):
   BME498Y1Y: Biomedical Engineering Capstone Design**
   Departmental Thesis (requires approval of Minor Director from BME (Biomedical pathway) or CHE (Bioprocess Pathway))**
   BME440H1F: Biomedical Engineering Technology and Investigation
   CHE450H1F: Bioprocess Technology and Design
   ** Students wishing to register in BME498Y1Y, must obtain approval from the Biomedical Engineering Undergraduate & Graduate Student Office. Some Departments have agreed to accept BME498Y1Y in place of their program's capstone course (existing agreement for ChemE, ECE, MSE, Mech. Alternatively, students who wish to count their departmental thesis or capstone design project towards the Bioengineering minor will be assessed on a case-by-case basis as is currently the case with Bioengineering and other minors.

4. Choose up to 3 courses as needed to bring the total to 3.0 FCE:
   Students may choose any of the below courses but those wishing to concentrate on a particular pathway are recommended to choose courses that fit within that pathway. Within each pathway, students may optionally choose to further focus on a particular theme by taking the recommended courses within that theme.

   1. Biomedical Engineering pathway.
   Courses relevant to the Biomedical Engineering pathway are further grouped into three themes: Molecular engineering, Cell and Tissue engineering, and Clinical engineering:

   Molecular engineering theme:
   BME412H1F: Introduction to Biomolecular Engineering
   BME440H1F: Biomedical Engineering Technology and Investigation
   BME595H1F: Medical Imaging
   CHE475H1S: Biocomposites: Mechanics and Bioinspiration
   ECE448H1S: Biocomputation
   MSE343H1F: Biomaterials

MSE440H1F: Biomaterial Processing and Properties

Cell and Tissue engineering theme:
BME350H1F: Biomedical Systems Engineering I: Organ Systems
BME395H1F: Biomedical Systems Engineering II: Cells and Tissues
BME455H1F: Cellular and Molecular Bioengineering II
MIE439H1F: Cell & Tissue Mechanics
MIE458H1F: Biofluid Mechanics
MIE520H1F: Biotransport Phenomena

Clinical engineering theme:
BME330H1S: Patents in Biology and Medical Devices
BME331H1S: Physiological Control Systems
BME445H1F: Neural Bioelectricity
BME530H1S: Human Whole-Body Biomechanics
ECE446H1F: Sensory Communications

2. Bioprocess Engineering pathway.
Courses relevant to the Bioprocess Engineering pathway are further grouped into two themes: Biomolecular and microbial engineering, and Biomanufacturing:

Biomolecular and Microbial engineering theme:
CHE354H1S: Cellular and Molecular Biology
ECE448H1S: Biocomputation
BCH441HF: Bioinformatics
CHE471H1S: Modeling in Biological and Chemical Systems
BCB420H1S: Computational Systems Biology
CHE4XXH1F: Synthetic Biology

Biomanufacturing theme:
CHE354H1S: Cellular and Molecular Biology
BME330H1S: Patents in Biology and Medical Devices
CHE450F1F: Bioprocess Technology and Design
CHE462H1S: Food Engineering
CHE475H1S: Biocomposites: Mechanics and Bioinspiration
CHE471H1S: Modeling in Biological and Chemical Systems
CHE564H1S: Pulp and Paper Processes
CIV342H1F: Water and Wastewater Treatment Processes
CIV541H1S: Environmental Biotechnology
MGY377H1F: Microbiology I: Bacteria
MSE343H1F: Biomaterials
MIE520H1F: Biotransport Phenomena

3. Additional Elective courses:
Courses related to Bioengineering, outside of the defined pathways above:
CHE416H1S: Chemical Engineering in Human Health

CHM456H1S: Organic Materials Chemistry
ECE331H1F: Analog Electronics
ECE335H1F: Introduction to Electronic Devices
ECE431H1F: Digital Signal Processing
ECE516H1F: Intelligent Image Processing
FOR308H1F: Discovering Wood and its Role in Societal Development *(HSS Elective)*
FOR421H1F: Green Urban Infrastructure: Suitable City Forests
FOR424H1S: Innovation and Manufacturing of Sustainable Materials
FOR425H1S: Bioenergy and Biorefinery Technology
HMB201H1S: Introduction to Genes, Genetics & Biotechnology
HMB265H1F: General & Human Genetics
HPS318H1F: History of Medicine I *(HSS Elective)*
HPS319H1S: History of Medicine II *(HSS Elective)*
IMM250H1F/S: The Immune System & Infectious Disease
MIE242H1F: Psychology for Engineers
MIE343H1F: Industrial Ergonomics and the Workplace
MIE523H1F: Engineering Psychology and Human Performance
MIE561H1S: Healthcare Systems
PCL201H1S: Introduction to Pharmacology and Pharmacokinetic Principles
PCL302H1S: Introduction to Pharmacology: Pharmadynamic Principles
PHL281H1S: Bioethics *(HSS Elective)*
PSL300H1F: Human Physiology I

5. Impact of the Change on Students

Currently, the Biomedical Engineering minor has a steadily high level of enrollment. Despite this, program completion is low. The enrollment and completion trends for the last few years are as follows:

Year	Enrollment		Completion	
	BME	BioEng	BME	BioEng
2014-15	26	41	1	29
2015-16	44	54	4	34
2016-17	72	57	3	36
2017-18	86	79	11	39
2018-19	77	45	12	41
2019-20	50	59	13	35
2020-21	46	71	8	51

New enrollments in the current Bioengineering and Biomedical Engineering minors will be suspended as of April 30, 2022. Students enrolled at that time in either minor will be given the option of completing the current requirements or changing to the new Bioengineering requirements. Given the way the minor is structured, many courses in the Biomedical Engineering

minor are also part of the Bioengineering minor and therefore students who want to switch will be able to do so easily.
All new enrollment in the Bioengineering minor after April 30, 2022 will follow the modified requirements.

The Cross-Disciplinary Programs Office will offer robust advising to ensure that students are aware of their options and able to complete the new program requirements if they choose the updated Bioengineering minor.

6. Consultation

The Biomedical Engineering minor was first discussed by the IBME undergraduate curriculum committee May 15, 2019. In a subsequent meeting on June 17, 2019 the committee agreed that a restructuring of the minor was needed. The committee discussed that changes should match what was discussed for Engineering Science's Biomedical Systems Engineering major. This included aligning courses with the research streams of the Institute. A draft of the initial restructuring proposal was developed following these discussions with the IBME undergraduate curriculum committee. The Associate Dean and the Assistant Director of the Cross-Disciplinary Programs Office were also consulted. Additionally, the proposed changes were discussed with IBME faculty at a faculty meeting on November 18, 2020. Faculty were supportive of changing the minor.

Given the large similarity between the Biomedical Engineering and Bioengineering minors, the Director of the Bioengineering minor was added to the discussion in January 2021 to discuss the Bioengineering minor in light of the proposed restructure of the Biomedical Engineering minor. After initial discussions, consensus was reached that merging the two minors would make the most sense and preliminary details were discussed in a meeting on April 22, 2021. Following this meeting, the IBME advisory committee was consulted along with Prof. Paul Santerre, who initiated the current BME minor, and Prof. Dawn Kilkenny, who oversaw the minor as Associate Director, Undergraduate at the Institute through June 2019. There was support for the merge and renaming the merged program the "Minor in Bioengineering". Preliminary discussions between the Director of the Bioengineering Minor and the Chair of Chemical Engineering, considered the original informal "home" of the Bioengineering Minor were also positive. Details regarding the proposed merged program were drafted and the program requirements outlined. It was agreed that the merged program would still offer the courses previously offered in the current Bioengineering minor but that the requirements would be restructured to include additional biomedical engineering courses and include a practical requirement that would benefit students enrolled in the existing Bioengineering Minor.

On October 13, 2021 students were consulted regarding the planned merger. Students invited to this meeting included current Bioengineering and Biomedical Engineering minor students and students currently in CHE353 (which could be future minor applicants). Student reps for the FASE Undergraduate Curriculum Committee were also invited. Although turnout was low with 16

students registering for the consultation and 8 who attended, feedback regarding the merger was very highly received. All participants were supportive of the change and thought that it offered more flexibility for students. Students echoed that choosing between the Bioengineering and Biomedical Engineering programs was confusing and that the current Biomedical Engineering minor was very restrictive, especially compared to the Bioengineering minor. Students appreciated the proposal that all previously offered bioengineering courses remained in the proposed structure.

Within IBME, a faculty meeting was held October 14, 2021 to discuss the current merger proposal. IBME faculty members expressed that they were supportive of the change and that it makes a lot of sense to combine the minors. The only major feedback regarding the proposal is that some faculty members want to see the program grow to include more electrical engineering courses and courses focused on entrepreneurship and industrialization.

The merger proposal was presented at the FASE Undergraduate Curriculum Committee on October 29th and was endorsed by the representatives there. The committee comprises curriculum representatives (Associate Chairs, Undergraduate or designates) from each of the departments and divisions.

The merger proposal was then circulated to all department chairs and the EngSci director in advance of the Executive Committee meeting. This spurred additional discussions and consultations within CHE, including with the BioZone leadership and CHE Curriculum Committee. CHE faculty members expressed their support for merging the Bioengineering Minor and Biomedical Minor, however, faculty members wanted to see a greater balance between biomedical engineering and bioprocess engineering elements of the minor. This led to the current proposal, which describes two main pathways within the Bioengineering Minor (i.e., Biomedical Engineering and Bioprocess Engineering), and co-leads (one from IBME and one from CHE) for the first two years of the new Bioengineering Minor, after which time a CHE faculty member (or member of another unit) will remain to guide the development of the Bioprocess pathway. An e-mail consultation with IBME was conducted (Dec 15-22) and no issues with the proposed changes were raised.

Feedback was also received at this time from ECE in support of the merged minor that there was a preference to retain the Biomedical Engineering name rather than Bioengineering. However, given the dual pathways of the merged minor, it is clear the content of the program goes beyond biomedical applications. Upon further consultation in January, it was agreed that a handful of courses on ECE-related topics be added to the course offering, as the current curriculum is heavy on biology and chemistry but scant on fundamental training critical to several areas of bioengineering, including devices, imaging, and machine learning. After consulting with ECE-BME stakeholders, four courses were added to the category of “3. Additional Elective Courses”. Additions to the learning outcomes in Appendix A were also included.

A final consultation with students was conducted on January 10, 2022, and the feedback was positive. A student indicated that they would like to see the pathways or streams included on the transcript notation. While students are free to highlight completion of a pathway or theme informally in a graduate school or job application, there is no plan to include them on transcripts currently.

The updated proposal was endorsed once again by UCC on January 10, 2022.

7. Resources

There will be no changes to the resources available to students regarding faculty complement, space, and libraries. Both IBME and Chemical Engineering have committed to staffing their respective core courses in the merged minor going forward. All elective courses offered previously will continue to be offered and will continue to be administered by their home department or division.

The IBME Undergraduate Program Administrator will continue to assist with course administration for BME courses and advise students on the minor, as they did for the current BME minor. The Cross-Disciplinary Programs Office will continue to oversee the minor administration and admissions and overall student advising. The initial Directorship of the merged minor will include representation from BME (Prof. Warren Chan) and CHE (Prof. Emma Master). The Directors and/or corresponding undergraduate program administrators will consult with appropriate colleagues across FASE as necessary to provide guidance to students and ensure courses within the pathways are consistent and appropriate. This may include identifying informal advisors for each of the pathways.

8. UTQAP Process

The UTQAP pathway is summarized in the table below.

Steps	**Dates**
Development in consultation with IBME, CDPO, Chemical Engineering	May 2019-December 2021
Consultation with Dean's Office (and Vice-Provost, Academic Programs)	October-November 2021
Endorsement of FASE Undergraduate Curriculum Committee	January 10, 2022
Approval of FASE Council	February 18, 2022
Submission to Provost's Office	January 2022
Reported to Provost for inclusion in annual report to AP&P	June 2022
Reported annually by Provost to Ontario Quality Council	July 2022

Appendix A: Proposed Learning Outcomes and Degree Level Expectations

The Faculty of Applied Science & Engineering aims to provide all of its undergraduate students with an education that will encourage them to be leaders in society in developing solutions to its most pressing problems. In order to achieve this, each graduate will have achieved the Degree-Level Expectations for the BASc described in Appendix B.

Engineering minors and certificates are designed to recognize students for focusing their degree-program electives in a particular area of study. They are optional structures above and beyond a student's degree requirements and are therefore enhancements to existing rigorous degree-level expectations for engineering programs.

Learning outcomes for the original Biomedical Engineering and Bioengineering minors are not available as, when these minors were first introduced, the creation of learning outcomes was not required. Below are the learning outcomes for the modified Bioengineering Minor program.

Degree-Level Expectations for the Bachelor of Applied Science (BASc)	Additional Program Learning Outcomes for the Modified Bioengineering Minor	How the Modified Bioengineering Minor's Design/Structure Supports the Degree Level Expectations
Depth and Breadth of Knowledge Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	Develop a basic understanding of how to apply engineering principles to biological systems.	Learners will take the required course CHE353. This course provides an overview of how to apply engineering techniques to address biology and health problems. The learners will take specialized courses in different areas of bioengineering for added depth and knowledge.
Knowledge of Methodologies Demonstrated competence in understanding the methods of engineering design.	Depending on their course selections, students will gain a theoretical understanding and practical competence in topics such as: measuring and analyzing biological signals, designing devices, designing biocompatible materials, applying fluid dynamics to flow phenomena, understanding tissue mechanics, kinetics of biological and biochemical processes, mass balances of biological and biochemical processes, DNA and protein manipulations.	We have developed both lab and capstone courses for the minor program. These courses teach practical skillsets applicable to different areas of bioengineering research, translation and development.

Degree-Level Expectations for the Bachelor of Applied Science (BASc)	Additional Program Learning Outcomes for the Modified Bioengineering Minor	How the Modified Bioengineering Minor's Design/Structure Supports the Degree Level Expectations
Application of Knowledge Demonstrated competence in applying science and mathematics to solve problems.	Depending on their course selections, students will apply their knowledge in areas such as engineering molecular devices and systems, building imaging platforms for diagnostics and intervention-guidance, building cell and tissue therapies, building engineering devices for treating or rehabilitating patients, synthesizing materials for drug delivery and therapy, applying machine learning to bioengineering problems, applying microbial processes in biomanufacturing, carbon capture and bioremediation.	We design a series of courses that covers various aspects of bioengineering. In parallel, we offer lab/capstone courses that allows learners to apply their knowledge. We will also encourage learners to do thesis projects, which provides students independent research experience to apply their knowledge.
Communication Skills Demonstrated ability to communicate information, arguments, and analysis accurately and reliably, orally and in writing, to specialist and non-specialist audiences.	Competence in data visualization and working in collaborative research teams, communicating results and ideas, and ability to write and explain bioengineering concepts.	Courses will contain writing assignments and presentation of ideas/concepts. The addition of these tasks will teach students communication skills. Additionally, writing and presentation are strong part of the practical courses.
Awareness of Limits of Knowledge Demonstrated knowledge and appreciation of the uncertainties, ambiguities and limitations of knowledge in the specific field.	Competencies in understanding the limits of bioengineering concepts and practical utility of resulting technologies.	Our practical courses plus thesis activities will teach learners limitations with bioengineering concepts. Our practical courses will teach the limitations of technologies. Our teachers will address these limitations through presentation, oral communication, and discussions with learners.
Autonomy and Professional Capacity Development of an awareness and understanding of professional practice; a demonstrated ability to work in teams and	Competencies with working on projects. This competency includes planning and executing projects, evaluation of progress, and addressing alternatives. It also includes a clear understanding of how one contributes to results.	Learning autonomy and professional capacity will occur through practical experience. Capstone courses will be provided for students to work in team and for clients. Mini projects in lab courses with teach students autonomy and project limitations.

Degree-Level Expectations for the Bachelor of Applied Science (BASc)	Additional Program Learning Outcomes for the Modified Bioengineering Minor	How the Modified Bioengineering Minor's Design/Structure Supports the Degree Level Expectations
accept responsibility for one's own work and contributions.		
Other Degree Level Expectations Developed competencies in quantitative reasoning (i.e., the ability to identify, assemble and interpret quantitative information; make and test hypotheses) and in information literacy.	We expect students to understand quantitative reasoning, decision making, and evaluation of information.	Our courses will provide problem sets to evaluate concepts and ideas. Our practical classes teach skillsets to evaluate problems and to make use information for effective decision making.

