SENATE

NOTICE OF MEETING

January 12, 2018

Please be advised that the next regular meeting of Senate will be held on Friday, January 19, 2018, at 2 p.m., in the Norman D. Hébert, LLD Meeting Room (Room EV 2.260) on the SGW Campus.

Members of Senate who cannot attend are requested to notify Evelyne Loo as soon as possible at evelyne.loo@concordia.ca or ext. 4814. You may also contact Evelyne if you have any problems accessing the documents.

D. Tessier

Danielle Tessier
Secretary of Senate

UNIVERSITÉ Concordia UNIVERSITY

AGENDA OF THE OPEN SESSION
OF THE MEETING OF SENATE

Held on Friday, January 19, 2018, at 2 p.m.
in the Norman D. Hébert, LLD Meeting Room
(Room EV 2.260) on the SGW Campus

Item		Presenter/s	Action
1.	Call to order	G. Carr	
1.1	Adoption of the Agenda	G. Carr	Approval
1.2	Adoption of December 8, 2017 Minutes	G. Carr	Approval
2.	Business arising from the Minutes not included on the Agenda	G. Carr	
3.	Academic update *(Document US-2018-1-D1)*	G. Carr	Information
4.	Report of Standing Committees:	G. Carr	Information
4.1	Finance *(Document US-2018-1-D2)*		
4.2	Library *(Document US-2018-1-D3)*		
CONSENT AGENDA		G. Carr	
5.	Committee appointments *(Document US-2018-1-D4)*		Approval
6.	Academic Programs Committee: Report and recommendations *(Document US-2018-1-D5)*		Approval
6.1	Undergraduate curriculum changes – Faculty of Engineering and Computer Science *(Document US-2018-1-D6)*		
6.2	Graduate curriculum changes – Faculty of Engineering and Computer Science *(Document US-2018-1-D11)*		

REGULAR AGENDA

7.	Academic Programs Committee: Report and recommendations *(Document US-2017-8-D5)*		
7.1	New graduate programs – Faculty of Engineering and Computer – Department of Chemical and Materials Engineering	P. Wood-Adams/ A. Asif/ A. De Visscher	Approval
7.1.1	Graduate Certificate in Chemical Engineering *(Document US-2018-1-D7)*		
7.1.2	Graduate Diploma in Chemical Engineering *(Document US-2018-1-D8)*		
7.1.3	Master of/Magisteriate in Applied Science (Chemical Engineering) *(Document US-2018-1-D9)*		
7.1.4	Doctor of/Doctorate in Philosophy (Chemical Engineering) *(Document US-2018-1-D10)*		
8.	Research Committee recommendation regarding Equity, Diversity and Inclusion Action Plan *(Document US-2018-1-D12)*	J. Powlowski	Approval
9.	Emeritus status for retiring librarians *(Document US-2018-1-D13)*	G. Beaudry	Approval
10.	Presentation by public scholars	P. Wood-Adams/ L. A. Hof/ N. Naffi	Information
11.	Question period *(maximum - 15 minutes)*		
12.	Other business	G. Carr	
13.	Adjournment	G. Carr	

US-2017-8

MINUTES OF THE OPEN SESSION OF THE MEETING OF SENATE

Held on Friday, December 8, 2017, at 2 p.m.
in the Norman D. Hébert, LLD Meeting Room
(Room EV 2.260) on the SGW Campus

PRESENT

Voting members: Alan Shepard *(Chair)*; Mohamed Allalou; Paul Allen; Amir Asif; Reena Atanasiadis; Guylaine Beaudry; Pascale Biron; Patrice Blais; Rory Blaisdell; Steven Brown; Saul Carliner; Graham Carr; Mikaela Clark-Gardner; Frank Crooks; Anne-Marie Croteau; Christine DeWolf; Jill Didur; Charles Draimin; Rebecca Duclos; Marcie Frank; Vince Graziano; Christophe Guy; Tevfik Karatop; Chiranjeevi Koduri; David Morris; Mahesh Natarajan; Brad Nelson *(Acting on behalf of Paula Wood-Adams);* Lorraine Oades; Harald Proppe; Martin Pugh; Omar Riaz; André Roy; Jonathan Roy; Daniel Salée; Francesca Scala; Yousef Shayan; Ali Sherra; Thufile Sirajudeen; Robert Soroka; Marc Steinberg; Shaumia Suntharalingam; Julia Sutera Sardo; Leyla Sutherland; Christopher Trueman; Sharon Yonan Renold

Non-voting members: Joanne Beaudoin; Philippe Beauregard; Roger Côté; Isabel Dunnigan; Emmet Henchey; Lisa Ostiguy; Daniel Therrien

ABSENT

Voting members: Philippe Caignon; Ricardo Dal Farra; Brigitte Jaumard; Virginia Penhune; John Potvin; Sofiène Tahar; Jean-Philippe Warren

Non-voting members: Denis Cossette; Bram Freedman; Frederica Jacobs

1. Call to order

The President called the meeting to order at 2:04 p.m., urging Senators to give generously to the Student Emergency and Food Fund, following the appeal made by Ellie Hummel in her letter which was forwarded with the meeting documentation.

1.1 Approval of Agenda

R-2017-8-1 *Upon motion duly moved and seconded, it was unanimously resolved that the Agenda of the Open Session be approved.*

1.2 Approval of the Minutes of the Open Session meeting of November 10, 2017

Ms. Tessier noted that the motion under item 6.8 of the Minutes should read "John Molson School of Business" in lieu "Faculty of Engineering and Computer Science".

R-2017-8-2 Upon motion duly moved and seconded, it was unanimously resolved that the Minutes of the Open Session meeting of November 10, 2017 be approved, as revised.

2. Business arising from the Minutes not included on the Agenda

There was no business arising from the Minutes not included on the Agenda.

3. President's remarks

The President's remarks are summarized as follows:

- Concordia was recently awarded three new Canada Research Chairs totaling $3.3 million.
- Concordia will be receiving $9.3 million from the Social Sciences and Humanities Research Council.
- Congratulations to Anne-Marie Croteau and Marc Denoncourt who have received the Métritic awards from the Réseau Action TI, in recognition of their significant contributions to Concordia and IT sector in general.
- Concordia and Equitas co-hosted the 8th International Conference on Human Rights Education, held from November 30 to December 3.
- Concordia International has concluded two new exchange agreements, which offer exchanges and opportunities for our students to study abroad.
- The Concordia Refugee Centre, in partnership with the United Nations High Commission for Refugees, hosted a hackathon to solve urgent refugee issues. The Centre was launched last year by students and alumni and so far has helped over 150 refugees.
- The University received a $1.5 million gift from the R. Howard Webster Foundation to support preventive health research and student athletes.

4. Academic update (Document US-2017-8-D1)

Referring to page 4 of his written update, Dr. Carr clarified that the Prix Pierre-Ayot and the Prix Louis-Comtois are jointly awarded by the City of Montréal and the Contemporary Art Galleries Association, the former being awarded to up and coming artists under the age of 35 and the latter to artists who have distinguished themselves in Montreal's contemporary art scene.

Dr. Guy announced that confirmation was just received that Concordia is one of nine Canadian universities whose proposal was accepted under the Canada Excellence Research Chair competition for its project on Smart, Sustainable and Resilient Cities and Communities. This new research chair will come with a $10 million award over seven years.

5. Report of Standing Committees

5.1 Research (Document US-2017-8-D2)

No questions were asked in connection with this report.

CONSENT

6. Committee appointments (Document US-2017-8-D3)

R-2017-8-3 *That the committee appointments, outlined in Document US-2017-8-D3, be approved.*

7. Academic Programs Committee: Report and recommendations (Document US-2017-8-D4)

7.1 Graduate curriculum changes – John Molson School of Business – Diploma in Chartered Professional Accountancy (Document US-2017-8-D6)

R-2017-8-4 *That the graduate curriculum changes in the John Molson School of Business, outlined in Document US-2017-8-D6 be approved, as recommended by the Academic Programs Committee in Document US-2017-8-D4.*

7.2 Graduate curriculum changes – School of Graduate Studies – Doctor of/Doctorate in Philosophy (Individualized Program) (Document US-2017-8-D7)

R-2017-8-5 *That the graduate curriculum changes in the School of Graduate Studies, outlined in Document US-2017-8-D7 be approved, as recommended by the Academic Programs Committee in Document US-2017-8-D4.*

REGULAR

8. Academic Programs Committee: Report and recommendations (Document US-2017-8-D4)

8.1 New graduate program – Faculty of Arts and Science – Départment d'Études françaises - Microprogramme en didactique et linguistique pour l'enseignement du français langue seconde (Document US-2017-8-D5)

Dean Roy apprised Senate that there is a demand for the *Microprogramme en didactique et linguistique pour l'enseignement du français langue seconde*, a 15-credit micro-program in teaching French as a second language. Its main features include combining both theoretical and practical approaches to computer-assisted learning, highlighting how linguistics theories are involved in language learning and teaching, and providing students experiential learning opportunities in classroom settings. This certificate will distinguish Concordia from other Quebec and Canadian universities. No additional resources are required for this new program.

Reporting on behalf of the Senate Finance Committee, Prof. Proppe read a statement on the financial aspects of the proposed program, specifying that the Committee does not comment on the academic merits. He indicated that the Committee received the proposal between meetings, such that the written report could not be prepared in time for the Senate meeting.

The Committee examined the budget included in the document and found that the anticipated financial gain for the University shown in the Chart of Expenses and Revenues is overstated. In order to get a more realistic estimate, the current income from the existing enrollment in the MA being suspended (approximately 3.3 WFTEs) as well as the enrollment in the 4 course sections (courses unknown) being replaced by courses in the new certificate need to be deducted from the projected new income generated by the enrollment in the certificate.

Dean Roy responded that the charts included in the proposal contain estimates of the number of students and that in general the Faculty is conservative in its estimates. He added that the MA in literature has been suspended for the last two years and students in the program are now ending their thesis. Full sections have not been taught. The cost-benefit analysis conducted to demonstrate the value of the new program shows a cost of $23,000 for the first six years. The revenues will outweigh those numbers by a large margin.

R-2017-8-6 *Upon motion duly moved and seconded, it was unanimously resolved that the new graduate program in the Faculty of Arts and Science, outlined in Document US-2017-8-D5, be approved, as recommended by the Academic Programs Committee in Document US-2017-8-D4.*

9. Update on Digital Strategy project

The Vice-Provost, Digital Strategy and University Librarian, Guylaine Beaudry, presented an overview of the new initiative to develop a university-wide digital strategy. She noted that this is one of five transformation projects being undertaken in 2017/2018 as part of the Strategic Directions initiative to position Concordia as a next-generation university.

She made the point that this is not an IT strategy. The goal is to create a coherent plan, since the digital strategy constitutes more than just tools, storage and processing. It is really about people, the objective being to create a digital culture that will allow our students, faculty and staff to thrive in a period of rapid change.

Dr. Beaudry reviewed the high-level deliverables and their timeline, as follows:

- → Inventory of information systems, digital technologies, platforms, software and services used for teaching, research and communications with students (December 2017)
- → Report on consultation – everyday work, goals, problems practices: personals, journeys and high-level requirements (Winter 2018)
- → Environment scan report – best practices in higher education and other large organizations – President's Speaker Series on Digital Futures (Winter 2018)
- → Elements for a shared vision (Winter 2018)
- → Preliminary roadmap (Spring 2018)

She also apprised Senate of the composition and mandate of the four working groups which oversee this project: the Executive Committee and the Steering Committee which meet twice a term, the Working Group which meets every 4 to 6 weeks, while the Project Support Team meets at least weekly.

So far, work has begun with a view to conduct a short survey of students' expectations and experiences of technology, using a tool developed by JISC, a United Kingdom not-for-profit organization that provides digital solutions in education and research. The JISC Tracker Working Group plans to run the full census survey in early March.

Dr. Beaudry concluded her presentation by apprising Senate of the Concordia President's Speaker Series on Digital Futures, which will be launched in January as part of the process to engage the Concordia community in conversations and reflection about the digital world. Senators can stay informed on the progress of the digital strategy project by consulting the Digital Strategy Website.

10. Student health and wellbeing review (Document US-2017-8-D8)

Dr. Ostiguy noted that the student health and wellbeing review was launched in the Fall, following a request by the President, to look at what the University is doing collectively. A committee was formed with University-wide representation, and a consultant was hired to provide a review of literature in the six areas to be examined as well as best practices and trends in health and wellbeing in North American universities.

The objective of today's exercise it to obtain feedback from Senators on a series of ideas put forward during three Ideas Cafés to enhance student services. A summary of those ideas is represented on three graphic displays posted around the room.

Dr. Ostiguy invited Senators to take a look at each graphic display and place a red dot next to the ideas that resonate the most with them. She also invited Senators to write down any suggestion regarding an alternate idea which is not included on the graphic displays and place it in the suggestion box. The Committee will review all the feedback.

Following this exercise, in response to a question, Dr. Ostiguy indicated that all ideas will be considered by the Committee, even those not identified by a red dot.

11. Question period

No questions were posed.

12. Other business

There was no other business to bring before Senate.

13. Adjournment

The meeting adjourned at 3:05 p.m.

D. Tessier

Danielle Tessier
Secretary of Senate

UNIVERSITÉ Concordia UNIVERSITY

Internal Memorandum

To:	Members of Senate
From:	Graham Carr, Provost and Vice-President, Academic Affairs
Date:	January 10, 2018
Re:	Academic Update

Happy New Year to everyone!

It hasn't been very long since our last update, but a lot has still happened.

As noted verbally at the last Senate, Concordia is one of only 9 Canadian institutions to advance in the CERC competition in this current round.

Launched in 2008, the Canada Excellence Research Chairs (CERC) program supports Canadian universities in their efforts to build on Canada's growing reputation as a global leader in research and innovation. The CERC awards are among the most prestigious and generous available globally. The new chair holder – who has yet to be identified and on whose hiring the funding is conditional – will build on Concordia's existing strengths in several areas:

- Net-zero and energy-efficient buildings
- Clean and renewable sources of energy
- Sustainable environmental engineering
- Information systems and smart technologies
- Urban planning and integrated design
- Climate science

The search for the CERC is being launched shortly.

Continuing with the good news, the Genomic Applications Partnership Program (GAPP) has awarded Prof. Adrian Tsang (Biology, Director of Concordia's Centre for Structural and Functional Genomics) $6 million over three years to support his work to develop an alternative to antibiotics in animal feed. The funding for his research comes from Genome Canada, Génome Québec and Elanco Animal Health. With it, Prof. Tsang hopes to identify and characterize how lysozymes – which are naturally occurring antimicrobial enzymes found in animals' immune systems – can be inexpensively recreated and used in livestock production to replace sub-therapeutic use of antibiotics.

At the end of November, the Chief Scientist of Québec, Rémi Quirion and the *Fonds de recherche du Québec*, MITACS, Aligo, and Robic joined Concordia's District 3 in a workshop to help STEM PhDs, postdocs and researchers explore non-academic career paths. Participants learned first-hand from fellow scientists and their experiences in successfully venturing outside of academia.

On December 6, we celebrated an important milestone with forty-four librarians and faculty at Concordia who were promoted and/or received tenure in 2017. Earning tenure or promotion signifies the excellence that individuals are deemed to have achieved by their peers. It was a pleasure to have the opportunity to recognize our gifted faculty members.

On December 11, JMSB received word that its application for Affiliated Membership to the European Foundation for Management Development (EFMD) was approved. This is important news as it marks the first required step towards the school's application for EFMD Quality Improvement System (EQUIS) accreditation, which is operated by EFMD.

A delegation of 90 undergraduate students from the John Molson School of Business won gold last week at the 2018 *Jeux du commerce* (JDC)—the largest academic competition in Eastern Canada. The annual event brought 1,300 business students to Concordia, who hosted this year, to battle it out in academic, athletic and social competitions. This was the 30th edition of the JDC and the second time in three years that JMSB wins gold.

From January 1 to 6, JMSB hosted the 37th annual John Molson MBA International Case Competition. Thirty-six teams of four students from around the world competed for the Concordia Cup and a $10,000 cash prize by analyzing seven unpublished business cases and preparing oral presentations on them. The event is the oldest and largest competition of its kind and is entirely student-run. Nine John Molson MBA student-organizers get academic credit for their work. Responsibilities range from recruiting to organizing the participating schools, as well as handling the hotel reservations, securing sponsorships, booking convention rooms and managing budgets, logistics and marketing. This year's winning team was UCD Michael Smurfit Graduate Business School from Dublin, Ireland.

I am pleased to announce that Dr. Donna Kahérakwas Goodleaf has assumed the new position of Indigenous Curriculum and Pedagogical Advisor, in the Centre for Teaching and Learning. Dr. Goodleaf joined Concordia as a part-time faculty member in 2016, and her previous experience includes serving as the Associate Director for the Office of First Nations and Inuit Teacher Training Program at McGill University and as a faculty instructor at various universities across the United States and Canada. She has extensive experience in curriculum development, research and course instruction at both the University and community-based levels and maintains a strong personal commitment to Indigenous-centered education and knowledge development from a culturally-based framework. Dr. Goodleaf is Turtle Clan and is from the Kanien'kehaka (Mohawk) Nation, Kahnawake Territory.

US-2018-1-D2

SENATE FINANCE COMMITTEE
REPORT TO SENATE
January 19, 2018

The second meeting of the Senate Finance Committee (SFC) was held on December 1 and continued on December 6, 2017 in order to complete the agenda. The CFO sent his regrets.

eConcordia
Robert Beauchemin, President and CEO of KnowledgeOne and eConcordia presented an update to SFC at the December 1 meeting. A brief summary of his presentation follows:

eConcordia was founded in 2001 as a not-for-profit entity to develop online courses for Concordia University. In 2010, commercial demand grew to the point where the University created the for-profit entity KnowledgeOne to receive contracts for commercial business. It is 100% owned by eConcordia, which, in turn, is 100% owned by the Concordia University Foundation. KnowledgeOne recently launched two MOOCS for the United Nations Environment Program.

At Concordia, there is an increasing demand for online courses. Students are seeking more flexibility in terms of time and methods of delivery; courses have evolved well beyond recording of lectures. Currently, there are 67 online courses with 33,000 yearly registrations, a median enrolment of 300 students, and an outlier with an enrolment of about 1800. The objective is to offer 100 courses and have 40,000 students by 2020. Mr. Beauchemin explained that currently there were three levels of course development and each level increases the developmental complexity and cost: level 3 courses are contextually detailed and involve highly immersive interactive and participatory learning. The vast majority of the courses that have been developed for Concordia are level 1 courses from a wide range of departments, but the intention is to create more level 2s and 3s. It should be noted that one of our courses, Medieval English (English 306), won an international award.

The only Quebec university with more online presence than Concordia is Laval, with about 67,000 registrations. In contrast to Concordia, Laval offers entire programs online.

The Concordia University Digital Strategy Steering Committee oversees some of the policy decisions on development of new online material. The high development rate for new courses and the resources required for level 3 courses are factors contributing to an operational deficit – roughly half of which is due to operational costs.

Mr. Beauchemin will return and present recent audited financial statements to SFC in the near future.

New Programs
Two new programs were also reviewed at the meetings on December 1 and 6.

Microprogramme en didactique et linguistique pour l'enseignement du français langue seconde. The SFC has already made an oral report on this program at the Senate meeting of December 8.

Graduate Programs in Chemical Engineering.
There are 4 new graduate programs in Chemical Engineering being proposed for the new department in Chemical and Materials Engineering: a 15-credit certificate, a 30-credit Diploma, a 45-cr MASc, and a 90-cr PhD. When the Department was created, it was expected that these programs would be developed with the associated costs. It should be noted, however, that this Faculty has always met its enrolment targets so, in all likelihood, the enrolment targets will be met for these programs. SFC considered two issues, in particular, which are not addressed in the proposals.

- First, there is no costing of attrition, i.e., a loss of students who do not complete the program. Attrition will reduce the income side of the ledger, leading to a reduction in the anticipated monetary gains for the University (see Section 5.5 in the proposals).
- Second, there is no costing of the reduction of students in mechanical engineering programs. The document acknowledges that these new programs will take some of the enrolment pressure from the mechanical programs, but it unclear whether this reduction will lead to a drop in enrolment in mechanical graduate programs.

LIBRARY

US-2018-1-D3

REPORT TO SENATE
FROM THE
LIBRARY COMMITTEE

(Senate Meeting – January 19, 2017)

The first meeting of the LC for the academic year was held on December 1, 2017.

1. General Information

- Mr. Tomasz Neugebauer, Digital Projects and Systems Development Librarian, has been nominated to serve on the Governing Committee of ORCID-CA. The ORCID identifier connects researchers with their works and organizations and enables data exchange between research information systems.

- On November 23, 2017, the Library was honored with the visit of Dr. Guy Berthiaume, Librarian and Archivist of Canada, who presented a talk on the National Heritage Digitization Strategy and other initiatives at Library and Archives Canada. The event was well attended with forty participants.

- Ms. Claire Burrows has been appointed as Concordia Library's 2018 Researcher-in-Residence. Ms. Burrows is a PhD candidate in Library and Information Science at Western University. Her doctoral research pertains to accessibility of academic libraries in Canada for students with disabilities. She plans to build on this research in the residency, as well as explore ways to implement these strategies through conversations with Concordia librarians. Ms. Burrows will begin her one-year appointment on Monday, January 8, 2018.

- The Library has launched the Indigenous Student Librarian Program which offers the opportunity for an indigenous student librarian to work part-time at Concordia Library, while pursuing a master's degree in information studies at either McGill or UdeM. This initiative, led by Concordia University Library, is a collaboration between three universities: Concordia, McGill University, and Université de Montréal. http://www.concordia.ca/about/indigenous.html

- Three librarian positions are being posted for a start date of June 1, 2018:
  - Digital Preservation Librarian
  - Digital Scholarship Librarian
  - Teaching & Research Librarian – Fine Arts

2. Concordia University Press

The Concordia University Press established its first series, Media Before 1800. Edited by Fiona Somerset (University of Connecticut), Daniel T. Kline (University of Alaska Anchorage), and Stephen Yeager (Concordia University). Media Before 1800 will bring cutting-edge discoveries from the disciplines of manuscript and early-print studies into conversation with the cognate disciplines of media archaeology, infrastructure studies, and media ecology. Yeager and Thora Brylowe (University of Colorado, Boulder) are working on the first book in the series.

3. LibQUAL+ 2017 survey results

Ms. Katharine Hall, Reference and Subject Librarian, presented the LibQUAL+ 2017 survey results. LibQual is a survey that measures respondents' expectations and perception of the library services across three domains: library spaces, collections & access tools and staff affect. The survey was run at Concordia in February 2017 and has previously been run in 2006, 2007, 2010 and 2013.

Undergraduate respondents ranked library spaces as their highest desired category, with their most desired item being "Quiet spaces for individual activities". When examining undergraduate respondents' perception of space across all LibQual surveys conducted at Concordia, LibQual 2017 was the first year where their perception of the space was greater than their minimum expectation.

Graduate respondents ranked the collection and access tools as their highest desired category, with "Easy-to-use access tools that allow me to find things on my own" as the top desired item.

LibQual also allows for users to leave written feedback and 642 respondents left comments, the highest proportion related to library space.

4. Presentation on Technology Sandbox and Visualization Studio

Ms. Jasia Stuart and Ms. Tina Salemeh, both Technology Analysts from the Library, made a presentation on the Technology Sandbox and the Visualization Studio. The Sandbox has been open for just over 9 months and provides space, tools, workshops and expertise to facilitate project in media creation, electronics, 3D printing and virtual reality. To learn more around this new space please consult http://library.concordia.ca/locations/technology-sandbox/index.php or drop by during our open hours from 10:00 a.m. – 6:00 p.m.

The Visualization Studio encourages and fosters a culture of data literacy, creative experimentation and interdisciplinary collaboration and discourse, in particular with data visualization tools. A large interactive wall of 30x6 feet, composed of 27x ultra-thin bezel 46” Planar LCD panels, each with a resolution of 1920x1080 is part of the studio infrastructure. The Visualization Studio is a space that not only enables but also actively encourages the exploration of new ways to support learning, teaching and research in the four faculties at Concordia and all the disciplines they encompass through digital tools, theory, processes and techniques.

Respectfully submitted,
Dr. Guylaine Beaudry
Vice-Provost, Digital Strategy and University Librarian
December 20, 2017

US-2018-1-D4

UNIVERSITÉ Concordia UNIVERSITY

COMMITTEE APPOINTMENTS

Appointments requiring Senate ratification	**Appointee**	**Term**
Student Tribunal Pool	Julia Sutera Sardo (CSU)	2018/2019
	Yuan Sun (CSU)	2018/2019

December 13, 2017

ACADEMIC PROGRAMS COMMITTEE
REPORT TO SENATE
Sandra Gabriele, PhD
January 19, 2018

The Academic Programs Committee requests that Senate consider the following undergraduate changes for the 2019-20 Undergraduate Calendar:

Following approval of Faculty Council, on **December 14, 2017** APC members reviewed the undergraduate curriculum submission from the Faculty of Engineering and Computer Science. As a result of discussions APC resolved that the following undergraduate curriculum proposal be forwarded to Senate for approval:

Faculty of Engineering and Computer Science

Department of Mechanical, Industrial and Aerospace Engineering (For May 2018 Implementation) **(US-2018-1-D6)**
[The proposal involves adding a Basic and Natural Science course to the Industrial Engineering core and subsequently reducing the minimum required elective course credits by three.]

- BEng in Industrial Engineering
- Requirements

The Academic Programs Committee requests that Senate consider the following graduate changes for the Fall 2018 Graduate Calendar[1]:

Following approval of Faculty Council, the Graduate Curriculum Committee, and the Council of the School of Graduate Studies for applicable proposals, on **December 14, 2017** APC members reviewed the graduate curriculum submissions from the Faculty of Engineering and Computer Science. As a result of discussions APC resolved that the following graduate curriculum proposals be forwarded to Senate for approval:

Faculty of Engineering and Computer Science

Department of Chemical and Materials Engineering (For Fall 2018 Implementation) **(US-2018-1-D7)**
[The proposal involves creating a new program.]

- Graduate Certificate in Chemical Engineering **- New Program**

Department of Chemical and Materials Engineering (For Fall 2018 Implementation) **(US-2018-1-D8)**
[The proposal involves creating a new program.]

- Graduate Diploma in Chemical Engineering **- New Program**

Department of Chemical and Materials Engineering **(US-2018-1-D9)**
[The proposal involves creating a new program.]

- Master of/Magisteriate in Applied Science (Chemical Engineering) **- New Program**

Department of Chemical and Materials Engineering **(US-2018-1-D10)**
[The proposal involves creating a new program.]

- Doctor of/Doctorate in Philosophy (Chemical Engineering) **- New Program**

[1] New programs requiring MEES approval shall be included in the relevant calendar upon final approval.

Department of Electrical and Computer Engineering (For Fall 2018 Implementation) **(US-2018-1-D11)**
[The proposal involves converting a slot course into a permanent offering.]

- Doctor of/Doctorate in Philosophy (Electrical and Computer Engineering)
- Master of/Magisteriate in Applied Science (Electrical and Computer Engineering)
- Master of/Magisteriate in Engineering (Electrical and Computer Engineering)
- Course offering

Sandra Gabriele, PhD
Vice-Provost, Innovation in Teaching and Learning
December 20, 2017

UNIVERSITÉ Concordia UNIVERSITY

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE

US-2018-1-D6

INTERNAL MEMORANDUM

TO: Dr. Sandra Gabriele, Vice- Provost, Innovation in Teaching and Learning

FROM: Dr. A. Asif, Dean; Chair, ENCS Faculty Council

DATE: December 5, 2017

RE: Curriculum Changes to the Industrial Engineering program in the MIAE Dept

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Please find attached the curriculum changes for the Industrial Engineering program. The Department proposes to add a Basic and Natural Science course as part of the Industrial Engineering Core courses.

This proposal passed the ENCS Undergraduate Studies Committee on November 15, 2017 as well as the Faculty Council on December 1, 2017. I would be grateful if you could put it on the agenda of the next APC meeting.

INTERNAL MEMORANDUM

TO: Ali Akgunduz, Associate Dean, Academic Programs, Faculty of Engineering and Computer Science

FROM: Martin D Pugh, Chair, MIAE

DATE: Wednesday, November 15th, 2017

SUBJECT: Curriculum changes in the INDU Undergraduate Program

Please find attached the curriculum package for the undergraduate program in Industrial Engineering. The present package contains one program change. This curriculum change has been reviewed and approved by the MIAE department council on November 14th, 2017.

Overview of Changes

The change in this package is summarized below.

B.Eng.: The students in the Industrial Engineering program must complete a Basic and Natural Science course as part of the core courses.

Resource Implications

There are no resource implications resulting from the proposed change.

We would be grateful if you could put this on the agenda of the next ENCS Undergraduate Studies Committee meeting.

DOSSIER TITLE:
DESCRIPTION OF CHANGE:
PROGRAM CHANGE - CALENDAR UPDATE FORM – *(please fill in all the appropriate information)* **Calendar for Academic Year:** 2019/2020
Proposed [X] Undergraduate or [ ] Graduate Curriculum Changes **Implementation Month/Year:** May 2018

Faculty: Engineering and Computer Science **Department:** Mechanical, Industrial and Aerospace Engineering

Program: Industrial Engineering **Degree:** B. Eng. **Section Title:** 71.40.2

Type of Change: *(please fill in all the appropriate boxes with an "X")* **A separate form is required for each change.**
[ ] Editorial [X] Requirements [ ] Regulations
[ ] New Program [ ] Program Deletion

Present Text (Text from 2017 – 2018 Calendar)	Proposed Text
Paste description from current calendar in 'present text' (~~strike-out text sections to be changed or deleted~~) and in 'proposed text' (<u>underline additions and changes proposed</u>). Attach a separate sheet if necessary.	
71.40.2 Course Requirements (BEng in Industrial Engineering) The program in Industrial Engineering consists of the Engineering Core, the Industrial Engineering Core, and elective credits as shown below. The minimum length of the program is 120 credits. **Engineering Core** (27 credits) See §71.20.5. **Industrial Engineering Core** *Credits* ENGR 245 Mechanical Analysis 3.00 ENGR 251 Thermodynamics I 3.00 ENGR 311 Transform Calculus and Partial Differential Equations 3.00 INDU 211 Introduction to Production and Manufacturing Systems 3.00 INDU 311 Simulation of Industrial Systems 3.50 INDU 320 Production Engineering 3.00 INDU 321 Lean Manufacturing 3.00 INDU 323 Operations Research I 3.50 INDU 324 Operations Research II 3.50 INDU 330 Engineering Management 3.00 INDU 342 Logistics Network Models 3.00	**71.40.2 Course Requirements (BEng in Industrial Engineering)** The program in Industrial Engineering consists of the Engineering Core, the Industrial Engineering Core, and elective credits as shown below. <u>Students must select one course from the list of Basic and Natural Science courses as part of the Industrial Engineering Core courses.</u> The minimum length of the program is 120 credits. **Engineering Core** (27 credits) See §71.20.5. **Industrial Engineering Core** *Credits* ENGR 245 Mechanical Analysis 3.00 ENGR 251 Thermodynamics I 3.00 ENGR 311 Transform Calculus and Partial Differential Equations 3.00 INDU 211 Introduction to Production and Manufacturing Systems 3.00 INDU 311 Simulation of Industrial Systems 3.50 INDU 320 Production Engineering 3.00 INDU 321 Lean Manufacturing 3.00 INDU 323 Operations Research I 3.50 INDU 324 Operations Research II 3.50

INDU 371	Stochastic Models in Industrial Engineering	3.00
INDU 372	Quality Control and Reliability	3.00
INDU 411	Computer Integrated Manufacturing	3.50
INDU 412	Human Factors Engineering	3.50
INDU 421	Facilities Design and Material Handling Systems	3.50
INDU 423	Inventory Control	3.50
INDU 490	Capstone Industrial Engineering Design Project	4.00
MECH 211	Mechanical Engineering Drawing	3.50
MECH 215	Programming for Mechanical and Industrial Engineers	3.50
MECH 221	Materials Science	3.00
MECH 311	Manufacturing Processes	3.75
MECH 313	Machine Drawing and Design	3.50
		~~75.75~~

Electives

Students must complete a minimum of ~~17.25~~ credits from the following courses, including at least three INDU courses and with no more than ~~two~~ of the courses marked *. With permission of the Department, students may take one technical elective course from another program or Faculty.

		Credits
BSTA 478*	Data Mining Techniques	3.00
BTM 430*	Enterprise Resource Planning and Information Technology Integration	3.00
BTM 480*	Project Management	3.00
ENGR 361	Fluid Mechanics I	3.00
ENGR 411	Special Technical Report	1.00
ENGR 412	Honours Research Project	3.00
INDU 410	Safety Engineering	3.50
INDU 440	Product Design and Development	3.00
INDU 441	Introduction to Six Sigma	3.00
INDU 466	Decision Models in Service Sector	3.00
INDU 475	Advanced Concepts in Quality Improvement	3.00
INDU 480	Cases in Industrial Engineering	3.00
INDU 498	Topics in Industrial Engineering	3.00
MANA 300*	Entrepreneurship: Launching Your Business	3.00

INDU 330	Engineering Management	3.00
INDU 342	Logistics Network Models	3.00
INDU 371	Stochastic Models in Industrial Engineering	3.00
INDU 372	Quality Control and Reliability	3.00
INDU 411	Computer Integrated Manufacturing	3.50
INDU 412	Human Factors Engineering	3.50
INDU 421	Facilities Design and Material Handling Systems	3.50
INDU 423	Inventory Control	3.50
INDU 490	Capstone Industrial Engineering Design Project	4.00
MECH 211	Mechanical Engineering Drawing	3.50
MECH 215	Programming for Mechanical and Industrial Engineers	3.50
MECH 221	Materials Science	3.00
MECH 311	Manufacturing Processes	3.75
MECH 313	Machine Drawing and Design	3.50
	One Basic and Natural Science course from the list below.	3.00
		78.75

Basic and Natural Science Courses

Students must complete one course from the following list:

		Credits
BIOL 206	Elementary Genetics	3.00
BIOL 261	Molecular and General Genetics	3.00
CHEM 217	Introductory Analytical Chemistry I	3.00
CHEM 221	Introductory Organic Chemistry I	3.00
GEOL 206	Earthquakes, Volcanoes, and Plate Tectonics	3.00
GEOL 208	The Earth, Moon and the Planets	3.00
PHYS 252	Optics	3.00
PHYS 260	Introductory Biophysics	3.00
PHYS 270	Introduction to Energy and Environment	3.00
PHYS 284	Introduction to Astronomy	3.00
PHYS 385	Astrophysics	3.00

MECH 321	Properties and Failure of Materials	3.50
MECH 370	Modelling and Analysis of Dynamic Systems	3.50
MECH 371	Analysis and Design of Control Systems	3.75
MECH 412	Computer-Aided Mechanical Design	3.50
MECH 415	Advanced Programming for Mechanical and Industrial Engineers	3.00
MECH 421	Mechanical Shaping of Metals and Plastics	3.50
MECH 423	Casting, Welding, Heat Treating and Non-Destructive Testing	3.50
MECH 425	Manufacturing of Composites	3.50

Electives

Students must complete a minimum of 14.25 credits from the following courses, including at least three INDU courses and with no more than one of the courses marked *. With permission of the Department, students may take one technical elective course from another program or Faculty.