Appendix B: Degree Level Expectations for Graduates Receiving the Degree of Bachelor of Applied Science

Faculty of Applied Science and Engineering
University of Toronto

1 Degree Learning Objectives and Requirements

1.1 Overall Learning Objectives

The Faculty of Applied Science and Engineering aims to provide all of its undergraduate students with an education that will allow them to be leaders in society in developing solutions to its most pressing problems. Our graduates will be able and inspired to:

- be leading practitioners of engineering and engineering design
- be known for their technical literacy as well as their knowledge of mathematics and the basic sciences and the role of technology in society
- be able to formulate and solve problems in complex systems independently and in teams
- pursue independent lifelong learning within their field of study and more broadly
- be prepared for careers, including graduate programs, that build upon their advanced technical knowledge
- participate meaningfully as leaders in society

In order to achieve this, each graduate will have achieved the following general learning objectives:

a. Depth of knowledge that cultivates critical understanding and intellectual rigour in at least one engineering discipline.
b. Competencies in learning and applying knowledge to solve problems facing society and that are fundamental to responsible and effective participation in the workplace, in the community, in scholarly activity, and in personal life:
    i. Critical and Creative Thinking
    ii. Oral and Written Communication
    iii. Quantitative Reasoning
    iv. Teamwork
    v. Information Literacy
    vi. Ethical Thinking and Decision-Making
c. Breadth of knowledge across mathematics, basic sciences, engineering sciences, engineering economics and engineering design that cut across the engineering disciplines and across a range of nontechnical areas including the humanities and social sciences and an awareness of the impact of technology on society.
d. Integration of skills and knowledge developed in a student's course of study through a capstone experience in the upper years.

1.2 Requirements to Graduate

In order to graduate with a B.A.Sc. degree, each student in the Faculty of Applied Science and Engineering will have completed a full undergraduate program as outlined in the Faculty Calendar within nine calendar years of first registration, exclusive of mandatory absences from his/her program. Current programs include Chemical, Civil, Computer, Electrical, Industrial, Mineral, Materials and Mechanical Engineering.

The practice of engineering is regulated, by statute, in all Canadian provinces and territories. To become a Professional Engineer, an individual must satisfy the requirements of the licensing bodies.

These requirements include a degree from an accredited program, successful completion of a professional practice examination in engineering law and ethics, and suitable experience. At present, all programs in the Faculty of Applied Science and Engineering are accredited and evaluated regularly by the Canadian Engineering Accreditation Board (CEAB) of the Canadian Council of Professional Engineers. Therefore, graduation from the Faculty may lead to registration in the provincial Associations of Professional Engineers, in accordance with individual policies. No student will be permitted to graduate who does not meet these requirements.

The criteria set out by the CEAB are designed to ensure that each graduate has a foundation in Mathematics and Basic Sciences, a broad preparation in Engineering Sciences and Engineering Design and an exposure to non-technical subjects (Complementary Studies) that complement the technical aspects of the curriculum. Basic Sciences must include physics and chemistry and also may include elements of life sciences and earth sciences; they impart an understanding of natural phenomena. Engineering Sciences normally involve mathematics and Basic Sciences but carry knowledge further to creative applications. Complementary studies include the humanities, social sciences, arts, management, engineering economics and communication skills.

Each program in the Faculty consists of a technical component and complementary studies component. The curriculum for students in their early years forms a basis in the fundamental subjects prior to subsequent specialization in the various engineering disciplines. Students are able to choose from a range of technical electives in their senior years. In the senior years, all programs contain a Capstone experience through a design project, which integrates their skills and knowledge and provides students with the opportunity to carry out original work in their chosen fields of study.

There are a set of common requirements, described below, that cut across all programs in the following categories: Coursework; Promotion; English Proficiency; and Practical Experience. In this context, a course is defined as one half-course equivalent, which may consist of a half course (“S”, “F” or “H”) or half of a full year “Y” course.

1. Coursework: Each program will have courses that provide the following:
    a. Complementary Studies Electives
    b. A basic knowledge of Engineering Economics

c. Technical Electives

d. Courses with substantial design content in Years 1, 2 and/or 3

e. Capstone course(s) in Years 3 and/or 4 with strong integrative, design and independent work elements

f. Across all four years, programs will provide sufficient opportunities for the development of professional awareness and practice.

2. Promotion: All undergraduate programs will consist of eight Fall and Winter Sessions taken in order.

   a. To gain credit for a session a student must:

      i. satisfy the academic regulations to proceed to the succeeding session as described in the calendar and

      ii. not be subsequently required to repeat the session for which credit is to be gained, and

      iii. achieve a course mark of 50% or greater in every course taken as part of the academic load in a session, and

      iv. not have any outstanding designations of 'standing deferred', 'incomplete' or 'No Grade Available' for any course in any session.

   b. To be eligible to graduate, each student must attain a weighted Session Average of 60% or greater in the final session of their program. Any student who does not achieve a weighted Session Average of 60% in their final session (4W), but has attained a weighted Session Average that allows them to proceed to the next session on probation, shall repeat the final session and achieve a weighted Session Average of 60% or greater to graduate.

3. English Proficiency: Each student must show an ability to write English coherently and correctly. Every student will also take at least one course that includes a written communication component within their curriculum. Satisfactory completion of the course or courses is required for graduation.

4. Practical Experience: The Faculty requires that all students complete a minimum of 600 hours of practical work before graduation.

2 Degree Level Expectations for the Bachelor of Applied Science

2.1 Depth and Breadth of Knowledge

The Faculty ensures that a student has mastered a body of knowledge with appropriate depth by requiring that each student completes the requirements of one of the degree Programs of Study (POSt) as described in the Faculty Calendar. The curriculum for students in First Year forms a common basis in the fundamental subjects, including the natural sciences and mathematics, prior to a subsequent specialization in the various engineering disciplines. Each program consists of a technical component and a complementary studies component.

Critical analysis and thinking and analytical skills are emphasized through the student's exposure to an increasingly sophisticated understanding of their program of study. Specialization within the discipline is developed through technical electives taken in the 3rd and 4th years of study. A detailed knowledge of and experience in design is ensured through the Design Course requirements, beginning with courses in the first three years as well as the Capstone course(s) in each program. Opportunity to further develop these skills is provided through a research thesis that is available in most POSts.

The Faculty assures that students have breadth of knowledge in a number of ways. Breadth across engineering is assured through a First Year of study that prepares a student for any of the programs of study. Breadth beyond engineering is developed through the Complementary Studies Electives as well as the Engineering Economics requirement.

2.2 Knowledge of Methodologies

Every POSt has requirements which demonstrates a student's understanding of the methods of engineering design. Students in all engineering programs must successfully complete courses with substantial design in their first three years and a Capstone design course in their senior years. These courses require students to evaluate the appropriateness of various approaches to analyze and solve the design problem and also to devise and sustain arguments for their design. In most POSts, students have the opportunity to participate in a research thesis course that familiarizes them with the specific methodologies currently in use in the development of knowledge in their discipline.

2.3 Application of Knowledge

The application of science and mathematics to solve problems is fundamental to all programs in Engineering and therefore is required in many of the courses within all POSt. A minimum level of instruction in Engineering Science and Engineering Design is required, both of which directly involve the application of knowledge.

2.4 Communication Skills

The Faculty requires students to communicate information, arguments and analysis accurately and reliably, orally and in writing, to specialist and non-specialists audiences. The requirement for courses with substantial engineering design that are required across all programs require a series of technical reports and presentations with direct involvement with our Engineering Communication Program. In addition, our Capstone Design Courses and research theses all involve a written report and most involve oral presentations. The course requirements for instruction in Complementary Studies also adds to the education our students receive in communication skills. Also, the English Proficiency requirement insures a minimum level of writing ability for all graduates.

2.5 Awareness of Limits of Knowledge

Each POSt develops, through a sequence of courses starting at the 100-series or 200-series and culminating at the 300-series or 400-series or 500-series of courses, an understanding of a discipline as it is currently appreciated by educators who are at the same time involved in

original scholarship in the subject area. The course content at the upper series level is designed, in part, to provide students with an appreciation of the uncertainties, ambiguities and limitations of knowledge in the specific area.

2.6 Autonomy and Professional Capacity

The development of an awareness and understanding of professional practice is required for all POSt. The required design courses require students to work in teams and also accept responsibility for their own contributions. Students are required to make their own decisions for their own learning through selection of their technical and nontechnical electives. Finally, in completing their course requirements, the Faculty expects strict adherence by students to the Code of Behaviour on Academic Matters, which requires students to not tolerate or encourage the creation of an environment of cheating, misrepresentation or unfairness.

2.7 Other Degree Level Expectations

The Faculty requires all students to have developed competency in several areas of learning and applying knowledge not identified explicitly in the previous sections. In particular, the Faculty requires students to have developed competencies in quantitative reasoning and in information literacy.

Quantitative reasoning is considered the ability to identify, assemble and interpret quantitative information and make and test hypotheses based on such data. Development of this competency is an explicit part of all POSts offered by the Faculty.

The Faculty requires all students to develop an advanced understanding of how to obtain information, manipulate and evaluate it and bring diverse sources together to develop a comprehensive understanding of specific issues, solve problems or apply the scientific method to create further knowledge in the discipline. These advanced information literacy skills are developed through the studies in their concentration(s) and are demonstrated in the advanced courses required in each POSt.

Appendix C: Current Calendar Copy with Changes Tracked or Highlighted

The Undergraduate Bioengineering Minor is a collaborative effort across the Faculty of Applied Science and Engineering and is open to engineering students interested in learning more about biology and its breadth of application to engineering. Our definition of bioengineering is broad, reaching to all areas at the interface of engineering and biology. The minor provides in-depth knowledge from molecular and cell scale engineering, manufacturing of biosystems and devices, to translation of technologies ranging from sustainable energy and renewable bioproducts to patient care. All undergraduate engineering students except students in Engineering Science's Biomedical Systems Engineering major are eligible to participate in this minor course of study.

Further information on the minor can be found at www.minors.engineering.utoronto.ca.

Requirements for the Minor in Bioengineering

The requirements for a Bioengineering Minor in the Faculty of Applied Science and Engineering are the successful completion of the following courses:

1. CHE353H1 OR BME205H1** (0.5 FCE)

2. Choose at least 1 course (0.5 FCE):
    a. BME412H1, recommended for Biomedical Engineering pathway
    b. BME455H1, recommended for both pathways
    c. BME331H1, recommended for Biomedical Engineering pathway
    d. CHE354H1, recommended for Bioprocess Engineering pathway

   Although students are required to only complete 1 out of the 4 courses listed above, it is highly recommended to complete 2 of the above courses if scheduling permits.

3. Choose at least 1 course (0.5 FCE):
    a. BME498Y1 #
    b. Departmental Thesis (requires approval of Minor Director from BME (Biomedical pathway) or CHE (Bioprocess Pathway))#
    c. BME440H1
    d. CHE450H1

4. Choose up to three electives as needed to bring the total to 3.0 FCE.
   Students may choose any of the below courses but those wishing to concentrate on a particular pathway are recommended to choose courses that fit within that category.

   Biomedical Engineering pathway:
   Courses relevant to the Biomedical Engineering pathway are further grouped into three themes: Molecular engineering, Cell and Tissue Engineering and Clinical Engineering:

a. *Molecular theme*: BME412H1X, BME440H1, BME595H1, CHE475H1, ECE448H1, MSE343H1, MSE440H1
b. *Cell & Tissue theme*: BME350H1, BME395H1, BME455H1, MIE439H1, MIE458H1, MIE520H1
c. *Clinical theme*: BME330H1, BME331H1, BME445H1, BME530H1, ECE446H1

Bioprocess Engineering pathway:
Courses relevant to the Bioprocess Engineering pathway are further grouped into two themes: Biomolecular and microbial engineering, and Biomanufacturing:

a. *Biomolecular and Microbial engineering theme*: CHE354H1, ECE448H1, BCH441H1, CHE471H1, BCB420H1, CHE4XXH1
b. *Biomanufacturing pathway theme*: CHE354H1, BME330H1, CHE450H1, CHE462H1, CHE475H1, CHE471H1, CHE564H1, CIV342H1, CIV541H1, MGY377H1, MSE343H1, MIE520H1

Additional elective courses: CHE416H1, CHM456H1, ECE331H1, ECE335H1, ECE431H1, ECE516H1, FOR308H1, FOR421H1, FOR424H1, FOR425H1, HMB201H1, HMB265H1, HPS318H1, HPS319H1, IMM250H1, MIE242H1, MIE343H1, MIE523H1, MIE561H1, PCL201H1, PCL302H1, PHL281H1, PSL300H1

**BME205 is only available for enrollment for Engineering Science students
Students wishing to register in BME498Y1Y must obtain approval from the Biomedical Engineering Undergraduate & Graduate Student Office. Some departments have agreed to accept BME498Y1Y in place of their program's capstone course (existing agreement for ChemE, ECE, MSE, ME. Alternatively, students who wish to count their departmental thesis or capstone design project towards the Bioengineering minor will be assessed on a case-by-case basis as is currently the case with Bioengineering and other minors.

		Lect.	Lab.	Tut.	Wgt.
One of:					
CHE353H1: Engineering Biology	F	2	-	2	0.50
BME205H1: Fundamentals of Biomedical Engineering	S	2	1.50	1	0.50
At least one of:					
BME331H1: Physiological Control Systems	S	3	1	1	0.50
BME412H1: Introduction to Biomolecular Engineering	F				
BME455H1: Cellular and Molecular Bioengineering II	F	3	1.50	1	0.50
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
At least one of:					

BME440H1: Biomedical Engineering Technology and Investigation	S	2	4	-	0.50
BME498Y1: Biomedical Engineering Capstone Design	Y				
CHE450H1: Bioprocess Technology and Design	F	3	0.66	1	0.50
Bioengineering-related capstone or thesis with Director's approval	F/S/Y				0.5 or 1.0
As needed to bring credit weight to 3.0:					
BME330H1: Patents in Biology and Medical Devices	S	3	-	-	0.50
BME350H1: Biomedical Systems Engineering I: Organ Systems	F	3	1	2	0.50
BME395H1: Biomedical Systems Engineering II: Cells and Tissues	F	2	1	2	0.50
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
BME530H1: Whole-Body Mechanics	S	3	2	-	0.50
BME595H1: Medical Imaging	F	2	3	1	0.50
CHE416H1: Chemical Engineering in Human Health	S	3	-	-	0.50
CHE450H1: Bioprocess Technology and Design	F				
CHE462H1: Food Engineering	S	3	-	1	0.50
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CHE564H1: Pulp and Paper Processes	S	3	-	1	0.50
CIV342H1: Water and Wastewater Treatment Processes	F	3	1	1	0.50
CIV541H1: Environmental Biotechnology	S	3	-	-	0.50
ECE331H1: Analog Electronics	F	3	1.5	1	0.50
ECE335H1: Introduction to Electronic Devices	F	3	-	2	0.50
ECE431H1: Digital Signal Processing	F	3	1.5	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
ECE516H1: Intelligent Imaging Processing	F	3	3	-	0.50
FOR308H1: Discovering Wood and its Role in Societal Development	F	3	-	1	0.50
FOR421H1: Green Urban Infrastructure: Sustainable City Forests	F	2	-	-	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50

FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50
MIE242H1: Psychology For Engineers	F	3	3	-	0.50
MIE343H1: Industrial Ergonomics and the Workplace	F	3	3	-	0.50
MIE439H1: Cell and Tissue Mechanics	F	3	2	-	0.50
MIE458H1: Biofluid Mechanics	F	3	-	1	0.50
MIE520H1: Biotransport Phenomena	F	3	-	1	0.50
MIE523H1: Engineering Psychology and Human Performance	F	3	3	-	0.50
MIE561H1: Healthcare Systems	S	3	-	2	0.50
MSE343H1: Biomaterials	F	3	-	1	0.50
MSE440H1: Biomaterial Processing and Properties	F				
BCB420H1: Computational Systems Biology	S	2	-	2	0.50
BCH441H1: Bioinfomatics	F	2	-	1	0.50
CHM456H1: Organic Materials Chemistry	S	2	-	-	0.50
HMB201H1: Introduction to Fundamental Genetics and its Applications	S	2	-	1	0.50
HMB265H1: General & Human Genetics	F	2	-	1	0.50
HPS318H1: History of Medicine I					
HPS319H1: History of Medicine II	S	-	-	-	0.50
IMM250H1: The Immune System & Infectious Disease	S	-	-	-	0.50
MGY377H1: Microbiology I: Bacteria	F	3	-	-	0.50
PCL201H1: Introduction to Pharmacology and Pharmacokinetic Principles	S	3	-	1	0.50
PCL302H1: Introduction to Pharmacology: Pharmadynamic Principles					
PHL281H1 (formerly PHL281Y1): Bioethics	S	-	-	-	0.50
PSL300H1: Human Physiology I	F	3	-	1	0.50

NOTE:

1. BME205H1, BME350H1 and BME395H1 are only open to Engineering Science Students.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3710 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (February 1, 2022)
Faculty Council (February 18, 2022)

From: Professor Evan Bentz
Chair, Undergraduate Curriculum Committee

Date: January 24, 2022; revised February 4, 2022

Re: Proposed Session Dates for the 2022-2023 Academic Year

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a regular motion (requiring a simple majority of members present and voting to carry).