		Credits
BSTA 478*	Data Mining Techniques	3.00
BTM 430*	Enterprise Resource Planning and Information Technology Integration	3.00
BTM 480*	Project Management	3.00
ENGR 361	Fluid Mechanics I	3.00
ENGR 411	Special Technical Report	1.00
ENGR 412	Honours Research Project	3.00
INDU 410	Safety Engineering	3.50
INDU 440	Product Design and Development	3.00
INDU 441	Introduction to Six Sigma	3.00
INDU 466	Decision Models in Service Sector	3.00
INDU 475	Advanced Concepts in Quality Improvement	3.00
INDU 480	Cases in Industrial Engineering	3.00
INDU 498	Topics in Industrial Engineering	3.00
MANA 300*	Entrepreneurship: Launching Your Business	3.00
MECH 321	Properties and Failure of Materials	3.50
MECH 370	Modelling and Analysis of Dynamic Systems	3.50
MECH 371	Analysis and Design of Control Systems	3.75
MECH 412	Computer-Aided Mechanical Design	3.50
MECH 415	Advanced Programming for Mechanical and Industrial Engineers	3.00
MECH 421	Mechanical Shaping of Metals and Plastics	3.50
MECH 423	Casting, Welding, Heat Treating and Non-Destructive Testing	3.50
MECH 425	Manufacturing of Composites	3.50

Rationale:

As a result of the Canadian Engineering Accreditation Board (CEAB) site visit and review, the B.Eng. Industrial Engineering program was found by the CEAB to be deficient in coverage of the natural sciences. Thus, the proposed changes require students of Industrial Engineering program to complete one 3-credit course from the list of Basic and Natural science courses in order to increase the corresponding content in the curriculum to comply with the CEAB's requirements.

The number of credits for MECH 313 is increased by 0.5 (from 3.0 to 3.5) and it was approved by Senate on November 10, 2017.

Resource Implications:
None.

Basic and Natural Science Course Descriptions

BIOL 206 ***Elementary Genetics*** (3 credits)
A survey of classical and contemporary developments in the study of heredity, with particular attention to human examples. This course is open to the general student body. Lectures only.
NOTE: Students who have received credit for BIOL 261 may not take this course for credit.
NOTE: Students transferring into a Biology program may retain degree credit for this course.

BIOL 261 ***Molecular and General Genetics*** (3 credits)
Prerequisite: Cegep Biology 301 or 101-NYA or BIOL 201; 202 NYA or CHEM 205; 202-NYB or CHEM 206. Basic genetic principles, including mechanisms of meiosis and mitosis, Mendelian genetics, recombination, gene mapping, and chromosome rearrangements; an introduction to molecular genetics, including nucleic acid structure and biosynthesis transcription and translation; the course also includes an introduction to recombinant DNA technology and to concepts of population genetics. Lectures and tutorials.

CHEM 217 ***Introductory Analytical Chemistry I*** (3 credits)
Prerequisite: CHEM 205, 206; PHYS 204, 206, 224, 226; MATH 203, 205; or equivalents for **all** prerequisite courses. Precipitation methods and solubility products; activity, chemical equilibria and titration curves of neutralization and complexation systems; treatment of analytical data. Lectures and laboratory.

CHEM 221 ***Introductory Organic Chemistry I*** (3 credits)
Prerequisite: CHEM 205, 206. Basic aspects of orbitals and their role in covalent bonding; delocalization of electrons. Alkanes: structure, nomenclature, isomerism, reactions. Introductory stereochemistry: enantiomers, diastereomers, conformers, Fischer and Newman projections, specification of chirality, E/Z isomerism. Conformations of cyclic compounds. Alkylhalides: S_N1; S_N2; E1; E2 reaction mechanisms. Free-radical reactions, organometallic compounds. Chemistry of alkenes, alkynes, and dienes. Lectures and laboratory.

GEOL 206 **Earthquakes, Volcanoes, and Plate Tectonics** (3 credits)
This course is for students with little or no previous background in the earth sciences, providing an up-to-date account of our present knowledge of earthquakes and volcanoes, and the use of this information in the development of the theory of plate tectonics. Areas of concentration are: nature, distribution, and causes of earthquakes and volcanic eruptions, measuring earthquakes, great earthquakes and volcanic eruptions in world history, products of volcanic eruptions, and hazards from, and prediction of, earthquakes and volcanic eruptions. The theory of plate tectonics and the evolution of mountain belts of the world are studied. Lectures only.

GEOL 208 **The Earth, Moon and the Planets** (3 credits)
The course emphasizes the cosmic perspective of the Earth and focuses attention on how the results of the last two decades of planetary exploration have brought about an intellectual revolution concerning the planets, especially their surface features, processes, and histories. Lectures only.

PHYS 252 ***Optics*** (3 credits)
Prerequisite: PHYS 206. Wave equation, phasors, EM waves, linear, circular and elliptical polarization, polariscope, Malus' law, dichroism, polaroid, polarizing Prism, quarter and half wave plates, wave superposition, interference, Young's double slit experiment, Michelson interferometer, reflectance and transmittance of thin films, interferometers, dispersion, elements of Fourier analysis, diffraction, single slit diffraction, double slit, Fraunhofer and Fresnel limits, diffraction grating, Fresnel diffraction, instruments, introduction to lasers.
NOTE: Students who have received credit for PHYS 352 may not take this course for credit.

PHYS 260 ***Introductory Biophysics*** (3 credits)
Cell physiology; macromolecules and molecular devices; transmission of genetic information; random walks, friction and diffusion; Reynolds number; entropy, temperature and free energy; entropic forces; chemical forces; self-assembly; membranes; active transport; nerve impulses. Overview of experimental techniques: X-ray crystallography; atomic force, electron and optical microscopies; patch-clamp techniques.
NOTE: Students who have received credit for this topic under a PHYS 298 number may not take this course for credit.

PHYS 270 ***Introduction to Energy and Environment*** (3 credits)
This course is designed for students who have little or no background in physics. Topics covered include relationship of physics to environment and energy. Concept and definition of work and energy. Interaction of people and inanimate objects with the environment. Heat and chemical energy. Electromagnetic and nuclear energy. Conservation of energy — how it affects everyday life. Sources of energy used on Earth. Solar energy. Production of wind power, water power, solar cells from sun's energy, biological uses, biopower. Lectures only.
NOTE: Students in programs leading to the BSc degree may not take this course for credit.

PHYS 284 ***Introduction to Astronomy*** (3 credits)
This course explores current knowledge of the cosmos from the celestial sphere towards the farthest reaches of the universe. The journey begins with a description of planet earth, its place in the solar system, and resulting seasonal changes, tidal movements, and earth's precession. Farther out, the solar system, the planets, star clusters, the Milky Way galaxy, and modern strange systems such as black holes, quasars, and supernovae are explored. The physical, theoretical and experimental grounds for understanding are described including Newton's laws, quantum and relativistic theories of light and matter, the science of visual and microwave telescopes, and techniques for discovering the existence of planets in other solar systems are also described. Lectures only.

PHYS 385 ***Astrophysics*** (3 credits)
Prerequisite: PHYS 284. The stars, stellar atmospheres, motion, interiors, and populations. Variable stars. Nebulae. Radio, X-ray, and infrared sources. The galaxy — population and dynamics. The extragalactic universe. Lectures only.

Concordia University
School of Graduate Studies

US-2018-1-D11

MEMO TO: Sandra Gabriele, Vice-Provost, Innovation in Teaching and Learning

FROM: Brad Nelson, Associate Dean, Academic Programs and Development
School of Graduate Studies

DATE: September 26, 2017

SUBJECT: **GRADUATE CURRICULUM CHANGES (ELEC-94)**
(CALENDAR – 2018/2019)
DEPARTEMENT OF ELECTRICAL AND COMPUTER ENGINEERING
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

The Graduate Curriculum Committee (GCC) reviewed the curriculum changes approved by the Faculty of Engineering and Computer Science.

The Department of Electrical and Computer Engineering is introducing a new course, *ELEC 6891 Broadcast Signal Transmission* which was formerly offered as slot course.

The GCC approved the proposed curriculum changes with minor edits. I therefore recommend that the Academic Programs Committee approve and recommend to Senate the above-mentioned curriculum changes in their final form.

cc: M. Debbabi, Associate Dean, Graduate Programs and Research, Faculty of Engineering and Computer Science
O. Ward, University Curriculum Administrator, Office of the Provost and Vice-President, Academic Affairs

Concordia University
Engineering and Computer Science
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Bradley Nelson
Chair, Graduate Curriculum Committee
School of Graduate Studies

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

CC: Ms. Frederica Martin
Academic Programs Analyst
School of Graduate Studies

DATE: June 1 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Faculty of Engineering and Computer Science

At its meeting on May 12th, 2017, the Council of the Faculty of Engineering and Computer Science reviewed and approved, with some modifications, the creation of a new course ***ELEC 6891 Broadcast Signal Transmission***, proposed by the Department of Electrical and Computer Engineering. The course was previously offered twice as a slot course in Fall 2015 and Winter 2016 with a combined enrolment of 11 (four undergraduate and seven graduate) and 25 (13 undergraduate and 12 graduate) students registered respectively. The class capacity is 20 for undergraduate and 40 for graduate students. The new course will enhance the department's offerings in the areas of communications.

Details of the course proposal are indicated and explained in the Department's internal memorandum and Provotrack dossier ELEC-94.

We kindly request that this dossier be placed on the next agenda of the Graduate Curriculum Committee.

Thank you for your consideration of this proposal.

Concordia University

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Amir Asif
Chair of the Faculty Council
Faculty of Engineering and Computer Science

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

DATE: May 4, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Department of Electrical and Computer Engineering (ECE)

At its meeting on May 3, 2017, the Engineering and Computer Science Graduate Studies Committee (ECSGSC) reviewed and approved, with minor modifications, the creation of a new permanent course **ELEC 6891 Broadcast Signal Transmission.** The course was previously offered as a slot course. The addition of the new course will enhance the Department's course offerings in the area of communications. In addition, the proposed course is especially important to the thesis students conducting advanced research in the said area of research.

Details of this curriculum item are indicated and explained in the Department's internal memorandum and Provotrack dossier ELEC-94.

We kindly request that this item be placed on the next agenda of the Faculty Council for approval.

Thank you for your consideration of this proposal.

Concordia University
Engineering and Computer Science

INTERNAL MEMORANDUM

DATE: April 19, 2017

TO: Dr. M. Debbabi, Associate Dean, Research and Graduate Studies
Faculty of Engineering and Computer Science

FROM: Dr. W.E. Lynch, Chair
Department of Electrical and Computer Engineering

SUBJECT: **Graduate Changes - 2018**

Please find enclosed Dossier #94 submitted by the Department of Electrical and Computer Engineering.

This curriculum package is aimed at upgrading the Electrical & Computer Engineering Program. The package consists a creation of one new course **ELEC 6891** to be listed in the Topic Area **E42 Communications** respectively**.**

ELEC 6891 Broadcast Signal Transmission
This goal of this course is to provide a comprehensive view of broadcasting systems by integrating techniques from different areas such as video and audio compression, communications, antenna and Radio Frequency. The students learn about techniques from compression, coding, in different courses but do not receive a comprehensive view of broadcasting. The course content has been developed in collaboration with the CBC. This course would go under topic area E42.

These graduate changes have been approved at the Department Curriculum Committee meeting held December 5, 2016, November, 2016, February 13, 2017 and at the Department Council meeting held March 3, 2017.

I would be grateful if you could put this on the agenda of the next ENCS Graduate Studies Committee meeting

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **ELEC-94** VERSION: 8

PROGRAM CHANGE: Topic Area

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: September 2018

Faculty/School: Engineering and Computer Science
Department: Department of Electrical and Computer Engineering
Program: Electrical and Computer Engineering
Degree: MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [X] Requirements [ ] Regulations [ ] Program Deletion [ ] New Program

Present Text (from 2017/2018) calendar	Proposed Text
List of Courses by Topic Areas **E42 - COMMUNICATIONS** **ELEC 6111 Detection and Estimation Theory** **ELEC 6131 Error Detecting and Correcting Codes** **ELEC 6141 Wireless Communications** **ELEC 6151 Information Theory and Source Coding** **ELEC 6171 Modelling and Analysis of Telecommunications Networks** **ELEC 6181 Real-time and Multimedia Communication over Internet** **ELEC 6831 Digital Communications** **ELEC 6841 Advanced Digital Communications** **ELEC 6851 Introduction to Telecommunications Networks** **ELEC 6861 Higher Layer Telecommunications Protocols** **ELEC 6871 Fiber-Optics Communication Systems and Networks** **ELEC 6881 Fundamentals and Applications of MIMO Communications** **ELEC 7151 Broadband Communications Networks** **ENCS 6811 Optical Networking: Architectures and Protocols** **E43 - MICRO-DEVICES AND FABRICATION PROCESSES** **ELEC 6221 Solid State Devices 9 (*)** **ELEC 6231 Design of Integrated Circuit Components (*)** **ELEC 6241 VLSI Process Technology (*)** **ELEC 6251 Microtransducer Process Technology** **ELEC 6261 Optical Devices for High-Speed Communications** **ELEC 6271 Nanoscience and Nanotechnology: Opto-Electronic Devices** **ELEC 6281 Principles of Solid State Nanodevices**	**List of Courses by Topic Areas** **E42 -COMMUNICATIONS** **ELEC 6111 Detection and Estimation Theory** **ELEC 6131 Error Detecting and Correcting Codes** **ELEC 6141 Wireless Communications** **ELEC 6151 Information Theory and Source Coding** **ELEC 6171 Modelling and Analysis of Telecommunications Networks** **ELEC 6181 Real-time and Multimedia Communication over Internet** **ELEC 6831 Digital Communications** **ELEC 6841 Advanced Digital Communications** **ELEC 6851 Introduction to Telecommunications Networks** **ELEC 6861 Higher Layer Telecommunications Protocols** **ELEC 6871 Fiber-Optics Communication Systems and Networks** **ELEC 6881 Fundamentals and Applications of MIMO Communications** **ELEC 6891 Broadband Signal Transmission (*)** **ELEC 7151 Broadband Communications Networks** **ENCS 6811 Optical Networking: Architectures and Protocols** **E43 - MICRO-DEVICES AND FABRICATION PROCESSES** **ELEC 6221 Solid State Devices 9 (*)** **ELEC 6231 Design of Integrated Circuit Components (*)**

	ELEC 6241 VLSI Process Technology (*) **ELEC 6251 Microtransducer Process Technology** **ELEC 6261 Optical Devices for High-Speed Communications** **ELEC 6271 Nanoscience and Nanotechnology: Opto-Electronic Devices** **ELEC 6281 Principles of Solid State Nanodevices**
Rationale: The topic area reflects the addition of the new course.	
Resource Implications: None	

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **ELEC-94** VERSION: 8

COURSE CHANGE: ELEC 6891 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: September 2018

Faculty/School: Engineering and Computer Science
Department: Department of Electrical and Computer Engineering
Program: Electrical and Computer Engineering
Degree: MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	ELEC 6891 Broadcast Signal Transmission (*) (4 credits) This course covers signal definition, human eye limitations, pixel representation schemes, serial digital interface (SDI); image formats (1080i, 720i, 4k, 8k); compression schemes: H.264/265; modulation and coding techniques used in broadcasting. Terrestrial transmission standards such as DVB-T2, ATSC-3; satellite broadcasting standards such as DVB/S2; MPEG transport stream (MPEG-TS), program specific information (PSI), program ID (PID), program association tables (PAT), program map table (PMT), conditional access, program, program clock reference (PCR); multiplexing and IP encapsulation, single program transport stream (SPTS) and multiple program transport stream (MPTS); video storage and retrieval. A project is required. **Note:** Students who have received credit for ELEC 691DD (Transmission in Broadcast Signal) may not take this course for credit.

Rationale:
The broadcasting industry (TV stations as well as Cable) needs broadcast engineers.
Our students learn about techniques from compression, coding, modulation in different courses, but do not receive a comprehensive view of broadcasting. The goal of this course is to provide a comprehensive view of a broadcasting system by integrating techniques from different areas such as video and audio compression, commuications, antenna and RF.
The course was offered in Fall 2015 with 4 undergraduate and 7 graduate students. It has been offered again in Winter 2016 with 12 graduate and 13 undergraduate students registered. This course would go under topic area E42 Communciations.

Resource Implications:
The course will be part of a faculty member's teaching load and drawn from our current course allotment.

Other Programs within which course is listed:

None

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SCHOOL OF GRADUATE STUDIES

US-2018-1-D7

To: Sandra Gabriele, Vice-Provost, Innovation in Teaching and Learning

cc: Olivia Ward, University Curriculum Administrator
Brad Nelson, Associate Dean, School of Graduate Studies

From: Joanne Beaudoin, Secretary, Council of the School of Graduate Studies

Date: November 14, 2017

Re: Graduate Curriculum Changes – CSGS November 13, 2017

This is to confirm that at the Council of the School of Graduate Studies meeting of Monday, November 13, 2017 the following *curriculum changes* were approved:

Faculty of Engineering and Computer Science

- Department of Chemical & Materials Engineering New Program: *Certificate in Chemical Engineering (MECH-101)* — CSGS 1718 2 D4
- Department of Chemical & Materials Engineering New Program: *Diploma in Chemical Engineering (MECH-102)* — CSGS 1718 2 D6
- Department of Chemical & Materials Engineering New Program: *MASc in Chemical Engineering (MECH-103)* — CSGS 1718 2 D8
- Department of Chemical & Materials Engineering New Program: *PhD in Chemical Engineering (MECH-104)* — CSGS 1718 2 D10

The documents can be forwarded to Senate for final approval.

Thank you.

Concordia University
School of Graduate Studies

MEMO TO: Paula Wood-Adams, Dean of Graduate Studies

FROM: Brad Nelson, Associate Dean, Academic Programs and Development
School of Graduate Studies

DATE: October 30, 2017

SUBJECT: **GRADUATE CURRICULUM CHANGES (MECH-101)**
(CALENDAR – 2018/2019)
DEPARTEMENT OF CHEMICAL AND MATERIALS ENGINEERING
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

The Graduate Curriculum Committee (GCC) reviewed the curriculum changes approved by the Faculty of Engineering and Computer Science.

The new Department of Chemical and Materials Engineering wishes to introduce a new Graduate Certificate in Chemical Engineering.

At the September 18th meeting of the GCC, the committee requested the following revisions: include a detailed rationale and resource implications in the Provotrack forms, update the budget table and admission requirements and lastly some editorial changes. The revised dossier was presented again on October 23rd where further minor edits were noted.

The GCC approved this document with the above inclusions. I therefore recommend that the Council of the School of Graduate Studies approve and recommend to Senate the above-mentioned curriculum changes in their final form.

cc: M. Debbabi, Associate Dean, Graduate Programs and Research, Faculty of Engineering and Computer Science
O. Ward, University Curriculum Administrator, Office of the Provost and Vice-President, Academic Affairs

Concordia University
Engineering and Computer Science

Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Bradley Nelson
Chair, Graduate Curriculum Committee
School of Graduate Studies

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

CC: Ms. Frederica Martin
Academic Programs Analyst
School of Graduate Studies

DATE: June 12, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Faculty of Engineering and Computer Science

At its meetings on May 12th, 2017, the Council of the Faculty of Engineering and Computer Science reviewed and approved, with minor modifications, the creation of the new Graduate Certificate in Chemical Engineering program from the new Department of Chemical and Materials Engineering (CME).

Details of the new program proposal are indicated and explained in the Department's and Engineering and Computer Science Graduate Studies Committee's (ECSGSC) internal memorandums and Provotrack dossier MECH-101.

We kindly request that this dossier be placed on the next agenda of the Graduate Curriculum Committee.

Thank you for your consideration of this proposal.

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Amir Asif
Chair of the Faculty Council
Faculty of Engineering and Computer Science

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

DATE: May 8, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Department of Chemical and Materials Engineering (CME**)**

At its meeting on May 3, 2017, the Engineering and Computer Science Graduate Studies Committee (ECSGSC) reviewed and approved, with minor modifications, the creation of a Graduate Certificate program, which is one of the four new programs, in Chemical Engineering from the new Department of Chemical and Materials Engineering (CME).

The Certificate program will be mainly attractive to Concordia students with a Bachelor's degree in Mechanical Engineering or Chemistry, who wish to deepen their knowledge and acquire the chemical engineering skills needed for industry or the pursuit of more advanced studies at the graduate diploma or master's level.

Details of this proposal are indicated and explained in the Department's internal memorandum and Provotrack dossier MECH-101.

We kindly request that this item be placed on the next agenda of the Faculty Council for approval.

Thank you for your consideration of this proposal.

INTERNAL MEMORANDUM

April 19, 2017
Revised October 30, 2017
December 4, 2017

To: Dr. M. Debbabi
Associate Dean Research and Graduate Studies, ENCS

From: Dr. Alex De Visscher

Re.: Proposal for a new Graduate Certificate Program in Chemical Engineering

Dear Dr. Debbabi,

Please find attached a proposal for a new Graduate Certificate program in Chemical Engineering. This program will be offered by the new Department of Chemical and Materials Engineering, to be established this spring. The proposal is one of five proposals for graduate programs in Chemical Engineering currently in development. Four of these (Certificate, Diploma, MASc and PhD) are currently submitted for approval. The fifth (M.Eng.) will be timed to start approximately one year after the M.A.Sc. and Ph.D. programs.

The Certificate program consists of four courses (15 or 16 credits), three of which are core courses. The target audience for this program is students who wish to deepen their knowledge in Chemical Engineering at the graduate level, but who do not wish to commit to taking a full Master's degree program. These could be students holding a Bachelor's degree in Chemical Engineering from other universities, or students holding a Bachelor's degree in Mechanical Engineering but whose first choice would have been Chemical Engineering if such a program had been available to them.

What will make the program more attractive is the fact that it will be part of Certificate – Diploma – M.Eng. and Certificate – Diploma – M.A.Sc. sequences that will allow students to work their way towards a Master's degree four courses at a time, while they are employed full-time. In particular, students who have completed a 16-credit Certificate program will be able to use these credits towards a Diploma program, and towards a M.Eng. degree. Likewise, students who have completed a 30-credit Diploma program will be able to use these credits towards a M.Eng. degree. With approval of the supervisor, students will also be able to use up to 16 credits from Certificate and Diploma programs towards an M.A.Sc. degree. It is expected that this will make the program more popular than existing Certificates, which are meant as terminal programs. The School of Graduate Studies recently made

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca
Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

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regulatory changes to make this possible.

The courses offered in the Certificate program will also be offered in other programs, such as the M.Eng. and M.A.Sc. programs, currently in development. Hence, the current program will only require a minimum of resources once the Master programs are in place. In the meantime, offering the Certificate will ensure continuity of course offerings when faculty members recruit graduate students, possibly through the MECH or INDI program, while the Master and Ph.D. programs are still pending.

The budget of a Certificate program is somewhat arbitrary because resources must be prorated based on the number of students in the program, but assuming that half of a full-time faculty member corresponds with an enrollment of 15 students, the program will run a slight profit. The proposal contains a high-level steady-state budget. A more detailed budget will be provided shortly in a separate document. Also pending are a library study and the results of a survey among senior undergraduate students, which are currently in progress. The reports will be provided as soon as they are available. The curriculum documents in Provotrack are also in development and will be provided as soon as possible.

An overview of course requirements per program is attached to this memo.

It is the intention of the new department to start offering the Certificate program in September 2018.

The attached proposal has been vetted by the Steering Committee of the Department of Chemical and Materials Engineering. I would greatly appreciate it if you could put this proposal on the agenda of the next Graduate Studies committee.

Best regards,

Alex De Visscher

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

Table 1 Status of courses per program

Code	Course Title	Certif	Dipl	MEng	MASc	PhD
CHME 6001	Project in Chemical and Materials Engineering	-	-	-	elective	elective
CHME 6011	Advanced Transport Phenomena	core, required	core, required	core, required	core, list	core, list
CHME 6021	Advanced Chemical Engineering Thermodynamics	core, list	core, required	core, required	core, list	core, list
CHME 6031	Chemical Kinetics and Reaction Engineering	core, list	core, required	core, required	core, list	core, list
CHME 6041	Chemical Engineering Process Dynamics and Control	elective	core, required	core, required	core, list	core, list
CHME 6051	Chemical Process Engineering and Design	elective	elective	core, required	core, list	core, list
CHME 6061	Advanced Biochemical Engineering	elective	elective	elective	elective	elective
CHME 6071	Materials Science and Engineering	elective	elective	core, list	core, list	core, list
CHME 6081	Advanced Separation Processes	elective	elective	elective	elective	elective
CHME 6091	Statistics for Chemical Engineering	elective	elective	elective	elective	elective
CHME 6101	Advanced Battery Materials and Technologies	elective	elective	elective	elective	elective
CHME 6111	Polymer Chemistry and Engineering	elective	elective	elective	elective	elective
CHME 6121	Nanomaterials Chemistry and Engineering	elective	elective	core, list	core, list	core, list
CHME 6131	Advanced Colloid and Interface Science and Engineering	elective	elective	elective	elective	elective
-	Capstone Project	-	-	core, required	-	-
CHME 6911	Topics in Chemical Engineering I	elective	elective	elective	elective	elective
CHME 7911	Topics in Chemical Engineering II	-	elective	elective	elective	elective
ENCS 6021	Engineering Analysis	core, required	core, required	core, required	core, list	core, list
	Other List 1 options	elective	elective	elective	elective	elective
	Other List 2 options	-	elective	elective	elective	elective

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	Other List 3 options	-	elective	elective	elective	elective
ENGR 8901	Master of Applied Science Research Thesis	-	-	-	core, required	-
ENCS 8011	Ph.D. Seminar	-	-	-	-	core, required
ENCS 8501	Doctoral Research Proposal	-	-	-	-	core, required
ENCS 8511	Comprehensive Examination	-	-	-	-	core, required
ENGR 8911	Doctoral Research and Thesis	-	-	-	-	core, required

Table 2 Number of courses per category, per program

Type of Course	Cert	Dipl	MEng	MASc	PhD
Core	3	5	8	2+	1+
List 1	1	1	1+	2-	2-
List 2		1	1+	2-	2-
List 3		1	1+	2-	2-
Total	**4**	**8**	**12**	**4**	**3**

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PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-101** VERSION: 12

PROGRAM CHANGE: Graduate Certificate in Chemical Engineering

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [ ] Requirements [ ] Regulations [ ] Program Deletion [X] New Program

<table>
<tr><th>Present Text (from 20xx/20xx) calendar</th><th>Proposed Text</th></tr>
<tr><td></td><td>
Graduate Certificate in Chemical Engineering

Admission Requirements
To be considered for admission to graduate certificate-level studies, applicants must hold a bachelor’s/baccalaureate degree (or equivalent) in engineering or the sciences with the Concordia equivalent of a GPA of at least 2.70 on a scale of 4.30.

The Department Graduate Studies Committee will determine the acceptability of an applicant for admission to the program and may require the applicant to do specific remedial coursework, including the bridge course CHME 401 Principles of Chemical Engineering, and/or other course(s) to meet the program requirements.

Credible academic reference letters and a statement of purpose should be included in the application.

Requirements for Completion
Depending on full/part-time status, the program can be completed in one to three years. Students with high standing in their bachelor program and whose academic records satisfy the requirements for good standing in the Master’s Program in Chemical Engineering may apply for transfer to the Master’s program.

1. Credits. Fully qualified students are required to complete at least 15 credits.
2. Courses. Candidates in the graduate certificate program must take 12 credits of core courses while the balance of credits may be chosen from the elective list or other courses offered by the Department. Core courses for which credits have been credited to another certificate or program must be replaced by elective courses in the program or by other courses on special permission.
3. Academic Standing. Please refer to the Academic Standing section of the Graduate Calendar for a detailed review of the Academic Regulations.
Program Specific Requirements. An Assessment Grade Point Average (AGPA) of at least 2.75, based on a minimum of 8 credits is required.
</td></tr>
</table>

4. **Time Limit.** Please refer to the Academic Regulation page for further details regarding the Time Limit requirements.
5. **Graduation**. To be eligible to graduate, students must have obtained a Cumulative Grade Point Average (CGPA) of at least 2.75.

Courses:

Note: All courses are four credits each unless specified otherwise.

Core: 12 credits
- CHME 6011 - Advanced Transport Phenomena
- ENCS 6021 - Engineering Analysis

and
- CHME - 6021 Advanced Chemical Engineering Thermodynamics

or
- CHME - 6031 Chemical Kinetics and Reaction Engineering

Elective: 3 or 4 credits (one course) from the list below, or any core Diploma, MEng, or MASc course in Chemical Engineering not included in the Certificate core course list. Students may take an elective course outside the elective list with permission of the Graduate Program Director.

<u>Elective Course List</u>

- CHME 6061 - Advanced Biochemical Engineering
- CHME 6081 - Advanced Separation Processes
- CHME 6091 - Statistics for Chemical Engineering
- CHME 6101 - Advanced Battery Materials and Technologies
- CHME 6111 - Polymer Chemistry and Engineering
- CHME 6131 - Advanced Colloid and Interface Science and Engineering
- CHME 6911 - Topics in Chemical Engineering I
- ENCS 6111 - Numerical Methods
- ENGR 6201 - Fluid Mechanics
- MECH 6131 - Conduction and Radiation Heat Transfer
- MECH 6141 - Heat Exchanger Design
- MECH 7101 - Convection Heat Transfer

Rationale:
The introduction of the Certificate program is part of the new Chemical and Materials Engineering Department's mandate. The development of the Department and its programs is a key part of Concordia’s strategy, which specifically includes building research capacity in Chemical and Materials Engineering.

The purpose of the proposed Certificate program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future.

According to Engineers Canada (Canadian Engineers for Tomorrow, 2012; 2015), the overall enrollment in Bachelor’s programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292).

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of Ph.D. students has increased by 41 % during that time (from 679 to 958).

It is anticipated that the course offerings will start ahead of the degree programs. The Certificate program is planned to start in Fall 2018.

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

The existing ENCS, ENGR and MECH courses have available space to accommodate the additional students. One extra course offering per year will be provided for course ENCS 6021, which is a core course in the program.

Resource Implications:
The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-101** VERSION: 12

PROGRAM CHANGE: TOPIC AREA 58

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [ ] Requirements [ ] Regulations [ ] Program Deletion [X] New Program

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	Engineering Courses **------** **List of Courses by Topic Areas** **------** **E58 - CHEMICAL PROCESS ENGINEERING** **CHME 6001 Project in Chemical and Materials Engineering** (1 credit) **CHME 6011 Advanced Transport Phenomena** (4 credits) **CHME 6021 Advanced Chemical Engineering Thermodynamics** (4 credits) **CHME 6031 Chemical Kinetics and Reaction Engineering** (4 credits) **CHME 6041 Chemical Engineering Process Dynamics and Control** (4 credits) **CHME 6051 Chemical Process Engineering and Design** (4 credits) **CHME 6061 Advanced Biochemical Engineering** (4 credits) **CHME 6071 Materials Science and Engineering** (4 credits) **CHME 6081 Advanced Separation Processes** (4 credits) **CHME 6091 Statistics for Chemical Engineering** (4 credits) **CHME 6101 Advanced Battery Materials and Technologies** (4 credits) **CHME 6111 Polymer Chemistry and Engineering** (4 credits) **CHME 6121 Nanomaterials Science and Engineering** (4 credits) **CHME 6131 Advanced Colloid and Interface Science and Engineering** (4 credits) **CHME 6911 Topics in Chemical Engineering I** (4 credits) **CHME 7911 Topics in Chemical Engineering II** (4 credits)

Rationale:
The changes reflect the addition of a new topic area and new courses of the proposed new program.

Resource Implications:
The new courses can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

COURSE CHANGE: CHME 6011 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6011 Advanced Transport Phenomena (4 credits) Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering and is a core course in the proposed Certificate. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6021 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6021 Advanced Chemical Engineering Thermodynamics (4 credits) Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering and can be chosen as a core course in the proposed Certificate program. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6031 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6031 Chemical Kinetics and Reaction Engineering (4 credits) Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering and can be chosen as a core course in the proposed Certificate program. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6041 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School:	Engineering and Computer Science
Department:	Chemical and Materials Engineering
Program:	Chemical Engineering
Degree:	Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number:	Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6041 Chemical Engineering Process Dynamics and Control (4 credits) Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.
Rationale: This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program. Certificate students may choose to take this course as an elective with permission of the graduate program director.	
Resource Implications: This course will be part of the teaching load of recently hired faculty members.	
Other Programs within which course is listed: None.	

COURSE CHANGE: CHME 6051 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Course Number [ ] Course Title [ ] Credit Value [ ] Prerequisite
[ ] Course Description [ ] Editorial [X] New Course
[ ] Course Deletion [ ] Other - Specify:

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6051 Chemical Process Engineering and Design (4 credits) Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program. Certificate students may choose to take this course as an elective with permission of the graduate program director.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6061 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number [ ] Course Title [ ] Credit Value [ ] Prerequisite
[ ] Course Description [ ] Editorial [X] New Course
[ ] Course Deletion [ ] Other - Specify:

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6061 Advanced Biochemical Engineering (4 credits) Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-101** VERSION: 12

COURSE CHANGE: CHME 6071 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6071 Materials Science and Engineering (4 credits) Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program. Certificate students may choose to take this course as an elective with permission of the graduate program director.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6081 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6081 Advanced Separation Processes (4 credits) Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6091 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6091 Statistics for Chemical Engineering (4 credits) Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Theory" and "Tools" learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6101 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6101 Advanced Battery Materials and Technologies (4 credits) Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-101** VERSION: 12

COURSE CHANGE: CHME 6111 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Course Number [ ] Course Title [ ] Credit Value [ ] Prerequisite
[ ] Course Description [ ] Editorial [X] New Course
[ ] Course Deletion [ ] Other - Specify:

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6111 Polymer Chemistry and Engineering (4 credits) Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6121 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6121 Nanomaterials Science and Engineering (4 credits) Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Theory" and "Tools" learning outcomes in the Certificate program. Certificate students may choose to take this course as an elective with permission of the graduate program director.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6131 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6131 Advanced Colloid and Interface Science and Engineering (4 credits) Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-101** VERSION: 12

COURSE CHANGE: CHME 6911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6911 Topics in Chemical Engineering I (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Certificate program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

Proposal

Graduate Certificate in Chemical Engineering

Faculty of Engineering and Computer Science

Concordia University

Executive Summary

On November 2, 2016, the Board of Governors approved the establishment of a Department of Chemical and Materials Engineering (CME) at Concordia University. The new department's mandate is to develop graduate and undergraduate programs for a total of approximately 500 students at steady state.

Implementing the first step of this mandate, a suite of five graduate programs is currently in development. The suite consists of a Graduate Certificate, a Graduate Diploma, a Master of Engineering, a Master of Applied Science, and a Doctor of Philosophy program in Chemical Engineering. The current proposal for a Graduate Certificate in Chemical Engineering is part of this suite. Four programs are submitted simultaneously; two for internal approval (Certificate, Diploma), and two for internal and external approval (MASc, PhD). The fifth (MEng) is in preparation and will be timed to start one year after the MASc and the PhD programs.

The Graduate Certificate program is expected to draw about 15 students at steady state. It will be complementary to existing programs of this nature in Québec. Currently, McGill offers a Diploma program in Mining, which is only peripherally related to the program proposed here. École Polytechnique offers three more narrowly specialized Diploma programs, each consisting of two modules or "microprogrammes" similar to Certificate programs. In contrast, the program proposed here is more focused on core chemical engineering. However, the program will be embedded in a multidisciplinary department covering the fields of Chemical and Materials Engineering, and this will give the students a unique, multifaceted outlook on the profession of Chemical Engineering. Concordia University already has extensive research strength in materials engineering, particularly with applications in the aerospace industry, for instance with the Concordia Centre for Composites, which includes 15 faculty members from multiple departments. The new department and the associated programs will build on these strengths.

Chemical Engineering programs in North America have experienced robust growth at all levels in the past decade, from undergraduate to doctoral. This strong performance indicates that there will be a market for the proposed program across the continent.

The development of a Department of Chemical and Materials Engineering and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering. Chemical Engineering programs also draw a larger proportion of female students than is average for Engineering. Hence, it is expected that the program will help mitigate the gender imbalance in engineering.

The Graduate Certificate program will contain a minimum of 15 credits, covered by four courses. Three of these will be core courses (two required and one to be chosen from a list of two), and one is an elective.

The Department of Chemical and Materials Engineering will consist of three regular faculty members, one joint member and two excluded members (Dean of Graduate Studies, VP Research & Grad studies) as of January 2018, and two more faculty recruitments are anticipated every year until the faculty count reaches 15 members. This will ensure that there will be a critical mass for the delivery of the program at the time of its planned start in Winter 2018. The first graduates are anticipated at the end of the Fall of 2018.

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Section 1 PROGRAM IDENTIFICATION

1.1 Program title, degree title and level

Program title: Certificate
Degree: Chemical Engineering
Level: Graduate

1.2 Areas of specialization

Chemical Engineering; Chemical Thermodynamics; Chemical Kinetics; Transport Phenomena; Chemical Reactor Engineering; Materials Engineering; Polymer Engineering; Electrochemical Engineering.

1.3 Administrative location

University: Concordia University
Faculty: Faculty of Engineering and Computer Science
Department: Department of Chemical and Materials Engineering
Address: 1455 de Maisonneuve Blvd. W
Montreal, Québec, H3G 1M8
Canada

SECTION 2 PROGRAM OBJECTIVES

2.1 Theoretical Foundation and General Academic Aims

Chemical Engineering is the application of chemical and engineering principles to the design and operation of industrial units for the manufacture of chemicals. This includes the manufacture of bulk chemicals (e.g., oil refinery products, fertilizers, plastics), fine chemicals (e.g., pharmaceuticals), metals, etc. It also includes the production of chemicals by micro-organisms (e.g., fermentation, brewing), and the conversion of biomaterials into chemicals (e.g., bio-oil, biodiesel). An emerging field of application for chemical engineers is new materials (nanomaterials, composites). Chemical engineers are responsible for the design and operation of safe and environmentally responsible processes.

Chemical engineers are primarily trained to be designers of chemical processes, but they also work in the operation and control of chemical processes, and in the research and development of new chemical processes.

Chemical engineers are closely related to Materials engineers. However, whereas the materials engineer is mainly focused on the *product*, the chemical engineer is mainly focused on the *process*. The proximity of the fields of chemical and materials engineering provides opportunities for cross-fertilization. The intention of the proposed program is to train chemical engineers with a solid grasp of the materials aspects of their profession. The training will be embedded in a research environment that is strong on materials engineering research.

Industrial chemical processes are generally built from unit operations, i.e., operations that carry out a single step of the overall process. Each unit operation is based on physical and chemical principles. This approach is mirrored in chemical engineering (undergraduate) programs. The program starts with mathematics, physics, and chemistry and then moves on to engineering sciences such as general and chemical thermodynamics, material balances, mass and heat transfer, fluid mechanics, and chemical kinetics. This is followed by the study of unit operations: pumps, compressors, filters, reactors, distillation towers, etc. Next, the dynamics and control of chemical processes is covered, and the program is concluded with chemical process design, where all the obtained knowledge is integrated, and augmented with heuristics for the design of entire chemical plants. At the graduate level, students deepen their expertise in these areas with additional courses.

Historically, the chemical engineering profession started as a largely empirical endeavor, where the design of chemical processes was mainly based on experience obtained with previous designs. This largely trial-and-error approach made way for a more rigorous, science-based approach in the mid-20th century. This relatively late development is largely owing to the fact that many chemical processes are highly nonlinear, and do not lend themselves well to linear engineering analysis. Hence, a scientific approach to chemical engineering is largely based on computer simulations, and this numerical approach has developed in lockstep with the development of ever faster and more powerful computers since the mid-20th century. Nevertheless, even the most powerful computer systems cannot resolve all aspects of every chemical process, and empiricism (rules of thumb) remains an important aspect of chemical engineering practice. It is the intention of the proposed program to provide contemporary tools of chemical process simulation to the students, without losing sight of the empirical, experience-based aspects of chemical engineering.

The purpose of the proposed Certificate program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future. The program will be embedded in a multidisciplinary Department of Chemical and Materials Engineering, giving the students a unique, multifaceted outlook on their profession. They will be exposed to problems of Materials Engineering though projects and examples, as instructors infuse their research into the graduate courses. The result will be an engineer who is not only capable of designing an industrial chemical process, but who will also have an appreciation of the materials produced in these processes.

The program is part of a suite of programs currently in development that will also include a Graduate Diploma, a Master of Engineering, a Master of Applied Science and a Doctor of Philosophy program. The Master of Engineering program will be timed to start one year after the Master of Applied Science and Doctor of Philosophy programs. In the long term, the intention is to develop a similar suite of programs in Materials Engineering. The department is establishing the core competences for a Chemical Engineering graduate education at this time, and will build on that core to develop the Materials Engineering programs at a later time.

2.2 Specific knowledge, expertise, skills (learning outcomes) which students will acquire

By the end of this program, successful students will be able to do the following:

- **Theory:** Apply chemical engineering concepts to solve industrially relevant research problems in the areas of mass and heat transfer, fluid mechanics, chemical equilibrium kinetics, and process dynamics.
- **Tools:** Use and develop chemical engineering tools that are relevant in an industrial setting.

2.3 Description of how the learning outcomes will be assessed

The learning outcomes of the program are assessed in the courses, which form the requirements of the program. This is shown in Table 1:

Table 1. Mapping Program Requirements with Learning Outcomes

	Program requirements		
Learning outcomes		Core courses	Elective courses List 1
	Theory	Major	Minor
	Tools	Major	Major

SECTION 3 RATIONALE FOR PROGRAM PROPOSAL

3.1 Socio-economic or cultural relevance

3.1.1 Detailed needs analysis, including projected student enrolment: Enrolment chart, including graduation and attrition, with justifications and explanations (projected for a five-year period)

According to data from the American Society for Engineering Education (ASEE), the number of students graduating with a Bachelor's degree in Chemical Engineering in the United States has increased from 4452 in 2006 to 9090 in 2015 [Yoder, B.L. *Engineering by the Numbers*. ASEE, 2015], an increase by 104 % in one decade. As a proportion of engineering students graduating with a Bachelor's degree in Chemical Engineering, the Chemical engineering program has gained popularity, from 6.0 % in 2006 to 8.5 % in 2015. In Canada, the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292) during the same time [Engineers Canada, *Canadian Engineers for Tomorrow*, 2012; 2015].

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The number of Master and PhD graduations in Chemical Engineering in the United States has also increased substantially: from 1204 to 1716, or 42 % from 2006 to 2015 for Master students, and from 834 to 1062, or 27 % for PhD students. In Canada, the graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The enrollment projections for the Certificate program, assuming an average duration of 1 year, and an attrition of 10 % per year are given in the table below. The Certificate program is planned to start in Fall 2018.

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

Table 2 Graduate enrollment projections for Certificate students Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5
Certificate	5	10	15	15	15

At steady state, there will be about 15 Certificate students, out of a total of 238 students in the various graduate programs in Chemical Engineering.

The table below shows the projected number of graduations per year. An average of one year is anticipated for the Certificate program.

Table 3 Graduation projections for the Certificate program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5
Certificate	4	9	13	13	13

At steady state, there will be about 13 graduations per year in the Certificate program, out of an approximate 100 graduations in Chemical Engineering graduate programs per year.

3.1.2 Identification of the main prospects for graduates from the program (employment, self-employment, creativity opportunities, career mobility, advanced education)

Students with a background in chemical engineering will deepen their core competences in a limited number of areas, which will give them an enhanced capability to solve not just chemical engineering problems they are familiar with, but to approach nonfamiliar problems from their core knowledge, and find novel ways to solve them. Students whose background is not chemical engineering but a related area (e.g., chemistry, mechanical engineering) will familiarize themselves with some of the chemical engineering core, possibly after taking bridge courses, and will be able to work with chemical engineers at a high level in the areas where they developed competences, and work on interdisciplinary projects.

It is expected that professionals who wish to upgrade their skills in chemical engineering, but who do not wish to commit to a more substantial graduate program, will take this program. Likewise, students who consider a thesis-based program, but who are not ready to commit to thesis-based research will take this program.

Students who complete the Certificate in Chemical Engineering will be able to use their courses for credit (up to 16 credits) towards a Diploma program, a MEng program, and, with permission of the supervisor, towards the MASc and PhD programs.

3.1.3 Existence of similar programs in Canada or elsewhere, their academic success; similarities and differences with the proposed program; how will the proposed program help bring the Province of Quebec up to par with the Canadian or International level; or how will the new program help the Province become a leader in this area of specialization

Canada currently offers Chemical Engineering programs at 20 universities. Four of these (McGill University, École Polytechnique, Université Laval and Université de Sherbrooke) are located in the Province of Québec. As a comparison, Ontario offers Chemical Engineering programs at ten universities. Hence, in terms of numbers of universities, Chemical Engineering is currently underrepresented in the Province of Québec.

Only two universities offer graduate certificate or diploma programs in areas related to Chemical Engineering. Both, McGill University and École Polytechnique, are located in the Province of Québec. An overview of certificate and diploma programs in Chemical Engineering and related fields is given below, within the context of the graduate program offerings at these two universities. The enrollment numbers refer to all graduate students and are for 2014 [Engineers Canada. *Canadian Engineers for Tomorrow*, 2014].

Where the proposed program will be different from the existing programs in the Province of Québec is in the level of integration between the Chemical Engineering graduate programs and Materials Engineering research as a driver for the program. Concordia University has prior experience with this strategy in the Department of Mechanical, Industrial, and Aerospace Engineering (MIAE), where Materials Engineering is a significant driver of the Mechanical Engineering and Aerospace Engineering programs. Of particular note is the Concordia Centre for Composites (CONCOM), which houses 15 faculty members and a total of 50 members.

Some key members of CONCOM and MIAE who can contribute to the new department are Dr. Suong Van Hoa, director of CONCOM, who conducts research in polymer nanocomposites with applications in the aerospace industry; Dr. Mamoun Medraj, who conducts research in thermodynamic modeling of phase diagrams relevant for composite materials, and Dr. Nabil Esmail, who conducts research in rheology and surface phenomena of fluids. Dr. Paula Wood-Adams, who will transfer to the Department of Chemical and Materials Engineering, is also a member of CONCOM.

In addition, collaborative research is anticipated with faculty members in the Department of Chemistry and Biochemistry. For instance, Dr. John Oh, also a member of CONCOM, conducts research in macromolecular nanoscale biomaterials.

Faculty members in these and other departments who provide significant and lasting contributions to the proposed programs will be appointed as associate members of the Department of Chemical and Materials Engineering. They will augment the research and graduate student supervision of the core members of the Department of Chemical and Materials Engineering. This broad range of expertise will enable the department to provide knowledge from the molecular scale to the scale of the industrial processes to manufacture materials.

McGill Universtiy

Degrees offered:	PhD MEng (thesis) MEng (non-thesis) Graduate Diploma
Programs offered:	Chemical Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining and Materials Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1

École Polytechnique

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based

	Diplôme d'études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD, M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD, M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD, M.(rech.), M.(prof.))
	Procédés	(PhD, M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD, M.(rech.), M.(prof.))
	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	

As the overview shows, McGill University offers a Diploma program in Mining Engineering, which is only remotely related to the Certificate program proposed here, and not Chemical Engineering. École Polytechnique offers a broad range of "Microprogrammes" (9-15 credits), as well as Diplomas (30 credits). However, these programs are very focused and specialized, covering the areas "Matériaux", "Energie et développement durable", "Procédés et environnement", and "Sciences et technologies de la plasturgie". The Certificate program proposed here is aimed more at chemical process engineering, and are thus complementary to the progams offered by École Polytechnique.

Details of the programs discussed are in Appendix 1.

3.2 Institutional relevance

3.2.1 Status of the discipline at Concordia; how the proposed program fits into the overall set of programs offered by the university (including undergraduate programs); in the same field, related fields, sector of education concerned; enrolment trends and graduates in related programs; impact of enrolments in related fields within the University

The programs most related to the proposed new programs are the Mechanical Engineering program in the Department of Mechanical and Industrial Engineering, and the Environmental Engineering specialization in the Department of Building, Civil, and Environmental Engineering.

Chemical Engineering is the only major engineering discipline that is currently missing in the Engineering program offerings at Concordia University. Hence, the development of Chemical Engineering programs fits in Concordia University's objective to become a more comprehensive university. Nearly all Engineering programs at Concordia University have grown rapidly in recent years. The number of full-time graduate students at Concordia University in all engineering fields combined increased from 1677 in 2012 to 2184 in 2016. Of these, full-time enrollments increased from 355 to 514 in Civil Engineering, and from

295 to 371 in Mechanical Engineering (not including Industrial Engineering). The demand exceeds the enrollments, so it is anticipated that the addition of Chemical Engineering programs will not affect the enrollments in other programs.

3.2.2 Collaboration with other departments within Concordia

The newly created Department of Chemical and Materials Engineering was incubated in the Department of Mechanical and Industrial Engineering, and a substantial amount of collaboration is anticipated with this department.

In addition, several technical electives, such as Fluid Mechanics, will be taught by faculty members outside the Department of Chemical and Materials Engineering.

Outside the Faculty of Engineering and Computer Science, collaborations are anticipated with the Department of Chemistry and Biochemistry, whose Department Chair, Dr. C. DeWolf, has degrees in Chemical Engineering. To foster these collaborations, the new department will be given space in the Loyola campus with the next building project, to be shared with faculty members from the Department of Chemistry and Biochemistry.

The Department of Chemical and Materials Engineering has a steering committee consisting of key faculty members from various departments in the Faculty of Engineering and Computer Science, and the Faculty of Arts and Science. This committee forms the basis for future collaborations between departments. The membership of the steering committee is given in Appendix 6.

3.2.3 How does the proposed program align with the Faculty's and University's academic plans

The development of graduate programs in Chemical Engineering is a direct consequence of the establishment of the Department of Chemical and Materials Engineering, and aligns the Strategic Plan, *Nine Directions for a Next-Generation University*. In particular, the cross-institutional strategy for Direction 1, Double our Research, specifically mentions building research capacity in Chemical and Materials Science and Engineering. To bring this plan to fruition, the Certificate program can help draw potential graduate students in this area, and to train them adequately for research in the area.

The modular Certificate – Diploma – Master structure aligns well with the Teach for Tomorrow direction in the Strategic Plan. It is a contemporary approach to graduate studies, more in tune with the ideal of lifelong learning than the traditional program structure, as it allows professionals to return to university, and take on graduate studies at their own pace, while they are professionally employed. It is also a way to "streamline and transform" as expressed in Direction 6: Grow Smartly.

The Montreal area has a large demand for Chemical and Materials Engineers, in the chemical and pharmaceutical industry, in oil refining, and in companies supplying the aerospace industry (composites). Hence, the proposal is aligned with Direction 7: Embrace the City, Embrace the World.

Section 4 PROGRAM DESCRIPTION AND REQUIREMENTS

4.1 Admission Requirements

4.1.1 General and specific admission requirements

General requirements

Applicants to Concordia University must meet the minimum university requirements to be considered for admission.

Academic Requirements

To be considered for admission to graduate diploma or graduate certificate-level studies, the applicants must hold a bachelor's/baccalaureate degree (or equivalent) in engineering or the sciences with the Concordia equivalent of a GPA of at least 2.70 on a scale of 4.30.

Language Proficiency Requirements

The language of instruction at Concordia is English.

A student whose primary language is not English must write a pre-admission proficiency test, if not exempted as indicated below. Test results must be reported directly to the Admissions Application Centre by the test centre. Results more than two years old will not be accepted as proof of language proficiency.

Proof of proficiency in English must be provided by achieving the appropriate score on one of the following:

- Test of English as a Foreign Language (TOEFL): The minimum acceptable score for the internet-based TOEFL (TOEFL iBT) is 85 and no part under 20.
- The minimum required score for the paper-based TOEFL is 563.
- International English Language Testing System (IELTS): The minimum band score for IELTS is 6.5 and no part under 6.5.

In all cases, Concordia reserves the right to require proof of English proficiency when such proof is deemed necessary. Concordia will accept test results for the paper-based TOEFL if they are less than 2 years old.

Applicants whose primary language is not English, regardless of citizenship, may be exempted from the proficiency test if they meet one or more of the following requirements:

- A minimum of three full years of study either at the undergraduate or graduate level in an institution where the sole language of instruction is English;

- Quebec applicants, the completion of a Diploma of Collegial Studies (DEC) and a university degree in Quebec

In addition to the general admission requirements, the Faculty may require applicants to write the Engineering Writing Test (EWT) as a condition of admission to all graduate programs in Engineering and Computer Science. Depending on the result, students may be required to complete remedial English language courses in addition to their program requirements.

The Engineering Writing Test examines students' ability to provide reasoned assessment of a short technical composition in English or French, and their ability to provide a qualitative account of quantitative or graphically presented data. The test is offered a number of times throughout the year. Based on their performance in the test, students may be asked to take remedial courses.

Program-specific admission requirements

- An undergraduate degree in engineering or the sciences;
- Students whose undergraduate degree is not chemical engineering will be assessed on a case-by-case basis, and may be required to take additional courses, including the bridge course CHME 401: Principles of Chemical Engineering, and/or others. The Graduate Program Director determines the additional course loads;
- Credible academic reference letters;
- A Statement of Purpose

4.1.2 Selection procedures

The Department will recommend on the acceptability of an applicant for admission to the program.

4.2 Academic activity

4.2.1 Degree requirements

Credits: Fully qualified students are required to complete at least 15 credits.

Time limit: All work for a Certificate program must be completed within 6 terms (2 years) from the time of initial registration in the program for full-time students; for part-time students the time limit is 9 terms (3 years).

4.2.2 Program schedule; Core and elective courses

All courses are 4 credits each unless indicated otherwise.

Core: 12 credits

- Advanced Transport Phenomena CHME 6011
- Engineering Analysis ENCS 6021

  and

  - CHME 6021 Advanced Chemical Engineering Thermodynamics
    Or
  - CHME 6031 Chemical Kinetics and Reaction Engineering

Elective: 3 or 4 credits (one course) from the list below, or any core course from the Diploma, MEng, or MASc program in Chemical Engineering not included in the Certificate core course list

Students may take an elective course outside the elective list with permission of the Graduate Program Director.

<u>Elective Course List</u>

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer
- ENGR 6201 Fluid Mechanics

4.2.3 Number of credits per term (part- and/or full-time) to allow students to meet program objectives; timeline to completion

Full-time students must take three courses per term to maintain full-time status, unless fewer courses are required to finish the program. In that case, students should take the required number of courses to finish the program.

The normal time to completion is 3 terms (1 year) for full-time students, and 6 terms (2 years) for part-time students. The maximum time to completion is 6 terms (2 years) for full-time students, and 9 terms (3 years) for part-time students.

4.2.4 Proposed Chemical Engineering course descriptions

Core courses (4 credits, graduate)

CHME 6011 Advanced Transport Phenomena

Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

CHME 6021 Advanced Chemical Engineering Thermodynamics

Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

CHME 6031 Chemical Kinetics and Reaction Engineering

Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

Elective courses

CHME 6061 Advanced Biochemical Engineering

Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

CHME 6081 Advanced Separation Processes

Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

CHME 6091 Statistics for Chemical Engineering

Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; response surface methodology. A project is required.

CHME 6101 Advanced Battery Materials and Technologies

Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

CHME 6111 Polymer Chemistry and Engineering

Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

CHME 6131 Advanced Colloid and Interface Science and Engineering

Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

CHME 6911 Topics in Chemical Engineering I

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Section 5 FACULTY RESOURCES; OTHER HUMAN RESOURCES; MATERIAL RESOURCES: Resource implications of the program

5.1 Faculty Resources (Qualifications and scholarly output)

5.1.1 Qualifications of individual professors: degrees, experience, summary of faculty achievements (previous five years) including: (i) publication in peer-reviewed journals; (ii) experience acquired supervising masters' and doctoral students and post-doctoral fellows, participation on thesis juries

The qualifications of faculty members directly involved are summarized below. More detailed CVs are given in Appendix 5. Two additional faculty members will be hired every year during the introduction of this program.

Alex De Visscher, Professor

Dr. De Visscher was trained in Chemical Engineering and Environmental Engineering at Ghent University, Belgium. He obtained his PhD in 2001. He held a faculty position at the University of Calgary from 2005 until 2016. In 2005-2015 he held a Tier II Canada Research Chair in Air Quality and Pollution Control Engineering. From 2014 until 2016 he was Associate Head Graduate (Graduate Program Director) of the Department of Chemical and Petroleum Engineering. During his Sabbatical Leave in 2011-2012 he was Visiting Professor at the Institute of Technical Chemistry in the Technical University Bergakademie Freiberg, where he wrote an academic textbook on Air Dispersion Modeling, which was published by Wiley. He also wrote and self-published an academic textbook on Chemical Engineering Kinetics and Chemical Reactor Design. Dr. De Visscher published over 50 peer-reviewed journal articles, 12 over the past 5 years. He currently supervises four PhD students and has graduated seven graduate students over the past five years. He has participated in more than 100 thesis juries. Over the last five years he was involved in 10 candidacy exams, 13 PhD final exams, and 30 MSc final exams. His areas of research include kinetics and catalysis, transport phenomena, environmental chemical engineering, solution thermodynamics and solubility.

Zhibin Ye, Professor

Dr. Ye obtained his Bachelor and Master degrees in Chemical Engineering at Zhejiang University, China, and his PhD in Chemical Engineering at McMaster University in 2004. He held a faculty position at Laurentian University from 2004 until 2017. From 2011 until 2017 he held a Tier II Canada Research Chair in Polymer Nanomaterials. During his Sabbatical Leave he was a Visiting Associate Professor in the Department of Chemistry at the University of Illinois at Urbana-Champaign. Dr. Ye published 75 peer-reviewed journal papers, 28 in the past five years. He currently supervises two research associates and two graduate students, and he has graduated six graduate students in the past five years. He also supervised several postdoctoral fellows. His areas of research include polymer engineering and polymer reactor engineering, nanotechnology and nanocomposites.

Xiaolei Wang, Assistant Professor

Dr. Wang obtained his Bachelor's and Master's degree in Chemical Engineering at Dalian University and Tianjin University, respectively, and his PhD in Chemical and Biomolecular Engineering at the University of California at Los Angeles. He held a postdoctoral fellowship at the University of Waterloo from 2013 until 2017. Dr. Wang published 33 peer-reviewed journal papers, 26 in the past five years. His areas of research include nanotechnology, electrical energy storage materials, electrochemical engineering, electrocatalysis.

5.1.2 Overall faculty characteristics: Ability of faculty to provide adequate supervision and cover all aspects of the discipline or profession; forecast changes in composition of faculty (growth renewal); Chart on present and future workloads and credit breakdown

As of January 2018, the Department of Chemical and Materials Engineering will have three regular members, one joint member, and two excluded members (the Dean of the School of Graduate Studies and the Vice President Research and Graduate Studies), offering expertise in chemical engineering fundamentals (transport phenomena, chemical thermodynamics), catalysis, kinetics, and reactor engineering, polymer engineering, and electrochemical engineering. The main gaps in the expertise currently available are in some of the proposed technical electives. These gaps will be covered with future hires. An additional faculty recruitment is in progress, and there is a commitment from Concordia University to recruit two faculty members in the 2018-19 cycle (see support letter in Appendix 6), and up to two in the 2019-20 cycle. It is anticipated that we will hire an average of two faculty members per year for the three to four years after that, bringing the total to 15 faculty members. In the meantime, the program will be strengthened through collaboration with other departments within Concordia University, with other universities in Montreal, and with local industry professionals.

Below is a table of current and anticipated faculty members, with anticipated course assignments, for the Certificate program. The table shows that no faculty members will teach more than two courses per year in the program, leaving room for the development of other graduate programs, and an undergraduate program alongside the graduate programs.

Table 5 Projected course assignments per faculty member for the Certificate program

Faculty member	**Course**	**Year**	**Status**
Alex De Visscher	Advanced Chemical Engineering Thermodynamics Advanced Transport Phenomena	F 2018 W 2019	new, core new, core
Zhibin Ye	Principles of Chemical Engineering Polymer Chemistry and Engineering	F 2018 W 2019	new, bridge new, elective
Xiaolei Wang	Advanced Battery Materials and Technologies Chemical Kinetics and Reaction Engineering	F 2018 W 2019	new, elective new, core

Hire 1	Engineering Analysis	F 2018	existing, core
Hire 2	Advanced Separation Processes	F 2019	new, elective
Hire 3	Statistics for Chemical Engineering	F 2019	new, elective
Hire 4	Topics in Chemical Engineering I	F 2020	new, elective

A number of existing electives will be taught outside the Department of Chemical and Materials Engineering. Because this represents no change with the existing condition, these courses are not shown in the table above. However, these courses affect the ability of students to progress their program. Hence, a projection of course offerings per term is given below. For elective courses, only a sample is given.

Fall 2018

- Principles of Chemical Engineering (Ye) (bridge)
- Engineering Analysis (Hire 1; existing course) (core)
- Advanced Chemical Engineering Thermodynamics (De Visscher) (core)
- Advanced Battery Materials and Technologies (Wang) (elective, list 1)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)

Winter 2019

- Advanced Transport Phenomena (De Visscher) (core)
- Chemical Kinetics and Reaction Engineering (Wang) (core)
- Polymer Chemistry and Engineering (Ye) (elective, list 1)

Summer 2019

- Engineering Analysis (Faculty; existing course) (core)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)

The sequence will repeat, with the Fall 2018 courses also taught in Fall 2019, etc. This schedule allows students starting in Fall to complete the program in two terms, and allows all students to complete the program in three terms, regardless of the starting term.

5.1.3 New faculty required, with specialization; profile of professors to be hired

It is anticipated that two faculty members will be hired per year on average over the next five years. While the recruitment will be flexible to enable us to hire the best people, recruitments in the following areas are desirable:

- Process design, process control, and process simulation
- Advanced separations, bio-separations
- Surface and coating engineering

- Transport phenomena, microfluidics, microreactors, process intensification
- Catalysis, kinetics, CO_2 conversion
- Biochemical, biomedical and metabolic chemical engineering
- Chemical engineering data, properties, computational chemistry, molecular dynamics
- Any Materials Engineering application domain not covered in the previous hires

5.2 Other Human Resources (required and available)

It is anticipated that the Certificate program will be run together with a Diploma program and a Master of Engineering program. The MEng program will draw 80 % of the course-based graduate students in Chemical Engineering. Hence, the human resources needed for the Certificate and Diploma combined are estimated at 20 % of the needs for all course-based students in Chemical Engineering.

Technical staff is needed to provide technical support with graduate course projects. A technician or an engineer-in-residence will be hired in 2018, to be shared between all the graduate programs of the department. This recruitment has been approved by the university.

An administrative support staff member will be needed to help program directors with student administration, book appointments, and guide students with their program requirements. A receptionist/administrative assistant and a graduate program administrator are anticipated, shared between all the graduate programs of the department. It is anticipated that the former will be recruited in 2018, whereas the latter will be recruited upon approval of the MASc and PhD programs.

Depending on the number of registered students, 1-2 teaching assistants per course are anticipated. Approximately 10 teaching assistant positions per year would cover the new courses introduced here. As these courses will be shared with other graduate programs, the incremental TA need is estimated at 5.

5.3 Material Resources (Reference materials, computers, equipment and space) (required and available)

A detailed library report outlining quality and quantity of collections, access, reference services and assistance, and interlibrary services is given in Appendix 3.

The program will require students to have access to computers with standard academic computing software (e.g., Matlab), as well as more specific engineering (e.g., Comsol) and chemical engineering (e.g., VMGsim) software. Except for specific chemical engineering software, the resources are already available at Concordia University. Licenses for the remaining software will be obtained.

Laboratory space is currently being renovated on Floor 14 of the Hall building (approx. 150 m^2), and additional renovations are in preparation on Floor 10 (approx. 400 m^2). The labs will host a mix of research and teaching space, and will be used by both course-based and thesis-based students. Graduate courses will use part of the space as project space, where students design and carry out experiments related to their course content. In addition, one floor of a major building expansion at the Loyola campus currently in the design stage will be allocated to the new Department of Chemical and Materials Engineering, with about 700 m^2 of labs, offices, student space, etc.

All courses in the program will be shared with other Chemical Engineering graduate programs. Hence, it is expected that class sizes will be in the 20-50 range at full deployment of the programs. For all graduate programs combined, about 10-12 courses will be taught in each of the Fall and Winter terms, 150 minutes per week. Standard classrooms with blackboard/whiteboard and computer projection will be adequate for these courses.

Some of the courses will need laboratory equipment to create the needed project space. This will consist of piping, connections, thermostatic systems, sensors and data acquisition systems. In addition, some characterization equipment is needed. Concordia University has approved $1 million for academic equipment for the Chemical Engineering programs. Faculty members contributing to the program as supervisors will bring in additional equipment obtained with research funding.

Some courses have projects that are not linked to the lab, and for these projects some student workspace will be needed. To accommodate this, a maker space is part of the renovation project on Floor 10 of the Hall building. This is in addition to the 400 m^2 dedicated to the Department of Chemical and Materials Engineering in this project. Students will generally work in groups. Proximity to computer labs is needed to ensure that students have access to process simulators (VMGSim, HYSYS) during these group activities.

To accommodate administrative needs, a reception area is available in the office space currently used by the Department of Chemical and Materials Engineering in the VA building. Over time, a similar area will be needed at the Loyola campus.

5.4 Funding for Graduate Students

Course-based students, including Certificate students, are self-funded. No separate funding is required for graduate student support.

5.5 Chart of Expenses and Revenues

The annual budget of the program at steady state is given in the table below.

Table 6 Budget of the Certificate program

Revenue	**$147,430**
Cost	
Faculty	$79,813
Staff, admin	$23,943
Staff, tech	$20,751
TA	$7,210
Operation	$12,500
Library	$1,563
Total	**$145,780**

Profit	**$1,650**

The faculty budget is based on half of a full-time teaching load necessary to teach the courses, based on a prorating of faculty members between the Certificate and other graduate programs. It is assumed that out of a total of 15 faculty members, 8 are needed to cover all the graduate programs (up to 24 courses per year at three courses per faculty member). Among the programs, faculty members are prorated based on the number of full-time equivalent students in the program, weighing course-based students twice as much as thesis-based students. These proportions can be maintained if the average class size is 40 for the Certificate courses. Administrative and technical staff costs are based on 25 % of a full-time position. Five TAs are assumed. For the operational cost, 10 % of the estimated operational cost of all graduate programs combined is used.

On the revenue side, Certificate students are counted as ½ of a full-time equivalent. Based on these numbers, a slight profit is projected.

Below is a more detailed budget table per year, over the first five years of the implementation of the program. The program will be profitable from Year 2 onwards. The program is more profitable in intermediate years than in steady state because of the way faculty members are prorated. The number of students reaches steady state before the number of faculty members does. What that means for the program is that it will run with fewer elective courses in the intermediate years, which is cheaper. However, the additional elective courses enrich the Certificate program, as well as other programs.