BACKGROUND

The Undergraduate Curriculum Committee (UCC) is comprised of faculty representatives from undergraduate programs; undergraduate student representatives; the Vice-Dean, Undergraduate Studies; The First Year Office; the Associate Dean, Cross-Disciplinary Programs; and the Registrar. The Committee meets regularly to review and approve proposed changes to the undergraduate curriculum. This time the dates from the Faculty of Arts & Science are not yet available and thus the UCC voted on the start date for January 2022. Thursday Jan 5th received the majority of the votes partly as it allows a longer exam period in April.

The Undergraduate Curriculum Committee is responsible for determining session dates for each academic year through consultation with the Colleges and Residences, as well as with the University holiday schedule.

Proposed Engineering Session Dates for 2022-2023

	Engineering – Jan 5 Winter Start	**Arts and Science****
Labour Day	September 5th	September 5th
First day of fall classes	September 8th	September 8th
Thanksgiving	October 10th	October 10th
Fall Reading Week	November 7th to November 11th	November 7th to November 11th
Last day of fall classes	December 7th	December 7th
Number of instructional days	59 or 60 (depending on Makeup Monday*)	-
Exam Study Day / Makeup Monday*	December 8th	December 8-9th
Fall exams start	December 9th	December 10th
Fall exams end	December 20th	December 20th
Fall Emergency Exam Day	January 7th, 2023	January 14th 2023
First day of winter classes	January 5rd, 2023	January 9th 2023
Reading Week	February 20th to February 24th	February 20th to February 24th
Good Friday	April 7th	April 7th
Last day of classes	April 12th	April 6th
Number of instructional days	64 days/12.8 weeks	-
Winter study days, including Exam Jam	April 13th	April 10th
Winter exams start	April 14th	April 12th
Winter exams end	April 28th	April 28th
Winter Emergency Exam Day	April 29th	April 29th
FAS Exams and Engineering Lectures Overlapping Period	April 10th – April 12th	

* Makeup Monday is an optional day of Monday classes on Thursday December 8th that instructors can use to compensate for the Thanksgiving Monday holiday.
** FAS dates not confirmed by FAS as of Feb 4th 2022

Proposed APSC Session Dates for Summer 2022

	Engineering T-Program	Engineering	Arts and Science**
First day of lectures (F and Y session course)	May 5th, 2022	May 5th, 2022	May 9th, 2022
Victoria Day	May 23rd	May 23rd	May 23rd
Last day of lectures for F session courses/(Y pause)	June 21st	June 21st	June 20th
Makeup Class	-	-	-
F session course Study Break	June 22nd	June 22nd	June 21st
Exam Period for F Session Course	June 23-29th	June 23-29th	June 22nd – 24th
UofT President's Day Closure	June 30th	June 30th	June 30th
Deferred Exams	-	-	-
Canada Day	July 1st	July 1st	July 1st
First day of lectures for S session course	July 4th	July 4th	July 4th
Civic Holiday	August 1st	August 1st	August 1st
Last day of lectures for S and Y session course	August 17th	August 17th	August 15th
FAS Makeup Class	-	-	-
Study Break	August 18th	Aug 18th	August 16th
Exam Period for S and Y session courses	August 19th – August 24th	August 19th - August 24th	August 17th - August 30th
Deferred Exam	-	-	August 26th – August 30th

** FAS dates not confirmed by FAS as of Feb 4th 2022

The Office of the Vice Provost, Students, compiles a list of dates for religious observances which may require accommodation. The dates for the 2022-2023 year can be found at: https://www.viceprovoststudents.utoronto.ca/policies-guidelines/accommodation-religious/.

PROGRAM

All programs are involved in these changes, and the impact on students in the various programs has been considered.

RECOMMENDATION

FOR COUNCIL

THAT the session dates for the 2022-2023 academic year be approved as described in Report 3710 Revised.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3711

MEMORANDUM

To: Executive Committee of Faculty Council (February 1, 2022)
Faculty Council (February 18, 2022)

From: Professor Evan Bentz
Chair, Undergraduate Curriculum Committee

Date: January 24, 2022

Re: **Major Curriculum Changes for the 2022-2023 Academic Year**

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a regular motion (requiring a simple majority of members present and voting to carry).

SUMMARY

The Undergraduate Curriculum Committee is tasked with managing the curriculum change process for the Faculty. This report summarizes additional course changes proposed for the 2022-2023 academic year.

PROCESS AND CONSULTATION

These changes have been reviewed and approved by the Undergraduate Curriculum Committee, which is comprised of faculty representatives from undergraduate programs; undergraduate student representatives; the Vice-Dean, Undergraduate Studies; The First Year Office; the Associate Dean, Cross-Disciplinary Programs; and the Registrar. The Committee meets regularly to review and approve proposed changes to the undergraduate curriculum. The impact of these changes on students in the relevant programs has been considered.

RECOMMENDATION FOR COUNCIL

THAT the proposed curriculum changes for the 2022-2023 academic year, as described in Report 3711, be approved.

PROPOSED CURRICULUM CHANGES

1. CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

1.1. Create new course **CHE408H1:** Data Analytics for Prediction, Control, and Optimization of Chemical Processes Elective 3/1/0

- **Proposed Calendar Entry**: Provides an industry-oriented approach of data analytics for chemical process engineers, including data acquisition methods and data sources, exploratory data analysis and sensitivity analysis, data-based modelling for prediction, data-based modelling for monitoring and control, and data-based optimization.
- 3 hours lecture, 1 hour tutorial per week.
- Prerequisites: APS106, CHE223, CHE322, CHE324 or equivalent

1.2. Create new course **CHE504H1f: Laboratory V** as a Tech Elective 0/0/6

- **Proposed Calendar Entry:** Involves experimental investigation in the application of physical chemistry, organic chemistry, inorganic chemistry, chemical pilot scale-up, chemical separation, chemical purification, data acquisition, etc. in chemical production.
- 6 hours practical per week.
- **Proposed Course Summary:** This course involves the operation of pilot-scale equipment to investigate common chemical process problems. Experimental investigation Students need to apply and integrate core engineering concepts/principles including fluid statics/dynamics and mechanical systems, thermodynamics and phase equilibria, thermochemistry and kinetics, and separation techniques to solve common unit operation/chemical process issues. In addition, common process design software including Aspen Plus, Computational Fluid Dynamics, and Distributed Control Systems such as Delta-V, and Computer Aided Design are used for problem solving and scale-up design process. Students will work as teams to complete projects involving the use of bench and pilot scale equipment, and simulation programs. Course projects will continue developing student's experimental and design skills; communication skills; critical thinking, problem-solving, and analysis skills.
- Prerequisites: CHE204, CHE205, CHE304, CHE305 or equivalent

2. BIOMEDICAL ENGINEERING

2.1. Remove prerequisite from **BME331**: Physiological Control Systems

- Course no longer depends on content from CHE353H1 according to course instructor so prerequisite can be removed.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3714 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (February 1, 2022)
Faculty Council (February 18, 2022)

From: Professor Julie Audet
Chair, Engineering Graduate Education Committee (EGEC)

Date: January 28, 2022; revised February 1, 2022

Re: EGEC Information Update

REPORT CLASSIFICATION

This is a routine or minor policy matter that has been approved by the Engineering Graduate Education Committee on behalf of Faculty Council[1]. It will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for information.

MAJOR MODIFICATION (to a program in the Faculty of Arts and Science which will impact the Faculty of Applied Science and Engineering)

Master of Science in Applied Computing (MScAC) (offered through the Department of Computer Science)	Creation of a new concentration in Artificial Intelligence (AI) in partnership with the Department of Statistical Sciences and the Faculty of Applied Science and Engineering (FASE). See Appendix I.

RECOMMENDATION FOR FACULTY COUNCIL

For information.

[1] As a result of the 2005 Task Force on Graduate Education at the University of Toronto, EGEC has delegated authority to "consider and approve on behalf of Faculty Council and/or recommend to Faculty Council and/or SGS, matters relating to graduate curriculum, policy, new initiatives, program and course changes".

University of Toronto
Major Modification Proposal:

New Field or Concentration Within an Existing Graduate Program

Program:	Master of Science in Applied Computing (MScAC) (offered through the Department of Computer Science)
Existing fields or concentrations:	Data Science, Applied Math, Quantum Computing
Proposed new field or concentration:	Artificial Intelligence (AI), Master's
Unit (if applicable):	Department of Computer Science in partnership with Department of Statistical Sciences, and Faculty of Applied Science and Engineering (FASE).
Faculty/academic division:	Faculty of Arts and Science (FAS) Faculty of Applied Science and Engineering (FASE).
Dean's office contact:	Antoinette Handley (Vice-Dean Graduate) / Sharon Kelly (staff)
Graduate unit contact:	Arvind Gupta, Annie En-Shiun Lee
Version date:	January 28, 2022

Summary

We propose a new concentration, Artificial Intelligence (AI), as part of the current Master of Science in Applied Computing (MScAC). The MScAC is offered through the Department of Computer Science (DCS), and the new Artificial Intelligence concentration will be offered in partnership with the Department of Statistical Sciences (DoSS) from the Faculty of Arts and Science (FAS), and the Faculty of Applied

Science and Engineering (FASE). Interested students will apply to the MScAC-AI concentration through the Department of Computer Science in the Faculty of Arts & Science.

The MScAC program began in 2010 and subsequently built concentrations in Data Science [DS] (introduced in 2017 jointly with the Department of Statistical Sciences); Applied Math [AM] (2019 jointly with Department of Mathematics), and Quantum Computing [QC] (2020 jointly with the Department of Physics). Interest from industry and students for the MScAC program has far exceeded the most optimistic projections. Recently, Forbes recognized the MScAC Data Science concentration as one of "The 10 Best Artificial Intelligence and Data Science Master's Courses For 2021". Leveraging the success of the program and the positioning of University of Toronto (U of T) as one of the best universities for AI research in the world, we propose to build an Artificial Intelligence concentration within the MScAC program.

The proposed AI concentration reflects the university's strength in Artificial Intelligence as the birthplace of Deep Learning through the work of Turing Award winner Geoffrey Hinton. In recognition of the increasing importance of many aspects of AI , curricular development in this area is critical to the research and training missions of these units. Leveraging faculty strength in this area is also aligned with the University's ambitions to become the global leader in Artificial Intelligence.

The demand for trainees with an expertise in Artificial Intelligence has become acute, as massive computational power and data storage became ubiquitous and simple to acquire. The proposed concentration in Artificial Intelligence builds on the current MScAC infrastructure by bringing in expertise from Artificial Intelligence, to meet:

1. Current student needs for master's level education in Artificial Intelligence;
2. Industrial demand for Artificial Intelligence experts (i.e., scientists, researchers, engineers);
3. Student demand for research experience with firms addressing significant challenges using techniques in Artificial Intelligence; and
4. UofT's burgeoning research emphasis in Artificial Intelligence.

Effective Date

Effective September 1, 2022. In-progress students who have taken the required coursework will be allowed to switch to the concentration as of September 1, 2022.

Academic Rationale

Artificial Intelligence (AI) germinated from a desire to imitate human behaviours with computational means. While much of AI is centered in Computer Science, the field draws on tool, techniques, and expertise from many disciplines including statistics, mathematics, and engineering. Today, AI includes intellectual focus such as knowledge representation, probabilistic and statistical theory, machine learning (deep learning), computational linguistics and natural language processing, computer vision, and robotics; AI is also being applied to a wide range of scientific domains, from medicine to the humanities. The efficacy of AI is embraced in industry as we witness rapid adoption from recommenders in e-commerce to self-driving vehicles in transportation. The COVID pandemic has accelerated this demand, as nearly every facet of human endeavour becomes digitally enabled. As such, there is an increasing need for automating processes, analyzing massive datasets, and modeling human tasks. Clearly this need will continue to grow, a trend that will substantially expand the need of the Artificial Intelligence expert.

An AI expert requires proficiency in AI techniques and methods; training in data management and distributed computing; and experience in scientific or industry collaboration. The proposed concentration in AI is unique at the University of Toronto and would become the pre-eminent program in Canada due to the strength and expertise in the partnering academic units. In addition, the fast-growing AI ecosystem in the Greater Toronto Area and the unrivalled wealth of potential collaborators in hospitals, research labs, and other entities would further enhance the quality and the attraction of the program. Note that many other institutions are also introducing graduate level programming in AI. For example, the University of Montreal, Carnegie Mellon University, and Northeastern University all offer several pathways to professional graduate-level education in AI. However, this MScAC concentration would be unique in offering industry-oriented applied research opportunities between collaborating faculties.

Currently, at the undergraduate level, the Department of Computer Science offers a focus in AI as part of its majors while the FASE offers a minor in AI engineering and a certificate in AI engineering. At the graduate level, students may choose to undertake research in AI through the research-based MSc or PhD programs or through an AI emphasis applied to areas such as in Health Policy, Management and Evaluation or Public Health. However, there are no disciplinary focused AI programs at the graduate level in either FAS or FASE. The structure of the MScAC program can readily accommodate a concentration in AI, and the curricular demand for training AI is best met through an AI concentration offered through the MScAC program.

This proposed new concentration within the current MScAC is characterised by the strong involvement of academic units within FAS and FASE that are responsible for a significant portion of the curriculum. This concentration also enhances and complements the current concentrations in the MScAC program. The concentration bears the name of the broad discipline of Artificial Intelligence, which couples interest from students for training in advanced computing, statistics, and engineering. With the growing demand for roles in industry with increasingly more sophistication in AI methodologies, this calls for customized curricula and training within the overall framework of the general MScAC program for an AI Concentration.

In summary, the massive growth in computational power, dataset availability, and problem complexity encountered by practitioners and researchers has been accompanied by increasing demand for specialized expertise lying at the interface of computational, statistical, and engineering sciences. This need is acutely felt in finance, life sciences, material sciences, and other crucial applications as the AI models used required either increased complexity or fundamentally different ways of problem solving. The partnership proposed for the AI concentration creates a seamless ecosystem that allows students to study AI from the vantage point of each of these disciplines. We believe that the proposed concentration will help meet demand, further integrating the activities between the partnering academic units, elevate the quality of training within those units, and align with the University's ambitions in and commitments to Artificial Intelligence.

Need and Demand

Media reports constantly remind us of the emergence of large-scale complex problems in nearly every facet of life. These reports speak to the already enormous demand for expertise at the interface of technology in society and the growing opportunities for employment.

Nearly 50% of applications to the MScAC program indicate strong interest in AI. While students in the program could take relevant AI courses and strive to secure an AI research project, we believe this concentration will:

- Bring together expertise from across campus to build a focal point for AI teaching;
- Act as a clear marker for industry to secure AI talent;
- Pool resources in various academic units to enhance AI offerings;
- Clearly demarcate students interested in AI who could then have some priority in securing seats in graduate level AI courses in FAS and FASE; and
- Establish U of T as a centre for applied AI research and training.

We note that this concentration is part of the strategy for planning and forecasting the course and supervisor capacity in AI graduate education to better plan for ongoing demand.

In addition to the flow of student interest in AI, industrial demand for AI experts also contributes to the advancement of this field. This demand is highly evident in the MScAC program. MScAC has a long list of employers interested in engaging AI talent including Layer 6 AI, Modiface, Samsung AI Research, Vanguard, SOTI, and a long list of many more. This is not a fleeting trend. There has been a massive increase in companies looking to establish AI capabilities by engaging an AI proficient workforce. As an exciting kick-off to the 2022 new year, Forbes has named Toronto as the most important AI hub (#8 in the 10 AI Predictions for 2022). With Toronto as a global centre for AI research, it is little wonder multinational firms are establishing AI labs in the city while there is a burgeoning AI start-up and SME ecosystem within the Greater Toronto Area.

Table 1: Graduate Enrolment Projections*

Year in Program	Academic Year 2021-22			Academic Year 2022-23			Academic Year 2023-24			Academic Year 2024-25			Academic Year 2025-26		
	Total #	# in Conc	# Dom.	Tot #	# in Conc	# Dom	#	#	#	#	#	#	#	#	#
1	79	0	15	90	30	20	105	35	25	120	40	30	135	45	35
2	64	0	22	79	15*	15	90	30	20	105	35	25	120	40	30
Total	143	0	37	169	45	35	195	65	45	225	75	55	255	85	65

*reflects current MScAC students who can choose to opt into the AI concentration with the approval of the MScAC director.

Students admitted into the concentration will apply directly to the concentration through the MScAC program (i.e., the concentration is not open to students enrolled in Statistical Sciences or FASE graduate programs).