Cost-revenue template Chemical Engineering (Certificate)

Concordia University		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**5-Year Total**
FTEs for Yr 1 students		2.50	5.00	7.50	7.50	7.50	30.00
FTEs for Yr 2 students							-
FTEs for Yr 3 students							-
FTEs for Yr 4 students							-
FTEs for Yr 5 students							-
Student Enrolment		**2.50**	**5.00**	**7.50**	**7.50**	**7.50**	**30.00**
Revenue							
Tuition Revenue ($1,036.01 per term per FTE x 2 terms)	2,072	5,180	10,360	15,540	15,540	15,540	62,161
Teaching grant (base of $3,594.89/FTE x 4.42)	15,889	39,724	79,447	119,171	119,171	119,171	476,682
Variable support grant (per raw FTE $1,695.87)	1,696	4,240	8,479	12,719	12,719	12,719	50,876
Total Anticipated University Revenue (Only includes teaching & tuition revenue)		**49,143**	**98,287**	**147,430**	**147,430**	**147,430**	589,719
Expenses							
Faculty (steady state = 15)		5	7	9	11	13	
Part-time faculty (0 courses at $10,700 at steady state)	-						
Faculty (0.5 FT x $125,000 x 1.277 at steady state)	0.5	26,604	37,246	47,888	58,529	69,171	239,438
Admin (0.25 FT x $75,000 x 1.277 at steady state)	0.25	7,981	11,174	14,366	17,559	20,751	71,831
Faculty (0.25 FT x $65,000 x 1.277 at steady state)	0.25	20,751	20,751	20,751	20,751	20,751	103,756
Course sections (GPD remission) From the Provost's Office)							
Teaching assistantships (5; $1,464 & 1,419 for Master and Ph.D. resp./student)	5	2,403	3,364	4,325	5,286	6,247	21,623
Masters bursaries ($)							
Library costs	1,563	1,563	1,563	1,563	1,563	1,563	7,815
Operation (labs, etc.)	12,500	4,167	8,333	12,500	12,500	12,500	50,000
Advertising		3,000	2,000				5,000
Recruitment		3,000	2,000				5,000
Total Anticipated Expenses (ENCS)		**69,474**	**86,438**	**101,402**	**116,199**	**130,996**	**504,463**
Anticipated Gain (Loss) for the University		(20,331)	11,849	46,028	31,231	16,434	85,257

Notes:
Attrition rate not applicable (1 year of study assumed)
Faculty/staff/TA costs are prorated based on the number of faculty members in a given year assuming 15 faculty members at steady state.
Library cost assumes that the overlapping budgets are prorated based on number of students at steady state

5.6 Implementation Timetable for the Program

A detailed plan of the introduction of courses is given in Section 5.1.2. What follows is a general overview of activities planned for the Certificate program.

- Fall 2018
  - Introduction of Certificate program
  - Admission of first students
  - Commitment of course offerings to complete Certificate program in two terms (Fall + Winter) or three terms (Winter + Summer + Fall)
- Winter 2019
  - Full deployment of all new electives planned for the program
  - End of term: First Certificate graduates

Section 6 APPENDICES

Appendix 1 Related programs in Quebec and the rest of Canada (descriptions, calendar excerpts, etc.)

McGill University

Graduate Diploma Mining Engineering

The Graduate Diploma is a one-year, course-based, 30-credit degree in Mining Engineering. It is open to professionals from industry, engineers and scientists, who wish to receive professional development education in mining engineering in a formal manner. The program includes a seminar course (6 credits), a minimum of six graduate level courses (18 credits), and a project (6 credits). 1-3 courses may be taken at the senior undergraduate level with approval.

Courses:

- MIME 513 Mine Plan Optim Under Uncert 3 Credits
- MIME 520 Stability of Rock Slopes 3 Credits
- MIME 522 Mineral Reserve Assess Techs 3 Credits
- MIME 525 Stochastic Orebody Modelling 3 Credits
- MIME 620 Rock Mechanics 1 4 Credits
- MIME 626 Applied Geostatistics 3 Credits
- MIME 631 Adv Stochastic Optim:Mine Plan 4 Credits
- MIME 635 Finite Elem Meth-Rock Mechs 4 Credits

École Polytechnique

Microprogramme Sciences et technologies de la plasturgie

Ce microprogramme vise à donner une formation spécialisée en mettant l'accent sur l'acquisition de connaissances théoriques et techniques nécessaires à la conception des procédés et au développement de produits dans le domaine de la plasturgie. L'étudiant inscrit dans ce microprogramme abordera différents thèmes tels que la chimie-physique des polymères et/ou les systèmes multiphasés ainsi que des aspects méthodologiques et techniques, amenant vers des activités de conception ou d'application pratiques associées de la plasturgie.

Le microprogramme comporte 15 crédits.

Cours au choix (15 crédits)

- GCH4310 Travaux pratiques de plasturgie 3 crédits
- GCH6101 Chimie physique des polymères 3 crédits
- GCH6108 Systèmes polymères multiphasés 3 crédits
- GCH6114 Projet de conception de produits polymériques 3 crédits
- GCH6914 Méthode des éléments finis en génie chimique 3 crédits
- GCH8102 Mise en forme des polymères 3 crédits

Diplôme d'études supérieures spécialisées (DESS) Option Énergie et développement durable

Le programme a pour objectif l'approfondissement des connaissances sur les caractéristiques des différentes sources d'énergie, le choix, le dimensionnement, l'analyse socio-économique et la maintenance des systèmes énergétiques selon le type d'installation.

Le programme comporte 30 crédits, se répartissant comme suit

- Cours du 1er cycle min. 0; max. 9
- Cours de cycles supérieurs min. 21; max. 30

Module A – Cours de base (15 crédits)

Cours obligatoires :

- DDI8001 Développement durable pour ingénieurs 3 cr.
- DDI8002 Études de cas en dévelop. durable pour ing. 3 cr.
- ENE8210 Efficacité des sources d'énergie 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6200 Sciences du génie de l'environnement 3 cr.
- DDI8003 Analyse du cycle de vie 3 cr.
- IND6140 Ing. résilience et continuité opérationnelle 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- IND8111 Aspects économiques des flux circulaires 3 cr.
- MEC6512A Conception de produits et proc. durables 3 cr.

Module B – Spécialisation (15 crédits)

Trois (3) cours au choix parmi les suivants :

- ENE8310 Stockage et intégration des syst. énergéti. 3 cr.
- GCH8103 Conversion de la biomasse 3 cr.
- GCH8211 Conception et intégration des procédés 3 cr.
- GCH8729 Déchets solides et énergie résiduelle 3 cr.
- MET8106 Énergie électrochimique 3 cr.
- MET8220A Énergie solaire photovoltaïque et applica. 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6205 Impacts des projets sur l'environnement 3 cr.
- CIV6214A Risques naturels et mesures d'urgence 3 cr.
- ELE2400 Électricité: Sécurité et environnement 2 cr.
- GCH6313 Modélis. environn. des émissions toxiques 3 cr.
- GCH6902 Conception des réacteurs gaz-solide 3 cr.
- GCH6918 Projet d'études supérieures 3 cr.
- GCH8107 Procédés pyrométallurgiques 3 cr.

- GCH8150 Systèmes de commande de procédés chimiques 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- MEC6214 Énergie solaire et applications 3 cr.
- MEC6216 Géothermie et applications 3 cr.
- MEC6618 Éoliennes et applications 3 cr.
- MEC8252 Combustion et pollution atmosphérique 3 cr.
- PHS8603 Énergie et environnement 3 cr.
- PHS8604 Conversion directe de l'énergie 3 cr.

Diplôme d'études supérieures spécialisées (DESS) Option Matériaux

Le programme a pour objectif l'approfondissement des connaissances des caractéristiques physico-chimiques, mécaniques et microstructurales des matériaux dans le cadre d'applications spécifiques, particulièrement sur les propriétés fonctionnelles des matériaux et sur leur mise en forme.

Structure du programme :

- A – Module de base (15 crédits)
- B – Module de spécialité (15 crédits)

A – Module de base (15 crédits)

- GCH6101 Chimie physique des polymères 3 cr.
- GCH8102 Mise en forme des polymères 3 cr.
- MEC6306A Comportement mécan. des matér. composites 3 cr.
- MEC6318 Fabrication des composites par injection 3 cr.
- MET6103A Techniques de caractérisation des matériaux I 4 cr.

B – Module de spécialité (15 crédits)

- GBM8540 Corrosion et dégradation des biomatériaux 3 cr.
- GCH6104A Rhéologie des polymères 4 cr.
- GCH6108 Systèmes polymères multiphasés 3 cr.
- GCH6112A Conc. des opér. d'agitation et de mélange 3 cr.
- GCH6914 Méthode des éléments finis en génie chimique 3 cr.
- GCH8102 Mise en forme des polymères 3 cr.
- GCH8106 Ingénierie des emballages polymères 3 cr.
- MEC6404 Éléments finis, concepts et applications 3 cr.
- MEC6413 Matériaux métalliques, caract. et utilisation 3 cr.
- MEC8415 Endommagement par fatigue-fluage 3 cr.
- MET6101B Mécanique de la rupture 3 cr.
- MET6108 Procédés de la métallurgie des poudres 3 cr.
- MET6208 Énergétique des solutions 4 cr.
- MET6211 Métallurgie de l'aluminium 3 cr.
- MET8106 Énergie électrochimique 3 cr.

- MET8220A Énergie solaire photovoltaïque et applica. 3 cr.

Diplôme d'études supérieures spécialisées (DESS) Option Énergie et développement durable

La formation est orientée de façon à couvrir à la fois les procédés d’assainissement et l’assainissement des procédés dans un contexte de développement durable. Le programme a pour objectif de permettre, entre autres, la conception ou la reconfiguration ainsi que la mise en œuvre des procédés industriels existants, afin de les rendre plus performants et efficaces en consommation d’énergie avec moins de rejets d’agents polluants.

Structure du programme :

- A – Module de base (15 crédits)
- B – Module de spécialisation (15 crédits)

Module A – Cours de base (15 crédits)

Cours obligatoires :

- DDI8001 Développement durable pour ingénieurs 3 cr.
- DDI8002 Études de cas en dévelop. durable pour ing. 3 cr.
- DDI8003 Analyse du cycle de vie 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6200 Sciences du génie de l'environnement 3 cr.
- ENE8210 Efficacité des sources d'énergie 3 cr.
- IND6140 Ing. résilience et continuité opérationnelle 3 cr.
- MEC6512A Conception de produits et proc. durables 3 cr.
- IND8111 Aspects économiques des flux circulaires 3 cr.

Module B – Spécialisation (15 crédits)

Trois (3) ou quatre (4) cours au choix dans les blocs 1 et 2, dont au moins un (1) dans chaque bloc :

Bloc 1 : Environnement

- GCH6301 Ingénierie des biosystèmes 3 cr.
- GCH6304 Contrôle de la pollution industrielle 3 cr.
- GCH6309 Valorisation énergétique des déchets solides 3 cr.
- GCH6313 Modélis. environn. des émissions toxiques 3 cr.
- GCH8103 Conversion de la biomasse 3 cr.
- GCH8729 Déchets solides et énergie résiduelle 3 cr.

Bloc 2 : Procédés

- GCH6112 Conception des opérations d’agitation et de mélange N/D
- GCH6201 Catalyse et cinétique appliquées 3 cr.

- GCH6210 Ingénierie des pâtes et papiers 3 cr.
- GCH6902 Conception des réacteurs gaz-solide 3 cr.
- GCH8104 Traitement des minerais 3 cr.
- GCH8107 Procédés pyrométallurgiques 3 cr.
- GCH8150 Systèmes de commande de procédés chimiques 3 cr.
- GCH8211 Conception et intégration des procédés 3 cr.

Bloc 3 : Un à deux cours au choix parmi les suivants, incluant les cours au choix du module A, les cours de l'UdeM et de HEC Montréal ou tout autre cours au choix approuvé par le directeur d'études :

- 4-084-13 Développement durable, politiques environnementales et gestion N/D
- 4-801-06 Analyse économique des enjeux environnementaux N/D
- CIV8210 Traitements physico-chimiques de l'eau 3 cr.
- CIV8220 Épuration biologique des eaux usées 3 cr.
- CIV8240 Traitement de l'eau et des rejets 3 cr.
- GCH6903 Phénomènes d'échanges avancés 3 cr.
- GCH6918 Projet d'études supérieures 3 cr.
- EDD6030 Biogéochimie N/D
- EDD6040 Gestion de l'eau N/D
- EDD6050 Gestion de la biodiversité N/D
- ENV6003 La protection de l'environnement N/D
- IND6126A Analyse et gestion des risques technologiques 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- MSN6115 Santé et environnement I N/D
- TXL6014 Toxicologie de l'environnement N/D

Appendix 2 Enrolment surveys and other indicators of student interest in the program and graduate employment opportunities

Introduction

Senior undergraduate students who have completed 60-120 credits were invited to complete the questionnaire below. This survey probed students' intentions to take a certificate, diploma, M.Eng., or M.A.Sc. program in Chemical Engineering. The students probed were in Bachelor's programs in Mechanical Engineering, Industrial Engineering, and Chemistry. The vast majority of respondents were Mechanical Engineering students, so the results mainly reflect the opinions of that group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Bachelor's degree)	40	70.2	70.2	70.2
	Industrial Engineering (Bachelor's degree)	8	14.0	14.0	14.0
	Chemistry (Bachelor's degree)	9	15.8	15.8	15.8
	Total	57	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	649
Number of students responded	57
Response rate	8.8%
Margin of error*	± 12.4%

*at a 95% confidence level

In addition, thesis-based Master students in Mechanical Engineering, Civil Engineering, and Chemistry were invited to complete the second questionnaire below. This survey probed students' intentions to take a M.A.Sc. or Ph.D. program in Chemical Engineering. The pool of respondents was fairly evenly spread, with Civil Engineering being the dominant group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Master's)	12	32.4	32.4	32.4
	Civil Engineering (Master's)	19	51.4	51.4	51.4
	Chemistry (Master's)	6	16.2	16.2	16.2
	Total	37	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	193
Number of students responded	37
Response rate	19.2%
Margin of error*	± 14.5%

*at a 95% confidence level

Results – Undergraduate students – Certificate

The response of the surveyed students is summarized here, followed by the detailed responses in tabular form.

On the question "Based on this description, how likely is it that you would apply to the Certificate in Chemical Engineering program if it became available?" 21/57 students (36.8 %) responded "likely" or "very likely". The majority of these students (29/57 or 50.9 %) would apply in 2018 or 2019.

On the question "How relevant are the proposed program objectives to your academic and professional goals?" 43/57 students (75.4 %) responded "relevant" or "very relevant". For a description of the program objectives as stated in the survey, see below.

On the question "Are the proposed courses relevant to your academic and professional goals?" 37/57 students (64.9 %) responded "relevant" or "very relevant".

On the question "In what ways do you see the Certificate in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)" 30/57 students (52.6 %) responded "Specialized expertise in Chemical Engineering will increase my career prospects.", whereas 22/57 students (38.6 %) responded "I can use it as a stepping stone towards a Graduate Diploma or a Master's degree in Chemical Engineering."

On the question "What drawbacks or disadvantages can you foresee in the proposed Certificate program with regard to your academic and professional goals? (Please select all that apply.)" 15/57 students (26.3 %) responded "The program is too general.", whereas 11/57 students (19.3 %) responded "The program may narrow my employment options.", and 9/57 students (15.8 %) responded "The program is too specialized."

Overall the survey results are favorable, with about a third of the students inclined to pursue the program, and a broad majority of the students evaluating the program as relevant for their careers. Overall, the students selected more advantages than disadvantages in the survey.

Detailed Survey Results – Undergraduate students – Certificate

Based on this description, how likely is it that you would apply to the Certificate in Chemical Engineering program if it became available?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very likely	8	14.0	14.3	14.3
	Likely	13	22.8	23.2	23.2
	Somewhat likely	16	28.1	28.6	28.6
	Unlikely	17	29.8	30.4	30.4
	Don't know	2	3.5	3.6	3.6
	Total	56	98.2	100.0	
Missing	System	1	1.8		
Total		57	100.0		

In what year would you most likely expect to apply to the Certificate in Chemical Engineering program?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	2017	1	1.8	1.8	1.8
	2018	12	21.1	21.1	21.1
	2019	17	29.8	29.8	29.8
	Later than 2019	5	8.8	8.8	8.8
	Don't know	8	14.0	14.0	14.0
	Would not apply	14	24.6	24.6	24.6
	Total	57	100.0	100.0	

How relevant are the proposed program objectives to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	13	22.8	22.8	22.8
	Relevant	30	52.6	52.6	52.6
	Not relevant	11	19.3	19.3	19.3
	Don't know	3	5.3	5.3	5.3
	Total	57	100.0	100.0	

Are the proposed courses relevant to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	11	19.3	19.3	19.3
	Relevant	26	45.6	45.6	45.6
	Not relevant	16	28.1	28.1	28.1
	Don't know	4	7.0	7.0	7.0
	Total	57	100.0	100.0	

In what ways do you see the Certificate in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Specialized expertise in Chemical Engineering will increase my career prospects.	30	52.6	52.6	52.6
	I can use it as a stepping stone towards a Graduate Diploma or a Master's degree in Chemical Engineering.	22	38.6	38.6	38.6
	I want to pursue a career in Chemical Engineering and this program would allow me to do so.	2	3.5	3.5	3.5
	Other	5	8.8	8.8	8.8
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

What drawbacks or disadvantages can you foresee in the proposed Certificate program with regard to your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	The program is too specialized.	9	15.8	15.8	15.8
	The program may narrow my employment options.	11	19.3	19.3	19.3
	The program is too general.	15	26.3	26.3	26.3
	Other	9	15.8	15.8	15.8
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

Survey Content – Undergraduate

Web Page 1:

Concordia University

New Programs in Chemical Engineering Survey

Welcome to the New Programs in Chemical Engineering Survey

Please copy the survey PIN found in your invitation email and paste it in the space below.

Enter your survey PIN below:

Start

Web Page 2:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Welcome!

<p>Concordia University's Faculty of Engineering and Computer Science is considering the possibility of offering graduate programs in Chemical Engineering. Chemical Engineering is the application of chemical and engineering principles for the design and operation of industrial processes for the manufacture of chemicals and materials. A total of five programs may potentially be created:</p>

a Graduate Certificate (4 courses, 15 credits);
a Graduate Diploma (8 courses, 30 credits);
a Master of Engineering (12 courses, 45 credits);
a Master of Applied Science (thesis-based); and
a Ph.D. (thesis-based).

<p>We are contacting you to solicit your feedback on some of the proposed programs, and to assess the level of interest in these programs among current Concordia students. The survey should take no longer than 10 minutes to complete. Should you find that your exact situation is not listed as a response to a given question, please select the closest response choice. Your responses will be held in strict confidence and will only be used to produce aggregate results.</p>

<p>Thank you for your participation -- your feedback is important.</p>

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New Programs in
Chemical Engineering Survey

Completed

Your Program

Please indicate your current program of study.

- Mechanical Engineering (Bachelor's degree)
- Industrial Engineering (Bachelor's degree)
- Chemistry (Bachelor's degree)

Please indicate the number of credits you have remaining to complete your degree.

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Web Page 4:

New Programs in
Chemical Engineering Survey

Completed

The New Certificate Program

The **Certificate in Chemical Engineering** is a course-based program. It consists of four courses: three core courses and one elective. The program provides students with a first exposure to Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the Graduate Diploma and the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Certificate** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Certificate** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 5:

New Programs in Chemical Engineering Survey

Completed

Objectives of the Certificate Program

The aim of the **Certificate** in Chemical Engineering program is to provide specialized expertise in a limited number of core subjects in Chemical Engineering. It will enable students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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New Programs in Chemical Engineering Survey

Completed

Requirements of the Certificate Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
One of the following two:
Chemical Kinetics and Reaction Engineering (chemical reactor design)
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Certificate** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Graduate Diploma or a Master's degree in Chemical Engineering.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Certificate** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Web Page 8:

New Programs in Chemical Engineering Survey

Completed

The New Diploma Program

The **Diploma in Chemical Engineering** is a course-based program. It consists of eight courses: five core courses and three electives. The program provides students with comprehensive specialized knowledge in Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Diploma** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Diploma** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Diploma Program

The aim of the **Diploma** in Chemical Engineering program is to provide specialized expertise in a broad range of core subjects in Chemical Engineering. It will allow students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Diploma Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One technical elective course outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One complementary course. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Diploma** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Master's degree.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Diploma** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Master of Engineering Program

The **Master of Engineering in Chemical Engineering** is a course-based program. It consists of twelve courses: seven core courses and five electives. The program provides students with extensive specialized knowledge in Chemical Engineering at the graduate level. The program is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.).

Based on this description, how likely is it that you would apply to the **Master of Engineering** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Engineering** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Engineering Program

The aim of the **Master of Engineering** in Chemical Engineering program is to provide specialized expertise in all areas of Chemical Engineering, and to solve problems from a thorough understanding of the underlying principles so students can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Engineering Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
One of the following two courses:
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. One to three technical elective courses in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One or two technical elective courses outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One or two complementary courses. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Engineering** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Engineering** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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New Programs in
Chemical Engineering Survey

Completed

The New Master of Applied Science Program

The **Master of Applied Science in Chemical Engineering** program is a thesis-based program. It consists of four courses and research culminating in the writing of a thesis. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Master of Applied Science** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Applied Science** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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New Programs in
Chemical Engineering Survey

Completed

Objectives of the Master of Applied Science Program

The aim of the **Master of Applied Science** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. Students who complete a Master of Applied Science program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Applied Science Program

<p>I. Core courses (at least two courses from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A thesis based on academic research in a chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Applied Science** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other: ____

What drawbacks or disadvantages can you foresee in the proposed **Master of Applied Science** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other: ____

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New Programs in Chemical Engineering Survey

Final Comments

If you have any final comments or questions regarding any of the proposed Chemical Engineering programs, please share them below.

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New Programs in Chemical Engineering Survey

Thank you for taking the time to complete this survey.
Your feedback is important.

We have received your responses.

Appendix 3 Library report

Library Report

For the Proposed

Certificate in Chemical Engineering

Joshua Chalifour, Digital Services & Engineering Librarian
Krista Alexander, Biochemistry/Chemistry & Physics Librarian

Created: April 2017

Purpose

The purpose of this report is to assess the adequacy of available library resources to support the proposed Certificate of Chemical Engineering, in the soon to be established Department of Chemical and Materials Engineering at Concordia University. The Department will be unique in Quebec and is slated to emphasize the development of new processes for producing specialized materials and the application of these materials in industry.

The comparators used throughout this report were identified by the Department of Chemical and Materials Engineering and include McGill University, École Polytechnique Montréal, University of Alberta, Stanford University, University of Houston, and Curtin University. Due to the University of Houston being the institution most similar (based on the number of students and professors, programs, founding dates, and rankings) among those identified offering a Certificate program in Chemical Engineering, it will be used as the key comparator for library holdings.

Monographs

To assess the relative strength of Concordia University Library's monograph collection in terms of the research needs of the proposed Certificate program, collection size was measured for a sample of relevant Library of Congress Subject Headings. The results are presented in Table 1.

The table that follows compares monograph holdings for each of the comparator universities. McGill is excluded from this table because the methods to search its holdings produce different types of results for total print and ebook numbers. It is reasonable to consider McGill's total number is greater than the other comparators except for Stanford.

LC Subject Heading	Number of Monograph Titles					
	Concordia	École Polytechnique	Alberta	Stanford	Houston	Curtin University
Alloys	54	38	198	13724	105	1676
Biochemical engineering	23	52	173	257	54	226
Biotechnology	172	259	862	4749	249	2042
Chemical engineering	88	162	537	1443	225	2128
Chemical industry	26	96	143	1553	81	366
Chemical kinetics	169	124	407	1730	271	239
Chemical processes	21	35	217	673	92	349
Chemical reactions	128	109	425	7304	205	246
Chemical technology	0	0	2	219	0	42
Chemistry	172	253	1356	40191	473	6762
Chemistry, Metallurgic	4	4	30	36	12	34
Composite materials	174	119	444	3530	173	378
Energy transfer	19	34	77	3129	22	40
Fluid mechanics	263	635	602	3864	324	613
Manufacturing processes	187	463	483	1258	174	400
Metals	128	130	341	26718	184	2067
Nanostructured materials	278	856	1513	1774	285	383
Nanotechnology	315	1575	1262	3182	319	1368
Photochemistry Industrial applications	3	1	12	19	5	6
Plasma chemistry Industrial applications	2	1	7	9	3	3
Plastics	100	100	343	5056	207	737
Polymers	237	1915	1016	6482	602	1656
Process control	121	262	365	1617	133	467
Separation technology	46	67	261	281	120	242
Synthetic fuels	14	6	63	1336	46	125
Synthetic products	3	1	28	48	13	18
Total	**2,747**	**7,297**	**11,167**	**130,182**	**4,377**	**22,613**

Table 1: Comparative Size of Monograph Collections for Selected Subject Areas

Concordia's monograph collection in the areas measured is considerably smaller than that of the comparator universities. Some of these universities are older institutions (e.g. McGill) or larger but others are more similar to Concordia. If Concordia's holdings are compared to the University of Houston for the reasons identified at the outset of this report, it should be noted that Concordia's monograph holdings are unsupported by 37%.

While there is no historical data on which to base an assessment of collection growth over time at Concordia, the library materials budget for monographs in Chemistry & Biochemistry, Mechanical and Industrial Engineering, and Physics is shown for the last six years in Table 2.

Year	Chemistry & Biochemistry Appropriation	Mechanical & Industrial Engineering Appropriation	Physics Appropriation
2011 - 12	$14,636	$26,826	$8,755
2012 - 13	$11,000	$18,778	$6,128
2013 - 14	$6,600	$11,267	$3,677
2014 - 15	$6,600	$11,267	$3,677
2015 - 16	$6,600	$11,267	$3,677
2016 - 17	$6,600	$9,000	$3,700

Table 2: Library Materials Budget for Monographs in Subject Areas

Despite the reduction in monograph funds over the years, the Concordia Library has been able to acquire a number of electronic book collections using some centralized (non-subject specific) funds as well as money from the Academic Plan. Electronic book collections bought using these funds include Springer Ebooks, ScienceDirect, and the IEEE-Wiley Ebooks Library. These collections (normally updated each year with new titles) include monographs relevant to chemical engineering.

One-time monies (known as development funds) are made available each year to support new programs or build specific areas of the library collection in answer to the changing needs of our community. These development funds come from undesignated donations to the library and as such, are not consistent from year to year. They are primarily used to acquire titles to address historical gaps in the monograph or ebook collections.

Finally, students at Concordia University benefit from services that provide access to collections outside of Concordia, including the BCI card, which allows for direct borrowing of books from other Canadian academic libraries, including major Montreal institutions such as McGill University and Montréal Polytechnique. The Library's interlibrary loans service enables users to obtain some books, articles, and conference papers from other institutions worldwide, which are not accessible at Concordia. Books are delivered directly to the Library and users can pick them up at the circulation desk.

Electronic Resources (Databases)

The Concordia University Library's current collection of relevant databases for the fields of chemical and materials engineering is slightly under par with other universities that offer similar programs. Of 67 databases used in relation to chemical and materials engineering programs, Concordia subscribes to 32. On average, libraries subscribe to 34 of these databases. The Concordia Library has key, commonly used databases as identified below.

In Concordia's collection, the three most important databases for chemical and materials engineering—providing access to indexed abstracts—are the following:

SciFinder

SciFinder searches Chemical Abstracts which indexes a wide range of international literature in chemistry and related fields (biology, engineering, physics, geology and material sciences). SciFinder includes journal articles, patents, dissertations, conference proceedings. It also contains millions of substances (CAS Registry) and reactions (CAS REACT), which can be searched by chemical structure, reactions, formulas or CAS Registry numbers. Commercial and regulated chemical information is included.

Compendex
The Compendex database is the largest source of engineering research literature (over 19 million records). Its coverage spans from 1884 to the present and is updated weekly. Compendex is a bibliographic database with references to engineering journals, conferences, trade publications, and more from over 76 countries. Focusing on just engineering disciplines, a significant portion of the Compendex records (about 13%) covers chemical engineering and a smaller quantity covers materials engineering.

Web of Science
This multidisciplinary database covers the journal literature of the sciences through the Science Citation Index (1979 – onwards), which includes the fields of science and engineering. Coverage also includes conference proceedings from the Conference Proceedings Citation Index (1990 – onwards).

Other important databases in the Library's collection that provide access to chemical engineering literature include:

Scopus
This multidisciplinary database covers journals and conference proceedings in science and technology. Physical sciences records (primarily chemistry, physics, and engineering) comprise 29% of the database's 60 million records. Scopus is updated daily with records from over 5000 publishers worldwide.

ACS Publications (American Chemical Society)
The American Chemical Society Journals covers more than 30 journals published by the ACS. Concordia also has access to the ACS legacy archives.

ScienceDirect
ScienceDirect provides full text of more than 1,800 Elsevier Science journals in the life, physical, medical, technical, and social sciences. ScienceDirect coverage spans from 1995 onward. In addition to some ebooks, the Concordia Library also has extensive backfile packages for journals in the areas of engineering, materials science, and technology prior to 1994.

Royal Society of Chemistry
The Royal Society of Chemistry provides databases, ebooks, and the full text of their journals. The Concordia Library subscribes to some of the databases, including the Merck Index (information on chemicals). Bibliographic databases include Synthetic Reaction Updates and Analytical Abstracts covering 1980 to the present. The Library purchases access to some of the RSC ebooks and has access to the journals archive (1841-2004) through its participation in the CRKN Canadian Site Licensing Project.

Journals

The Concordia Library has a substantial collection of electronic journals, which are usually acquired in bundles, either from the publisher or an aggregator. These subscription bundles, generally managed on a provincial or national level through academic library consortia, include journals relevant to chemical engineering. These electronic subscriptions have largely displaced the print journal collections and are available to Concordia researchers on- and off-campus. The relevant subscription bundles for chemical engineering include (but are not limited to): Elsevier (ScienceDirect), American Chemical Society, Royal Society of Chemistry, American Physical Society, Sage, Springer, Taylor & Francis, and Wiley-Blackwell.

Below is a list of 25 top chemical engineering journals based on 5 year impact factor, according to Thomson Reuters' *InCites Journal Citation Report*, and the Library's current holdings for these journals, along with holdings at the comparator institutions.

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Progress in Energy and Combustion Science	23.634	1975 - Present	1976 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1976 - Present
Energy & Environmental Science	22.118	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present
Annual Review of Chemical and Biomolecular Engineering	9.337	2010 - Present	2010 - Present		2010 - Present	2010 - Present	2010 - Present	2010 - Present
Applied Catalysis B - Environmental	8.142	1995 - Present	1992 - Present	1995 - Present	1992 - Present	1992 - Present	1992 - Present	1992 - Present
Journal of Catalysis	7.482	1962 - Present	1962 - Present	1970 - Present	1962 - Present	1962 - Present	1962 - Present	1962 - Present
Applied Energy	6.222	1995 - Present	1975 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1975 - Present
Journal of Membrane Science	5.741	1995 - Present	1976 - Present	1995 - Present	1976 - Present	1976 - Present	1976 - Present	1976 - Present
Chemical Engineering Journal	5.439	1997 - Present	1997 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present
ACS Sustainable Chemistry & Engineering	5.319	2013 - Present	2013 - Present	2013 - Present	1995 - Present	2013 - Present	2013 - Present	2013 - Present
Separation and Purification Reviews	5.050	2003 - Present	1973 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present
Combustion and Flame	4.806	1957 - Present	1957 - Present	1970-1993 1995-Present	1957 - Present	1957 - Present	1957 - Present	1957 - Present
Desalination	4.800	1995 - Present	1966 - Present	1995 - Present	1966 - Present	1966 - Present	1966 - Present	1966 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Journal of CO2 Utilization	4.778	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present
Proceedings of the Combustion Institute	4.303	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present
Fuel	4.140	1995 - Present	1970 - Present	1995 - Present	1965 - Present	1968 - Present	1953 - Present	1970 - Present
Catalysis Today	4.105	1995 - Present	1987 - Present	1995 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Fuel Processing Technology	3.949	1995 - Present	1977 - Present	1995 - Present	1977 - Present	1977 - Present	1977 - Present	1977 - Present
Current Opinion in Chemical Engineering	3.810	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present
Separation and Purification Technology	3.758	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present
Dyes and Pigments	3.708	1980 - Present	1980 - Present	1995 - Present	1980 - Present	1980 - Present	1980 - Present	1980 - Present
Journal of Food Engineering	3.512	1995 - Present	1982 - Present	1995 - Present	1982 - Present	1982 - Present	1982 - Present	1982 - Present
Food and Bioproducts Processing	3.511	1996 - Present	1996 - Present	1996 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present
Journal of Industrial and Engineering Chemistry	3.458	2008 - Present	2008 - Present	2008 - Present	1995 - Present	1995 - Present	2008 - Present	1995 - Present
Energy & Fuels	3.340	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Process Biochemistry	3.067	1995 - Present	1991 - Present	1995 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present

Table 3: The print or electronic holdings of 25 chemical engineering journals for Concordia, McGill, École Polytechnique, University of Alberta, Stanford, University of Houston, and Curtin University.

We have current access to 25 of the 25 titles listed. The following table shows backfile access. Backfile access refers to any titles that are not currently received (whether due to cancellation or a one year publisher embargo) but for which there is complete or partial backfile access.

	Concordia University	McGill	École Polytechnique	U Alberta	U Houston	Curtin University
Current Access	25	25	24	25	25	25
Backfile Access	25	25	24	25	25	25
No access	0	0	1	0	0	0

Table 4: Comparative Access to Select Journals

Concordia University access to these chemical engineering journal titles is strong and very similar to the comparator institutions examined here.

Recurring Library Collection Expenditures

To fully support the proposed Certificate in Chemical Engineering, certain areas of Concordia Library's collection should be enhanced. In particular, the proposed program is estimated to be unsupported by the monograph collection at 37%.

As per Section 5 of the document ***How to Calculate Revenues & Expenses for New Courses and New Programs***, prepared by the Resources Committee, the weighting grid for Cycle 2 in Engineering is 4.42 and the weighting grid for Cycle 2 in the Pure Sciences is 6.59. The multidisciplinary nature of the proposed program makes it necessary to use each of these values to determine a range of recurring library collection expenditures. Each of these numbers was multiplied by 10,000 (see Section 5 in the document mentioned above) and further multiplied by 37% (the amount by which the collection is considered to be unsupported). The recurring library collection expenditures would then fall between $16,354 and $24,383.

Concordia subscribes to many chemical engineering journals in addition to those listed in table 3 and the current journal collection is adequate to support the proposed program. The database collections are also adequate to support the proposed program.

It is important to note that these figures are all of a recurring nature—additional funds that the library would need **each year**, in order to support the Certificate program in Chemical Engineering.

The Library will require additional funds of between $16,354 and $24,383 each year to support the Certificate in Chemical Engineering program.

Resources needed	Recurring annual total in CAD
Monographs/ebooks	$16,354 - $24,383

Table 5: Additional funds needed per year to support the proposed program

***Please note**: It is important to note that if a Masters or PhD program in the same subject area was to be created, the additional funds indicated above would not be necessary for the Certificate program, as the resources used for those programs would be the same, albeit far more extensive, than those used for a Certificate program. Thus additional funds on top of those allocated to purchase resources to support a Masters or PhD program, would not be required.

Conclusion

With the addition of recurring funds to allow for the establishment of an appropriate annual monograph allocation, and the understanding that interlibrary loans will need to be used to supplement our journal and monograph collections, the Concordia University Library will be able to support a Certificate in Chemical Engineering.

Appendix 4 Curriculum documents

Please see the Provotrack sheets starting on p. 6 of the Dossier.

Appendix 5 Abridged curricula vitae of current department members

Alex De Visscher, Professor

Education:

- 2001: PhD Bioscience Engineering. Ghent University, Belgium
- 1993: BSc/MSc Chemical Engineering. Ghent University, Belgium

Positions/Accomplishments/Experience:

- 2014-2016: Associate Head Graduate, Department of Chemical and Petroleum Engineering, University of Calgary
- 2015-2016: Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2005-2015: Tier II Canada Research Chair in Air Quality and Pollution Control Engineering, Department of Chemical and Petroleum Engineering, University of Calgary
- 2010-2015: Associate Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2011-2012: Visiting Professor, Technical University Bergakademie Freiberg, Germany; Institute of Technical Chemistry
- 2005-2010: Assistant Professor, Department of Chemical and Petroleum Engineering, University of Calgary

Publications: Books (2012-2017):

- De Visscher A. (2013). Air Dispersion Modeling. Foundations and Applications. J. Wiley & Sons, Hoboken, NJ. 634 pp. ISBN 978-1-1180-7859-4.
- De Visscher A. (2013). Lecture Notes in Chemical Engineering Kinetics and Reactor Design. Self-published through CreateSpace, Charleston, SC. 345 pp. ISBN 9781492792642.

Publications: Peer-reviewed journal articles (2012-2017):

- Mahmoudkhani F., Rezaei M., Asili V., Atyabi M., Vaisman E., Langford C.H., De Visscher A. Benzene degradation in waste gas by photolysis and photolysis-ozonation: Experiments and modeling. Front. Environ. Eng. 10(6), 10 (2016).
- Rahnama K. & De Visscher A. Simplified flare combustion model for flare plume rise calculations. Can. J. Chem. Eng. 94, 1249–1261 (2016).
- Harper L.A., Weaver K.H. & De Visscher A. Dinitrogen and methane gas production during the anaerobic/anoxic decomposition of animal manure. Nutr. Cycl. Agroecosyst. 100, 53–64 (2014).
- Asili V., De Visscher A. Mechanistic model for ultraviolet degradation of H_2S and NO_x in waste gas. Chem. Eng. J. 244, 597–603 (2014).
- Malekshahian M., De Visscher A., Hill J.M. A non-equimolar mass transfer model for carbon dioxide gasification studies by thermogravimetric analysis. Fuel Proc. Technol. 124, 1–10 (2014).
- Fraser S., Marceau D., De Visscher A., Roth S.H. Estimating exposure by loose-coupling an air dispersion model and a geospatial information system. J. Environ. Informat. 21, 84–92 (2013).

- De Visscher A., Conejo M.S. Solubility phenomena related to CO_2 capture and storage. Pure Appl. Chem. 85, 2051–2058 (2013).
- De Visscher A. Response to "Remarks on the paper by A. De Visscher, "What does the g-index really measure?"" J. Am. Soc. Informat. Sci. Technol. 64, 1960–1962 (2013).
- De Visscher A. A new Price's estimate on the size of scientific specialties based on scientific community structure. Scientometrics 96, 937–940 (2013).
- De Visscher A., Vanderdeelen J. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 2: Ca. J. Phys. Chem. Ref. Data 41, 023105 (137pp) (2012).
- De Visscher A., Vanderdeelen J., Königsberger E., Churgalov B.R., Tsurumi M. & Ichikuni M. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 1: Introduction, Be and Mg. J. Phys. Chem. Ref. Data 41, 013105 (67pp) (2012).
- De Visscher A. The thermodynamics-bibliometrics consilience and the meaning of h-type indices – Reply. J. Am. Soc. Informat. Sci. Technol. 63, 630–631 (2012).

HQP Supervision (2012-2017):

- Chongchong Wu, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Sonochemistry for wastewater treatment. Co-supervisor: Dr. I. Gates.
- Michael Süß, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Environmental Engineering. Thesis: Biofiltration of BTEX.
- Mehrshad Parchei Esfahani, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Ultrasound-assisted peroxone for waste gas treatment.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2013–present), PhD student in Chemical Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of Air Pollutants in waste gas.
- Ali Shafaghat, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2016), MEng (thesis) student in Chemical Engineering, Environmental Engineering Specialization. Thesis: Depressurization Dynamic Modeling and Effect on Flare Flame Distortion. Final exam: 14 March 2016.
- Farshid Shayganpour, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2015), MEng (thesis) student in Chemical and Petroleum Engineering, Petroleum Engineering specialization, Thesis: Comparison of CSS and SAGD in Cold Lake. Final exam: 27 April 2015. Co-supervised, with Dr. Ian Gates as supervisor.
- Farzana Haque, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2008–2014), PhD student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Biofiltration of BTX from Glycol Dehydration Units. Final exam: 8 May 2014.
- Maria Conejo, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2014), MSc student in Chemical and Petroleum Engineering, Energy and Environment Engineering specialization, Thesis: Interactions between carbon dioxide and calcium carbonate in carbon storage conditions. Final exam: 10 March 2014.

- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2011–2013), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of H2S in waste gas: A comprehensive first-principles model. Final exam: July 2013.
- Mahsasadat Atyabi, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2013), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of BTX in waste gas: Effects of photocatalysis and ozone premixing. Final exam: 18 January 2013.
- Kamran Rahnama, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2012), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Plume dispersion: A new flare combustion and plume rise model. Final exam: December 10, 2012.

Participation in thesis juries (2012-2017):

- March 3, 2017: Deependra Singh. Department of Mechanical and Industrial Engineering, Concordia University, PhD, Comprehensive Exam. Subject: Comprehensive Review of Electro-Chemical Machining (ECM) Process (Supervisor: R. Wuthrich).
- November 24, 2016: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering. PhD, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: P. Pereira Almao).
- September 12, 2016: Marlon Vargas-Ferrer. Department of Chemical and Petroleum Engineering. MSc, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: N. Mahinpey).
- September 1, 2016: Jun Cui. Department of Chemistry, University of Calgary, MSc, Final exam. Thesis title: Rapid characterization and degradation of dissolved organic matter for improving the quality of boiler feed water in Steam Assisted Gravity Drainage process (Supervisors: C.H. Langford and G. Achari).
- August 24, 2016: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Processing of Peroxidized Asphaltene in Aqueous Media. (Supervisor: P. Pereira Almao).
- August 9, 2016: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: New Pathways for Asphaltenes Upgrading via Oxy-Cracking in Liquid Phase. (Supervisor: P. Pereira Almao).
- May 13, 2016: Saeed Sampouri. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, Final exam. Thesis title: Catalytic Steam Reforming and Esterification of Bio-Oil. (Supervisor: J. Abedi).
- March 24, 2016: Karen Cañon-Rubio. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, Final exam. Thesis title: Strategies for Improving the Productivity and Cost-Effectiveness of Microalgal Production Systems. (Supervisor: H. De la Hoz Siegler).
- March 23, 2016: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Candidacy exam. (Supervisor: J. Bergerson).
- February 26, 2016: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Sorption-enhanced hydrogen production from catalytic steam gasification of coal. (Supervisor: N. Mahinpey).

- January 18, 2016: An Le. Biomedical Engineering Graduate Program, University of Calgary, MSc, Final exam. Thesis title: Computational Fluid Dynamics Modeling of Scalable Stirred Suspension Bioreactors for Pluripotent Stem Cell Expansion. (Supervisors: M. Kallos, I. Gates).
- November 27, 2015: Daniel Lincoln. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Development and characterization of an LED-based light source for high-speed schlieren imaging. (Supervisor: C. Johansen).
- November 23, 2015: Masoud Alrmah. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: (Supervisor: A. Mohamad).
- November 4, 2015: Jennifer Pauls. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Simulation of air-steam gasification of woody biomass in Aspen Plus: A comprehensive model including pyrolysis, hydrodynamics and tar production. (Supervisor: N. Mahinpey).
- September 10, 2015: Amir Ahmad Shirazi Manesh. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Thermodynamic modeling of asphaltene precipitation using cubic plus association equation of state. (Supervisor: J. Abedi).
- August 19, 2015: Mohamed Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary. PhD, final exam. Thesis title: Computational modelling of the wind flow over the University of Calgary campus. (Supervisor: D. Wood).
- April 27, 2015: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Comprehensive kinetic study of carbon dioxide and steam gasification: New findings and fundamentals. (Supervisor: N. Mahinpey).
- April 20, 2015: Amjad El-Qanni. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Nassar)
- October 22, 2014: Mahida Khurshid. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Serum-free co-expansion of mesenchymal stem cells and chondrocytesas aggregates in suspension bioreactors. (Supervisor: M. Kallos).
- August 29, 2014: Christopher Arisman. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Nitric oxide chemistry and velocity slip effects in hypersonic boundary layers (Supervisor: C. Johansen).
- August 28, 2014: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: D. Wood).
- August 25, 2014: Khaled Omar Sebakhy. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: M. Husein).
- July 10, 2014: Adeem Hassan Khan. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Measurement of the physical properties of MacKay bitumen and solvent mixtures (Supervisor: J. Abedi).
- June 16 2014: Mahdieh Shafiee Neistanak. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Kinetics of asphaltene precipitation and flocculation from diluted bitumen (Supervisor: H. Yarranton).
- April 29 2014: Mona Amiri. Department of Civil Engineering, University of Calgary, MSc, final exam. Thesis title: A methodology for estimating greenhouse gas emissions from heavy-duty diesel trucks in construction road transportation (Supervisor: F. Sadeghpour).

- April 17 2014: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- April 16 2014: Virginia Andrade Tovar. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Feasibility study for a small scale integrated on-farm ethanol plant (Supervisor: M. Foley).
- April 8 2014: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- March 27 2014: Ehsan Esmaili Darki. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Modeling and economic assessment of integrated gasification with sorbent CO2 capture (Supervisor: N. Mahinpey).
- January 22 2014: Belal Abu Tarboush. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Adsorption and oxidation of asphaltenes onto in situ prepared and commercial nanoparticles (Supervisor: M. Husein).
- January 10 2014: Xiaojian Wei. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: The effect of varying inlet conditions on the turbulent wake of a fence (Supervisor: D. Rival).
- December 18 2013: Alireza Saidi-Mehrabad. Department of Biological Sciences. MSc, final exam. Thesis title: Characterization of aerobic methane oxidizing bacteria in oil sands tailings ponds (Supervisor: P. Dunfield).
- December 16 2013: Lante Carbognani. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Upgrading of Visbroken vacuum residue by adsorption and catalytic steam gasification of the adsorbed components (Supervisor: P. Pereira Almao).
- December 13 2013: Claudia Bess-Ouko. Department of Civil Engineering, University of Calgary, MSc, final exam. Thesis title: Development of a LCA screening tool: Assessment of biochar in the removal of organic carbon in SAGD produced water (Supervisors: J. Bergerson and G. Achari).
- November 26 2013: Yanghong Liu. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Separation of water-in-heavy oil emulsions using porous particles in coalescence column (Supervisor: M. Dong).
- November 25 2013: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Template-free synthesis and modification of LTY, ZSM-5 and LTL zeolite catalysts and investigation of the catalytic pyrolysis of Saskatchewan Boundary Dam coal (Supervisor: N. Mahinpey).
- November 20 2013: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Mahinpey).
- October 8 2013: Sarah Alamolhoda. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: J. Hill).
- September 20, 2013: Krishna Morgan Panchalingam. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Bioprocessing of human stem cells applied to diseases of the central nervous system. (Supervisor: L. Behie).
- August 15 2013: Santiago Ortiz Ruiz. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Development of a computational tool for low-temperature geothermal-solar power generation plants (Supervisor: A. Mohamad).

- August 1 2013: Rozita Habibi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Co-gasification of biomass and non-biomass feedstocks (Supervisor: J. Hill).
- July 9 2013: Saleh Bawazeer. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Stability and accuracy of Lattice Boltzmann method (Supervisor: A. Mohamad).
- June 20 2013: Upasana Chamoli. Department of Chemistry, University of Calgary, MSc, final exam. Thesis title: Disinfection and self-sensitized degradation of NOM (Natural Organic Matter) by TiO2 photocatalysis with visible light (Supervisors C. Langford and G. Achari).
- June 18 2013: Mostafa Meibod. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Bio-oil from wheat straw and hydrogen from aqueous phase of bio-oil (Supervisor J. Abedi).
- June 11 2013: Hesham Alhumade. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Reversible reactive flow displacements in porous media (Supervisor J. Azaiez).
- April 23 2013: Jaime McKenzie Graham. Department of Biological Sciences, University of Calgary, MSc, final exam. Thesis title: Effect of Drainage on Carbon Biogeochemistry and Microbiological Communities in Western Canadian Boreal Peatlands (Supervisor: P. Dunfield)
- April 18 2013: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Wet air oxidation of asphaltene particles (Supervisor: P. Pereira)
- January 18 2013: Giuseppe Rosi. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Characterizing coherent structures within the lower log region of the atmospheric boundary layer (Supervisor: D. Rival)
- December 17 2013: Sobhan Iranmesh. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Removal of naphthenic acid from water using biomass-based activated carbon.
- December 11, 2012: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Catalytic steam gasification of low grade coal with in situ CO2 capture process: Experimental and modeling approach (Supervisor: N. Mahinpey).
- December 6 2012: Esther Ramos-Padron. Department of Biological Sciencies, University of Calgary, PhD, final exam. Thesis title: Physiology and molecular characterization of microbial communities in oil sands tailings ponds (Supervisors: L. Gieg and G. Voordouw).
- June 28 2012: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Vertical wind speed extrapolation using the k-? turbulence model (Supervisor: D. Wood).
- May 4 2012: Punitkumar Kapadia. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Gasification of Althabasca bitumen: Hydrogen generation, kinetics, and in situ process design (Supervisor: I. Gates).

Zhibin Ye, Professor

Education:

- PhD Chemical Engineering, McMaster University, Hamilton, Ontario 2004
- MEng Chemical Engineering, Zhejiang University, China 1999
- BEng Chemical Engineering, Zhejiang University, China 1996

Positions/Accomplishments/Experience:

- July 2012−present: Full Professor of Chemical Engineering
- Jan. 2011−present: Canada Research Chair (Tier 2) in Polymer Nanomaterials
- Sept. 2010−Feb. 2011: Visiting Associate Professor Department of Chemistry, University of Illinois at Urbana-Champaign
- Jan. 2010−present: Cross-Appointment to Department of Chemistry and Biochemistry
- July 2009−June 2012: Associate Professor (Tenured) of Chemical Engineering
- July 2004−June 2009: Assistant Professor (Tenure Track) of Chemical Engineering, School of Engineering, Laurentian University, Sudbury, Ontario, Canada

Publications: Peer-reviewed journal articles (2012-2017):

- L. Xu, L. Huang, Z. Ye*, Z. Gu, "Polycyclopentene-decorated carbon nanotubes by convenient large-scale in situ polymerization and their lotus leaf-like superhydrophobic films", Macromolecular Rapid Communications 2017, 38, 1600608.
- L. Huang, Z. Ye*, R. Berry, "Modification of cellulose nanocrystals with quaternary ammonium-containing hyperbranched polyethylene ionomers by ionic assembly", ACS Sustainable Chemistry & Engineering 2016, 4, 4937–4950. (Impact Factor: 5.267)
- Z. Dong, P. Xiang, L. Huang, Z. Ye*, "Efficient, robust surface functionalization and stabilization of gold nanorods with quaternary ammonium-containing ionomers as multidentate macromolecular ligands", RSC Advance 2016, 6, 43574–43590 (Impact Factor: 3.289).
- P. Xiang, Z. Ye*, "Hyperbranched polyethylene ionomers containing cationic tetralkylammonium ions synthesized by Pd–diimine-catalyzed direct one-pot ethylene copolymerization with ionic liquid comonomers", Macromolecules 2015, 48, 6096–6107. (Impact Factor: 5.554)
- P. Govindaiah, E. Guerra, Y. Choi, Z. Ye*, "Pressure oxidation leaching of an enargite concentrate in the presence of polytetrafluoroethylene beads", Hydrometallurgy 2015, 157, 340−347. (Impact Factor: 2.290)
- P. Xiang, Z. Ye*, "Homo- and co-polymerization of norbornene and methyl acrylate with Pd–diimine catalysts", Journal of Organometallic Chemistry 2015, 798, 429−436. (Impact Factor: 2.336)
- P. Govindaiah, M. Grundy, E. Guerra*, Y. Choi, Z. Ye*, "Polytetrafluoroethylene/TiO2 composite pellets as sulfur adsorbents for pressure oxidization leaching of chalcopyrite", Metallurgical and Materials Transaction B 2015, 46B, 550−556. (Impact factor: 1.474)
- Z. Dong, Z. Ye*, "Heterogeneous palladium catalyst constructed with cross-linked hyperbranched poly(phenylacetylene) as polymer support: a reusable highly active ppm-level catalyst for multiple cross-coupling reactions", Applied Catalysis A: General 2015, 489, 61−71. (Impact factor: 4.012)
- M. Grundy, Z. Ye*, "Cross-linked polymers of diethynylbenzene and phenylacetylene as new polymer precursors for high-yield synthesis of nanoporous activated carbons of high performance

for supercapacitors, hydrogen storage, and CO2 capture”, Journal of Materials Chemistry A 2014, 2, 20316−20330. (Impact factor: 8.262) [Invited to be featured on journal back cover]

- Z. Dong, Z. Ye*, “Reusable, highly active heterogeneous Pd catalyst by convenient selfencapsulation cross-linking polymerization for multiple carbon–carbon cross-coupling reactions at ppm to ppb Pd loadings”, Advanced Synthesis & Catalysis 2014, 356, 3401−3414. (Impact factor: 5.663)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, “Synthesis of polyethylene and polystyrene miktoarm star copolymers using an ‘in-out’ strategy”, Polymer Chemistry 2014, 5, 5443−5452. (Impact factor: 5.687)
- L. Xu, Z. Ye*, S. Siemann, Z. Gu, “Noncovalent solubilization of multi-walled carbon nanotubes in common low-polarity organic solvents with branched Pd–diimine polyethylenes: effects of polymer chain topology, molecular weight and terminal pyrene group”, Polymer 2014, 55, 3120−3129. (Impact factor: 3.586; 2 citations)
- O. Osazuwa, M. Kontopoulou, P. Xiang, Z. Ye, A. Docoslis*, “Electrically conducting polyolefin composites containing electric field-aligned multiwall carbon nanotube structures: the effects of process parameters and filler loading”, Carbon 2014, 72, 89−99. (Impact factor: 6.198)
- P. Liu, Z. Dong, Z. Ye*, W.-J. Wang*, B.-G. Li, “A conveniently synthesized polyethylene gel encapsulating palladium nanoparticles as a reusable high-performance catalyst for Heck and Suzuki coupling reactions”, Journal of Materials Chemistry A 2013, 1, 15469−15478. (Impact factor: 8.262)
- L. Xu, Z. Ye*, “A Pd−diimine catalytic inimer for synthesis of polyethylenes of hyperbranchedon-hyperbranched and star architectures”, Chemical Communications 2013, 49, 8800−8802. (Impact factor: 6.567)
- E. Landry, Z. Ye*, “Convenient Pd-catalyzed ‘arm-first’ synthesis of large unimolecular star polyethylene nanoparticles”, Macromolecular Rapid Communications 2013, 34, 1493−1498. (Impact factor: 4.638) [This paper was invited to be featured on the cover page]
- A. A. Vasileiou, A. Docoslis, M. Kontopoulou*, P. Xiang, Z. Ye, “The role of non-covalent functionalization and matrix viscosity on the dispersion and properties of LLDPE/MWCNT nanocomposites”, Polymer 2013, 54, 5230−5240. (Impact factor: 3.586; 2 citations)
- Z. Ye*, L. Xu, Z. Dong, P. Xiang, “Designing polyethylenes of complex chain architectures by Pd–diimine-catalyzed ‘living’ ethylene polymerization”, Chemical Communications 2013, 49, 6235−6255. (Impact factor: 6.567; 3 citations) [Invited feature article]
- L. Xu, J.-W. McGraw, F. Gao, M. Grundy, Z. Ye*, Z. Gu, J. L. Shepherd, “Production of high concentration graphene dispersions in low-boiling-point organic solvents by liquid-phase noncovalent exfoliation of graphite with a hyperbranched polyethylene and formation of graphene/ethylene copolymer composites”, Journal of Physical Chemistry C 2013, 117, 10730−10742. (Impact factor: 4.509; 2 citations)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, “Hyperbranched polyethylenes encapsulating selfsupported palladium (II) species as efficient and recyclable catalysts for Heck reaction”, Macromolecules 2013, 46, 72−82. (Impact factor: 5.554; 3 citations)
- P. Xiang, K. Petrie, M. Kontopoulou, Z. Ye*, R. Subramanian, “Tuning structural parameters of polyethylene brushes in surface-initiated ethylene ‘living’ polymerization from silica nanoparticles and effects on nanocomposite properties”, Polymer Chemistry 2013, 4, 1381−1395. (Impact factor: 5.687; 3 citations) [This paper was invited to be featured on back cover]

- P. Xiang, Z. Ye*, “Alternating, gradient, block, and block-gradient copolymers of ethylene and norbornene by Pd−diimine catalyzed ‘living’ copolymerization”, Journal of Polymer Science, Part A: Polymer Chemistry 2013, 51, 672−686. (Impact factor: 3.11; 2 citations)
- O. Oaszuwa, K. Petrie, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Characterization of non-covalently, non-specifically functionalized multi-wall carbon nanotubes and their melt compounded composites with an ethylene-octene copolymer”, Composite Science and Technology 2012, 73, 27−33. (Impact factor: 3.897; 8 citations)
- O. Osazuwa, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Polymer composites containing non-covalently functionalized carbon nanotubes: a study of their dispersion characteristics and response to AC electric fields”, Procedia Engineering 2012, 42, 1414−1424. (1 citation)
- P. Liu, W. Lu, W.-J. Wang*, B.-G. Li, Z. Ye*, S. Zhu*, “Synthesis and characterization of PE-b-POGEMA copolymers prepared by linear/hyperbranched telechelic polyethylene-initiated ATRP of oligo(ethylene glycol) Methacrylates”, Chapter 4 in ACS Symposium Series 1101, Progress in Controlled Radical Polymerization: Materials and Applications, Edited by K. Matyjaszewski, B. S. Sumerlin, and N. V. Tsarevsky, 2012, pp 39−64.
- Z. Zhang, Z. Ye*, “A ligand exchange strategy for one-pot sequential synthesis of (hyperbranched polyethylene)-b-(linear polyketone) block polymers”, Chemical Communications 2012, 48, 7940−7942. (Impact factor: 6.567; 9 citations)
- Z. Dong, Z. Ye*, “Synthesis of hyperbranched poly(phenylacetylene)s containing pendant alkyne groups by one-pot Pd-catalyzed copolymerization of phenylacetylene with diynes”, Macromolecules 2012, 45, 5020−5031. (Impact factor: 5.554; 8 citations) [This paper is one (19th) of top 20 most read articles in the Journal in June 2012; it is also highlighted in ACS Noteworthy Chemistry on August 6, 2012.]
- Z. Dong, Z. Ye*, “Hyperbranched polyethylenes by chain walking polymerization: synthesis, properties, functionalization, and applications”, Polymer Chemistry 2012, 3, 286−301. (Impact factor: 5.687; 17 citations)

HQP Supervision (2012-2017):

- Zhe Chen (MASc, Laurentian University) [Research Associate, Nov. 2015–Dec. 2016]
- Junbin Liao (PhD in Chemical Engineeirng, Zhejiang University of Technology) [PDF, August 2015−June 2017]
- Mark Grundy (MASc in Chemical Engineering, Laurentian University) [Research Associate, Jan. 2015−Jan. 2016]
- Patakamuri Govindaiah (PhD in Chemical Engineering, Yonsei University, South Korea) [PDF, June 2013−Dec. 2014]
- Vimal Tiwari (PhD in Polymer Physics, Banaras Hindu University, Inda) [PDF, May 2013−Dec. 2014]
- Zhichao Zhang (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, Oct. 2011−Sept. 2012]
- Zhongmin Dong (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, March 2011−Dec. 2014]
- Lixin Xu (PhD in Polymer Science and Engineering, Zhejiang University, China) [MRI PDF, September 2010−April 2012]

- Syed Atif Haider Zaidi [MEng, Jan. 2017−]
- Hui Su [MASc, Sept. 2014−Oct. 2016]
- Lingqi Huang [PhD, Sept. 2014−]
- Zhe Chen [MASc, Sept. 2013−Oct. 2015]
- Mark Grundy [MASc, May 2012−Oct. 2014]
- Peng Xiang [PhD, May 2011−Aug. 2015]
- Eric Landry [MASc, Sept. 2010−Oct. 2012]
- Pingwei Liu [PhD, 2009−2014]

Participation in thesis juries (2012-2017):

Xiaolei Wang, Assistant Professor

Education:

- PhD in Chemical and Biomolecular Engineering; University of California, Los Angeles (UCLA), USA, 2013
- MS in Chemical Engineering; Tianjin University, P.R. China, 2007
- B.S. in Chemical Engineering (Polymer Chemical Engineering); Dalian University of Technology, P.R. China, 2004

Positions/Accomplishments/Experience:

- Nov. 2013-present: Postdoctoral Fellow Researcher (advisor: Prof. Zhongwei Chen); Department of Chemical Engineering, University of Waterloo

Publications: Peer-reviewed journal articles (2012-2017):

- Xiaolei Wang, Ge Li, Min Ho Seo, Gregory Lui, Fathy Hassan, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Carbon-Coated Silicon Nanowires on Carbon Fabric as Self-Supported Electrodes for Flexible Lithium-Ion Batteries. ACS Applied Materials and Interfaces, accepted, 2016. DOI: adfm.10.1021/acsami.6b12080
- Matthew Li, Yining Zhang, Xiaolei Wang, Wook Ahn, Gaopeng Jiang, Gregory Lui, Zhongwei Chen*, Gas Pickering Emulsion Templated Hollow Carbon for High Rate Performance Lithium Sulfur Batteries. Advanced Functional Materials, 2016, 26(46), 8408-8417.
- Xiaolei Wang, Ge Li, Jingde Li, Yining Zhang, Wook Ahn, Aiping Yu, Zhongwei Chen*, Structural and Chemical Synergistic Encapsulation of Polysulfides Enables Ultralong-Life Lithium-Sulfur Batteries. Energy and Environmental Science, 2016, 9, 2533-2538. (Highlighted in inside back cover)
- Xiaolei Wang§, Ge Li§, Yining Zhang, Zhongwei Chen*, Pomegranate-Inspired Rational Design of Highly Active and Durable Bifunctional Electrocatalysts for Rechargeable Metal-Air Batteries. Angewandte Chemie International Edition, 2016, 55(16), 4977-4982. (VIP paper) (co-first author)

- Xiaolei Wang§, Xingye Fan§, Ge Li, Aiping Yu, Zhongwei Chen*, High-Performance Flexible Electrodes Based on Electrodeposited Polypyrrole/MnO2 on Carbon Cloth for Low-Cost Supercapacitors. Journal of Power Sources, 2016, 326, 357-364. (co-first author)
- Gregory Lui, Ge Li, Xiaolei Wang, Aiping Yu, Zhongwei Chen*, Flexible, 3D Ordered Macroporous TiO2 Electrode with Enhanced Electrode-Electrolyte Interaction in High-Power Li-Ion Batteries. Nano Energy, 2016, 24, 72-77.
- Xiaolei Wang, Ge Li, Min Ho Seo, Fathy M. Hassan, Md Ariful Hoque, Zhongwei Chen*, Sulfur Atoms Bridging Few-layered MoS2 with S-doped Graphene Enables Highly Robust Anode for Lithium-ion Batteries. Advanced Energy Materials, 2015, 5(23), 1501106.
- Xiaolei Wang, Ge Li, Fathy M. Hassan, Jingde Li, Xingye Fan, Rasim Batmaz, Xingcheng Xiao, Zhongwei Chen*, Sulfur Covalently Bonded Graphene with Large Capacity and High Rate for High- Performance Sodium-ion Batteries Anodes. Nano Energy, 2015, 15, 746-754.
- Xiaolei Wang, Xingye Fan, Ge Li, Matthew Li, Xingcheng Xiao, Aiping Yu*, Zhongwei Chen*, Composites of MnO2 Nanocrystals/Partially Graphitized Hierarchically Porous Carbon Spheres with Enhanced Rate Capability for High-performance Supercapacitors. Carbon, 2015, 93, 258-265.
- Xiaolei Wang, Ge Li, Fathy M Hassan, Matthew Li, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Building Sponge-like Robust Architecture of CNT-Graphene-Si Composites with Enhanced Rate and Cycling Performance for Lithium-Ion Batteries. Journal of Materials Chemistry A, 2015, 3, 3962-3967.
- Xiaolei Wang, Ge Li, Fathy M. Hassan, Rasim Batmaz, Xingcheng Xiao, Aiping Yu*, Fast Lithium-ion Storage of Nb2O5 Nanocrystals in-situ Grown on Carbon Nanotube for High-performance Asymmetric Supercapacitors. RSC Advances, 2015, 5, 41179-41185.
- Ge Li, Xiaolei Wang, Fathy M. Hassan, Matthew Li, Rasim Batmaz, Xingcheng Xiao, Aiping Yu*, Vanadium Pentoxide Nanorods Anchored to and Wrapped with Graphene Nanosheets for High-Performance Asymmetric Supercapacitors. ChemElectroChem, 2015, 2(9), 1264-1269.
- Fathy M. Hassan, Rasim Batmaz, Jingde Li, Xiaolei Wang, Aiping Yu, Xingcheng Xiao*, Zhongwei Chen*, Covalent Synergy of Silicon-Sulfur-Graphene as Peculiar Material Design for Cutting-edge Lithium-ion Battery. Nature Communications, 2015, 6, 8597.
- Wook Ahn, Min Ho Seo, Yun-Seok Jun, Dong Un Lee, Xiaolei Wang, Aiping Yu, Zhongwei Chen*, Sulfur Nanofilm Coated Three-Dimensional Graphene Sponge based High Power Lithium Sulfur Battery. ACS Applied Materials & Interfaces, 2016, 8(3), 1984-1991.
- Dong Un Lee, Moon Gyu Park, Hey Woong Park, Min Ho Seo, Xiaolei Wang, Zhongwei Chen, Highly Active and Durable Nanocrystals-Decorated Bifunctional Electrocatalyst for Rechargeable Zinc-Air Batteries. ChemSusChem, 2015, 8(18), 3129-3138.
- Kun Feng, Wook Ahn, Gregory Lui, Hey Woong, Ali Ghorbani Kashkooli, Gaopeng Jiang, Xiaolei Wang, Zhongwei Chen*, Implementing an in-situ carbon network in Si/reduced graphene oxide for high performance lithium-ion battery anodes. Nano Energy, 2015, 19, 187-197.
- Chao Lei, Zheng Chen, Hiesang Sohn, Xiaolei Wang, Ding Weng, Meiqing Shen*, Yunfeng Lu*, Better Lithium-Ion Storage Materials Made through Hierarchical Assemblies of Active Nanorods and Nanocrystals. Journal of Materials Chemistry A, 2014, 2, 17536-17544.
- Kun Feng, Hey Woong Park, Xiaolei Wang, Dong Un Lee, Zhongwei Chen*, High Performance Porous Anode Based on Template-Free Synthesis of Co3O4 Nanowires for Lithium-Ion Batteries. Electrochimica Acta, 2014, 109, 145-151.

- Ge Li, Xiaolei Wang*, Xueming Ma, Nb2O5-Carbon Core-Shell Nanocomposite as Anode Material for Lithium Ion Battery. Journal of Energy Chemistry, 2013, 22(3), 357-362.
- Ge Li, Xiaolei Wang*, Xueming Ma*, Tetragonal VNb9O24.9-based Nanorods: A Novel Form of Lithium Battery Anode with Superior Cyclability. Journal of Materials Chemistry A, 2013, 1, 12409-12412.
- Ge Li, Xiaolei Wang, Zheng Chen, Xueming Ma*, Yunfeng Lu*, Characterization of Niobium and Vanadium Oxide Nanocomposites with Improved Rate Performance and Cycling Stability. Electrochimica Acta, 2013, 102, 351-357.
- Zheng Chen, Yin Yuan, Huihui Zhou, Xiaolei Wang, Zhihua Gan, Fosong Wang*, Yunfeng Lu*, 3D Nanocomposite Architectures from Carbon-Nanotube-Threaded Nanocrystals for High-Performance Electrochemical Energy Storage. Advanced Materials, 2013 36(2), 339-345.
- Xilai Jia, Zheng Chen, Xia Cui, Yiting Peng, Xiaolei Wang, Fei Wei*, Yunfeng Lu*, Building Robust Architectures of Carbon and Metal Oxide Nanocrystals towards High-Performance Anodes for Lithium Ion Batteries. ACS Nano, 2012, 6(11), 9911-9919.
- Zheng Chen, Dieqing Zhang, Xiaolei Wang, Xilai Jia, Fei Wei, Hexing Li, Yunfeng Lu*, High-Performance Energy Storage Architectures from Carbon Nanotubes and Nanocrystal Building Blocks. Advanced Materials, 2012, 24(15), 2030-2036.
- Zheng Chen, Ding Weng, Xiaolei Wang, Yanhua Cheng, Ge Wang, Yunfeng Lu*, Ready fabrication of thin-film electrodes from building nanocrystals for micro-supercapacitors. Chemical Communications, 2012, 48, 3736-3738.
- Xilai Jia, Zheng Chen, Arnold Suwarnasarn, Xiaolei Wang, Hiesang Sohn, Qiang Zhang, Fei Wei, Yunfeng Lu*, High-performance flexible lithium-ion electrodes based on robust network architecture. Energy and Environmental Science, 2012, 5, 6845-6849.