Notes:

1. Number of domestic students is an estimate of domestic enrolment across all MScAC concentrations (i.e. not just only the AI concentration). Traditionally about 35% of MScAC enrolments have been domestic but COVID seems to have disrupted this. We are projecting those domestic students will comprise a larger share of students going forward but not back to the pre-COVID numbers.
2. We are aware that some students who began the program in September 2021 may wish to be in the AI concentration once approved. We are providing an estimate of the number of such requests that may be granted in Summer, 2022. There is no material impact on the program for granting such a request since those students must show they will have fulfilled the academic requirements for this concentration by December 2022.
3. Admission targets in the table are conservative, based on:

a. Staffing: We are in discussions with FAS to expand the MScAC team commensurate with growth in the program.

b. Faculty supervision and available seats in courses: Targets are set in consultation with each partner department. We are being conservative in projecting the numbers in the table.

c. Space to house students: The program is housed at 700 University. There are currently 135 dedicated desks for MScAC and we plan to assign these to incoming students in first year (row marked as 1 for Year in the Program) since second year students will be spending the majority of their time at their internship and thus are not assigned seating (row marked as 2 for Year in the Program).
d. New concentrations: Discussions are on-going to build four additional concentrations. This may expand the partnership to additional departments which would increase resources and allow the program to expand further.
e. Quality of Applicants: Admission targets may not be met if there are insufficient applicants who meet the quality standards of the program.

These projections are commensurate with known demand. For example, the AI sector in Toronto has seen a rapid increase in demand for AI Experts in recent years. For the 2019 MScAC cohort, 41/54 (77%) of the internship projects involve some aspect of AI or Data Science; for the 2020 cohort, this demand has increased to 52/64 (81%). Student demand for AI courses also continues to increase.

Admission Requirements

Students entering the Artificial Intelligence concentration of the MScAC program at the University of Toronto will register in the Department of Computer Science. The minimum admission requirements listed below are consistent with those criteria in the Department of Computer Science MSc program, and are similar to those of the current MScAC program concentrations.

Minimum Admission Requirements:

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.
- An appropriate bachelor's degree from a recognized university in a related area such as physics, computer science, mathematics, statistics, engineering, or any discipline where there is a significant quantitative component. The completed bachelor's degree must include significant exposure to computer science or statistics or engineering including coursework in, calculus, linear algebra, probability and statistics,

programming languages, and computational methods as well as data structures and algorithms and computer systems.

- A standing equivalent to at least B+ in the final year of undergraduate studies.
- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores: Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections. IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of reference from faculty and/or employers, with preference for at least one such letter from a faculty member in Artificial Intelligence.
- Answers to four questions explaining applicant's interest in Artificial Intelligence and objectives for the program.
- Applicants must indicate a preference for a concentration in AI in their application. Admission to the AI concentration is on a competitive basis. Students admitted to the MScAC program are not automatically admitted to the AI concentration upon request.

As noted in the minimum admission requirements, admission to the AI Concentration is competitive. Achievement of the minimum standards does not guarantee admission into the program. Those accepted will normally have achieved a standing considerably higher than the minimum B+ standing and/or have demonstrated exceptional ability through appropriate workplace experience.

6 Program Requirements

Program Requirements

- **Coursework.** Students must successfully complete a total of **3.0 full-course equivalents (FCEs)** as follows:
  - 1.5 FCEs of coursework in the area of Artificial Intelligence
    - 1.0 FCE selected from the core list of AI courses (see list below)[1] from at least two different research areas
    - 0.5 FCE selected from additional AI courses outside the core list.
- 1.0 FCE in required courses:
  CSC2701H *Communication for Computer Scientists* (0.5 FCE)
  CSC2702H *Technical Entrepreneurship* (0.5 FCE)
- The remaining 0.5 FCE of coursework will be chosen from outside of AI.
  - Course selections should be made in consultation with and approved by the Program Director. Appropriate substitutions may be possible with approval.
  - A maximum of 1.0 FCE may be chosen from outside the Computer Science (CSC course designator) graduate course listings.
- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.

Please see Appendix B for a full list of the course numbers and titles. Note that these are existing courses offered by the participating departments. The creation of the AI concentration does not, has prompted the cross-listing of a new cross-listing of a robotics course at the graduate level. Students enrolled in the AI concentration will select existing courses from the Department of Computer Science, Department of Statistical Sciences, and Faculty of Applied Science and Engineering.

The AI concentration program requirements follow the structure of the existing MScAC program. The existing program and new concentration are designed as a 16-month (4 session, F/W/S/F) full-time program comprised of 4 half courses (2.0 FCEs) that will be completed in 8-months (2 sessions), 2 required courses in technical communications and entrepreneurship (1.0 FCE) and an 8-month (2 session) industrial internship (3.5 FCE).

Students in the new AI concentration, like those in the existing MScAC program, follow a course of study that is fully integrated; course projects and assignments will be designed to integrate the material learned from a variety of the courses and to utilize it in a practical context. Excellent communication and presentation skills will be emphasized in both the oral and written components of the projects and assignments. The program contains an 8-month internship component from May – December. The students will enter the internship immediately after coursework is completed at the end of the Winter term.

The required course work can be completed during the regular academic year. The course load of two half courses per session is identical to that of the current MScAC program.

In addition to the 4 half courses taken during the first 2 sessions, an additional two specialized half courses (in Technical Communication, and in Technical Entrepreneurship) are required. One of these courses is taken during the first eight months of the student's study, while the other is taken during the eight-month internship period.

Whereas the Province's Quality Assurance Framework requires that students complete a minimum of 2/3 courses at the graduate level, the University of Toronto requires graduate students to complete all their course requirements from amongst graduate level courses. This proposed AI Concentration complies with this requirement.

Among the total 2.0 FCEs, a minimum 1.0 FCE will come from the Computer Science graduate course listings, while a maximum of 1.0 FCE may be taken outside of Computer Science. Course selection must be approved by the program director.

Within the MScAC program support for establishing and maintaining industrial partners for internships is key to attracting students. The internship provides a critical experiential learning component, and helps students improve their communication skills. Students will not only gain practical experience in knowledge and technology transfer but will also have access to well-trained professional support staff in their

[1] Please refer to the proposed SGS calendar copy in Appendix A to see the list of core courses that students can choose from.

host company to realize their vision and make further connections in industry. An internship will be required for all students in the AI Concentration. This concentration would make MScAC interns even more attractive to employers.

For academic supervision, students in the AI concentration may choose a supervisor from any of the partner academic units (DCS, DoSS, FASE). Supervisors from other units may be chosen with approval of the program director. Note that the selection of an appropriate academic supervisor is facilitated by the program director once the student has accepted a qualifying internship placement.

All students in the MScAC, including students in the new concentration, receive individualized advising to ensure that they select courses that a) meet the program requirements, including any requirements specific to the concentration; b) have sufficient academic preparation for each course; and c) support their professional goals.

Students currently enrolled in the MScAC program may, as of September 2022, apply to join the AI concentration and will be considered on a case-by-case basis.

Degree Level Expectations (DLEs), Program Learning Outcomes and Program Structure

Table 2: Master's DLEs

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
Expectations: This AI Concentration in the MScAC program is awarded to students who have demonstrated:		
Depth and Breadth of Knowledge A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of the academic discipline, field of study or area of professional practice.	Depth and breadth of knowledge is understood in the MScAC program as the ability to explore, manipulate, and visualize complex data and models into informed decisions. This is reflected in students who are able to: • Use advanced problem-solving skills utilizing appropriate computational tools. • Perform deep quantitative analysis of a given problem across a variety of domains.	Students will be able to understand the concepts of AI; use a variety of computational resources; and develop new AI algorithms to fit specific application areas. Relevant AI courses include: CSC2515 - Introduction to Machine Learning ECE1513 - Introduction to Machine Learning CSC2516 - Neural Networks and Deep Learning MIE1517 - Introduction to Deep Learning CSC2502 - Knowledge Representation & Reasoning CSC2533 - Foundations of Knowledge Representation CSC2503 - Foundations of Computer Vision

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
	• Use abstract reasoning and demonstrable critical and logical thinking.	ECE1512 - Digital Image Processing and Applications CSC2501 - Computational Linguistics CSC2511 - Natural Language Computing AER1513 - State Estimation for Aerospace Vehicles (State Estimation for Robotics) AER1517 - Control for Robotics CSC2630 - Introduction to Mobile Robotics The program design and requirement elements that ensure these student outcomes for depth and breadth of AI knowledge are the CSC, STA and/or FASE graduate courses selected by the student, or relevant courses from other departments. This includes 1.5 FCEs of coursework in the area of Artificial Intelligence with 1.0 FCE selected from the core list of AI courses (see list above) from at least two different research areas for breadth and 0.5 FCE

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	**Master's Program Learning Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
		selected from selected from additional AI courses outside the core list for depth.
Research and Scholarship A conceptual understanding and methodological competence that • Enables a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline. • Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence.	Research and Scholarship is defined in the MScAC program as the ability to abstract information. This is reflected in students who are able to: • Apply quantitative techniques to produce effective designs and solutions to a given problem. • Identify, analyze and synthesize scholarly literature relevant to the problem at hand. • Formulate hypotheses, and test these against given data. • Create, review, validate and refine quantitative models to validate hypotheses.	In achieving these learning outcomes, students in the Artificial Intelligence concentration will be able to • Define and describe AI techniques and where these differ from classical techniques, • Identify when where there is an advantage to using AI in the broader context of enterprise-wide AI efforts and algorithm development, • Formulate AI methods, spanning existing techniques and algorithms, which are tailored to new problems and applications, • Communicate models and their analysis to non-experts verbally and in written form.

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes

• Enables a treatment of complex issues and judgments based on established principles and techniques; and, on the basis of that competence, has shown at least one of the following:
  • the development and support of a sustained argument in written form; or
  • originality in the application of knowledge.
		The MScAC program offers professional courses (CSC2701 – Communication for Computer Scientists and technical entrepreneurship and business CSC2702 – Technical Entrepreneurship) designed to assist students in presenting themselves and their work as well as in scientific communications and business writing.
		
		The program requirements that ensure these student outcomes for research and scholarship come from coursework training – students must select courses that have been vetted for appropriate technical content. Relevant courses could include:
		CSC2416 - Machine Learning Theory
		CSC2506 - Probabilistic Learning, Uncertainty, and Reasoning
		CSC2518 - Spoken Language Processing
		CSC2523 - Object Modelling and Recognition
		CSC2528 - Advanced Computational Linguistics

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
		CSC2532 - Statistical Learning Theory CSC2534 - Decision Making Under Uncertainty CSC2539 - Topics in Computer Vision CSC2541 - Topics in Machine Learning CSC2542 - Topics in Knowledge Representation & Reasoning CSC2545 - Kernel Methods & Support Vector Machines CSC2547 - Current Algorithms and Techniques in Machine Learning CSC2548 - Machine Learning in Computer Vision CSC2556 - Algorithms for Collective Decision Making CSC2558 - Human Computation, Randomized A/B Experiments and Statistical Machine Learning CSC2559 / ECE1784 - Trustworthy Machine Learning CSC2606 - Introduction to Continuum Robotics CSC2621 - Topics in Robotics CSC2626 - Imitation Learning for Robotics

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	**Master's Program Learning Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
Level of Application of Knowledge Competence in the research process by applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting.	Level of application of knowledge is defined in the MScAC program as the ability for systematic inquiry involving the practical application of quantitative techniques in a professional setting (company site, hospital, etc.) during an applied research internship. This is reflected in students who are able to: • Demonstrate competence in applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting. • Deploy advanced theories, knowledge, methodologies, and techniques for a specific, often stated, business or client-driven challenge. • Showcase an ability to take unstructured problems and deploy empirical methodologies.	The program design and requirement elements that ensure these student outcomes for level of application of knowledge are: The application of research knowledge is assured through an industrial research internship that is jointly supervised by an academic AI expert and an industrial expert. During the internship, students will be required to apply their knowledge of AI to real-world problems in an industrial setting. Internships are carefully procured and are reviewed by the MScAC program to ensure students are presented with problems requiring quantitative solutions with insights coming from the capabilities of AI. The industry supervisor ensures problems are well formulated, and resources such as data are adequately provided while the academic supervisor is responsible for ensuring the student

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	**Master's Program Learning Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
		is utilizing advanced AI techniques and helps the student develop new techniques as needed.

Professional Capacity/Autonomy
 	
• The qualities and transferable skills necessary for employment requiring
  • the exercise of initiative and of personal responsibility and accountability; and
  • decision-making in complex situations;
	Professional capacity/autonomy is defined in the MScAC program as the qualities and transferable skills necessary for employment requiring the exercise of initiative and of personal responsibility and accountability; decision-making in complex situations; the intellectual independence required for continuing professional development; the ethical behaviour consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and the ability to appreciate the broader implications of applying knowledge to particular contexts.
	
	This is reflected in students who are able to:
	• Prepare written reports and deliver oral presentations to
		The program design and requirement elements that ensure these student outcomes for professional capacity/autonomy are:
		
		• The industrial research internship that focuses on the exploration of new or specific problems, coupled with the students' quantitative skills and statistical rationale all with the aim of solving practical issues in an environment requiring complex AI techniques.
		• In addition, as outlined in section 6, there is a special course on technical communications CSC2701 – Communication for Computer Scientists and technical entrepreneurship and business

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
• The intellectual independence required for continuing professional development. • The ethical behavior consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research. • The ability to appreciate the broader implications of applying knowledge to particular contexts.	expert (quantitative teams) and non-expert audiences (upper management) • Provide a holistic perspective on advanced problem solving utilizing quantitative techniques in industry problems in a real-world setting.	CSC2702 – Technical Entrepreneurship. This is a required course. • Students attend regularly scheduled meetings with both their academic and industrial supervisors and, at the industry site, with a broader team. • Students present their research findings to both their supervisors in a research report that is assessed for their ability to apply knowledge in a new and creative manner, for their intellectual independence, and their ability to abstract their own work into a broader setting.
Level of Communication Skills	Level of communication skills is defined in the MScAC program as the ability to communicate ideas, issues, and conclusions clearly.	The program design and requirement elements that ensure these student outcomes for level of communication skills are:

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
	This is reflected in students who are able to: • Construct a credible argument and present it in appropriate formats • Construct detailed research reports and executive summaries • Deliver professional presentations to expert (quantitative teams) and non-expert audiences (upper management)	• The required written report on the internship experience is designed for students to connect their course work with their industrial experience. • The oral presentation in front of faculty, industry experts and students will require students to discuss and critically assess their success at applying their academic knowledge to specific problems they encountered in their internship. In addition, as outlined in section 6, there is a special course on technical communications skills; CSC2701 – Communication for Computer Scientists. This is a required course.
Awareness of the Limits of Knowledge Cognizance of the complexity of knowledge and of the	This DLE and its PLOs are being developed through the current CSC UTQAP review.	Will be documented via the current CSC UTQAP review.

Master's Degree Level Expectations (Based on the Ontario Council of Academic Vice-Presidents [OCAV] DLEs)	Master's Program Learning Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
potential contributions of other interpretations, methods, and disciplines.		

Assessment of Teaching and Learning

- Please describe the methods of evaluation for the various program requirements as they relate to the proposed field or concentration.
- Describe how the methods for assessing student achievement are appropriate and effective relative to established program learning outcomes and DLEs (in other words, how will faculty be able to determine whether students have learned and can do what we expect them to by the end of the program).
- How will the program document and demonstrate the level of performance of students consistent with the University's DLEs?

Student performance in the program will be assessed through a variety of methods including reports, presentations, assignments, case studies, and exams. Students will receive letter grades for their performance in all courses except that CR/NCR is given for their written reports on industrial internship.

The MScAC program has several formal processes in place to ensure the quality and excellence of the student's performance at each stage in the program.
Entering students create a relevant study plan that is assessed for what they have already studied, what they plan to study, and then ascertain whether that meets the PLO's, program requirements, and the student's personal learning objectives. This study plan is assessed by the concentration lead who works with the students on refining it; the final plan is assessed by the program director and finally the DCS graduate chair.

There is also a formal process to ensure each of the procured internships contains an appropriate level of applied research for the program by three MScAC research and business development officers. Any revision request discrepancies are further assessed by the program director.

Lastly, the MScAC program has a formal review process to ensure that the MScAC academic requirements are met for each student. Three individuals must sign off on the final research report – the industry supervisor, the academic supervisor, and the program Director. The MScAC program will assess the final report to decide whether the final report should require minor revisions or major revisions.