HQP Mentoring (2012-2017):

- 2016-2018: Yuanli Ding, Postdoctoral Fellow, Chemical Engineering. Advanced Battery Technology beyond Lithium-Ion
- 2016-2017: Wen Lei, exchange PhD student, Chemical Engineering. Novel Phosphorous-based Materials for LIBs and SIBs
- 2016-2018: Steven Sherman, PhD candidate, Chemical Engineering. Scalable Production of Cathode Materials through Spray Drying Process for LIBs
- 2016-2018: Dan Luo, PhD candidate, Chemical Engineering. Cable-Like LIBs and Novel Alkaline Batteries and Supercapacitors
- 2016-2018: Justin Raimbault, MASc candidate, Chemical Engineering. Rational Design of Flexible Cathodes for LIBs
- 2014-2015: Xinlong Ma, PhD candidate, Chemical Engineering. Design of Onion-Like Materials Architecture for LIBs and Supercapacitors
- 2014-2015: Xingye Fan, M.A.Sc candidate, Chemical Engineering. Design and Fabrication of Flexible Electrodes for High-Performance Supercapacitors
- 2009-2010: Xing Zhong, M.A.Sc student, Chemical Engineering. Synthesis of 1D CuInS2 Nanowires and Nanorods for Solar Cell Applications

Appendix 6 Letters of support and list of persons consulted when developing the proposal

This proposal was developed in consultation with the Department of Chemical and Materials Engineering Steering Committee. The members of the Steering Committee are:

- Dr. Amir Aghdam (Electrical and Computer Engineering, Associate Dean SGS)
- Dr. Amir Asif (Electrical and Computer Engineering, Dean ENCS)
- Dr. Christine DeWolf (Chemistry, Arts and Science)
- Dr. Nabil Esmail (Mechanical and Industrial Engineering)
- Dr. Fariborz Haghighat (Building, Civil, and Environmental Engineering)
- Dr. Van Suong Hoa (Mechanical and Industrial Engineering)
- Dr. Paul Joyce (Chemistry, Associate Dean Arts and Science)
- Dr. Muthukumaran Packirisamy (Mechanical and Industrial Engineering)
- Dr. Rolf Wuthrich (Mechanical and Industrial Engineering)

Other persons who have provided advice or who have contributed to this proposal are:

- Frédérica Martin, Manager, Academic Programs and Development, SGS
- Joshua Chalifour, Digital Services & Engineering Librarian

A letter of support from Dr. Amir Asif, Dean of the Faculty of Engineering and Computer Science, and Dr. Graham Carr, Provost, is included on the next page.

Concordia University
FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

October 24, 2017

School of Graduate Studies Graduate Curriculum Committee
School of Graduate Studies
GM 930.01

Dear Colleagues,

We write in support of the proposal for establishing graduate programs (Certificate, Diploma, MASc, and PhD) in Chemical Engineering in the recently created Department of Chemical and Materials Engineering.

The proposal is well aligned with the Faculty's strategic planning, touching on many of our strategic directions, especially our commitment to two important ENCS strategic imperatives, namely Enhancing Research Quality and Reputation, and Enhancing Through Innovation in Academic Programs. The proposal being brought forward also demonstrates our commitment to a third Faculty strategic imperative, Embracing Integration across Engineering, Arts, Science, and Business – Dr. De Visscher and his team have worked closely with colleagues in the Faculty of Arts and Science, in particular Dr. Christine De Wolf (Department of Chemistry and Biochemistry) and Dr. Paul Joyce (Associate Dean, Faculty of Arts and Science). Being interdisciplinary and involving faculty members working in physical sciences and engineering, the proposed programs are sufficiently different from existing graduate programs in chemical engineering offered elsewhere in Quebec. In addition, the proposed programs are modular in structure and offer flexibility to the students, allowing for several exit and entry points.

The institutional commitment to the programs is firm at both the Faculty and the University level. Since its establishment in May 01, 2017, three tenure-track/tenured faculty members have been hired in the Department of Chemical and Materials Engineering with one open position advertised in the 2017/18 hiring cycle. The University is committed to hiring two new faculty members in the Department in the 2018/19 hiring cycle and up to two faculty in 2019/20. Renovations for creating research and wet lab space have started in the Hall building. More space would be made available in the extension to the Science and Engineering Pavilion at the Loyola campus.

Interim Chair De Visscher and his team have shown true leadership and vision in proposing these innovative graduate programs, and we are pleased to offer our full support.

Sincerely,

Amir Asif, PhD, PEng
Dean, Engineering and Computer Science

Graham Carr, PhD
Provost and Vice-President, Academic Affairs

1455 De Maisonneuve Blvd. W., EV 2.139, Montreal, Quebec, Canada H3G 1M8
Tel. 514-848-2424 ext. 3109 Fax 514-848-4509 encs.concordia.ca

Appendix 7   Elective Courses Referred to by Subject Areas

Note: Students in the Certificate program in Chemical Engineering will not normally take courses from List 2 or List 3, which are meant for the other programs. However, Certificate students may take an elective course outside the elective course list with permission of the Graduate Program Director. Hence, for the sake of completeness, the course lists of the Subject Areas relevant for the program is included here.

List 2

E03 - SYSTEMS AND CONTROL

- ELEC 6041 Large-scale Control Systems
- ELEC 6061 Real-time Computer Control Systems
- ELEC 6091 Discrete Event Systems
- ENGR 6071 Switched and Hybrid Control Systems
- ENGR 6131 Linear Systems (*)
- ENGR 6141 Nonlinear Systems
- ENGR 7121 Analysis and Design of Linear Multivariable Systems
- ENGR 7131 Adaptive Control
- ENGR 7181 Digital Control of Dynamic Systems
- MECH 6681 Dynamics and Control of Nonholonomic Systems

E04 - FLUID MECHANICS

- ENGR 6201 Fluid Mechanics
- ENGR 6221 Microfluidic Systems
- ENGR 6241 Hydrodynamics
- ENGR 6251 The Finite Difference Method in Computational Fluid Dynamics
- ENGR 6261 The Finite Element Method in Computational Fluid Dynamics
- ENGR 6281 Modelling Turbulent Flows
- ENGR 6291 Rheology

E07 - ENERGY CONVERSION

- BLDG 6951 Solar Building Modelling and Design
- ENGR 6601 Principles of Solar Engineering
- ENGR 6611 Equipment Design for Solar Energy Conversion
- ENGR 6661 Solar Energy Materials Science
- ENGR 6811 Energy Resources: Conventional and Renewable

E37 - ENVIRONMENTAL ENGINEERING

- CIVI 6601 Modelling in Building and Environmental Engineering
- CIVI 6611 Environmental Engineering
- CIVI 6621 Engineering Aspects of Biological Treatment for Air and Water
- CIVI 6641 Unit Operations in Environmental Engineering
- CIVI 6651 Water Pollution and Control
- CIVI 6681 Environmental Nanotechnology
- CIVI 6691 Greenhouse Gases and Control
- CIVI 6901 Selected Topics in Civil Engineering I

E52 - THERMODYNAMICS AND HEAT TRANSFER

- MECH 6101 Kinetic Theory of Gases
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 6181 Heating, Air Conditioning and Ventilation (*)
- MECH 6191 Combustion
- MECH 7101 Convection Heat Transfer

E57 - COMPOSITE MATERIALS

- MECH 6501 Advanced Materials
- MECH 6521 Manufacturing of Composites
- MECH 6581 Mechanical Behaviour of Polymer Composite Materials
- MECH 6601 Testing and Evaluation of Polymer Composite Materials and Structures
- MECH 6651 Structural Composites
- MECH 7501 Design Using Composite Materials

<u>List 3</u>

E08 - ACADEMIC COMMUNICATION SKILLS

- ENCS 5721 Composition and Argumentation for Engineers
- ENCS 6721 Technical Writing and Research Methods for Scientists and Engineers

E09 - PROFESSIONAL LEADERSHIP SKILLS

- ENCS 6041 Creativity, Innovation, and Critical Thinking
- ENCS 6042 Communication Techniques for the Innovation Process
- ENCS 6821 Development and Global Engineering

UNIVERSITÉ Concordia UNIVERSITY

SCHOOL OF GRADUATE STUDIES

US-2018-1-D8

To: Sandra Gabriele, Vice-Provost, Innovation in Teaching and Learning

cc: Olivia Ward, University Curriculum Administrator
Brad Nelson, Associate Dean, School of Graduate Studies

From: Joanne Beaudoin, Secretary, Council of the School of Graduate Studies

Date: November 14, 2017

Re: Graduate Curriculum Changes – CSGS November 13, 2017

This is to confirm that at the Council of the School of Graduate Studies meeting of Monday, November 13, 2017 the following *curriculum changes* were approved:

Faculty of Engineering and Computer Science

- Department of Chemical & Materials Engineering New Program: *Certificate in Chemical Engineering (MECH-101)* — CSGS 1718 2 D4
- Department of Chemical & Materials Engineering New Program: *Diploma in Chemical Engineering (MECH-102)* — CSGS 1718 2 D6
- Department of Chemical & Materials Engineering New Program: *MASc in Chemical Engineering (MECH-103)* — CSGS 1718 2 D8
- Department of Chemical & Materials Engineering New Program: *PhD in Chemical Engineering (MECH-104)* — CSGS 1718 2 D10

The documents can be forwarded to Senate for final approval.

Thank you.

Concordia University
School of Graduate Studies

MEMO TO: Paula Wood-Adams, Dean of Graduate Studies

FROM: Brad Nelson, Associate Dean, Academic Programs and Development
School of Graduate Studies

DATE: October 30, 2017

SUBJECT: **GRADUATE CURRICULUM CHANGES (MECH-102)**
(CALENDAR – 2018/2019)
DEPARTEMENT OF CHEMICAL AND MATERIALS ENGINEERING
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

The Graduate Curriculum Committee (GCC) reviewed the curriculum changes approved by the Faculty of Engineering and Computer Science.

The new Department of Chemical and Materials Engineering wishes to introduce a new Graduate Diploma in Chemical Engineering.

At the September 18th meeting of the GCC, the committee requested the following revisions: include a detailed rationale and resource implications in the Provotrack forms, update the budget table and admission requirements and lastly some editorial changes. The revised dossier was presented again on October 23rd where further minor edits were noted.

The GCC approved this document with the above inclusions. I therefore recommend that the Council of the School of Graduate Studies approve and recommend to Senate the above-mentioned curriculum changes in their final form.

cc: M. Debbabi, Associate Dean, Graduate Programs and Research, Faculty of Engineering and Computer Science
O. Ward, University Curriculum Administrator, Office of the Provost and Vice-President, Academic Affairs

Concordia University
Engineering and Computer Science
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Bradley Nelson
Chair, Graduate Curriculum Committee
School of Graduate Studies

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

CC: Ms. Frederica Martin
Academic Programs Analyst
School of Graduate Studies

DATE: June 12, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Faculty of Engineering and Computer Science

At its meetings on May 12th, 2017, the Council of the Faculty of Engineering and Computer Science reviewed and approved, with minor modifications, the creation of the new Graduate Diploma in Chemical Engineering program from the new Department of Chemical and Materials Engineering (CME).

Details of the new program proposal are indicated and explained in the Department's and Engineering and Computer Science Graduate Studies Committee's (ECSGSC) internal memorandums and Provotrack dossier MECH-102.

We kindly request that this dossier be placed on the next agenda of the Graduate Curriculum Committee.

Thank you for your consideration of this proposal.

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Amir Asif
Chair of the Faculty Council
Faculty of Engineering and Computer Science

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

DATE: May 8, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Department of Chemical and Materials Engineering (CME)

At its meeting on May 3, 2017, the Engineering and Computer Science Graduate Studies Committee (ECSGSC) reviewed and approved, with minor modifications, the creation of a Diploma program, which is one of the four new programs, in Chemical Engineering from the new Department of Chemical and Materials Engineering (CME).

The Diploma program will be mainly attractive to Concordia students with a Bachelor's degree in Mechanical Engineering or Chemistry, who wish to deepen their knowledge and acquire the chemical engineering skills needed for industry or the pursuit of more advanced studies at the master's level.

Details of this proposal are indicated and explained in the Department's internal memorandum and Provotrack dossier MECH-102.

We kindly request that this item be placed on the next agenda of the Faculty Council for approval.

Thank you for your consideration of this proposal.

INTERNAL MEMORANDUM

April 19, 2017
Revised October 30, 2017
December 4, 2017

To: Dr. M. Debbabi
Associate Dean Research and Graduate Studies, ENCS

From: Dr. Alex De Visscher

Re.: Proposal for a new Graduate Diploma Program in Chemical Engineering

Dear Dr. Debbabi,

Please find attached a proposal for a new Graduate Diploma program in Chemical Engineering. This program will be offered by the new Department of Chemical and Materials Engineering, to be established this spring. The proposal is one of five proposals for graduate programs in Chemical Engineering currently in development. Four of these (Certificate, Diploma, MASc and PhD) are currently submitted for approval. The fifth (MEng) will be timed to start approximately one year after the MASc and PhD programs.

The Diploma program consists of eight courses (minimum 30 credits), five of which are core courses. The target audience for this program is students who wish to deepen their knowledge in Chemical Engineering at the graduate level, but who do not wish to commit to taking a full Master's degree program. These could be students holding a Bachelor's degree in Chemical Engineering from other universities, or students holding a Bachelor's degree in Mechanical Engineering but whose first choice would have been Chemical Engineering if such a program had been available to them.

What will make the program more attractive is the fact that it will be part of Certificate – Diploma – MEng and Certificate – Diploma – MASc sequences that will allow students to work their way towards a Master's degree four courses at a time, while they are employed full-time. In particular, students who have completed a 15 or 16-credit Certificate program will be able to use these credits towards a Diploma program, and towards a MEng degree. Likewise, students who have completed a 30-credit Diploma program will be able to use these credits towards a MEng degree. With approval of the supervisor, students will be able to use up to 16 credits from Certificate and Diploma programs towards an MASc degree. It is expected that this will make the program more popular than existing Diplomas, which are meant as terminal programs. The School of Graduate Studies recently made regulatory

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

changes to make this possible.

The courses offered in the Diploma program will also be offered in other programs, such as the MEng and MASc programs, currently in development. Hence, the current program will only require a minimum of resources once the Master programs are in place. In the mean time, offering the Diploma will ensure continuity of course offerings when faculty members recruit graduate students, possibly through the MECH or INDI program, while the Master and PhD programs are still pending.

The budget of a Diploma program is somewhat arbitrary because resources must be prorated based on the number of students in the program, but assuming that half of a full-time faculty member corresponds with an enrollment of 15 students, the program will run a slight profit. This number reflects the profitability of course-based graduate programs in general rather than the Diploma program in particular. The proposal contains a high-level steady-state budget. A more detailed budget will be provided shortly in a separate document. Also pending are a library study and the results of a survey among senior undergraduate students, which are currently in progress. The reports will be provided as soon as they are available. The curriculum documents in Provotrack are also in development and will be provided as soon as possible.

An overview of course requirements per program is attached to this memo.

It is the intention of the new department to start offering the Diploma program in September 2018.

The attached proposal has been vetted by the Steering Committee of the Department of Chemical and Materials Engineering. I would greatly appreciate it if you could put this proposal on the agenda of the next Graduate Studies committee.

Best regards,

Alex De Visscher

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

Table 1 Status of courses per program

Code	Course Title	Certif	Dipl	MEng	MASc	PhD
CHME 6011	Advanced Transport Phenomena	core, required	core, required	core, required	core, list	core, list
CHME 6021	Advanced Chemical Engineering Thermodynamics	core, list	core, required	core, required	core, list	core, list
CHME 6031	Chemical Kinetics and Reaction Engineering	core, list	core, required	core, required	core, list	core, list
CHME 6041	Chemical Engineering Process Dynamics and Control	elective	core, required	core, required	core, list	core, list
CHME 6051	Chemical Process Engineering and Design	elective	elective	core, required	core, list	core, list
CHME 6061	Advanced Biochemical Engineering	elective	elective	elective	elective	elective
CHME 6071	Materials Science and Engineering	elective	elective	core, list	core, list	core, list
CHME 6081	Advanced Separation Processes	elective	elective	elective	elective	elective
CHME 6091	Statistics for Chemical Engineering	elective	elective	elective	elective	elective
CHME 6101	Advanced Battery Materials and Technologies	elective	elective	elective	elective	elective
CHME 6111	Polymer Chemistry and Engineering	elective	elective	elective	elective	elective
CHME 6121	Nanomaterials Chemistry and Engineering	elective	elective	core, list	core, list	core, list
CHME 6131	Advanced Colloid and Interface Science and Engineering	elective	elective	elective	elective	elective
-	Capstone Project	-	-	core, required	-	-
CHME 6911	Topics in Chemical Engineering I	elective	elective	elective	elective	elective
CHME 7911	Topics in Chemical Engineering II	-	elective	elective	elective	elective
ENCS 6021	Engineering Analysis	core, required	core, required	core, required	core, list	core, list
	Other List 1 options	elective	elective	elective	elective	elective
	Other List 2 options	-	elective	elective	elective	elective
	Other List 3 options	-	elective	elective	elective	elective

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Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

Table 2 Number of courses per category, per program

Type of Course	Cert	Dipl	MEng	MASc	PhD
Core	3	5	8	2+	1+
List 1	1	1	1+	2-	2-
List 2		1	1+	2-	2-
List 3		1	1+	2-	2-
Total	**4**	**8**	**12**	**4**	**3**

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PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

PROGRAM CHANGE: Graduate Diploma in Chemical Engineering

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Graduate Diploma
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [ ] Requirements [ ] Regulations [ ] Program Deletion [X] New Program

Present Text (from 20xx/20xx) calendar	Proposed Text
	Graduate Diploma in Chemical Engineering **Admission Requirements** To be considered for admission to graduate diploma-level studies, applicants must hold a bachelor's/baccalaureate degree (or equivalent) in engineering or the sciences with the Concordia equivalent of a GPA of at least 2.70 on a scale of 4.30. The Department Graduate Studies Committee will determine the acceptability of an applicant for admission to the program and may require the applicant to do specific remedial coursework, including the bridge course CHME 401 Principles of Chemical Engineering, and/or other course(s) to meet the program requirements. Credible academic reference letters and a statement of purpose should be included in the application. **Requirements for Completion** Students transferring from a Master's to the Diploma in a similar area of study are granted a time limit of 2 years, less the number of years in the Master's, or 1 year, whichever is greater; or the equivalent for part-time study. 1. **Credits.** Fully qualified students are required to complete at least 30 credits. 2. **Courses.** Candidates in the Diploma program must take 20 credits of core courses and the balance may be chosen from the elective lists: one course in a core area, one in a technical area outside chemical engineering, and one complementary course. Students who hold a Certificate in Chemical Engineering must complete at least 15 credits in this program to qualify with a Diploma in Chemical Engineering. According to the University regulations on transfer of credits, students who have completed a Certificate in a different discipline may have credits transferred into a Diploma. Please refer to the Transfer Credits section of the Graduate Calendar for further information.

3. **Academic Standing.** Please refer to the Academic Standing section of the Calendar for a detailed review of the Academic Regulations.
   Program Specific Requirements. An Assessment Grade Point Average (AGPA) of at least 2.75, based on a minimum of 8 credits is required.
4. **Time limit.** Please refer to the Academic Regulation page for further details regarding the Time Limit requirements.
5. **Graduation.** To be eligible to graduate, students must have obtained a CGPA of at least 2.75.

Core and elective courses

Core: 20 credits

- CHME 6011 Advanced Transport Phenomena
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control
- ENCS 6021 Engineering Analysis

Elective 1: 3 or 4 credits from List 1 or any core MEng or MASc course in Chemical Engineering not included in the Diploma core course list
Elective 2: 3 or 4 credits from List 2
Elective 3: 3 or 4 credits from List 3
Students may take an elective course outside the elective list with permission of the Graduate Program Director.

Elective Course Lists
List 1:

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2:

- CHME 7911 Topics in Chemical Engineering II
- ENGR 6601 Principles of Solar Engineering
- MECH 6571 Corrosion and Oxidation of Metals

	• Any courses listed in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering or in List 1 List 3: • Any course(s) listed in Topic Areas E08 and E09.

Rationale:
The introduction of the Diploma program is part of the new Chemical and Materials Engineering Department's mandate. The development of the Department and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering.

The purpose of the proposed program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future.

According to Engineers Canada (Canadian Engineers for Tomorrow, 2012; 2015), the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292).

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

It is anticipated that the course offerings will start one year ahead of the degree programs. The starting year in the timeline below is labeled Year 0 for that reason, and starts in Fall 2017. The Certificate program is planned to start in Fall 2018.

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

Resource Implications:
The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

PROGRAM CHANGE: Topic Area E58

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [X] Requirements [ ] Regulations [ ] Program Deletion [ ] New Program

Present Text (from 20xx/20xx) calendar	Proposed Text
	Engineering Courses ------ **List of Courses by Topic Areas** ------ **E58 - CHEMICAL PROCESS ENGINEERING** **CHME 6011 Advanced Transport Phenomena** (4 credits) **CHME 6021 Advanced Chemical Engineering Thermodynamics** (4 credits) **CHME 6031 Chemical Kinetics and Reaction Engineering** (4 credits) **CHME 6041 Chemical Engineering Process Dynamics and Control** (4 credits) **CHME 6051 Chemical Process Engineering and Design** (4 credits) **CHME 6061 Advanced Biochemical Engineering** (4 credits) **CHME 6071 Materials Science and Engineering** (4 credits) **CHME 6081 Advanced Separation Processes** (4 credits) **CHME 6091 Statistics for Chemical Engineering** (4 credits) **CHME 6101 Advanced Battery Materials and Technologies** (4 credits) **CHME 6111 Polymer Chemistry and Engineering** (4 credits) **CHME 6121 Nanomaterials Science and Engineering** (4 credits) **CHME 6131 Advanced Colloid and Interface Science and Engineering** (4 credits) **CHME 6911 Topics in Chemical Engineering I** (4 credits) **CHME 7911 Topics in Chemical Engineering II** (4 credits)

Rationale:
The changes reflect the addition of a new topic area and new courses of the proposed new program.

Resource Implications:

The courses can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6011 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6011 Advanced Transport Phenomena (4 credits) Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6021 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6021 Advanced Chemical Engineering Thermodynamics (4 credits) Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6031 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6031 Chemical Kinetics and Reaction Engineering (4 credits) Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6041 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School:	Engineering and Computer Science
Department:	Chemical and Materials Engineering
Program:	Chemical Engineering
Degree:	Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number:	Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6041 Chemical Engineering Process Dynamics and Control (4 credits) Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program. While it is not listed by name in any of the elective course lists, it is listed as a core courses in the MASc and PhD programs, which means it is included in List 1 of the Diploma Program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6051 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6051 Chemical Process Engineering and Design (4 credits) Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program. While it is not listed by name in any of the elective course lists, it is listed as a core courses in the MASc and PhD programs, which means it is included in List 1 of the Diploma Program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6061 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6061 Advanced Biochemical Engineering (4 credits) Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6071 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6071 Materials Science and Engineering (4 credits) Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program. While it is not listed by name in any of the elective course lists, it is listed as a core courses in the MASc and PhD programs, which means it is included in List 1 of the Diploma Program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6081 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6081 Advanced Separation Processes (4 credits) Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6091 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6091 Statistics for Chemical Engineering (4 credits) Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6101 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6101 Advanced Battery Materials and Technologies (4 credits) Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6111 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6111 Polymer Chemistry and Engineering (4 credits) Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6121 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6121 Nanomaterials Science and Engineering (4 credits) Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program. While it is not listed by name in any of the elective course lists, it is listed as a core courses in the MASc and PhD programs, which means it is included in List 1 of the Diploma Program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 6131 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6131 Advanced Colloid and Interface Science and Engineering (4 credits) Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6911 Topics in Chemical Engineering I (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-102** VERSION: 10

COURSE CHANGE: CHME 7911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 2018/2019
Implementation Month/Year: Fall 2018

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 7911 Topics in Chemical Engineering II (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Theory and "Tools" learning outcomes in the Diploma program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

Proposal

Graduate Diploma in Chemical Engineering

Faculty of Engineering and Computer Science

Concordia University

Executive Summary

On November 2, 2016, the Board of Governors approved the establishment of a Department of Chemical and Materials Engineering (CME) at Concordia University. The new department's mandate is to develop graduate and undergraduate programs for a total of approximately 500 students at steady state.

Implementing the first step of this mandate, a suite of five graduate programs is currently in development. The suite consists of a Graduate Certificate, a Graduate Diploma, a Master of Engineering, a Master of Applied Science, and a Doctor of Philosophy program in Chemical Engineering. The current proposal for a Graduate Diploma in Chemical Engineering is part of this suite. Four programs are submitted simultaneously; two for internal approval (Certificate, Diploma), and two for internal and external approval (MASc, PhD). The fifth (MEng) is in preparation and will be timed to start one year after the MASc and the PhD programs.

The Graduate Diploma program is expected to draw about 15 students at steady state. It will be complementary to existing programs of this nature in Québec. Currently, McGill offers a Diploma program in Mining, which is only peripherally related to the program proposed here. École Polytechnique offers three more narrowly specialized Diploma programs, whereas the program proposed here is more focused on core chemical engineering. However, the program will be embedded in a multidisciplinary department covering the fields of Chemical and Materials Engineering, and this will give the students a unique, multifaceted outlook on the profession of Chemical Engineering. Concordia University already has extensive research strength in materials engineering, particularly with applications in the aerospace industry, for instance with the Concordia Centre for Composites, which includes 15 faculty members from multiple departments. The new department and the associated programs will build on these strengths.

Chemical Engineering programs in North America have experienced robust growth at all levels in the past decade, from undergraduate to doctoral. This strong performance indicates that there will be a market for the proposed program across the continent.

The development of a Department of Chemical and Materials Engineering and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering. Chemical Engineering programs also draw a larger proportion of female students than is average for Engineering. Hence, it is expected that the program will help mitigate the gender imbalance in engineering.

The Graduate Diploma program will contain a minimum of 30 credits, covered by eight courses. Five of these will be core courses, and three are electives: one in a core area, one in a technical area outside chemical engineering, and one complementary course.

The Department of Chemical and Materials Engineering will consist of three regular faculty members, one joint member and two excluded members (Dean of Graduate Studies, VP Research & Grad studies) as of January 2018, and two more faculty recruitments are anticipated every year until the faculty count reaches 15 members. This will ensure that there will be a critical mass for the delivery of the program at the time of its planned start in Winter 2018. The first graduates are anticipated at the end of the Fall of 2018.

Table of Contents

Section 1 PROGRAM IDENTIFICATION

1.1 Program title, degree title and level

Program title: Diploma
Degree: Chemical Engineering
Level: Graduate

1.2 Areas of specialization

Chemical Engineering; Chemical Thermodynamics; Chemical Kinetics; Transport Phenomena; Chemical Reactor Engineering; Materials Engineering; Polymer Engineering; Electrochemical Engineering.

1.3 Administrative location

University: Concordia University
Faculty: Faculty of Engineering and Computer Science
Department: Department of Chemical and Materials Engineering
Address: 1455 de Maisonneuve Blvd. W
Montreal, Québec, H3G 1M8
Canada

SECTION 2 PROGRAM OBJECTIVES

2.1 Theoretical Foundation and General Academic Aims

Chemical Engineering is the application of chemical and engineering principles to the design and operation of industrial units for the manufacture of chemicals. This includes the manufacture of bulk chemicals (e.g., oil refinery products, fertilizers, plastics), fine chemicals (e.g., pharmaceuticals), metals, etc. It also includes the production of chemicals by micro-organisms (e.g., fermentation, brewing), and the conversion of biomaterials into chemicals (e.g., bio-oil, biodiesel). An emerging field of application for chemical engineers is new materials (nanomaterials, composites). Chemical engineers are responsible for the design and operation of safe and environmentally responsible processes.

Chemical engineers are primarily trained to be designers of chemical processes, but they also work in the operation and control of chemical processes, and in the research and development of new chemical processes.

Chemical engineers are closely related to Materials engineers. However, whereas the materials engineer is mainly focused on the *product*, the chemical engineer is mainly focused on the *process*. The proximity of the fields of chemical and materials engineering provides opportunities for cross-fertilization. The intention of the proposed program is to train chemical engineers with a solid grasp of the materials aspects of their profession. The training will be embedded in a research environment that is strong on materials engineering research.

Industrial chemical processes are generally built from unit operations, i.e., operations that carry out a single step of the overall process. Each unit operation is based on physical and chemical principles. This approach is mirrored in chemical engineering (undergraduate) programs. The program starts with mathematics, physics, and chemistry and then moves on to engineering sciences such as general and chemical thermodynamics, material balances, mass and heat transfer, fluid mechanics, and chemical kinetics. This is followed by the study of unit operations: pumps, compressors, filters, reactors, distillation towers, etc. Next, the dynamics and control of chemical processes is covered, and the program is concluded with chemical process design, where all the obtained knowledge is integrated, and augmented with heuristics for the design of entire chemical plants. At the graduate level, students deepen their expertise in these areas with additional courses.

Historically, the chemical engineering profession started as a largely empirical endeavor, where the design of chemical processes was mainly based on experience obtained with previous designs. This largely trial-and-error approach made way for a more rigorous, science-based approach in the mid-20th century. This relatively late development is largely owing to the fact that many chemical processes are highly nonlinear, and do not lend themselves well to linear engineering analysis. Hence, a scientific approach to chemical engineering is largely based on computer simulations, and this numerical approach has developed in lockstep with the development of ever faster and more powerful computers since the mid-20th century. Nevertheless, even the most powerful computer systems cannot resolve all aspects of every chemical process, and empiricism (rules of thumb) remains an important aspect of chemical engineering practice. It is the intention of the proposed program to provide contemporary tools of chemical process simulation to the students, without losing sight of the empirical, experience-based aspects of chemical engineering.

The purpose of the proposed Diploma program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future. The program will be embedded in a multidisciplinary Department of Chemical and Materials Engineering, giving the students a unique, multifaceted outlook on their profession. They will be exposed to problems of Materials Engineering though projects and examples, as instructors infuse their research into the graduate courses. The result will be an engineer who is not only capable of designing an industrial chemical process, but who will also have an appreciation of the materials produced in these processes.

The program is part of a suite of programs currently in development that will also include a Graduate Certificate, a Master of Engineering, a Master of Applied Science and a Doctor of Philosophy program. The Master of Engineering program will be timed to start one year after the Master of Applied Science and Doctor of Philosophy programs. In the long term, the intention is to develop a similar suite of programs in Materials Engineering. The department is establishing the core competences for a Chemical Engineering graduate education at this time, and will build on that core to develop the Materials Engineering programs at a later time.

2.2 Specific knowledge, expertise, skills (learning outcomes) which students will acquire

By the end of this program, successful students will be able to do the following:

- **Theory:** Apply chemical engineering concepts to solve industrially relevant research problems in the areas of mass and heat transfer, fluid mechanics, chemical equilibrium kinetics, and process dynamics.
- **Tools:** Use and develop chemical engineering tools that are relevant in an industrial setting.
- **Broadening:** Apply engineering concepts in a field of engineering outside chemical engineering.
- **Engineers and Society:** Evaluate their role as engineers in society.

2.3 Description of how the learning outcomes will be assessed

The learning outcomes of the program are assessed in the courses, which form the requirements of the program. This is shown in Table 1:

Table 1. Mapping Program Requirements with Learning Outcomes

	Program requirements				
Learning outcomes		Core courses	Elective courses List 1	Elective courses List 2	Elective courses List 3
	Theory	Major	Minor		
	Tools	Major	Major		
	Broadening		Minor	Major	Minor
	Eng in Society				Major

SECTION 3 RATIONALE FOR PROGRAM PROPOSAL

3.1 Socio-economic or cultural relevance

3.1.1 Detailed needs analysis, including projected student enrolment: Enrolment chart, including graduation and attrition, with justifications and explanations (projected for a five-year period)

According to data from the American Society for Engineering Education (ASEE), the number of students graduating with a Bachelor's degree in Chemical Engineering in the United States has increased from 4452 in 2006 to 9090 in 2015 [Yoder, B.L. *Engineering by the Numbers*. ASEE, 2015], an increase by 104 % in one decade. As a proportion of engineering students graduating with a Bachelor's degree in Chemical Engineering, the Chemical engineering program has gained popularity, from 6.0 % in 2006 to 8.5 % in 2015. In Canada, the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292) during the same time [Engineers Canada, *Canadian Engineers for Tomorrow*, 2012; 2015].

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The number of Master and PhD graduations in Chemical Engineering in the United States has also increased substantially: from 1204 to 1716, or 42 % from 2006 to 2015 for Master students, and from 834 to 1062, or 27 % for PhD students. In Canada, the graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The enrollment projections for the Diploma program, assuming an average duration of 2 years, and an attrition of 10 % per year are given in the table below. The Diploma program is planned to start in Fall 2018.

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

Table 2 Graduate enrollment projections for Diploma students in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5
Diploma	5	12	15	15	15

At steady state, there will be roughly 15 Diploma students in Chemical Engineering, out of a total of 238 students in the various graduate programs in Chemical Engineering.

The table below shows the projected number of graduations per year. An average of two years is anticipated for the Diploma program.

Table 3 Graduation projections for the Diploma program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5
Diploma	0	4	6	6	6

At steady state, there will be about 6 graduations per year in the Diploma program in Chemical Engineering, out of an approximate 100 graduations per year in Chemical Engineering.

3.1.2 Identification of the main prospects for graduates from the program (employment, self-employment, creativity opportunities, career mobility, advanced education)

Chemical Engineers are employed in the chemical industry, in consulting, and in government. Other sectors often require chemical engineers for their specific expertise. Examples are insurance companies, banks, etc.

In the Diploma program, students with a background in chemical engineering will deepen their core competences in a number of areas, which will give them a substantially enhanced capability to solve not just chemical engineering problems they are familiar with, but to approach non-familiar problems from their core knowledge, and find novel ways to solve them. They will also deepen their knowledge in new areas. Students whose background is not chemical engineering but a related area (e.g., chemistry, mechanical engineering) will familiarize themselves with some of the chemical engineering core, possibly after taking bridge courses, and will be able to work with chemical engineers at a high level in the areas where they developed competences, and work on interdisciplinary projects.

Students who complete the Diploma in Chemical Engineering will be able to use their courses for credit (up to 32 credits) towards a MEng program, and, with permission of the supervisor, towards the MASc and PhD programs.

3.1.3 Existence of similar programs in Canada or elsewhere, their academic success; similarities and differences with the proposed program; how will the proposed program help bring the Province of Quebec up to par with the Canadian or International level; or how will the new program help the Province become a leader in this area of specialization

Canada currently offers Chemical Engineering programs at 20 universities. Four of these (McGill University, École Polytechnique, Université Laval and Université de Sherbrooke) are located in the Province of Québec. As a comparison, Ontario offers Chemical Engineering programs at ten universities. Hence, in terms of numbers of universities, Chemical Engineering is currently underrepresented in the Province of Québec.

Only two universities offer graduate diploma programs in areas related to Chemical Engineering. Both, McGill University and École Polytechnique, are located in the Province of Québec. An overview of diploma programs in Chemical Engineering and related fields is given below, within the context of the graduate program offerings at these two universities. The enrollment numbers refer to all graduate students and are for 2014 [Engineers Canada. *Canadian Engineers for Tomorrow*, 2014].

Where the proposed program will be different from the existing programs in the Province of Québec is in the level of integration between the Chemical Engineering graduate programs and Materials Engineering research as a driver for the program. Concordia University has prior experience with this strategy in the

Department of Mechanical, Industrial, and Aerospace Engineering (MIAE), where Materials Engineering is a significant driver of the Mechanical Engineering and Aerospace Engineering programs. Of particular note is the Concordia Centre for Composites (CONCOM), which houses 15 faculty members and a total of 50 members.

Some key members of CONCOM and MIAE who can contribute to the new department are Dr. Suong Van Hoa, director of CONCOM, who conducts research in polymer nanocomposites with applications in the aerospace industry; Dr. Mamoun Medraj, who conducts research in thermodynamic modeling of phase diagrams relevant for composite materials, and Dr. Nabil Esmail, who conducts research in rheology and surface phenomena of fluids. Dr. Paula Wood-Adams, who will transfer to the Department of Chemical and Materials Engineering, is also a member of CONCOM.

In addition, collaborative research is anticipated with faculty members in the Department of Chemistry and Biochemistry. For instance, Dr. John Oh, also a member of CONCOM, conducts research in macromolecular nanoscale biomaterials.

Faculty members in these and other departments who provide significant and lasting contributions to the proposed programs will be appointed as associate members of the Department of Chemical and Materials Engineering. They will augment the research and graduate student supervision of the core members of the Department of Chemical and Materials Engineering. This broad range of expertise will enable the department to provide knowledge from the molecular scale to the scale of the industrial processes to manufacture materials.

McGill Universtiy

Degrees offered:	PhD
	MEng (thesis)
	MEng (non-thesis)
	Graduate Diploma
Programs offered:	Chemical Engineering (PhD, MEng (thesis), MEng (non-thesis))
	Mining and Materials Engineering (PhD, MEng (thesis), MEng (non-thesis))
	Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1

École Polytechnique

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based
	Diplôme d’études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD, M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD, M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD, M.(rech.), M.(prof.))
	Procédés	(PhD, M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD, M.(rech.), M.(prof.))

	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	

As the overview shows, McGill University offers a Diploma program in Mining Engineering, which is only remotely related to the Diploma program proposed here, and not Chemical Engineering. École Polytechnique offers a broad range of "Microprogrammes" (9-15 credits), as well as Diplomas (30 credits). However, these programs are very focused and specialized, covering the areas "Matériaux", "Energie et développement durable", "Procédés et environnement", and "Sciences et technologies de la plasturgie". The Diploma program proposed here is aimed more at chemical process engineering, and are thus complementary to the progams offered by École Polytechnique.

Details of the programs discussed are in Appendix 1.

3.2 Institutional relevance

3.2.1 Status of the discipline at Concordia; how the proposed program fits into the overall set of programs offered by the university (including undergraduate programs); in the same field, related fields, sector of education concerned; enrolment trends and graduates in related programs; impact of enrolments in related fields within the University

The programs most related to the proposed new programs are the Mechanical Engineering program in the Department of Mechanical and Industrial Engineering, and the Environmental Engineering specialization in the Department of Building, Civil, and Environmental Engineering.

Chemical Engineering is the only major engineering discipline that is currently missing in the Engineering program offerings at Concordia University. Hence, the development of Chemical Engineering programs fits in Concordia University's objective to become a more comprehensive university. Nearly all Engineering programs at Concordia University have grown rapidly in recent years. The number of full-time graduate students at Concordia University in all engineering fields combined increased from 1677 in 2012 to 2184 in 2016. Of these, full-time enrollments increased from 355 to 514 in Civil Engineering, and from 295 to 371 in Mechanical Engineering (not including Industrial Engineering). The demand exceeds the enrollments, so it is anticipated that the addition of Chemical Engineering programs will not affect the enrollments in other programs.

3.2.2 Collaboration with other departments within Concordia

The newly created Department of Chemical and Materials Engineering was incubated in the Department of Mechanical and Industrial Engineering, and a substantial amount of collaboration is anticipated with this department.

In addition, several technical electives, such as Fluid Mechanics, and the courses in Elective Lists 2 and 3, will be taught by faculty members outside the Department of Chemical and Materials Engineering.

Outside the Faculty of Engineering and Computer Science, collaborations are anticipated with the Department of Chemistry and Biochemistry, whose Department Chair, Dr. C. DeWolf, has degrees in Chemical Engineering. To foster these collaborations, the new department will be given space in the Loyola campus with the next building project, to be shared with faculty members from the Department of Chemistry and Biochemistry.

The Department of Chemical and Materials Engineering has a steering committee consisting of key faculty members from various departments in the Faculty of Engineering and Computer Science, and the Faculty of Arts and Science. This committee forms the basis for future collaborations between departments. The membership of the steering committee is given in Appendix 6.

3.2.3 How does the proposed program align with the Faculty's and University's academic plans

The development of graduate programs in Chemical Engineering is a direct consequence of the establishment of the Department of Chemical and Materials Engineering, and aligns with the Strategic Plan, *Nine Directions for a Next-Generation University*. In particular, the cross-institutional strategy for Direction 1, Double our Research, specifically mentions building research capacity in Chemical and Materials Science and Engineering. To bring this plan to fruition, the Diploma program can help draw potential graduate students in this area, and to train them adequately for research in the area.

The modular Certificate – Diploma – Master structure aligns well with the Teach for Tomorrow direction in the Strategic Plan. It is a contemporary approach to graduate studies, more in tune with the ideal of lifelong learning than the traditional program structure, as it allows professionals to return to university, and take on graduate studies at their own pace, while they are professionally employed. It is also a way to "streamline and transform" as expressed in Direction 6: Grow Smartly.

The Montreal area has a large demand for Chemical and Materials Engineers, in the chemical and pharmaceutical industry, in oil refining, and in companies supplying the aerospace industry (composites). Hence, the proposal is aligned with Direction 7: Embrace the City, Embrace the World.

Section 4 PROGRAM DESCRIPTION AND REQUIREMENTS

4.1 Admission Requirements

4.1.1 General and specific admission requirements

General requirements

Applicants to Concordia University must meet the minimum university requirements to be considered for admission.

Academic Requirements

To be considered for admission to graduate diploma or graduate certificate-level studies, the applicant must have completed a bachelor's/baccalaureate degree (or equivalent) in engineering or the sciences with the Concordia equivalent of a GPA of at least 2.70 on a scale of 4.30.

Language Proficiency Requirements

The language of instruction at Concordia is English.

A student whose primary language is not English must write a pre-admission proficiency test, if not exempted as indicated below. Test results must be reported directly to the Admissions Application Centre by the test centre. Results more than two years old will not be accepted as proof of language proficiency.

Proof of proficiency in English must be provided by achieving the appropriate score on one of the following:

- Test of English as a Foreign Language (TOEFL): The minimum acceptable score for the internet-based TOEFL (TOEFL iBT) is 85 and no part under 20.
- The minimum required score for the paper-based TOEFL is 563.
- International English Language Testing System (IELTS): The minimum band score for IELTS is 6.5 and no part under 6.5.

In all cases, Concordia reserves the right to require proof of English proficiency when such proof is deemed necessary. Concordia will accept test results for the paper-based TOEFL if they are less than 2 years old.

Applicants whose primary language is not English, regardless of citizenship, may be exempted from the proficiency test if they meet one or more of the following requirements:

- A minimum of three full years of study either at the undergraduate or graduate level in an institution where the sole language of instruction is English;
- Quebec applicants, the completion of a Diploma of Collegial Studies (DEC) and a university degree in Quebec

In addition to the general admission requirements, the Faculty may require applicants to write the Engineering Writing Test (EWT) as a condition of admission to all graduate programs in Engineering and Computer Science. Depending on the result, students may be required to complete remedial English language courses in addition to their program requirements.

The Engineering Writing Test examines students' ability to provide reasoned assessment of a short technical composition in English or French, and their ability to provide a qualitative account of quantitative or graphically presented data. The test is offered a number of times throughout the year. Based on their performance in the test, students may be asked to take remedial courses.

Program-specific admission requirements

- An undergraduate degree in engineering or the sciences;
- Students whose undergraduate degree is not chemical engineering will be assessed on a case-by-case basis, and may be required to take additional courses, including the bridge course CHME 401: Principles of Chemical Engineering, and/or others. The Graduate Program Director determines the additional course loads;
- Credible academic reference letters;
- A Statement of Purpose

4.1.2 Selection procedures

The Department will recommend on the acceptability of an applicant for admission to the program.

4.2 Academic activity

4.2.1 Degree requirements

Credits: Fully qualified students are required to complete a minimum of 30 credits. Students who have completed a Certificate in Chemical Engineering must complete at least 15 credits to complete a Diploma in Chemical Engineering. Students who have completed a Certificate in a different discipline may have courses transferred into a diploma. This will be evaluated on an individual basis.

Time limit: All work for a Diploma program must be completed within 6 terms (2 years) from the time of initial registration in the program for full-time students; for part-time students the time limit is 12 terms (4 years).

Students transferring from a Master's to the Diploma in a similar area of study are granted a time limit of 2 years, less the number of years in the Master's, or 1 year, whichever is greater; or the equivalent for part-time study.

4.2.2 Program schedule; Core and elective courses

All courses are 4 credits each unless indicated otherwise.

Core: 20 credits

- CHME 6011 Advanced Transport Phenomena
- ENCS 6021 Engineering Analysis
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control

Elective 1: 3 or 4 credits from List 1 or any core course from the MEng or MASc program in Chemical Engineering not included in the Diploma core course list

Elective 2: 3 or 4 credits from List 2

Elective 3: 3 or 4 credits from List 3

Students may take an elective course outside the elective list with permission of the Graduate Program Director.

Elective Course Lists

List 1

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2

- CHME 7911 Topics in Chemical Engineering II
- ENGR 6601 Principles of Solar Engineering
- MECH 6571 Corrosion and Oxidation of Metals
- All courses in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering, or in List 1

List 3

- All courses in Topic Areas E08 and E09.

Note: A list of courses in Topic Areas E03, E04, E07, E37, and E57 (List 2), and of Topic Areas E08 and E09 (List 3) is given in Appendix 7.

4.2.3 Number of credits per term (part- and/or full-time) to allow students to meet program objectives; timeline to completion

Full-time students must take three courses per term to maintain full-time status, unless fewer courses are required to finish the program. In that case, students should take the required number of courses to finish the program.

The normal time to completion is 3 terms (1 year) for full-time students, and 6 terms (2 years) for part-time students. The maximum time to completion is 6 terms (2 years) for full-time students, and 12 terms (4 years) for part-time students.

4.2.4 Proposed Chemical Engineering course descriptions

Core courses (4 credits, graduate)

CHME 6011 Advanced Transport Phenomena

Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

CHME 6021 Advanced Chemical Engineering Thermodynamics

Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

CHME 6031 Chemical Kinetics and Reaction Engineering

Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered;

residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

CHME 6041 Chemical Engineering Process Dynamics and Control

Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

<u>Elective courses</u>

CHME 6061 Advanced Biochemical Engineering

Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

CHME 6081 Advanced Separation Processes

Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

CHME 6091 Statistics for Chemical Engineering

Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

CHME 6101 Advanced Battery Materials and Technologies

Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

CHME 6111 Polymer Chemistry and Engineering

Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization;

polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

CHME 6131 Advanced Colloid and Interface Science and Engineering

Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

CHME 6911 Topics in Chemical Engineering I

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

CHME 7911 Topics in Chemical Engineering II

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Section 5 FACULTY RESOURCES; OTHER HUMAN RESOURCES; MATERIAL RESOURCES: Resource implications of the program

5.1 Faculty Resources (Qualifications and scholarly output)

5.1.1 Qualifications of individual professors: degrees, experience, summary of faculty achievements (previous five years) including: (i) publication in peer-reviewed journals; (ii) experience acquired supervising masters' and doctoral students and post-doctoral fellows, participation on thesis juries

The qualifications of faculty members directly involved are summarized below. More detailed CVs are given in Appendix 5. Two additional faculty members will be hired every year during the introduction of this program.

Alex De Visscher, Professor

Dr. De Visscher was trained in Chemical Engineering and Environmental Engineering at Ghent University, Belgium. He obtained his PhD in 2001. He held a faculty position at the University of Calgary from 2005 until 2016. In 2005-2015 he held a Tier II Canada Research Chair in Air Quality and Pollution Control Engineering. From 2014 until 2016 he was Associate Head Graduate (Graduate Program Director) of the Department of Chemical and Petroleum Engineering. During his Sabbatical Leave in 2011-2012 he was Visiting Professor at the Institute of Technical Chemistry in the Technical University Bergakademie Freiberg, where he wrote an academic textbook on Air Dispersion Modeling, which was published by Wiley. He also wrote and self-published an academic textbook on Chemical Engineering Kinetics and Chemical Reactor Design. Dr. De Visscher published over 50 peer-reviewed journal articles, 12 over the past 5 years. He currently supervises four PhD students and has graduated seven graduate students over the past five years. He has participated in more than 100 thesis juries. Over the last five years he was involved in 10 candidacy exams, 13 PhD final exams, and 30 MSc final exams. His areas of research include kinetics and catalysis, transport phenomena, environmental chemical engineering, solution thermodynamics and solubility.

Zhibin Ye, Professor

Dr. Ye obtained his Bachelor and Master degrees in Chemical Engineering at Zhejiang University, China, and his PhD in Chemical Engineering at McMaster University in 2004. He held a faculty position at Laurentian University from 2004 until 2017. From 2011 until 2017 he held a Tier II Canada Research Chair in Polymer Nanomaterials. During his Sabbatical Leave he was a Visiting Associate Professor in the Department of Chemistry at the University of Illinois at Urbana-Champaign. Dr. Ye published 75 peer-reviewed journal papers, 28 in the past five years. He currently supervises two research associates and two graduate students, and he has graduated six graduate students in the past five years. He also supervised several postdoctoral fellows. His areas of research include polymer engineering and polymer reactor engineering, nanotechnology and nanocomposites.

Xiaolei Wang, Assistant Professor

Dr. Wang obtained his Bachelor's and Master's degree in Chemical Engineering at Dalian University and Tianjin University, respectively, and his PhD in Chemical and Biomolecular Engineering at the University of California at Los Angeles. He held a postdoctoral fellowship at the University of Waterloo from 2013 until 2017. Dr. Wang published 33 peer-reviewed journal papers, 26 in the past five years. His areas of research include nanotechnology, electrical energy storage materials, electrochemical engineering, electrocatalysis.

5.1.2 Overall faculty characteristics: Ability of faculty to provide adequate supervision and cover all aspects of the discipline or profession; forecast changes in composition of faculty (growth renewal); Chart on present and future workloads and credit breakdown

As of January 2018, the Department of Chemical and Materials Engineering will have three regular members, one joint member, and two excluded members (the Dean of the School of Graduate Studies and the Vice President Research and Graduate Studies), offering expertise in chemical engineering fundamentals (transport phenomena, chemical thermodynamics), catalysis, kinetics, and reactor engineering, polymer engineering, and electrochemical engineering. The main gaps in the expertise currently available are in some of the proposed technical electives. These gaps will be covered with future hires. An additional faculty recruitment is in progress, and there is a commitment from Concordia University to recruit two faculty members in the 2018-19 cycle (see support letter in Appendix 6), and up to two in the 2019-20 cycle. It is anticipated that we will hire an average of two faculty members per year for the three to four years after that, bringing the total to 15 faculty members. In the meantime, the program will be strengthened through collaboration with other departments within Concordia University, with other universities in Montreal, and with local industry professionals.

Below is a table of current and anticipated faculty members, with anticipated course assignments, for the Diploma program. The table shows that no faculty members will teach more than two courses per year in the program, leaving room for the development of other graduate programs, and an undergraduate program alongside the graduate programs.

Table 5 Projected course assignments per faculty member for the Diploma program

Faculty member	**Course**	**Year**	**Status**
Alex De Visscher	Advanced Chemical Engineering Thermodynamics Advanced Transport Phenomena	F 2018 W 2019	new, core new, core
Zhibin Ye	Principles of Chemical Engineering Polymer Chemistry and Engineering	F 2018 W 2019	new, bridge new, elective
Xiaolei Wang	Advanced Battery Materials and Technologies Chemical Kinetics and Reaction Engineering	F 2018 W 2019	new, core new, elective
Hire 1	Engineering Analysis Chemical Engineering Process Dynamics and Control	F 2018 W 2019	existing, core new, core
Hire 2	Advanced Separation Processes Materials Science and Engineering	F 2019 W 2020	new, elective new, core
Hire 3	Statistics for Chemical Engineering	F 2019	new, elective

Hire 4	Topics in Chemical Engineering I	F 2020	new, elective

A number of existing electives will be taught outside the Department of Chemical and Materials Engineering. Because this represents no change with the existing condition, these courses are not shown in the table above. However, these courses affect the ability of students to progress their program. Hence, a projection of course offerings per term is given below. For elective courses, only a sample is given.

Fall 2018

- Principles of Chemical Engineering (Ye) (bridge)
- Engineering Analysis (Hire 1; existing course) (core)
- Advanced Chemical Engineering Thermodynamics (De Visscher) (core)
- Advanced Battery Materials and Technologies (Wang) (elective, list 1)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Linear Systems (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Winter 2019

- Advanced Transport Phenomena (De Visscher) (core)
- Chemical Kinetics and Reaction Engineering (Wang) (core)
- Chemical Engineering Process Dynamics and Control (Hire 1) (core)
- Polymer Chemistry and Engineering (Ye) (elective, list 1)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Summer 2019

- Engineering Analysis (Faculty; existing course) (core)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Principles of Solar Engineering (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

The sequence will repeat, with the Fall 2018 courses also taught in Fall 2019, etc. This schedule allows students starting in Fall to complete the program in two terms, and allows all students to complete the program in three terms, regardless of the starting term.

5.1.3 New faculty required, with specialization; profile of professors to be hired

It is anticipated that two faculty members will be hired per year on average over the next five years. While the recruitment will be flexible to enable us to hire the best people, recruitments in the following areas are desirable:

- Process design, process control, and process simulation

- Advanced separations, bio-separations,
- Surface and coating engineering
- Transport phenomena, microfluidics, microreactors, process intensification
- Catalysis, kinetics, CO_2 conversion
- Biochemical, biomedical and metabolic chemical engineering
- Chemical engineering data, properties, computational chemistry, molecular dynamics
- Any Materials Engineering application domain not covered in the previous hires

The list is not in any particular order, except for the first area, which is a priority for the program.

5.2 Other Human Resources (required and available)

It is anticipated that the Diploma program will be run together with a Certificate program and a Master of Engineering program. The MEng program will draw 80 % of the course-based graduate students in Chemical Engineering. Hence, the human resources needed for the Certificate and Diploma combined are estimated at 20 % of the needs for all course-based students in Chemical Engineering.

Technical staff is needed to provide technical support with graduate course projects. A technician or an engineer-in-residence will be hired, to be shared between all the graduate programs of the department. This recruitment has been approved by the university.

An administrative support staff member will be needed to help program directors with student administration, book appointments, and guide students with their program requirements. A receptionist/administrative assistant and a graduate program administrator are anticipated, shared between all the graduate programs of the department. It is anticipated that the former will be recruited in 2018, whereas the latter will be recruited upon approval of the MASc and PhD programs.

Depending on the number of registered students, 1-2 teaching assistants per course are anticipated. Approximately 10 teaching assistant positions per year would cover the new courses introduced here. As these courses will be shared with other graduate programs, the incremental TA need is estimated at 5.

5.3 Material Resources (Reference materials, computers, equipment and space) (required and available)

A detailed library report outlining quality and quantity of collections, access, reference services and assistance, and interlibrary services is given in Appendix 3.

The program will require students to have access to computers with standard academic computing software (e.g., Matlab), as well as more specific engineering (e.g., Comsol) and chemical engineering (e.g., VMGsim) software. Except for specific chemical engineering software, the resources are already available at Concordia University. Licenses for the remaining software will be obtained.

Laboratory space is currently being renovated on Floor 14 of the Hall building (approx. 150 m^2), and additional renovations are in preparation on Floor 10 (approx. 400 m^2). The labs will host a mix of research and teaching space, and will be used by both course-based and thesis-based students. Graduate courses will use part of the space as project space, where students design and carry out experiments related to their course content. In addition, one floor of a major building expansion at the Loyola campus currently in the design stage will be allocated to the new Department of Chemical and Materials Engineering, with about 700 m^2 of labs, offices, student space, etc.

All courses in the program will be shared with other Chemical Engineering graduate programs. Hence, it is expected that class sizes will be in the 20-50 range at full deployment of the programs. For all graduate programs combined, about 10-12 courses will be taught in each of the Fall and Winter terms, 150 minutes per week. Standard classrooms with blackboard/whiteboard and computer projection will be adequate for these courses.

Some of the courses will need laboratory equipment to create the needed project space. This will consist of piping, connections, thermostatic systems, sensors and data acquisition systems. In addition, some characterization equipment is needed. Concordia University has approved $1 million for academic equipment for the Chemical Engineering programs. Faculty members contributing to the program as supervisors will bring in additional equipment obtained with research funding.

Some courses have projects that are not linked to the lab, and for these projects some student workspace will be needed. To accommodate this, a maker space is part of the renovation project on Floor 10 of the Hall building. This is in addition to the 400 m^2 dedicated to the Department of Chemical and Materials Engineering in this project. Students will generally work in groups. Proximity to computer labs is needed to ensure that students have access to process simulators (VMGSim, HYSYS) during these group activities.

To accommodate administrative needs, a reception area is available in the office space currently used by the Department of Chemical and Materials Engineering in the VA building. Over time, a similar area will be needed at the Loyola campus.

5.4 Funding for Graduate Students

Course-based students, including Diploma students, are self-funded. No separate funding is required for graduate student support.

5.5 Chart of Expenses and Revenues

The annual budget of the program at steady state is given in the table below.

Table 6 Budget of the Diploma program

Revenue	**$147,430**
Cost	
Faculty	$79,813
Staff, admin	$23,943
Staff, tech	$20,751
TA	$7,210
Operation	$12,500
Library	$1,563
Total	**$145,780**

Profit	$1,650

The faculty budget is based on half of a full-time teaching load necessary to teach the courses, based on a prorating of faculty members between the Diploma and other graduate programs. It is assumed that out of a total of 15 faculty members, 8 are needed to cover all the graduate programs (up to 24 courses per year at three courses per faculty member). Among the programs, faculty members are prorated based on the number of full-time equivalent students in the program, weighing course-based students twice as much as thesis-based students. These proportions can be maintained if the average class size is 40 for the Diploma courses. Administrative and technical staff costs are based on 25 % of a full-time position. Five TAs are assumed. For the operational cost, 10 % of the estimated operational cost of all graduate programs combined is used.

On the revenue side, Diploma students are counted as ½ of a full-time equivalent. Based on these numbers, a slight profit is projected.

Below is a more detailed budget table per year, over the first five years of the implementation of the program. The program will be profitable from Year 2 onwards. The program is more profitable in intermediate years than in steady state because of the way faculty members are prorated. The number of students reaches steady state before the number of faculty members does. What that means for the program is that it will run with fewer elective courses in the intermediate years, which is cheaper. However, the additional elective courses enrich the Diploma program, as well as other programs.

Cost-revenue template Chemical Engineering (Diploma)

Concordia University		Year 1	Year 2	Year 3	Year 4	Year 5	5-Year Total
FTEs for Yr 1 students		2.50	4.00	4.00	4.00	4.00	18.50
FTEs for Yr 2 students			2.00	3.50	3.50	3.50	12.50
FTEs for Yr 3 students				-			-
FTEs for Yr 4 students					-		-
FTEs for Yr 5 students						-	-
Student Enrolment		**2.50**	**6.00**	**7.50**	**7.50**	**7.50**	**31.00**
Revenue							
Tuition Revenue ($1,036.01 per term per FTE x 2 terms)	2,072	5,180	12,432	15,540	15,540	15,540	64,233
Teaching grant (base of $3,594.89/FTE x 4.42)	15,889	39,724	95,336	119,171	119,171	119,171	492,572
Variable support grant (per raw FTE $1,695.87)	1,696	4,240	10,175	12,719	12,719	12,719	52,572
Total Anticipated University Revenue (Only includes teaching & tuition revenue)		**49,143**	**117,944**	**147,430**	**147,430**	**147,430**	609,376
Expenses							
Faculty (steady state = 15)		5	7	9	11	13	
Part-time faculty (0 courses at $10,700 at steady state)	-						
Faculty (0.5 FT x $125,000 x 1.277)	0.5	26,604	37,246	47,888	58,529	69,171	239,438
Admin (0.25 FT x $75,000 x 1.277)	0.25	7,981	11,174	14,366	17,559	20,751	71,831
Faculty (0.25 FT x $65,000 x 1.277)	0.25	20,751	20,751	20,751	20,751	20,751	103,756
Course sections (GPD remission) From the Provost's Office)							
Teaching assistantships (5; $1,464 & 1,419 for Master and Ph.D. resp./student)	5	2,403	3,364	4,325	5,286	6,247	21,623
Masters bursaries ($)							
Library costs	1,563	1,563	1,563	1,563	1,563	1,563	7,815
Operation (labs, etc.)	12,500	12,500	12,500	12,500	12,500	12,500	62,500
Advertising		3,000	2,000				5,000
Recruitment		3,000	2,000				5,000
Total Anticipated Expenses (ENCS)		**77,807**	**90,604**	**101,402**	**116,199**	**130,996**	**516,963**
Anticipated Gain (Loss) for the University		(28,664)	27,339	46,028	31,231	16,434	92,414

Notes:
Attrition rate not applicable (1 year of study assumed)
Faculty/staff/TA costs are prorated based on the number of faculty members in a given year assuming 15 faculty members at steady state.
Library cost assumes that the overlapping budgets are prorated based on number of students at steady state

5.6 Implementation Timetable for the Program

A detailed plan of the introduction of courses is given in Section 5.1.2. What follows is a general overview of activities planned for the Diploma program.

- Fall 2018
    - Introduction of Diploma program
    - Admission of first students
    - Commitment of course offerings to complete Diploma program in two terms (Fall + Winter) or three terms (Winter + Summer + Fall)
- Winter 2019
    - Full deployment of all new electives planned for the program
- Winter 2020
    - End of term: First Diploma graduates

Section 6 APPENDICES

<u>Appendix 1 Related programs in Quebec and the rest of Canada (descriptions, calendar excerpts, etc.)</u>

<u>McGill University</u>

Graduate Diploma Mining Engineering

The Graduate Diploma is a one-year, course-based, 30-credit degree in Mining Engineering. It is open to professionals from industry, engineers and scientists, who wish to receive professional development education in mining engineering in a formal manner. The program includes a seminar course (6 credits), a minimum of six graduate level courses (18 credits), and a project (6 credits). 1-3 courses may be taken at the senior undergraduate level with approval.

Courses:

- MIME 513 Mine Plan Optim Under Uncert 3 Credits
- MIME 520 Stability of Rock Slopes 3 Credits
- MIME 522 Mineral Reserve Assess Techs 3 Credits
- MIME 525 Stochastic Orebody Modelling 3 Credits
- MIME 620 Rock Mechanics 1 4 Credits
- MIME 626 Applied Geostatistics 3 Credits
- MIME 631 Adv Stochastic Optim:Mine Plan 4 Credits
- MIME 635 Finite Elem Meth-Rock Mechs 4 Credits

<u>École Polytechnique</u>

Microprogramme Sciences et technologies de la plasturgie

Ce microprogramme vise à donner une formation spécialisée en mettant l'accent sur l'acquisition de connaissances théoriques et techniques nécessaires à la conception des procédés et au développement de produits dans le domaine de la plasturgie. L'étudiant inscrit dans ce microprogramme abordera différents thèmes tels que la chimie-physique des polymères et/ou les systèmes multiphasés ainsi que des aspects méthodologiques et techniques, amenant vers des activités de conception ou d'application pratiques associées de la plasturgie.

Le microprogramme comporte 15 crédits.

Cours au choix (15 crédits)

- GCH4310 Travaux pratiques de plasturgie 3 crédits
- GCH6101 Chimie physique des polymères 3 crédits
- GCH6108 Systèmes polymères multiphasés 3 crédits
- GCH6114 Projet de conception de produits polymériques 3 crédits
- GCH6914 Méthode des éléments finis en génie chimique 3 crédits
- GCH8102 Mise en forme des polymères 3 crédits

Diplôme d'études supérieures spécialisées (DESS) Option Énergie et développement durable

Le programme a pour objectif l'approfondissement des connaissances sur les caractéristiques des différentes sources d'énergie, le choix, le dimensionnement, l'analyse socio-économique et la maintenance des systèmes énergétiques selon le type d'installation.

Le programme comporte 30 crédits, se répartissant comme suit

- Cours du 1er cycle min. 0; max. 9
- Cours de cycles supérieurs min. 21; max. 30

Module A – Cours de base (15 crédits)

Cours obligatoires :

- DDI8001 Développement durable pour ingénieurs 3 cr.
- DDI8002 Études de cas en dévelop. durable pour ing. 3 cr.
- ENE8210 Efficacité des sources d'énergie 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6200 Sciences du génie de l'environnement 3 cr.
- DDI8003 Analyse du cycle de vie 3 cr.
- IND6140 Ing. résilience et continuité opérationnelle 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- IND8111 Aspects économiques des flux circulaires 3 cr.
- MEC6512A Conception de produits et proc. durables 3 cr.

Module B – Spécialisation (15 crédits)

Trois (3) cours au choix parmi les suivants :

- ENE8310 Stockage et intégration des syst. énergéti. 3 cr.
- GCH8103 Conversion de la biomasse 3 cr.
- GCH8211 Conception et intégration des procédés 3 cr.
- GCH8729 Déchets solides et énergie résiduelle 3 cr.
- MET8106 Énergie électrochimique 3 cr.
- MET8220A Énergie solaire photovoltaïque et applica. 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6205 Impacts des projets sur l'environnement 3 cr.
- CIV6214A Risques naturels et mesures d'urgence 3 cr.
- ELE2400 Électricité: Sécurité et environnement 2 cr.
- GCH6313 Modélis. environn. des émissions toxiques 3 cr.
- GCH6902 Conception des réacteurs gaz-solide 3 cr.
- GCH6918 Projet d'études supérieures 3 cr.
- GCH8107 Procédés pyrométallurgiques 3 cr.
- GCH8150 Systèmes de commande de procédés chimiques 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- MEC6214 Énergie solaire et applications 3 cr.
- MEC6216 Géothermie et applications 3 cr.

- MEC6618 Éoliennes et applications 3 cr.
- MEC8252 Combustion et pollution atmosphérique 3 cr.
- PHS8603 Énergie et environnement 3 cr.
- PHS8604 Conversion directe de l'énergie 3 cr.

Diplôme d'études supérieures spécialisées (DESS) Option Matériaux

Le programme a pour objectif l'approfondissement des connaissances des caractéristiques physico-chimiques, mécaniques et microstructurales des matériaux dans le cadre d'applications spécifiques, particulièrement sur les propriétés fonctionnelles des matériaux et sur leur mise en forme.

Structure du programme :

- A – Module de base (15 crédits)
- B – Module de spécialité (15 crédits)

A – Module de base (15 crédits)

- GCH6101 Chimie physique des polymères 3 cr.
- GCH8102 Mise en forme des polymères 3 cr.
- MEC6306A Comportement mécan. des matér. composites 3 cr.
- MEC6318 Fabrication des composites par injection 3 cr.
- MET6103A Techniques de caractérisation des matériaux I 4 cr.

B – Module de spécialité (15 crédits)

- GBM8540 Corrosion et dégradation des biomatériaux 3 cr.
- GCH6104A Rhéologie des polymères 4 cr.
- GCH6108 Systèmes polymères multiphasés 3 cr.
- GCH6112A Conc. des opér. d'agitation et de mélange 3 cr.
- GCH6914 Méthode des éléments finis en génie chimique 3 cr.
- GCH8102 Mise en forme des polymères 3 cr.
- GCH8106 Ingénierie des emballages polymères 3 cr.
- MEC6404 Éléments finis, concepts et applications 3 cr.
- MEC6413 Matériaux métalliques, caract. et utilisation 3 cr.
- MEC8415 Endommagement par fatigue-fluage 3 cr.
- MET6101B Mécanique de la rupture 3 cr.
- MET6108 Procédés de la métallurgie des poudres 3 cr.
- MET6208 Énergétique des solutions 4 cr.
- MET6211 Métallurgie de l'aluminium 3 cr.
- MET8106 Énergie électrochimique 3 cr.
- MET8220A Énergie solaire photovoltaïque et applica. 3 cr.

Diplôme d'études supérieures spécialisées (DESS) Option Énergie et développement durable

La formation est orientée de façon à couvrir à la fois les procédés d'assainissement et l'assainissement des procédés dans un contexte de développement durable. Le programme a pour objectif de permettre, entre autres, la conception ou la reconfiguration ainsi que la mise en œuvre des procédés industriels existants, afin de les rendre plus performants et efficaces en consommation d'énergie avec moins de rejets d'agents polluants.