Teaching and Learning Outcomes	Assignments	Projects	Exam	Presentations	Internship
1. Depth and Breadth of Knowledge					
Display expertise in AI methods and algorithms	Yes	Yes	Yes	Yes	Yes
Critically assess a problem that is complex and has alternative design approaches		Yes		Yes	Yes
Adjust communications to address different audiences	Yes			Yes	Yes
Identify key debates that result from conflicting practitioner/scientists/business views		Yes		Yes	Yes
2. Scholarship					
Conceptualize, design, implement an AI project	Yes	Yes		Yes	Yes
Make informed judgments on complex issues in the context of complex analysis	Yes	Yes	Yes	Yes	Yes
Articulate those strategies and judgments	Yes	Yes		Yes	Yes
3. Application of Knowledge					
Assess a complex problem from the viewpoints of practitioners/scientists/business	Yes	Yes			Yes
4. Professional Capacity					
Complete the degree requirements in a timely manner	Yes	Yes		Yes	Yes
Demonstrate project management skills	Yes	Yes		Yes	Yes
5. Communication Skills					
Communicate complex ideas effectively	Yes	Yes		Yes	Yes

Prepare reports and presentations that outline the problem, option, and solutions	Yes	Yes		Yes	Yes

Consultation

The proposed AI concentration is the result of a lengthy discussion with faculty members from various departments from FAS and FASE.
There has been broad consultation for the AI concentration within the Department of Computer Science. Starting in 2019, faculty in the Department began discussing the potential for a Masters in AI. In 2020, the DCS graduate affairs committee created a working group to consider how best to construct an AI concentration within the MScAC program. The working group concluded that we should explore a partnership with the Department of Statistical Sciences, and Faculty of Applied Science and Engineering (primarily but not exclusively with the Department of Electrical and Computer Engineering and the Department of Mechanical and Industrial Engineering). A working group of these four departments was established in Summer 2021, resulting in this major modification proposal. Additional consultations took place with current students and alumni of the MScAC program, the latter through the MScAC alumni association. A roundtable was held with industry partners in April, 2021 to discuss the concentration. This was followed by a focused roundtable in August, 2021 with AI leaders in the Toronto tech . All verified that an AI concentration would be extremely well received.

With respect to the broader University of Toronto community, we consulted with the Office of the Vice-Provost, Research and Innovation about broader research interests in AI at U of T. We also consulted with the Industry Partnership Office and verified they are also witnessing significant demand for advanced AI in the Toronto Information Technology ecosystem. We consulted with a number of other academic units, primarily through a Data Science working group established by the Faculty of Arts and Science. This consultation included representatives from the Faculty of Medicine, Faculty of Applied Science and Engineering, the Dalla Lana School of Public Health, as well as departments in FAS. This consultation allowed us to position the AI concentration and the existing MScAC Data Science concentration as unique and non-overlapping. A number of meetings have been held with the leadership in FASE

including with the Office of the Dean and with the Chairs of ECE and MIE. All were very supportive of jointly building this concentration.

We are cognizant that Artificial Intelligence is a strategic priority for the university and that a number of other academic units are planning to bolster their faculty complement in this area. This should create additional opportunities for partnership with the MScAC AI concentration. We welcome discussions with any academic unit that may be interested in participating in this concentration (or more broadly in the MScAC program).

Resources

As the program grows, there will be resource implications on various fronts.
The concentration will be housed within the MScAC space at 700 University and additional space needs will be minimal (see Space/Infrastructure section). There are currently 135 dedicated desks for MScAC and we plan to assign these to incoming first year students, since second year outgoing students will be at their internship location.

Administrative staffing will be handled by the MScAC program and will be funded through revenues from the concentration itself. No new central funds will be required as this is intended to be a self-sustaining concentration within the existing MScAC program. MScAC revenue consists of student tuition, ancillary fees, and funds from industry; these funds are sufficient to cover all incremental expenses.

Our research and business team procures and reviews applied research internships from industry partners to help match students to high quality research projects. Therefore, incremental increase of enrolment targets is retrospectively adjusted based on the number of internships seen in the previous year by the team. The research and business development team are starting to build demand outside the Greater Toronto Area; there should be significant potential in other major Canadian tech centres (Waterloo, Ottawa, Montreal, Vancouver, etc).
The internships are fully funded by the industry partner who will provide salary for the student, the project may also be eligible for MITACS funding. Our current relationship with Mitacs Inc indicates that these internships should qualify for partial funding under the Mitacs Accelerate Canada program, which would offset $10,000 of the employer's costs. Note that current average total compensation is $63,000 per

student over eight months. The MScAC provides a loan structure for those students who demonstrate need and students are able to pay back the loan based on their internship and post-graduate job.

The program will continue to communicate annually with each of the collaborating departments on available resources in supervision and seats in courses in order to project admission targets. The DoSS and FASE will contribute in course/teaching capacity (see Appendix B) and in supervisory capacity (see Table 4). The MScAC has developed a revenue sharing model across academic units facilitating students taking courses or being supervised outside DCS. Simultaneously, the working group that was formed for the AI Concentration composed of faculty members from both FAS and FASE will continue to meet annually to provide oversight on the AI course offerings, such as removing courses that are no longer offered and adding new courses to the list, and the curriculum more broadly.

Faculty Complement

The U of T Strategic Research Plan identifies artificial intelligence as one of the thematic areas for research excellence and collaboration due to U of T researchers being world-leaders in advancing artificial intelligence in areas such as computer vision, computational linguistic and natural language processing, knowledge representation and reasoning, cognitive robotics, and machine learning.
The concentration will require faculty expertise in various areas of AI as listed above and DCS is currently in the process of hiring several FTEs in the area of Artificial Intelligence. The Department of Chemical Engineering and Applied Chemistry has recently hired a faculty member in AI. There are faculty members working in AI or using AI in every FASE Department, with the advancement goal of having an AI/DS faculty member in each department. In the coming years, given the significant focus on AI within these departments and across the University, we expect additional faculty hiring in AI related areas, which will be in-sync with the expected growth rate of the proposed concentration: Knowledge Representation and Reasoning, Computer Vision and Computational Imaging, Systems, including Data Systems, Security and Cryptography, and Machine Learning with a focus on Deep Learning.

Table 4: Detailed Listing of Committed Faculty

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Arvind Gupta, Professor and Director of MScAC	*Computer Science, FAS	Innovation policy
James Stafford, Professor & Vice-Dean of Academic Operations	* Statistical Sciences, FAS	Data Science
Chris J. Maddison, Assistant Professor	*Computer Science, FAS *Statistical Sciences, FAS Vector Institute	Machine learning
Marsha Chechik, Professor & Chair	*Computer Science, FAS	Software engineering
Graeme Hirst, Professor & Graduate Chair	*Computer Science, FAS	Computational linguistics
Suzanne Stevenson, Professor & Vice Chair	*Computer Science, FAS	Computational linguistics
Sven Dickinson, Professor	*Computer Science, FAS Samsung Toronto AI Research Center	Computer vision
Michael Brudno, Professor	*Computer Science, FAS University Health Network Vector Institute	Computational medicine
Peter Marbach, Professor	*Computer Science, FAS	Social networks
Eyal de Lara, Professor, Associate Chair, Research	*Computer Science, FAS	Systems & mobile
Daniel Wigdor Professor Associate Chair, Partnerships and Innovation	*Computer Science, FAS Facebook Research Science	Input sensors

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Sam Toueg, Professor	Computer Science, FAS	Distributed computing
Richard Zemel, Professor	*Computer Science, FAS Vector Institute	Machine learning methods, with a specific focus on unsupervised learning, and probabilistic models of neural representations
Ravin Balakrishnan, Professor	*Computer Science, FAS	Human-computer interaction (HCI)
Geoffrey Hinton, Distinguished Emeritus Professor	*Computer Science, FAS Google Vector Institute	Machine learning
Anna Goldenberg, Associate Professor	Computer Science, FAS SickKids Research Institute Vector Institute	Machine learning
Allan Borodin, University Professor	*Computer Science, FAS	Theoretical computer science
Amir-Massoud Farahmand, Assistant Professor, Status-Only	Vector Institute Computer Science, FAS Mechanical and Industrial Engineering, FASE	Reinforcement learning
Sushant Sachdeva, Associate Professor	*Computer Science, FAS Vector Institute	Theoretical computer science
Frank Rudzicz, Associate Professor, Status-Only	St. Michael's Hospital Surgical Safety Technologies Computer Science, FAS	Computational linguistics
Fanny Chevalier, Assistant Professor	*Computer Science, FAS *Statistical Science, FAS	Information visualization
Igor Gilitschenski, Assistant Professor	*Computer Science, FAS	Robotics, computer vision
Florian Shkurti, Assistant Professor	*Computer Science, FAS	Robotics, computer vision

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Bo Wang, Assistant Professor	*Computer Science, FAS Vector Institute Faculty of Medicine University Health Network	Machine learning
David Duvenaud, Assistant Professor	*Computer Science, FAS	Machine learning
Daniel Roy, Assistant Professor	*Statistical Sciences, FAS *Computer Science, FAS Electrical and Computer Engineering, FASE	Machine learning
Sanja Fidler, Associate Professor	*Computer Science, FAS NVIDIA	Computer vision
Raquel Urtasun, Professor	*Computer Science, FAS Waabi Vector Institute	Autonomous driving
Jimmy Ba, Associate Professor	*Computer Science, FAS Vector Institute	Deep learning
Roger Grosse, Associate Professor	*Computer Science, FAS Vector Institute	Neural networks
Animesh Garg, Associate Professor	*Computer Science, FAS Mechanical and Industrial Engineering, FASE Vector Institute NVIDIA	Reinforcement learning, Robotics
Gerald Penn, Professor	* Computer Science, FAS	Spoken language processing
Alán Aspuru-Guzik, Professor	* Computer Science, FAS	Machine learning
Anthony Bonner, Associate Professor	* Computer Science, FAS	Machine learning
Steve Easterbrook, Professor	* Computer Science, FAS	Sustainability informatics

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Murat Erdogdu, Assistant Professor	* Computer Science, FAS	Machine learning
Nick Koudas, Professor	* Computer Science, FAS	Data management systems
Rahul G. Krishnan, Assistant Professor	* Computer Science, FAS	Computational medicine
Kyros Kutulakos, Professor	* Computer Science, FAS	Computer vision
David Lindell, Assistant Professor	* Computer Science, FAS	Computer graphics
Maryam Mehri Dehnavi, Assistant Professor	* Computer Science, FAS	Systems
Gennady Pekhimenko, Assistant Professor	* Computer Science, FAS	Computer architecture
Toniann Pitassi, Professor	* Computer Science, FAS	Theoretical Computer Science
Bianca Schroeder, Professor	* Computer Science, FAS	Computer systems
Nisarg Shah, Assistant Professor	* Computer Science, FAS	Theoretical computer science
Florian Shkurti, Assistant Professor	* Computer Science, FAS	Robotics, computer vision
Nandita Vijaykumar, Assistant Professor	* Computer Science, FAS	Computer architecture,
Joseph Jay Williams, Assistant Professor	* Computer Science, FAS	Computer science & education
Fahiem Bacchus, Professor	* Computer Science, FAS	Knowledge Representation
David Fleet, Professor	* Computer Science, FAS	Computer vision
Kyros Kutulakos, Professor	* Computer Science, FAS	Computer vision
Sheila McIlraith, Professor	* Computer Science, FAS	Knowledge representation and reasoning

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Jessica Burgner-Kahrs, Associate Professor	* Computer Science, FAS	Robotics
Ashton Anderson, Assistant Professor	* Computer Science, FAS	Computational social science
Parham Arabi, Associate Professor	* Electrical & Computer Engineering, FASE Founder & CEO ModiFace Inc	Internet Search
Ravi Adve, Professor	* Electrical & Computer Engineering, FASE	Wireless communications
Jason Anderson, Professor	* Electrical & Computer Engineering, FASE Chief Scientific Advisor and Co-Founder of LegUp Computing Inc.	CAD
Vaughn Betz, Professor	* Electrical & Computer Engineering, FASE Faculty Affiliate, Vector Institute for Artificial Intelligence	CAD
Paul Chow, Professor	* Electrical & Computer Engineering, FASE	Computer architectures
Stark Draper, Professor	* Electrical & Computer Engineering, FASE	Information theory
Brendan Frey, Professor	* Electrical & Computer Engineering, FASE CEO Deep Genomics	AI biology, medicine and healthcare
Dimitrios Hatzinakos, Professor	* Electrical & Computer Engineering, FASE Co-founder and Director of Identity, Privacy and Security Institute (IPSI)	Signal Processing
Ashish Khisti, Professor	* Electrical & Computer Engineering, FASE	Communication systems

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Deepa Kundur, Professor and Chaire	* Electrical & Computer Engineering, FASE	Cybersecurity
Alberto Leon-Garcia, Professor	* Electrical & Computer Engineering, FASE CTO of AcceLight Networks	Application platforms
Ben Liang, Professor	* Electrical & Computer Engineering, FASE	Networked systems
Xilin Liu, Assistant Professor	* Electrical & Computer Engineering, FASE	IC and system design
Mo Mojahedi, Professor	* Electrical & Computer Engineering, FASE	Electromagnetics
Kostas Plataniotis, Professor	* Electrical & Computer Engineering, FASE	Image/signal processing
Joanathan Rose, Professor	* Electrical & Computer Engineering, FASE	Applied mental health
Ervin Sejdic, Professor	* Electrical & Computer Engineering, FASE	Biomedical signal processing
Ali Sheikholeslami, Professor	* Electrical & Computer Engineering, FASE	Integrated circuits
Shahrokh Valaee, Professor	* Electrical & Computer Engineering, FASE	Wireless networks
Wei Yu, Professor	* Electrical & Computer Engineering, FASE	Network information theory
Shurui Zhou, Assistant Professor	* Electrical & Computer Engineering, FASE	Software collaboration
David Lie, Professor	* Electrical & Computer Engineering, FASE	Security
Andreas Moshovos, Professor	* Electrical & Computer Engineering, FASE	High-performance processor
Nicolas Papernot, Assistant Professor	* Electrical & Computer Engineering, FASE Faculty Member at the Vector Institute Canada CIFAR AI Chair	Security and privacy

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Christopher Lawson, Assistant Professor	* Chemical Engineering, FASE	Microbiome engineering
Arun Ramchandran, Associate Professor	* * Chemical Engineering, FASE	Microscale/nanoscale interactions
Edgar Acost, Professor	Chemical Engineering, FASE	Colloids and formulation engineering
Will Cluett, Professor	* Chemical Engineering, FASE	Process identification
Radhakrishnan Mahadevan, Professor	* Chemical Engineering, FASE	Systems biology
Christopher Yip, Professor and Dean	* Chemical Engineering, FASE	Molecular self-assembly
Tamer El-Diraby, Associate Professor	* Civil & Mineral Engineering, FASE	Asset management
Sebastian Goodfellow, Assistant Professor	* Civil & Mineral Engineering, FASE	Laboratory experimentation
Kamran Esmaeili, Associate Professor	* Civil & Mineral Engineering, FASE	Mining Engineering
Baher Abdulhai, Professor	* Civil & Mineral Engineering, FASE	Intelligent Transportation Systems
Michael Garton, Assistant Professor	* Institute of Biomedical Engineering, FASE	Computational protein design
Azadeh Kushki, Assistant Professor	* Institute of Biomedical Engineering, FASE	Pattern analysis and machine learning
Babak Taati, Assistant Professor	* University Health Network Institute of Biomedical Engineering, FASE Computer Science	Health & assistive technology
Azadeh Yadollahi, Assistant Professor (cross appointed)	* University Health Network Institute of Biomedical Engineering, FASE	Biological Systems
Rodrigo Fernandez-Gonzalez, Associate Professor	Institute of Biomedical Engineering, FASE	Cell coordination

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
José Zariffa, Associate Professor	* Institute of Biomedical Engineering, FASE	Rehabilitation technology
Jonathan Rocheleau	* Institute of Biomedical Engineering, FASE	Biological Interaction
Chirag Variawa, Assistant Professor Teaching Stream	* Institute for Studies in Transdisciplinary Engineering, FASE	Engineering Education
Yu Zou, Assistant Professor	* Materials Science & Engineering, FASE	Material Engineering
Kinnor Chattopadhyay, Associate Professor and Dean's Catalyst Professor	* Materials Science & Engineering, FASE	Material Engineering
Chandra Veer Singh, Associate Professor	* Materials Science & Engineering, FASE	Computational materials science
Jason Hattrick-Simpers, Professor	* Materials Science & Engineering, FASE	Corrosion Resistant Complex Alloy Coatings
Jonathan Kelly, Assistant Professor	* University of Toronto Institute for Aerospace Studies (UTIAS), FASE	Robotics
Angela Schoellig, Assistant Professor	* University of Toronto Institute for Aerospace Studies (UTIAS), FASE	Robotics
Tim Barfoot, Associate Professor	* University of Toronto Institute for Aerospace Studies (UTIAS), FASE	Robotics
Steven Waslander, Associate Professor	* University of Toronto Institute for Aerospace Studies (UTIAS), FASE	Autonomous driving.
Dionne M. Aleman, Associate Professor	* Mechanical & Industrial Engineering, FASE	Medical applications
Samin Aref , Assistant Professor, Teaching Stream	* Mechanical & Industrial Engineering, FASE	Data science

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Fae Azhari, Assistant Professor	* Mechanical & Industrial Engineering, FASE	Structural health monitoring
Christopher Beck, Professor	* Mechanical & Industrial Engineering, FASE	Optimization
Kamran Behdinan, Professor	* Mechanical & Industrial Engineering, FASE	Multidisciplinary Engineering Design
Beno Benhabib, Professor	* Mechanical & Industrial Engineering, FASE	Robotics
Amy Bilton, Associate Professor	* Mechanical & Industrial Engineering, FASE	Energy systems
Merve Bodur, Assistant Professor	* Mechanical & Industrial Engineering, FASE	Optimization
Michael W. Carter, Professor	* Mechanical & Industrial Engineering, FASE	Healthcare resourcing
Timothy C. Y. Chan, Professor	* Mechanical & Industrial Engineering, FASE	Operations research
Mark H. Chignell, Professor	* Mechanical & Industrial Engineering, FASE	Human factors
Eldan Cohen, Assistant Professor	* Mechanical & Industrial Engineering, FASE	Machine learning
Sinisa Colic, Assistant Professor, Teaching Stream	* Mechanical & Industrial Engineering, FASE	Mental Health
Mariano P. Consens, Associate Professor	* Mechanical & Industrial Engineering, FASE	Data management
Eric Diller, Associate Professor	* Mechanical & Industrial Engineering, FASE	Micro-scale robotics
Birsen Donmez, Professor	* Mechanical & Industrial Engineering, FASE	Human factors
Mark S. Fox, Professor	* Mechanical & Industrial Engineering, FASE	Reasoning
Daniel M. Frances, Professor, Teaching Stream	* Mechanical & Industrial Engineering, FASE	Simulation techniques

Faculty Name and Rank	Home Unit (*) & Major Affiliations	Area(s) of Specialization
Michael Gruninger, Professor	* Mechanical & Industrial Engineering, FASE	Ontologies
Michael Guerzhoy, Assistant Professor, Teaching Stream	* Mechanical & Industrial Engineering, FASE	Machine learning
Greg A. Jamieson, Professor	* Mechanical & Industrial Engineering, FASE	Human interaction automation
Elias B. Khalil, Assistant Professor	* Mechanical & Industrial Engineering, FASE	Machine learning
Roy H. Kwon, Professor	* Mechanical & Industrial Engineering, FASE	Mathematical optimization
Chi-Guhn Lee, Professor	* Mechanical & Industrial Engineering, FASE	Logistics problems
Xinyu Liu, Professor	* Mechanical & Industrial Engineering, FASE	Microfluidics and lab-on-a-chip
Matthew Mackay, Associate Professor	* Mechanical & Industrial Engineering, FASE	Vision
Scott Sanner, Associate Professor	* Mechanical & Industrial Engineering, FASE	Data Analysis and AI
Vahid Sarhangian, Assistant Professor	* Mechanical & Industrial Engineering, FASE	Stochastic modelling
Anthony N. Sinclair, Professor	* Mechanical & Industrial Engineering, FASE	Material characterization
David Sinton, Professor	* Mechanical & Industrial Engineering, FASE	Energy; environment; fluid mechanics
Yu Sun, Professor	* Mechanical & Industrial Engineering, FASE	Robotics and automation
Edmond Young, Associate Professor	* Mechanical & Industrial Engineering, FASE	Microfluidics

Space/Infrastructure

Students in the concentration will be provided office space in the new MScAC space at 700 University Ave, alongside the current MScAC students. IT support is provided by a 0.25 FTE IT staff member in the Department of Computer Science. There is no lab space or specialized

equipment requirement for the program beyond that which is already made available to DCS graduate students.

UTQAP Process

The UTQAP pathway is summarized in the table below.

Steps	**Approval**
Development/consultation within unit	Fall 2021 / Winter 2022
Consultation with Dean's office (and VPAP)	Winter / Spring 2022 (October 3rd, 2021)
VPAP	January 20, 2022
Graduate unit approval as appropriate	Fall 2021
Faculty/divisional council	GCC: February 3rd, 2022 A&S Council: February 9, 2022
Submission to Provost's office	February 9, 2022
Report to AP&P	May 2022
Report to Ontario Quality Council	July 2022

Appendix A: Calendar Entry

2021-22 SGS Calendar: Computer Science

Exported on June 14, 2021. For editing purposes only.

Computer Science: Introduction

Faculty Affiliation

Arts and Science

Degree Programs

Applied Computing

MScAC

- Concentrations:
  - Applied Mathematics;
  - Artificial Intelligence;
  - Data Science;
  - Quantum Computing

Computer Science

MSc and PhD

Collaborative Specializations

The following collaborative specializations are available to students in participating degree programs as listed below:

- Genome Biology and Bioinformatics
  - Computer Science, PhD
- Knowledge Media Design
  - Computer Science, MSc, PhD
- Neuroscience
  - Computer Science, MSc, PhD

Overview

Graduate faculty in the Department of Computer Science are interested in a wide range of subjects related to computing, including programming languages and methodology, software engineering, operating systems, compilers, distributed computation, networks, numerical analysis and scientific computing, financial computation, data structures, algorithm design and analysis, computational complexity, cryptography, combinatorics, graph theory, artificial intelligence, neural networks, knowledge representation, computational linguistics, computer vision, robotics, database systems, graphics, animation, interactive computing, and human-computer interaction.

For further details, consult the graduate student handbook prepared by the department and available online.

Contact and Address

MSc and PhD Programs

Web: web.cs.toronto.edu
Email: gradapplications@cs.toronto.edu
Telephone: (416) 978-8762

Department of Computer Science Graduate Office
University of Toronto
Bahen Centre for Information Technology
40 St. George Street
Toronto, Ontario M5S 2E4
Canada

MScAC Program

Web: mscac.utoronto.ca
Email: mscac@cs.toronto.edu
Telephone: (416) 978-5180

University of Toronto
700 University Avenue, 9th Floor
Toronto, ON M5G 1Z5
Canada

Computer Science: Applied Computing MScAC

Master of Science in Applied Computing

Program Description

The MScAC program is offered as a general Computer Science program (i.e., no concentration) or as a concentration in

- Applied Mathematics~~,~~, offered jointly by the Department of Computer Science and the Department of Mathematics;
- Artificial Intelligence, offered jointly by the Department of Computer Science, the Department of Statistical Sciences, and the Faculty of Engineering and Applied Science;
- Data Science, offered jointly by the Department of Computer Science and the Department of Statistical Sciences; or
- Quantum Computing, offered jointly by the Department of Computer Science and the Department of Physics.

~~The Applied Mathematics concentration is offered jointly by the Department of Computer Science and the Department of Mathematics. The Data Science concentration is offered jointly by the Department of Computer Science and the Department of Statistical Sciences. The Quantum Computing concentration is offered jointly by the Department of Computer Science and the Department of Physics. The Artificial Intelligence concentration is offered jointly by the Department of Computer Science and collaborating units: the Department of Statistical Sciences, and the Faculty of Engineering and Applied Science.~~

There is no thesis requirement.

MScAC General Program (No Concentration)

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.
- An appropriate bachelor's degree from a recognized university in computer science or a related discipline.
- A standing equivalent to at least B+ in the final year of undergraduate studies.

- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores:
  - Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections.
  - IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of support from faculty and/or employers.
- A statement of purpose explaining the applicant's interest in computer science and objectives for the program.

Program Requirements

- **Coursework.** Students must successfully complete a total of **3.0 full-course equivalents (FCEs)** including:
  - 1.0 FCE in required courses: technical communications (CSC2701H) and technical entrepreneurship (CSC2702H).
- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.
- ~~There is no thesis requirement.~~

Program Length

4 sessions full-time (typical registration sequence: F/W/S/F)

Time Limit

3 years full-time

MScAC Program (Artificial Intelligence Concentration)

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.

- An appropriate bachelor's degree from a recognized university in a related area such as physics, computer science, mathematics, statistics, engineering, or any discipline where there is a significant quantitative component. The completed bachelor's degree must include significant exposure to computer science or statistics or engineering including coursework in, calculus, linear algebra, probability and statistics, programming languages, and computational methods as well as data structures and algorithms and computer systems.
- ~~A minimum average grade of B+ over the final two years of undergraduate studies.~~ A standing equivalent to at least B+ in the final year of undergraduate studies.
- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores: Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections. IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of reference from faculty and/or employers, with preference for at least one such letter from a faculty member in Artificial Intelligence.
- Answers to four questions explaining applicant's interest in Artificial Intelligence and objectives for the program.
- Applicants must indicate a preference for a concentration in AI in their application. Admission to the AI concentration is on a competitive basis. Students admitted to the MScAC program are not automatically admitted to the AI concentration upon request.

Program Requirements

- **Coursework.** Students must successfully complete a total of **3.0 full-course equivalents (FCEs)** as follows:

1.5 FCEs of coursework in the area of Artificial Intelligence

- 1.0 FCE selected from the core list of AI courses (see list below) from at least two different research areas

- 0.5 FCE selected from additional AI courses outside the core list.

1.0 FCE in required courses:

- CSC2701H *Communication for Computer Scientists* (0.5 FCE)
- CSC2702H *Technical Entrepreneurship* (0.5 FCE)

Remaining 0.5 FCE of coursework will be chosen from outside of AI .

- Course selections should be made in consultation with and approved by the Program Director. Appropriate substitutions may be possible with approval.
- A maximum of 1.0 FCE may be chosen from outside the Computer Science (CSC course designator) graduate course listing.

- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.

Artificial Intelligence Core Courses

Course Code	Title
CSC2515H*	Introduction to Machine Learning (exclusion: ECE 1513H)
ECE1513H*	Introduction to Machine Learning (exclusion: CSC 2515H)
CSC2516H**	Neural Networks and Deep Learning (exclusion: MIE 1517H)
MIE1517H**	Introduction to Deep Learning (exclusion: CSC 2516H)
CSC2502H	Knowledge Representation & Reasoning
CSC2533H	Foundations of Knowledge Representation
CSC2503H	Foundations of Computer Vision
ECE1512H	Digital Image Processing and Applications
CSC2501H	Computational Linguistics
CSC2511H	Natural Language Computing
AER1513H	State Estimation for Aerospace Vehicles (State Estimation for Robotics)
AER1517H	Control for Robotics
CSC2630H	Introduction to Mobile Robotics (pending governance approval – April 2022)

*different courses with same title, offered by different faculties.

**different courses with similar titles, offered by different faculties.

MScAC Program (Applied Mathematics Concentration)

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.

- An appropriate bachelor's degree from a recognized university in a related area such as applied mathematics, mathematics, physics, computational mathematics, statistics, computer science, or any discipline where there is a significant quantitative and/or mathematical component. The completed bachelor's degree must include significant exposure to advanced mathematics, statistics, and computer science, including coursework in advanced and multivariate calculus (preferably analysis), linear algebra, probability and statistics, programming languages, and general computational methods.
- A standing equivalent to at least B+ in the final year of undergraduate studies.
- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores:
  - Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections.
  - IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of reference from faculty and/or employers, with preference for at least one such letter from a faculty member in Mathematics or Applied Mathematics.
- A statement of purpose explaining the applicant's interest in applied mathematics and objectives for the program.
- Applicants must indicate a preference for the concentration in Applied Mathematics in their application. Admission is competitive, and students who are admitted into the MScAc program are not automatically admitted to this concentration upon request.
- There is no thesis requirement.

Program Requirements

- **Coursework.** Completion of **3.0 full-course equivalents (FCEs)** including:

- 1.0 FCE chosen from the MAT 1000-level courses or higher. This may include courses cross-listed as APM400 level.
- 1.0 FCE chosen from the Computer Science (CSC course designator) graduate course listings.
- 1.0 FCE in required courses:

CSC2701H *Communication for Computer Scientists* (0.5 FCE) and
CSC2702H *Technical Entrepreneurship* (0.5 FCE).

- Course selections should be made in consultation with the Program Director.

- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.

Program Length

4 sessions full-time (typical registration sequence: F/W/S/F)

Time Limit

3 years full-time

MScAC Program (Data Science Concentration)

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.
- An appropriate bachelor's degree from a recognized university in a related area such as statistics, computer science, mathematics, or any discipline where there is a significant quantitative component. The completed bachelor's degree must include significant exposure to statistics, computer science, and mathematics, including coursework in advanced calculus, linear algebra, probability and statistics, programming languages, and computational methods.
- A standing equivalent to at least B+ in the final year of undergraduate studies.
- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores:
  - Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections.
  - IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of support from faculty and/or employers.
- A statement of purpose explaining the applicant's interest in data science and objectives for the program.
- Applicants must indicate a preference for the concentration in Data Science in their application. Admission is competitive, and students who are admitted to the MScAC program are not automatically admitted to this concentration upon request.

Program Requirements

- **Coursework.** Completion of **3.0 full-course equivalents (FCEs)** including:

- 1.0 FCE chosen from the STA 2000-level courses or higher. This may include a maximum of 0.5 FCE chosen from the STA 4500-level of six-week modular courses (0.25 FCE each).
- 1.0 FCE chosen from the Computer Science (CSC course designator) graduate course listings.
- 1.0 FCE in required courses:

CSC2701H *Communication for Computer Scientists* (0.5 FCE) and
CSC2702H *Technical Entrepreneurship* (0.5 FCE).

- Course selections should be made in consultation with the Program Director.

- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.
- There is no thesis requirement.

Program Length

4 sessions full-time (typical registration sequence: F/W/S/F)

Time Limit

3 years full-time

MScAC Program (Quantum Computing Concentration)

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Department of Computer Science's additional admission requirements stated below.
- An appropriate bachelor's degree from a recognized university in a related area such as physics, computer science, mathematics, or any discipline where there is a significant quantitative component. The completed bachelor's degree must include significant exposure to physics, computer science, and mathematics, including coursework in advanced quantum mechanics, multivariate calculus, linear algebra, probability and statistics, programming languages, and computational methods.
- A standing equivalent to at least B+ in the final year of undergraduate studies.

- Applicants whose primary language is not English and who have graduated from a university where the primary language of instruction is not English must submit results of the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) with the following minimum scores:
  - Internet-based TOEFL: 93/120 and 22/30 on the writing and speaking sections.
  - IELTS: an overall score of 7.0, with at least 6.5 for each component.
- If students complete a portion of their degree in English, or part of their degree at another university where English is the language of instruction, applicants must still provide proof of English-language proficiency.
- Three letters of reference from faculty and/or employers, with preference for at least one such letter from a faculty member in Physics.
- A statement of purpose explaining the applicant's interest in quantum computing and objectives for the program.
- Applicants must indicate a preference for the concentration in Quantum Computing in their application. Admission is competitive, and students who are admitted to the MScAC program are not automatically admitted to this concentration upon request.

Program Requirements

- **Coursework.** Completion of **3.0 full-course equivalents (FCEs)** as follows:
  - 1.0 FCE chosen from the Physics (PHY course designator) graduate course listings. Of eligible courses, the following are examples that are particularly relevant to the Quantum Computing concentration:

PHY1500H *Statistical Mechanics* (0.5 FCE)
PHY1520H *Quantum Mechanics* (0.5 FCE)
PHY1610H *Scientific Computing for Physicists* (0.5 FCE)
PHY2203H *Quantum Optics I* (0.5 FCE)
PHY2204H *Quantum Optics II* (0.5 FCE)
PHY2211H *Quantum Information Theory* (0.5 FCE)
PHY2212H *Entanglement Physics* (0.5 FCE)

  - 1.0 FCE chosen from the Computer Science (CSC course designator) graduate course listings. Of eligible courses, the following are examples that are particularly relevant to the Quantum Computing concentration:

CSC2305H *Numerical Methods for Optimization Problems* (0.5 FCE)

CSC2414H *Topics in Applied Discrete Mathematics* (0.5 FCE)
CSC2421H *Topics in Algorithms* (0.5 FCE)
CSC2451H *Quantum Computing, Foundations to Frontier* (0.5 FCE)

- 1.0 FCE in required courses:

CSC2701H *Communication for Computer Scientists* (0.5 FCE)
CSC2702H *Technical Entrepreneurship* (0.5 FCE)

- Course selections should be made in consultation with the Program Director. Appropriate substitutions may be possible with approval.

- An eight-month industrial **internship**, CSC2703H (3.5 FCEs). The internship is coordinated by the department and evaluated on a pass/fail basis.
- There is no thesis requirement.

Program Length

4 sessions full-time (typical registration sequence: F/W/S/F)

Time Limit

3 years full-time

Computer Science: Computer Science MScAC, MSc, PhD Courses

Not all courses are offered every year. Please consult the department for course offerings.

CSC2104H	Formal Methods of Program Design
CSC2107H	Compilers and Interpreters
CSC2108H	Automated Verification
CSC2125H	Algorithmic Program Verification
CSC2206H	Computer Systems Modelling
CSC2208H	Advanced Operating Systems
CSC2209H	Computer Networks
CSC2221H	Introduction to Distributed Computing

CSC2222H	Applications of Parallel and Distributed Computing
CSC2224H	Parallel Computer Architecture and Programming
CSC2226H	Topics in Verification
CSC2227H	Topics in the Design and Implementation of Operating Systems
CSC2228H	Topics in Mobile, Pervasive, and Cloud Computing
CSC2231H	Topics in Computer Systems
CSC2233H	Topics in Storage Systems
CSC2305H	Numerical Methods for Optimization Problems
CSC2306H	High Performance Scientific Computing
CSC2310H	Computational Methods for Partial Differential Equations
CSC2321H	Matrix Calculations
CSC2326H	Topics in Numerical Analysis
CSC2401H	Introduction to Computational Complexity
CSC2404H	Computability and Logic
CSC2405H	Automata Theory
CSC2410H	Introduction to Graph Theory
CSC2412H	Algorithms for Private Data Analysis (Prerequisite: CSC 373 or equivalent, or permission of the instructor.)
CSC2414H	Topics in Applied Discrete Mathematics
CSC2415H	Advanced Topics in the Theory of Distributed Computing
CSC2416H	Machine Learning Theory
CSC2417H	Algorithms for Genome Sequence Analysis
CSC2419H	Topics in Cryptography
CSC2420H	Algorithm Design, Analysis, and Theory

CSC2421H	Topics in Algorithms
CSC2426H	Fundamentals of Cryptography
CSC2427H	Topics in Graph Theory
CSC2429H	Topics in the Theory of Computation
CSC2431H	Topics in Computational Molecular Biology
CSC2451H	Quantum Computing, Foundations to Frontier (Exclusion: MAT1751H Quantum Computing, Foundations to Frontier.)
CSC2501H	Computational Linguistics
CSC2502H	Knowledge Representation and Reasoning
CSC2503H	Foundations of Computer Vision
CSC2504H	Computer Graphics
CSC2506H	Probabilistic Learning and Reasoning
CSC2508H	Advanced Management Systems
CSC2510H	Topics in Information Systems
CSC2511H	Natural Language Computing
CSC2512H	Constraint Satisfaction Problems
CSC2513H	Critical Thinking for Human Computer Interaction (Prerequisite: CSC 318 or equivalent, or permission of the instructor.)
CSC2514H	Human-Computer Interaction
CSC2515H	Introduction to Machine Learning
CSC2516H	Neural Networks and Deep Learning
CSC2518H	Spoken Language Processing
CSC2520H	Geometry Processing
CSC2521H	Topics in Computer Graphics

CSC2523H	Object Modelling and Recognition
CSC2524H	Topics in Interactive Computing
CSC2525H	Research Topics in Database Management
CSC2526H	HCI: Topics in Ubiquitous Computing
CSC2527H	The Business of Software
CSC2528H	Advanced Computational Linguistics
CSC2530H	Computer Vision for Advanced Digital Photography
CSC2532H	Statistical Learning Theory (Prerequisite: CSC2515H.)
CSC2533H	Foundations of Knowledge Representation
CSC2534H	Decision Making Under Uncertainty
CSC2536H	Topics in Computer Science and Education
CSC2537H	Information Visualization
CSC2539H	Topics in Computer Vision
CSC2540H	Computational Cognitive Models of Language
CSC2541H	Topics in Machine Learning
CSC2542H	Topics in Knowledge Representation and Reasoning
CSC2546H	Computational Neuroscience
CSC2547H	Current Algorithms and Techniques in Machine Learning
CSC2548H	Machine Learning in Computer Vision
CSC2549H	Physics-Based Animation
CSC2552H	Topics in Computational Social Science
CSC2556H	Algorithms for Collective Decision Making
CSC2558H	Topics in Multidisciplinary HCI
CSC2600H	Topics in Computer Science

CSC2604H	Topics in Human-Centred and Interdisciplinary Computing
CSC2606H	Introduction to Continuum Robotics (Prerequisite: Introduction to Robotics; e.g, CSC376 offered at UTM or AER525. Exclusion: CSC476 offered at UTM.)
CSC2611H	Computational Models of Semantic Change
CSC2612H	Computing and Global Development (Prerequisite: CSC 318 or equivalent, or permission of the instructor.)
CSC2621H	Topics in Robotics (Prerequisite: CSC411H or CSC2515H or ECE521H.)
CSC2626H	Imitation Learning for Robotics (Prerequisite: CSC411/2515 Machine Learning and Data Mining or ECE521 Inference Algorithms and Machine Learning or equivalent.)
CSC2699H	Special Reading Course in Computer Science
CSC2701H	Communication for Computer Scientists
CSC2702H	Technical Entrepreneurship
CSC2703H	MScAC Internship
CSC2720H	Systems Thinking for Global Problems
CSC4000Y	MSc Research Project in Computer Science
ECE1785H	Empirical Software Engineering

Appendix B: List of Courses associated with the new concentration

All students in the MScAC, including students in the new concentration, receive individualized advising to ensure that they select courses http://www.cs.toronto.edu/dcs/graddocs/Grad_CourseDescriptions_ResearchArea.pdf that a) meet the program requirements, including any requirements specific to the

concentration; b) have sufficient academic preparation for each course; and c) support their professional goals.

Students pursuing the new concentration in AI may select graduate-level courses from the participating departments, in compliance with the requirements listed in the SGS calendar, and subject to approval of the program director.

For these graduate courses, the content can change yearly depending on the faculty member delivering the course, therefore the syllabus must be reviewed for each non-CS course every single year and revise the classification and permission for whether MScAC students can take them accordingly. Permission is granted based on technical content within the course.

Courses related to or in AI

Introductory/Fundamental Courses:

(captured in calendar copy in Appendix A, as well).

Course Code	Title	Methodology	Research Area	Exclusion
CSC2515	Introduction to Machine Learning	2 Cont Models	12 ML	ECE1513
ECE1513	Introduction to Machine Learning	2 Cont Models	12 ML	CSC2515
CSC2516	Neural Networks and Deep Learning	2 Cont Models	12 ML	MIE1517
MIE1517	Introduction to Deep Learning	2 Cont Models	12 ML	CSC2516
CSC2502	Knowledge Representation & Reasoning	1 Disc Models	11 KR	
CSC2533	Foundations of Knowledge Representation	1 Disc Models	11 KR	

CSC2503	Foundations of Computer Vision	2 Cont Models	7 CV	
ECE1512H	Digital Image Processing and Applications	2 Cont Models	7 CV	
CSC2501	Computational Linguistics	4 Human-Centred & Interdisciplinary	4 CL	
CSC2511	Natural Language Computing	4 Human-Centred & Interdisciplinary	4 CL	*new cross-listed course
AER1513	State Estimation for Aerospace Vehicles (State Estimation for Robotics)	2 Cont Models	16 Robotics	
AER1517	Control for Robotics	2 Cont Models	16 Robotics	

*Footnote: CSC2515 and ECE1513 are different courses from different faculties, the content and instructors are different

Additional courses students may choose to take to meet their AI course requirements are available. Other courses may be eligible. Please consult with the program director for approval.

DRAFT

Faculty of Applied Science and Engineering
Guidelines for the Assessment of Effectiveness of Teaching in Tenure, Continuing Status and Promotion Decisions

Preamble

A commitment to effectiveness in teaching and research is at the core of our mission as a university and is crucial to the success of the Faculty of Applied Science and Engineering (FASE). Effective teaching by faculty provides an environment that facilitates student learning, and FASE appreciates that its position as a professional faculty within the University of Toronto places a special onus on its instructors to demonstrate real-world applications.

FASE recognizes that effective teaching aspires to provide to all students not only knowledge of facts but also the skills to analyze, to assess critically, to develop creative expression, to understand in context, to present arguments in a clear and compelling fashion, to solve problems, and to generate new knowledge. As well, effective teaching promotes professionalism, academic integrity, the pursuit of learning as a life-long endeavor, and a commitment to responsible citizenship to succeed in, and enhance, a diverse, global society.

Building on existing divisional guidelines at the University of Toronto, this document establishes the norms and expectations for teaching in FASE. Fundamentally, teaching includes lecturing, activity in seminars and tutorials, individual and group discussion, laboratory teaching, thesis and/or research supervision, and any other means by which students derive educational benefit. These Guidelines describe how teaching effectiveness is to be evaluated at FASE in the Tenure Stream (Section A); the Teaching Stream (Section B); and the documentation that should be collected to support that assessment (Section C).

University of Toronto Policies and Guidelines

This document is intended to provide guidance on implementation of the following University of Toronto policies, procedures, and guidelines. Where text is taken directly from these documents, the document is referenced using the abbreviation indicated in square brackets.

1. *Policy and Procedures on Academic Appointments [PPAA]*
   https://governingcouncil.utoronto.ca/secretariat/policies/academic-appointments-policy-and-procedures-january-1-2021
2. *Policy and Procedures Governing Promotions [PPP]*
   https://governingcouncil.utoronto.ca/secretariat/policies/promotions-policy-and-procedures-governing-april-20-1980
3. *Policy and Procedures Governing Promotions in the Teaching Stream [PPPTS]*
   https://governingcouncil.utoronto.ca/secretariat/policies/promotions-teaching-stream-policy-and-procedures-governing-january-1-2021

4. *Provostial Guidelines for the Assessment of Teaching Effectiveness [PGATE]* https://governingcouncil.utoronto.ca/secretariat/policies/teaching-promotion-and-tenure-decisions-provostial-guidelines-developing
5. *FASE Divisional Guidelines for the Evaluation of Teaching Effectiveness for Promotion to Professor, Teaching Stream* https://www.aapm.utoronto.ca/wp-content/uploads/sites/129/2018/06/FASE-Divisional-Guidelines-for-Evaluation-of-Teaching-Effectiveness-for-Promotion-to-Teaching-Stream-May-2018.pdf

A. Teaching Effectiveness for Tenure Stream Faculty and appointed faculty with a similar workload

Assessment of teaching effectiveness normally occurs during Interim Review (A.1), Tenure Review (A.2), and Review for Promotion to Professor, Tenure Stream (A.3). This assessment also applies to the promotion of part-time, CLTA, and status only faculty. See Promotion of Part-Time and other non-tenure stream Faculty (A.4). The criteria for assessing teaching effectiveness at these various stages are listed in Section A.5.

A.1 Interim Review

Assistant Professors in the tenure stream should undergo an Interim Review no earlier than May 1 of the third year of their contract. The Interim Review is a mechanism to assess a candidate's performance and determine whether they will receive a second probationary appointment. It is also an opportunity to provide feedback on performance and counselling on areas for improvement.

As stated in PPAA, II, 8, "The committee should consider two questions: a) Has the appointee's performance been sufficiently satisfactory for a second probationary appointment? b) If reappointment is recommended, what counselling should be given to the appointee to assist him or her to improve areas of weakness and maintain areas of strength?" [PPAA].

A.2 Tenure Review

In accordance with the PPAA, III, 13, "Tenured appointments should be granted on the basis of three essential criteria: achievement in research and creative professional work, effectiveness in teaching, and clear promise of future intellectual and professional development. Contributions in the area of university service may constitute a fourth factor in the tenure decision but should not, in general, receive a particularly significant weighting" [PPAA].

A positive recommendation for tenure and promotion to Associate Professor requires the judgement of demonstrated excellence in one of research and teaching, and clearly established competence in the other [PPAA].

As specified in PPAA, III, 13, "Three major elements should be considered in assessing the effectiveness of a candidate's teaching: the degree to which he or she is able to stimulate and challenge the intellectual

capacity of students; the degree to which the candidate has an ability to communicate well; and the degree to which the candidate has a mastery of his or her subject area" [PPAA].

A.3 Promotion to Professor

As specified in the PPP, 7, "The successful candidate for promotion will be expected to have established a wide reputation in his or her field of interest, to be deeply engaged in scholarly work, and to have shown himself or herself to be an effective teacher. These are the main criteria. However, either excellent teaching alone or excellent scholarship alone sustained over many years, could also in itself justify eventual promotion to the rank of Professor. Administrative or other service to the University and related activities will be taken into account in assessing candidates for promotion but given less weight than the main criteria: promotion will not be based primarily on such service" [PPP].

A.4 Promotion of Part-Time and CLTA Faculty (non-tenure stream)

Insofar as the PPP also applies to part-time faculty and faculty in CLTA appointments in the non-tenure stream, Section A3 also applies to part-time and CLTA faculty. Colleagues should be aware that Sections 7 and 8 of the PPP set out the criteria against which part-time faculty and faculty in CLTA appointments are assessed for promotion from Assistant Professor to Associate Professor (section 8) and for promotion from Associate Professor to Professor (section 7) [PPP].

A.5 Criteria for Assessment of Teaching Effectiveness as part of A1-A4

Tenure stream faculty and faculty with a comparable workload demonstrate their effectiveness as teachers in lectures, seminars, laboratories, and tutorials, in less formal teaching situations, including directing the research of undergraduate and graduate students, and advising students, and through involvement in curriculum development [PPAA]. Below are listed the criteria for which teaching effectiveness may be assessed at the various levels of evaluation or promotion. For the criteria below, the numbered points have been drawn from policy statements and provostial guidelines. Under these are sub-criteria (hollow-bullet points) suggesting specific ways a candidate ***might*** show effectiveness in these areas. These sub-criteria are not exhaustive, nor must all of them under a given main heading be satisfied in order to demonstrate effectiveness for those criteria.

A.5.1 Competence in Teaching

In FASE, competence in teaching is considered a highly respectable level of achievement and should not be interpreted as merely passable or mediocre. At a minimum, tenure stream FASE faculty and those with comparable non tenure stream appointments are expected to establish competence in the following eight core teaching skills:

1. Strong communication skills [PGATE], for example:
    - Presenting information clearly and in an organized manner
    - Maintaining a clear channel of communication with students

- Responding within a reasonable period of time through established communication channels

2. Success in stimulating and challenging students and promoting their intellectual and scholarly development [PPAA], for example:
    - Developing rigorous and well-planned learning outcomes as part of course planning
    - Creating opportunities for students to take risks and think outside the box
    - Employing active learning techniques for lecture and tutorials
    - Providing assessments that students generally perceive as challenging but fair
    - Presenting material at a steady and reasonable pace
3. Active engagement with students' learning progress and accessibility to students [PGATE], for example:
    - Promoting self-efficacy as part of the student learning experience
    - Scheduling one-on-one and small group consultations with students
    - Monitoring student learning through in-class polls and learning checks
    - Encouraging students to participate in mid-term and end-of-term course evaluations
    - Adapting lesson plans or content delivery based on the feedback and performance of students
4. Creation of opportunities for students to learn through discovery-based methods [PGATE], for example:
    - Implementing discovery-based methods during lectures
    - Building problem-based activities and assignments
    - Encouraging independent learning through creative activity
    - Proposing discovery-based learning methods for tutorials where appropriate
    - Basing these opportunities around real-world engineering applications where possible
5. Mastery of the subject area [PPAA], for example:
    - Showing deep engagement with the course content
    - Developing relations between the subject area and adjacent subject areas
    - Being able to answer student questions that extend content delivered to them
6. Success in developing students' mastery of a subject and awareness of the latest developments in the field [PPAA], for example:
    - Continuing to keep up to date with the latest developments in the field
    - Relating developments in the field to the course content when possible
    - Presenting media coverage that relates to the course's content
7. Promotion of academic integrity and adherence to grading standards of the division and, as appropriate, the ethical standards of the profession [PGATE], for example:
    - Communicating the ethical standards of the profession to students as they apply to the subject
    - Reminding students of policies on academic integrity when appropriate
8. Creation of supervisory conditions conducive to a student's research and academic progress consistent with the School of Graduate Studies Guidelines for Graduate Supervision [PGATE], for example:
    - Following the guidelines set forth by the School of Graduate Studies
    - Consulting students for feedback on their experience with the supervision they are receiving, as well as on the quality of their working environment

A.5.2 Excellence in Teaching

To meet the standard of excellence in teaching for tenure or promotion, FASE faculty in tenure stream and comparable non-tenure stream appointments must demonstrate excellent teaching skills, i.e., a high level of achievement in the numbered criteria (1-8) shown above in A.5.1. In addition, the candidate must demonstrate excellence in some combination of the following elements or particularly strong performance in one:

9. Enhancement of student learning through the successful development of new teaching models [PPPTS], for example:
    - Implementing strategic programs or teaching policies
    - Acknowledging the importance of local cultures and contexts
    - Exploring and critically examining new and emerging approaches to assessment
    - Critically reflecting on one's leadership approaches and practices with a focus on growth
10. Engagement in the scholarly conversation via pedagogical scholarship or creative professional activity [PPPTS], for example:
    - Implementing strategic programs, initiatives, and policies to improve teaching and student learning
    - Mentoring junior colleagues and graduate students
    - Disseminating information about teaching successes and/or challenges to colleagues
    - Engaging in community activities/outreach related to teaching and education
11. Development of significant new courses and/or reform of curricula [PGATE]
12. Publication of innovative textbooks, websites and other online material and/or teaching guides [PGATE]
13. Successful innovations in the teaching domain, including the creation of new and innovative teaching processes and forms of evaluation [PGATE]
14. Technological or other advances in the delivery of education in a discipline or profession [PPPTS], for example:
    - Instigating the adoption of a technology for use in the delivery of education
15. Development of innovative and creative ways to promote students' involvement in the research process [PGATE], for example:
    - Organizing creative research opportunities
16. Participation at, and contributions to, academic conferences where sessions on pedagogical research and technique are prominent [PPAA], for example:
    - Attending, contributing to and/or organizing academic conferences in areas of pedagogical research
17. Teaching-related activity by the candidate outside of his or her classroom functions and responsibilities [PPAA][PPPTS], for example:
    - Tutoring students outside of class hours
    - Guest lecturing in other courses or outside of course hours
    - Engaging students in research opportunities
    - Attending tutorial, practical and/or lab sessions
    - Observing peers' teaching (within and outside one's field of study)
    - Seeking support or services offered through teaching and learning centres

18. Significant contribution to pedagogical changes in the discipline [PGATE], for example:
    - Authoring of extramural guidelines, position papers, etc.
19. Professional work that allows the candidate to maintain a mastery of their subject area in accordance with appropriate divisional guidelines [PPPTS], for example:
    - Working in the field of the candidate's area of teaching
    - Owning or operating a business that connects with the candidate's area of teaching

For promotion to the rank of Professor based on excellent teaching alone, candidates must have consistently met the standard of excellence described above, sustained over many years.

B. Teaching Effectiveness for Teaching Stream Faculty

Assessment of teaching effectiveness occurs during Probationary Review (B.1), Continuing Status Review (B.2), Review for Promotion to Professor, Teaching Stream (B.3), and Review for Promotion of Part-Time Faculty (B.4). The criteria for assessing teaching effectiveness at these various stages are listed in Section B.5.

B.1 Probationary Review

Assistant Professors, Teaching Stream should undergo a Probationary Review no earlier than May 1 of the third year of their contract. The Probationary Review is a mechanism to assess a candidate's performance and determine whether he or she will receive a second probationary appointment. It is also an opportunity to provide feedback on performance and, more often, specifically, on areas for improvement.

As stated in PPAA, II, 8, "The committee should consider two questions: a) Has the appointee's performance been sufficiently satisfactory for a second probationary appointment? b) If reappointment is recommended, what counselling should be given to the appointee to assist him or her to improve areas of weakness and maintain areas of strength?" [PPAA].

B.2 Continuing Status Review

In accordance with the PPAA, VII, 30, x, "A positive recommendation for continuing status will require the judgment of excellence in teaching and evidence of demonstrated and continuing future pedagogical/professional development" [PPAA].

B.3 Review for Promotion to Professor, Teaching Stream

In conformity with the PPPTS, 6, "Promotion to Professor, Teaching Stream will be granted on the basis of excellent teaching, educational leadership and/or achievement, and ongoing pedagogical/professional development, sustained over many years" [PPPTS]. These criteria are detailed below (Section B.5.1; B.5.2). Administrative or other service to the University and related activities will be taken into account in assessing candidates for promotion but given less weight than the main criteria: promotion will not be based primarily on such service [PPPTS]. The criteria and procedures for promotion through the ranks for part-time teaching stream faculty shall be the same as for full-time candidates with an appropriately reduced expectation as to

the quantity of work [PPPTS]. Please also see FASE Divisional Guidelines for the Evaluation of Teaching Effectiveness for Promotion to Professor, Teaching Stream (linked as Document #5 in Preamble).

B.4 Promotion of Part-Time Faculty (Teaching Stream)

Insofar as the PPPTS also applies to part-time faculty in the teaching stream, section B3 also applies to part-time faculty. Colleagues should be aware that sections 6 and 7 of the PPPTS set out the criteria against which part-time faculty are assessed for promotion from Assistant Professor, Teaching Stream to Associate Professor, Teaching Stream (section 7) and for promotion from Associate Professor, Teaching Stream to Professor, Teaching Stream (section 6) [PPPTS].

B.5 Criteria for Evaluation of Teaching Effectiveness in the Teaching Stream

Teaching stream faculty are expected to demonstrate excellence in teaching. Excellence in teaching may be demonstrated through a combination of i) excellent teaching skills (B.5.1a) and creative educational leadership and/or achievement, and innovative teaching initiatives (B.5.1b), and ii) pedagogical and professional development (B.5.2).

For the criteria below, the numbered points have been drawn from policy statements and provostial guidelines. Under these are sub-criteria (hollow-bullet points) suggesting specific ways a candidate ***might*** show effectiveness in these areas. These are not exhaustive, nor must all of the sub-criteria be satisfied in order to demonstrate effectiveness for those criteria.

B.5.1 Excellence in Teaching

To meet the standard of excellence in teaching for continuing status or promotion in the teaching stream, FASE faculty in in teaching stream appointments must demonstrate:

B.5.1a: Teaching Skills

Excellent teaching, i.e., a high level of achievement, in the numbered criteria (1-8) that follow:

1. Strong communication skills [PGATE], for example:
    - Presenting information clearly and in an organized manner
    - Maintaining a clear channel of communication with students
    - Responding within a reasonable period of time through established communication channels
2. Success in stimulating and challenging students and promoting their intellectual and scholarly development [1], for example:
    - Developing rigorous and well-planned learning outcomes as part of course planning
    - Creating opportunities for students to take risks and think outside the box
    - Employing active learning techniques for lecture and tutorials
    - Providing assessments that students generally perceive as challenging but fair
    - Presenting material at a steady and reasonable pace

3. Active engagement with students' learning progress and accessibility to students [PGATE], for example:
    - Promoting self-efficacy as part of the student learning experience
    - Scheduling one-on-one and small group consultations with students
    - Monitoring student learning through in-class polls and learning checks
    - Encouraging students to participate in mid-term and end-of-term course evaluations
    - Adapting lesson plans or content delivery based on the feedback and performance of students
4. Creation of opportunities for students to learn through discovery-based methods [PGATE], for example:
    - Implementing discovery-based methods during lectures
    - Building problem-based activities and assignments
    - Encouraging independent learning through creative activity
    - Proposing the implementation of discovery-based learning methods for tutorials where appropriate
    - Basing these opportunities around real-world engineering applications where possible
5. Mastery of the subject area [PPAA], for example:
    - Showing deep engagement with the course content
    - Developing relations between the subject area and adjacent subject areas
    - Being able to answer student questions that extend content delivered to them
6. Success in developing students' mastery of a subject and awareness of the latest developments in the field [PPAA], for example:
    - Continuing to keep up to date with the latest developments in the field
    - Relating developments in the field to the course content when possible
    - Presenting media coverage that relates to the course's content
7. Promotion of academic integrity and adherence to grading standards of the division and, as appropriate, the ethical standards of the profession [PGATE], for example:
    - Communicating the ethical standards of the profession to students as they apply to the subject
    - Reminding students of policies on academic integrity when appropriate
8. Creation of supervisory conditions conducive to a student's research and academic progress consistent with the School of Graduate Studies Guidelines for Graduate Supervision [PGATE], for example:
    - Following the guidelines set forth by the School of Graduate Studies
    - Consulting students for feedback on their experience with the supervision they are receiving, as well as on the quality of their working environment.

B.5.1.b: Educational Leadership and/or Achievement, and Innovative Teaching Initiatives

In addition, the candidate must demonstrate excellence in some combination of the following elements or particularly strong performance in one area:

Creative Educational Leadership:

1. Enhanced student learning through the successful development of new teaching models [PPPTS], for example:
    - Implementing strategic programs or teaching policies
    - Acknowledging the importance of local cultures and contexts
    - Exploring and critically examining new and emerging approaches to assessment
    - Critically reflecting on one's leadership approaches and practices with a focus on growth
2. Engagement in the scholarly conversation via pedagogical scholarship or creative professional activity [PPPTS], for example:
    - Implementing strategic programs, initiatives, and policies to improve teaching and student learning
    - Mentoring junior colleagues and graduate students
    - Disseminating information about teaching successes and/or challenges to colleagues
    - Engaging in community activities/outreach related to teaching and education
3. Technological or other advances in the delivery of education in a discipline or profession [PPPTS]

Innovative Teaching Initiatives:

4. Development of significant new courses and/or reform of curricula [PGATE]
5. Publication of innovative textbooks, websites and other online material and/or teaching guides [PGATE]
6. Successful innovations in the teaching domain, including the creation of new and innovative teaching processes and forms of evaluation [PGATE]
7. Technological or other advances in the delivery of education in a discipline or profession [PPPTS], for example:
    - Instigating the adoption of a technology for use in the delivery of education
8. Development of innovative and creative ways to promote students' involvement in the research process [PGATE], for example:
    - Organizing creative research opportunities

B.5.2 Pedagogical & Professional Development

For continuing status review and promotion, faculty in the teaching stream must also demonstrate pedagogical/professional development. This may be demonstrated in a number of ways, including:

1. Discipline-based scholarship in relation to, or relevant to, the field in which the faculty member teaches [PPAA][PPPTS], for example:
    - Researching and publishing in the area in which the candidate teaches
2. Participation at, and contributions to, academic conferences where sessions on pedagogical research and technique are prominent [PPAA], for example:
    - Attending, contributing to and/or organizing academic conferences in areas of pedagogical research
3. Teaching-related activity by the candidate outside of his or her classroom functions and responsibilities [PPAA][PPPTS], for example:
    - Tutoring students outside of class hours
    - Guest lecturing in other courses or outside of course hours

- Engaging students in research opportunities
- Attending tutorial, practical and/or lab sessions
- Observing peers' teaching (within and outside one's field of study)
- Seeking support or services offered through teaching and learning centres

4. Significant contribution to pedagogical changes in the discipline [PGATE], for example:
   - Authoring of extramural guidelines, position papers, etc.
5. Professional work that allows the candidate to maintain a mastery of their subject area in accordance with appropriate divisional guidelines [PPPTS], for example:
   - Working in the field of the candidate's area of teaching
   - Owning or operating a business that connects with the candidate's area of teaching

C. Documentation and Procedures

Documentation required for a committee to evaluate *teaching effectiveness* is to be provided by the candidate (Section C.1), the Department Chair (Section C.2), and the Teaching Evaluation Committee struck by them (Section C.3).

These guidelines below apply to all faculty above*;* however, items that may be specific to **teaching stream** (or optional for **tenure stream**) will be noted as such. For **tenure stream**, candidates and Chairs should additionally consult PPAA III, 15-16 regarding Documentation and Procedures for evaluation of scholarly and professional accomplishments.

C.1 From the Candidate

Candidates must submit the following items in a *teaching portfolio or dossier* [PPAA][PGATE]:

- Curriculum Vitae - The curriculum vitae should contain:
  - The academic history of the candidate
  - Scholarly & professional work
  - Courses taught
  - Administration services
- A statement of teaching interests and teaching philosophy
- A description of teaching methods and material or texts developed and/or other pedagogical tools utilized
- A list of awards for which the candidate has been nominated and/or which the candidate has received for teaching
- A statistical summary of teaching evaluations, including a comparison of Institutional Composite Mean (ICM) scores with FASE and departmental averages
- Evidence of teaching-related activity by the candidate outside of their classroom functions and responsibilities
- For **teaching stream** faculty being reviewed for continuing status or promotion (and, optionally, for **tenure stream** faculty being reviewed for tenure and promotion) candidates should also include, as appropriate:
  - Evidence of educational leadership and or achievement relating to teaching
  - Evidence of pedagogical/professional development

In addition to the teaching portfolio, the candidate should include:

- For **teaching stream** faculty being reviewed for continuing status or promotion, a list of three potential appraisers/referees who are *external* to the University and well-placed to assess the candidate against the criteria for continuing status or promotion. (A list of *internal* referees may additionally be provided, c.f. Section C.2.) The list(s) should include the name, title and institution/organization of each referee; a brief statement of their expertise; and the reason they were selected. All appraisers/referees must be at arm's length (e.g., no recent collaboration). For **tenure stream**, such external appraisers focus on scholarly research and professional accomplishments (see PPAA III, 15, ii); however, candidates seeking to demonstrate excellence in teaching may additionally provide a list of external appraisers to evaluate teaching effectiveness.
- For **teaching stream** (and, optionally, **tenure stream**), a list of up to three colleagues, collaborators, or co-instructors who could be asked to provide letters of support regarding effectiveness in teaching.
- A list of former students able to speak to any of the criteria (i.e., Sections A.5 or B.5, as appropriate) and the influence or impact of the candidate on their subsequent career paths
- Supplementary material to the CV that provides a fuller picture of any area that the candidate would like to highlight that is not already covered by the teaching portfolio, particularly with regards to demonstrating impact outside of FASE or the University. This may include testimonial letters collected by the candidate and any discussion of these by way of context.
- Description of innovations in teaching and contributions to curricular development
- Copies of students' papers, especially those that have been published, and student theses
- Data that will enable the unit to assess the candidate's success in graduate supervision, including number of students being supervised; quality of theses produced; quality of supervision; number graduated and time-to-degree; and information on other efforts to foster scholarly and professional advancement of graduate students

C.2 From the Department Chair

The Department Chair, in consultation with the Dean, is responsible for soliciting appraisals from the various referees: external, internal, colleagues, as well as students. These referees should include names suggested by the candidate, as well as others recommended by the Department Chair.

- **External**: For **teaching stream**, confidential written assessments of the candidate against the criteria as set out in policy provided by at least three referees who are specialists in the candidate's field from outside the University, and including at least one referee suggested by the candidate. Assessment of course syllabi is also encouraged. For **tenure stream**, these assessments focus on scholarly research and professional accomplishments (see PPAA, III, 15, ii), but may optionally and additionally include an assessment of teaching.
- **Internal:** At the Chair's discretion, confidential written assessments of the candidate against the criteria as set out in policy may be solicited from departmental, divisional, or college faculty within the University, especially where cross-appointment is involved and/or excellence in teaching is being considered for **tenure stream** candidates.
- **Colleagues:** At the Chair's discretion, confidential letters from a candidate's colleagues, especially where co-teaching is involved.

- **Students:** Confidential letters solicited from former students who are able to speak to any of the relevant criteria from Section A.5 or Section B.5, as well as the influence or impact of the candidate on their subsequent career paths

The Department Chair is responsible for ensuring the collection and completeness of all required materials.

The Department Chair must also ensure that the candidate is informed of the following information:

- The policy and procedures around the entire review process
- The divisional/departmental guidelines and procedures to be used to evaluate the candidate
- The membership of the Tenure/CSR/Promotion Committee
- The membership of the Teaching Evaluation Committee
- All required deadlines and materials to be submitted

The Department Chair is responsible for sending a final recommendation to the Vice-President and Provost for approval.

C.3 Teaching Evaluation Committee

Prior to a tenure, continuing status, or promotion committee meeting, the Department Chair will establish a Teaching Evaluation Committee to assess the collected material.

The Teaching Evaluation Committee is responsible for the following:

- Conducting a careful and rigorous review of the candidate's teaching portfolio and the feedback collected, including letters and course evaluations
- Preparing a summary report for the Interim/Probationary Review, Continuing Status Review, Tenure or Promotions Committee. This report should not make a recommendation regarding the candidate's application, but is instead a thorough evaluation of all the submitted material. It should, however, conclude with an opinion on whether the candidate has met the criteria for competence (tenure stream only) or excellence (tenure or teaching stream) as detailed in Sections A and B. Note that where there is an opinion of excellence in teaching for a tenure stream candidate, it is important that the grounds for this view be explicit.
- Observing classroom teaching is a key component of assessing teaching effectiveness for tenure (and comparable non-tenure stream) and teaching streams., At least two teaching observations should be conducted. (A single observer should review at least two classroom lectures, ideally one each from different courses. Two observers may choose to observe the same classroom lecture(s), independently; or they may observe separate lecture(s).) Advance notice and permission of the candidate is required prior to an observation. (If a candidate refuses, this should be noted in the Teaching Evaluation Committee Report.) The Teaching Observation Report may be completed by members of the Teaching Evaluation Committee (where relevant), or by at least two other tenured or continuing-status faculty commissioned by the unit head, with the condition that the faculty doing the teaching observation cannot include any members of the continuing status or promotion committee. These observations can be conducted live, online, or, if necessary, a recording may be used. The following can be used as a general guideline of teaching behaviours to assess:
    - Organization of material
    - Communication with students
    - Rapport with students

For more detailed information on effective peer observation, please see the following document provided by the Centre for Teaching Support and Innovation: https://teaching.utoronto.ca/wp-content/uploads/2017/01/Peer-Observation-of-Teaching-Guide.pdf