Structure du programme :

- A – Module de base (15 crédits)
- B – Module de spécialisation (15 crédits)

Module A – Cours de base (15 crédits)

Cours obligatoires :

- DDI8001 Développement durable pour ingénieurs 3 cr.
- DDI8002 Études de cas en dévelop. durable pour ing. 3 cr.
- DDI8003 Analyse du cycle de vie 3 cr.

Et deux (2) cours au choix parmi les suivants :

- CIV6200 Sciences du génie de l'environnement 3 cr.
- ENE8210 Efficacité des sources d'énergie 3 cr.
- IND6140 Ing. résilience et continuité opérationnelle 3 cr.
- MEC6512A Conception de produits et proc. durables 3 cr.
- IND8111 Aspects économiques des flux circulaires 3 cr.

Module B – Spécialisation (15 crédits)

Trois (3) ou quatre (4) cours au choix dans les blocs 1 et 2, dont au moins un (1) dans chaque bloc :

Bloc 1 : Environnement

- GCH6301 Ingénierie des biosystèmes 3 cr.
- GCH6304 Contrôle de la pollution industrielle 3 cr.
- GCH6309 Valorisation énergétique des déchets solides 3 cr.
- GCH6313 Modélis. environn. des émissions toxiques 3 cr.
- GCH8103 Conversion de la biomasse 3 cr.
- GCH8729 Déchets solides et énergie résiduelle 3 cr.

Bloc 2 : Procédés

- GCH6112 Conception des opérations d'agitation et de mélange N/D
- GCH6201 Catalyse et cinétique appliquées 3 cr.
- GCH6210 Ingénierie des pâtes et papiers 3 cr.
- GCH6902 Conception des réacteurs gaz-solide 3 cr.
- GCH8104 Traitement des minerais 3 cr.
- GCH8107 Procédés pyrométallurgiques 3 cr.
- GCH8150 Systèmes de commande de procédés chimiques 3 cr.
- GCH8211 Conception et intégration des procédés 3 cr.

Bloc 3 : Un à deux cours au choix parmi les suivants, incluant les cours au choix du module A, les cours de l'UdeM et de HEC Montréal ou tout autre cours au choix approuvé par le directeur d'études :

- 4-084-13 Développement durable, politiques environnementales et gestion N/D
- 4-801-06 Analyse économique des enjeux environnementaux N/D
- CIV8210 Traitements physico-chimiques de l'eau 3 cr.
- CIV8220 Épuration biologique des eaux usées 3 cr.
- CIV8240 Traitement de l'eau et des rejets 3 cr.
- GCH6903 Phénomènes d'échanges avancés 3 cr.
- GCH6918 Projet d'études supérieures 3 cr.
- EDD6030 Biogéochimie N/D
- EDD6040 Gestion de l'eau N/D
- EDD6050 Gestion de la biodiversité N/D
- ENV6003 La protection de l'environnement N/D
- IND6126A Analyse et gestion des risques technologiques 3 cr.
- IND8110 Enjeux éco. du développement durable en génie 3 cr.
- MSN6115 Santé et environnement I N/D
- TXL6014 Toxicologie de l'environnement N/D

Appendix 2 Enrolment surveys and other indicators of student interest in the program and graduate employment opportunities

Introduction

Senior undergraduate students who have completed 60-120 credits were invited to complete the questionnaire below. This survey probed students' intentions to take a certificate, diploma, M.Eng., or M.A.Sc. program in Chemical Engineering. The students probed were in Bachelor's programs in Mechanical Engineering, Industrial Engineering, and Chemistry. The vast majority of respondents were Mechanical Engineering students, so the results mainly reflect the opinions of that group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Bachelor's degree)	40	70.2	70.2	70.2
	Industrial Engineering (Bachelor's degree)	8	14.0	14.0	14.0
	Chemistry (Bachelor's degree)	9	15.8	15.8	15.8
	Total	57	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	649
Number of students responded	57
Response rate	8.8%
Margin of error*	± 12.4%

*at a 95% confidence level

In addition, thesis-based Master students in Mechanical Engineering, Civil Engineering, and Chemistry were invited to complete the second questionnaire below. This survey probed students' intentions to take a M.A.Sc. or Ph.D. program in Chemical Engineering. The pool of respondents was fairly evenly spread, with Civil Engineering being the dominant group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Master's)	12	32.4	32.4	32.4
	Civil Engineering (Master's)	19	51.4	51.4	51.4
	Chemistry (Master's)	6	16.2	16.2	16.2
	Total	37	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	193
Number of students responded	37
Response rate	19.2%
Margin of error*	± 14.5%

*at a 95% confidence level

Results – Undergraduate students – Diploma

The response of the surveyed students is summarized here, followed by the detailed responses in tabular form.

On the question “Based on this description, how likely is it that you would apply to the Diploma in Chemical Engineering program if it became available?” 16/57 students (28.1 %) responded “likely” or “very likely”. About a third of the students (20/57 or 35.1 %) would apply in 2018 or 2019.

On the question “How relevant are the proposed program objectives to your academic and professional goals?” 36/57 students (63.2 %) responded “relevant” or “very relevant”. For a description of the program objectives as stated in the survey, see below.

On the question “Are the proposed courses relevant to your academic and professional goals?” 33/57 students (57.9 %) responded “relevant” or “very relevant”.

On the question “In what ways do you see the Diploma in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)” 28/57 students (49.1 %) responded “Specialized expertise in Chemical Engineering will increase my career prospects.”, whereas 19/57 students (33.3 %) responded “I can use it as a stepping stone towards a Master's degree in Chemical Engineering.”

On the question “What drawbacks or disadvantages can you foresee in the proposed Diploma program with regard to your academic and professional goals? (Please select all that apply.)” 15/57 students (26.3

%) responded “The program is too specialized.”, whereas 15/57 students (26.3 %) responded “The program may narrow my employment options.”

Overall the survey results are favorable, with nearly a third of the students inclined to pursue the program, and a broad majority of the students evaluating the program as relevant for their careers. Overall, the students selected more advantages than disadvantages in the survey.

Detailed Survey Results – Undergraduate students – Diploma

Based on this description, how likely is it that you would apply to the Diploma in Chemical Engineering program if it became available?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very likely	6	10.5	10.5	10.5
	Likely	10	17.5	17.5	17.5
	Somewhat likely	15	26.3	26.3	26.3
	Unlikely	21	36.8	36.8	36.8
	Don't know	5	8.8	8.8	8.8
	Total	57	100.0	100.0	

In what year would you most likely expect to apply to the Diploma in Chemical Engineering program?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	2018	9	15.8	15.8	15.8
	2019	11	19.3	19.3	19.3
	Later than 2019	9	15.8	15.8	15.8
	Don't know	13	22.8	22.8	22.8
	Would not apply	15	26.3	26.3	26.3
	Total	57	100.0	100.0	

How relevant are the proposed program objectives to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	6	10.5	10.7	10.7
	Relevant	30	52.6	53.6	53.6
	Not relevant	14	24.6	25.0	25.0

		Frequency	Percent	Valid Percent	Valid Percent
	Don't know	6	10.5	10.7	10.7
	Total	56	98.2	100.0	
Missing	System	1	1.8		
Total		57	100.0		

Are the proposed courses relevant to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	7	12.3	12.3	12.3
	Relevant	26	45.6	45.6	45.6
	Not relevant	19	33.3	33.3	33.3
	Don't know	5	8.8	8.8	8.8
	Total	57	100.0	100.0	

In what ways do you see the Diploma in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Specialized expertise in Chemical Engineering will increase my career prospects.	28	49.1	49.1	49.1
	I can use it as a stepping stone towards a Master's degree in Chemical Engineering.	19	33.3	33.3	33.3
	I want to pursue a career in Chemical Engineering and this program would allow me to do so.	7	12.3	12.3	12.3
	Other	6	10.5	10.5	10.5
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

What drawbacks or disadvantages can you foresee in the proposed Diploma program with regard to your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	The program is too specialized.	15	26.3	26.3	26.3
	The program may narrow my employment options.	15	26.3	26.3	26.3
	The program is too general.	6	10.5	10.5	10.5
	Other	5	8.8	8.8	8.8
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

Survey Content – Undergraduate

Web Page 1:

Concordia University

New Programs in Chemical Engineering Survey

Welcome to the New Programs in Chemical Engineering Survey

Please copy the survey PIN found in your invitation email and paste it in the space below.

Enter your survey PIN below:

[ ] Start

Web Page 2:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Welcome!

<p>Concordia University's Faculty of Engineering and Computer Science is considering the possibility of offering graduate programs in Chemical Engineering. Chemical Engineering is the application of chemical and engineering principles for the design and operation of industrial processes for the manufacture of chemicals and materials. A total of five programs may potentially be created:</p>

a Graduate Certificate (4 courses, 15 credits);
a Graduate Diploma (8 courses, 30 credits);
a Master of Engineering (12 courses, 45 credits);
a Master of Applied Science (thesis-based); and
a Ph.D. (thesis-based).

<p>We are contacting you to solicit your feedback on some of the proposed programs, and to assess the level of interest in these programs among current Concordia students. The survey should take no longer than 10 minutes to complete. Should you find that your exact situation is not listed as a response to a given question, please select the closest response choice. Your responses will be held in strict confidence and will only be used to produce aggregate results.</p>

<p>Thank you for your participation -- your feedback is important.</p>

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Web Page 3:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

Your Program

Please indicate your current program of study.

- Mechanical Engineering (Bachelor's degree)
- Industrial Engineering (Bachelor's degree)
- Chemistry (Bachelor's degree)

Please indicate the number of credits you have remaining to complete your degree.

<< Back Next >>

Web Page 4:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

The New Certificate Program

The **Certificate in Chemical Engineering** is a course-based program. It consists of four courses: three core courses and one elective. The program provides students with a first exposure to Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the Graduate Diploma and the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Certificate** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Certificate** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 5:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Certificate Program

The aim of the **Certificate** in Chemical Engineering program is to provide specialized expertise in a limited number of core subjects in Chemical Engineering. It will enable students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Certificate Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
One of the following two:
Chemical Kinetics and Reaction Engineering (chemical reactor design)
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Certificate** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Graduate Diploma or a Master's degree in Chemical Engineering.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Certificate** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Diploma Program

The **Diploma in Chemical Engineering** is a course-based program. It consists of eight courses: five core courses and three electives. The program provides students with comprehensive specialized knowledge in Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Diploma** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Diploma** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Diploma Program

The aim of the **Diploma** in Chemical Engineering program is to provide specialized expertise in a broad range of core subjects in Chemical Engineering. It will allow students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Diploma Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One technical elective course outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One complementary course. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Diploma** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Master's degree.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Diploma** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Master of Engineering Program

The **Master of Engineering in Chemical Engineering** is a course-based program. It consists of twelve courses: seven core courses and five electives. The program provides students with extensive specialized knowledge in Chemical Engineering at the graduate level. The program is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.).

Based on this description, how likely is it that you would apply to the **Master of Engineering** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Engineering** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Engineering Program

The aim of the **Master of Engineering** in Chemical Engineering program is to provide specialized expertise in all areas of Chemical Engineering, and to solve problems from a thorough understanding of the underlying principles so students can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Engineering Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
One of the following two courses:
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. One to three technical elective courses in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One or two technical elective courses outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One or two complementary courses. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Engineering** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Engineering** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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New Programs in Chemical Engineering Survey

Completed

The New Master of Applied Science Program

The **Master of Applied Science in Chemical Engineering** program is a thesis-based program. It consists of four courses and research culminating in the writing of a thesis. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Master of Applied Science** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Applied Science** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Applied Science Program

The aim of the **Master of Applied Science** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. Students who complete a Master of Applied Science program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Applied Science Program

<p>I. Core courses (at least two courses from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A thesis based on academic research in a chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Applied Science** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Applied Science** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Université Concordia University

New Programs in Chemical Engineering Survey

Final Comments

If you have any final comments or questions regarding any of the proposed Chemical Engineering programs, please share them below.

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New Programs in Chemical Engineering Survey

Thank you for taking the time to complete this survey.
Your feedback is important.

We have received your responses.

Appendix 3 Library report

Library Report

For the Proposed

Diploma in Chemical Engineering

Joshua Chalifour, Digital Services & Engineering Librarian
Krista Alexander, Biochemistry/Chemistry & Physics Librarian

Created: April 2017

Purpose

The purpose of this report is to assess the adequacy of available library resources to support the proposed Diploma of Chemical Engineering, in the soon to be established Department of Chemical and Materials Engineering at Concordia University. The Department will be unique in Quebec and is slated to emphasize the development of new processes for producing specialized materials and the application of these materials in industry.

The comparators used throughout this report were identified by the Department of Chemical and Materials Engineering and include McGill University, École Polytechnique Montréal, University of Alberta, Stanford University, University of Houston, and Curtin University. Out of those comparators, École Polytechnique Montréal and Curtin University have Diploma programs in Chemical Engineering. However, considering the number of students and professors, programs, founding dates, and rankings Concordia is most similar to the University of Houston, and therefore the University of Houston will be used as the main comparator for the purposes of this report, instead of École Polytechnique Montréal or Curtin University.

Monographs

To assess the relative strength of Concordia University Library's monograph collection in terms of the research needs of the proposed Diploma program, collection size was measured for a sample of relevant Library of Congress Subject Headings. The results are presented in Table 1.

The table that follows compares monograph holdings for each of the comparator universities. McGill is excluded from this table because the methods to search its holdings produce different types of results for total print and ebook numbers. It is reasonable to consider McGill's total number is greater than the other comparators except for Stanford.

LC Subject Heading	Number of Monograph Titles					
	Concordia	École Polytechnique	Alberta	Stanford	Houston	Curtin University
Alloys	54	38	198	13724	105	1676
Biochemical engineering	23	52	173	257	54	226
Biotechnology	172	259	862	4749	249	2042
Chemical engineering	88	162	537	1443	225	2128
Chemical industry	26	96	143	1553	81	366
Chemical kinetics	169	124	407	1730	271	239
Chemical processes	21	35	217	673	92	349
Chemical reactions	128	109	425	7304	205	246
Chemical technology	0	0	2	219	0	42
Chemistry	172	253	1356	40191	473	6762
Chemistry, Metallurgic	4	4	30	36	12	34
Composite materials	174	119	444	3530	173	378
Energy transfer	19	34	77	3129	22	40
Fluid mechanics	263	635	602	3864	324	613
Manufacturing processes	187	463	483	1258	174	400
Metals	128	130	341	26718	184	2067
Nanostructured materials	278	856	1513	1774	285	383
Nanotechnology	315	1575	1262	3182	319	1368
Photochemistry Industrial applications	3	1	12	19	5	6
Plasma chemistry Industrial applications	2	1	7	9	3	3
Plastics	100	100	343	5056	207	737
Polymers	237	1915	1016	6482	602	1656
Process control	121	262	365	1617	133	467
Separation technology	46	67	261	281	120	242
Synthetic fuels	14	6	63	1336	46	125
Synthetic products	3	1	28	48	13	18
Total	**2,747**	**7,297**	**11,167**	**130,182**	**4,377**	**22,613**

Table 1: Comparative Size of Monograph Collections for Selected Subject Areas

Concordia's monograph collection in the areas measured is considerably smaller than that of the comparator universities. Some of these universities are older or larger institutions but others are more similar to Concordia. Considering the number of students and professors, programs, founding dates, and rankings Concordia is most similar to the University of Houston, which suggests that Concordia's monograph collection is unsupported by 37%.

While there is no historical data on which to base an assessment of collection growth over time at Concordia, the library materials budget for monographs in Chemistry & Biochemistry, Mechanical and Industrial Engineering, and Physics is shown for the last six years in Table 2.

Year	Chemistry & Biochemistry Appropriation	Mechanical & Industrial Engineering Appropriation	Physics Appropriation
2011 - 12	$14,636	$26,826	$8,755
2012 - 13	$11,000	$18,778	$6,128
2013 - 14	$6,600	$11,267	$3,677
2014 - 15	$6,600	$11,267	$3,677
2015 - 16	$6,600	$11,267	$3,677
2016 - 17	$6,600	$9,000	$3,700

Table 2: Library Materials Budget for Monographs in Subject Areas

Despite the reduction in monograph funds over the years, the Concordia Library has been able to acquire a number of electronic book collections using some centralized (non-subject specific) funds as well as money from the Academic Plan. Electronic book collections bought using these funds include Springer Ebooks, ScienceDirect, and the IEEE-Wiley Ebooks Library. These collections (normally updated each year with new titles) include monographs relevant to chemical engineering.

One-time monies (known as development funds) are made available each year to support new programs or build specific areas of the library collection in answer to the changing needs of our community. These development funds come from undesignated donations to the library and as such, are not consistent from year to year. They are primarily used to acquire titles to address historical gaps in the monograph or ebook collections.

Finally, students at Concordia University benefit from services that provide access to collections outside of Concordia, including the BCI card, which allows for direct borrowing of books from other Canadian academic libraries, including major Montreal institutions such as McGill University and Montréal Polytechnique. The Library's interlibrary loans service enables users to obtain some books, articles, and conference papers from other institutions worldwide, which are not accessible at Concordia. Books are delivered directly to the Library and users can pick them up at the circulation desk.

Electronic Resources (Databases)

The Concordia University Library's current collection of relevant databases for the fields of chemical and materials engineering is slightly under par with other universities that offer similar programs. Of 67 databases used in relation to chemical and materials engineering programs, Concordia subscribes to 32. On average, libraries subscribe to 34 of these databases. The Concordia Library has key, commonly used databases as identified below.

In Concordia's collection, the three most important databases for chemical and materials engineering—

providing access to indexed abstracts—are the following:

SciFinder
SciFinder searches Chemical Abstracts which indexes a wide range of international literature in chemistry and related fields (biology, engineering, physics, geology and material sciences). SciFinder includes journal articles, patents, dissertations, conference proceedings. It also contains millions of substances (CAS Registry) and reactions (CAS REACT), which can be searched by chemical structure, reactions, formulas or CAS Registry numbers. Commercial and regulated chemical information is included.

Compendex
The Compendex database is the largest source of engineering research literature (over 19 million records). Its coverage spans from 1884 to the present and is updated weekly. Compendex is a bibliographic database with references to engineering journals, conferences, trade publications, and more from over 76 countries. Focusing on just engineering disciplines, a significant portion of the Compendex records (about 13%) covers chemical engineering and a smaller quantity covers materials engineering.

Web of Science
This multidisciplinary database covers the journal literature of the sciences through the Science Citation Index (1979 – onwards), which includes the fields of science and engineering. Coverage also includes conference proceedings from the Conference Proceedings Citation Index (1990 – onwards).

Other important databases in the Library's collection that provide access to chemical engineering literature include:

Scopus
This multidisciplinary database covers journals and conference proceedings in science and technology. Physical sciences records (primarily chemistry, physics, and engineering) comprise 29% of the database's 60 million records. Scopus is updated daily with records from over 5000 publishers worldwide.

ACS Publications (American Chemical Society)
The American Chemical Society Journals covers more than 30 journals published by the ACS. Concordia also has access to the ACS legacy archives.

ScienceDirect
ScienceDirect provides full text of more than 1,800 Elsevier Science journals in the life, physical, medical, technical, and social sciences. ScienceDirect coverage spans from 1995 onward. In addition to some ebooks, the Concordia Library also has extensive backfile packages for journals in the areas of engineering, materials science, and technology prior to 1994.

Royal Society of Chemistry
The Royal Society of Chemistry provides databases, ebooks, and the full text of their journals. The Concordia Library subscribes to some of the databases, including the Merck Index (information on chemicals). Bibliographic databases include Synthetic Reaction Updates and Analytical Abstracts

covering 1980 to the present. The Library purchases access to some of the RSC ebooks and has access to the journals archive (1841-2004) through its participation in the CRKN Canadian Site Licensing Project.

Journals

The Concordia Library has a substantial collection of electronic journals, which are usually acquired in bundles, either from the publisher or an aggregator. These subscription bundles, generally managed on a provincial or national level through academic library consortia, include journals relevant to chemical engineering. These electronic subscriptions have largely displaced the print journal collections and are available to Concordia researchers on- and off-campus. The relevant subscription bundles for chemical engineering include (but are not limited to): Elsevier (ScienceDirect), American Chemical Society, Royal Society of Chemistry, American Physical Society, Sage, Springer, Taylor & Francis, and Wiley-Blackwell.

Below is a list of 25 top chemical engineering journals based on 5 year impact factor, according to Thomson Reuters' *InCites Journal Citation Report*, and the Library's current holdings for these journals, along with holdings at the comparator institutions.

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Progress in Energy and Combustion Science	23.634	1975 - Present	1976 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1976 - Present
Energy & Environmental Science	22.118	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present
Annual Review of Chemical and Biomolecular Engineering	9.337	2010 - Present	2010 - Present		2010 - Present	2010 - Present	2010 - Present	2010 - Present
Applied Catalysis B - Environmental	8.142	1995 - Present	1992 - Present	1995 - Present	1992 - Present	1992 - Present	1992 - Present	1992 - Present
Journal of Catalysis	7.482	1962 - Present	1962 - Present	1970 - Present	1962 - Present	1962 - Present	1962 - Present	1962 - Present
Applied Energy	6.222	1995 - Present	1975 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1975 - Present
Journal of Membrane Science	5.741	1995 - Present	1976 - Present	1995 - Present	1976 - Present	1976 - Present	1976 - Present	1976 - Present
Chemical Engineering Journal	5.439	1997 - Present	1997 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present
ACS Sustainable Chemistry & Engineering	5.319	2013 - Present	2013 - Present	2013 - Present	1995 - Present	2013 - Present	2013 - Present	2013 - Present
Separation and Purification Reviews	5.050	2003 - Present	1973 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Combustion and Flame	4.806	1957 - Present	1957 - Present	1970-1993 1995-Present	1957 - Present	1957 - Present	1957 - Present	1957 - Present
Desalination	4.800	1995 - Present	1966 - Present	1995 - Present	1966 - Present	1966 - Present	1966 - Present	1966 - Present
Journal of CO2 Utilization	4.778	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present
Proceedings of the Combustion Institute	4.303	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present
Fuel	4.140	1995 - Present	1970 - Present	1995 - Present	1965 - Present	1968 - Present	1953 - Present	1970 - Present
Catalysis Today	4.105	1995 - Present	1987 - Present	1995 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Fuel Processing Technology	3.949	1995 - Present	1977 - Present	1995 - Present	1977 - Present	1977 - Present	1977 - Present	1977 - Present
Current Opinion in Chemical Engineering	3.810	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present
Separation and Purification Technology	3.758	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present
Dyes and Pigments	3.708	1980 - Present	1980 - Present	1995 - Present	1980 - Present	1980 - Present	1980 - Present	1980 - Present
Journal of Food Engineering	3.512	1995 - Present	1982 - Present	1995 - Present	1982 - Present	1982 - Present	1982 - Present	1982 - Present
Food and Bioproducts Processing	3.511	1996 - Present	1996 - Present	1996 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present
Journal of Industrial and Engineering Chemistry	3.458	2008 - Present	2008 - Present	2008 - Present	1995 - Present	1995 - Present	2008 - Present	1995 - Present
Energy & Fuels	3.340	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Process Biochemistry	3.067	1995 - Present	1991 - Present	1995 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present

Table 3: The print or electronic holdings of 25 chemical engineering journals for Concordia, McGill, École Polytechnique, University of Alberta, Stanford, University of Houston, and Curtin University.

We have current access to 25 of the 25 titles listed. The following table shows backfile access. Backfile access refers to any titles that are not currently received (whether due to cancellation or a one year publisher embargo) but for which there is complete or partial backfile access.

	Concordia University	McGill	École Polytechnique	U Alberta	U Houston	Curtin University
Current Access	25	25	24	25	25	25
Backfile Access	25	25	24	25	25	25
No access	0	0	1	0	0	0

Table 4: Comparative Access to Select Journals

Concordia University access to these chemical engineering journal titles is strong and very similar to the comparator institutions examined here.

Recurring Library Collection Expenditures

To fully support the proposed Diploma in Chemical Engineering, certain areas of Concordia Library's collection should be enhanced. In particular, the proposed program is estimated to be unsupported by the monograph collection at 37%.

As per Section 5 of the document ***How to Calculate Revenues & Expenses for New Courses and New Programs***, prepared by the Resources Committee, the weighting grid for Cycle 2 in Engineering is 4.42 and the weighting grid for Cycle 2 in the Pure Sciences is 6.59. The multidisciplinary nature of the proposed program makes it necessary to use each of these values to determine a range of recurring library collection expenditures. Each of these numbers was multiplied by 10,000 (see Section 5 in the document mentioned above) and further multiplied by 37% (the amount by which the collection is considered to be unsupported). The recurring library collection expenditures would then fall between $16,354 and $24,383.

Concordia subscribes to many chemical engineering journals in addition to those listed in table 3 and the current journal collection is adequate to support the proposed program. The database collections are also adequate to support the proposed program.

It is important to note that these figures are all of a recurring nature—additional funds that the library would need **each year**, in order to support the Diploma program in Chemical Engineering.

The Library will require additional funds of between $16,354 and $24,383 each year to support the Diploma in Chemical Engineering program.

Resources needed	Recurring annual total in CAD
Monographs/ebooks	$16,354 - $24,383

Table 5: Additional funds needed per year to support the proposed program

***Please note**: It is important to note that if a Masters or PhD program in the same subject area was to be created, the additional funds indicated above would not be necessary for the Diploma program, as the resources used for those programs would be the same, albeit far more extensive, than those used for a Diploma program. Thus additional funds on top of those allocated to purchase resources to support a Masters or PhD program, would not be required.

Conclusion

With the addition of recurring funds to allow for the establishment of an appropriate annual monograph allocation, and the understanding that interlibrary loans will need to be used to supplement our journal and monograph collections, the Concordia University Library will be able to support a Diploma in Chemical Engineering.

Appendix 4 Curriculum documents

Please see the Provotrack sheets starting on p. 6 of the Dossier.

Appendix 5 Abridged curricula vitae of current department members

Alex De Visscher, Professor

Education:

- 2001: PhD Bioscience Engineering. Ghent University, Belgium
- 1993: B.Sc./MSc Chemical Engineering. Ghent University, Belgium

Positions/Accomplishments/Experience:

- 2014-2016: Associate Head Graduate, Department of Chemical and Petroleum Engineering, University of Calgary
- 2015-2016: Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2005-2015: Tier II Canada Research Chair in Air Quality and Pollution Control Engineering, Department of Chemical and Petroleum Engineering, University of Calgary
- 2010-2015: Associate Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2011-2012: Visiting Professor, Technical University Bergakademie Freiberg, Germany; Institute of Technical Chemistry
- 2005-2010: Assistant Professor, Department of Chemical and Petroleum Engineering, University of Calgary

Publications: Books (2012-2017):

- De Visscher A. (2013). Air Dispersion Modeling. Foundations and Applications. J. Wiley & Sons, Hoboken, NJ. 634 pp. ISBN 978-1-1180-7859-4.
- De Visscher A. (2013). Lecture Notes in Chemical Engineering Kinetics and Reactor Design. Self-published through CreateSpace, Charleston, SC. 345 pp. ISBN 9781492792642.

Publications: Peer-reviewed journal articles (2012-2017):

- Mahmoudkhani F., Rezaei M., Asili V., Atyabi M., Vaisman E., Langford C.H., De Visscher A. Benzene degradation in waste gas by photolysis and photolysis-ozonation: Experiments and modeling. Front. Environ. Eng. 10(6), 10 (2016).
- Rahnama K. & De Visscher A. Simplified flare combustion model for flare plume rise calculations. Can. J. Chem. Eng. 94, 1249–1261 (2016).
- Harper L.A., Weaver K.H. & De Visscher A. Dinitrogen and methane gas production during the anaerobic/anoxic decomposition of animal manure. Nutr. Cycl. Agroecosyst. 100, 53–64 (2014).
- Asili V., De Visscher A. Mechanistic model for ultraviolet degradation of H2S and NOx in waste gas. Chem. Eng. J. 244, 597–603 (2014).
- Malekshahian M., De Visscher A., Hill J.M. A non-equimolar mass transfer model for carbon dioxide gasification studies by thermogravimetric analysis. Fuel Proc. Technol. 124, 1–10 (2014).
- Fraser S., Marceau D., De Visscher A., Roth S.H. Estimating exposure by loose-coupling an air dispersion model and a geospatial information system. J. Environ. Informat. 21, 84–92 (2013).
- De Visscher A., Conejo M.S. Solubility phenomena related to CO2 capture and storage. Pure Appl. Chem. 85, 2051–2058 (2013).

- De Visscher A. Response to “Remarks on the paper by A. De Visscher, “What does the g-index really measure?”” J. Am. Soc. Informat. Sci. Technol. 64, 1960–1962 (2013).
- De Visscher A. A new Price’s estimate on the size of scientific specialties based on scientific community structure. Scientometrics 96, 937–940 (2013).
- De Visscher A., Vanderdeelen J. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 2: Ca. J. Phys. Chem. Ref. Data 41, 023105 (137pp) (2012).
- De Visscher A., Vanderdeelen J., Königsberger E., Churgalov B.R., Tsurumi M. & Ichikuni M. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 1: Introduction, Be and Mg. J. Phys. Chem. Ref. Data 41, 013105 (67pp) (2012).
- De Visscher A. The thermodynamics-bibliometrics consilience and the meaning of h-type indices – Reply. J. Am. Soc. Informat. Sci. Technol. 63, 630–631 (2012).

HQP Supervision (2012-2017):

- Chongchong Wu, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Sonochemistry for wastewater treatment. Co-supervisor: Dr. I. Gates.
- Michael Süß, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Environmental Engineering. Thesis: Biofiltration of BTEX.
- Mehrshad Parchei Esfahani, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Ultrasound-assisted peroxone for waste gas treatment.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2013–present), PhD student in Chemical Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of Air Pollutants in waste gas.
- Ali Shafaghat, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2016), MEng (thesis) student in Chemical Engineering, Environmental Engineering Specialization. Thesis: Depressurization Dynamic Modeling and Effect on Flare Flame Distortion. Final exam: 14 March 2016.
- Farshid Shayganpour, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2015), MEng (thesis) student in Chemical and Petroleum Engineering, Petroleum Engineering specialization, Thesis: Comparison of CSS and SAGD in Cold Lake. Final exam: 27 April 2015. Co-supervised, with Dr. Ian Gates as supervisor.
- Farzana Haque, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2008–2014), PhD student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Biofiltration of BTX from Glycol Dehydration Units. Final exam: 8 May 2014.
- Maria Conejo, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2014), MSc student in Chemical and Petroleum Engineering, Energy and Environment Engineering specialization, Thesis: Interactions between carbon dioxide and calcium carbonate in carbon storage conditions. Final exam: 10 March 2014.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2011–2013), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of H2S in waste gas: A comprehensive first-principles model. Final exam: July 2013.
- Mahsasadat Atyabi, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2013), MSc student in Chemical and Petroleum Engineering, Environmental

Engineering specialization, Thesis: Ultraviolet degradation of BTX in waste gas: Effects of photocatalysis and ozone premixing. Final exam: 18 January 2013.

- Kamran Rahnama, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2012), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Plume dispersion: A new flare combustion and plume rise model. Final exam: December 10, 2012.

Participation in thesis juries (2012-2017):

- March 3, 2017: Deependra Singh. Department of Mechanical and Industrial Engineering, Concordia University, PhD, Comprehensive Exam. Subject: Comprehensive Review of Electro-Chemical Machining (ECM) Process (Supervisor: R. Wuthrich).
- November 24, 2016: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering. PhD, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: P. Pereira Almao).
- September 12, 2016: Marlon Vargas-Ferrer. Department of Chemical and Petroleum Engineering. MSc, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: N. Mahinpey).
- September 1, 2016: Jun Cui. Department of Chemistry, University of Calgary, MSc, Final exam. Thesis title: Rapid characterization and degradation of dissolved organic matter for improving the quality of boiler feed water in Steam Assisted Gravity Drainage process (Supervisors: C.H. Langford and G. Achari).
- August 24, 2016: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Processing of Peroxidized Asphaltene in Aqueous Media. (Supervisor: P. Pereira Almao).
- August 9, 2016: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: New Pathways for Asphaltenes Upgrading via Oxy-Cracking in Liquid Phase. (Supervisor: P. Pereira Almao).
- May 13, 2016: Saeed Sampouri. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, Final exam. Thesis title: Catalytic Steam Reforming and Esterification of Bio-Oil. (Supervisor: J. Abedi).
- March 24, 2016: Karen Cañon-Rubio. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, Final exam. Thesis title: Strategies for Improving the Productivity and Cost-Effectiveness of Microalgal Production Systems. (Supervisor: H. De la Hoz Siegler).
- March 23, 2016: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Candidacy exam. (Supervisor: J. Bergerson).
- February 26, 2016: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Sorption-enhanced hydrogen production from catalytic steam gasification of coal. (Supervisor: N. Mahinpey).
- January 18, 2016: An Le. Biomedical Engineering Graduate Program, University of Calgary, MSc, Final exam. Thesis title: Computational Fluid Dynamics Modeling of Scalable Stirred Suspension Bioreactors for Pluripotent Stem Cell Expansion. (Supervisors: M. Kallos, I. Gates).
- November 27, 2015: Daniel Lincoln. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Development and characterization of an LED-based light source for high-speed schlieren imaging. (Supervisor: C. Johansen).
- November 23, 2015: Masoud Alrmah. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: (Supervisor: A. Mohamad).

- November 4, 2015: Jennifer Pauls. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Simulation of air-steam gasification of woody biomass in Aspen Plus: A comprehensive model including pyrolysis, hydrodynamics and tar production. (Supervisor: N. Mahinpey).
- September 10, 2015: Amir Ahmad Shirazi Manesh. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Thermodynamic modeling of asphaltene precipitation using cubic plus association equation of state. (Supervisor: J. Abedi).
- August 19, 2015: Mohamed Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary. PhD, final exam. Thesis title: Computational modelling of the wind flow over the University of Calgary campus. (Supervisor: D. Wood).
- April 27, 2015: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Comprehensive kinetic study of carbon dioxide and steam gasification: New findings and fundamentals. (Supervisor: N. Mahinpey).
- April 20, 2015: Amjad El-Qanni. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Nassar)
- October 22, 2014: Mahida Khurshid. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Serum-free co-expansion of mesenchymal stem cells and chondrocytesas aggregates in suspension bioreactors. (Supervisor: M. Kallos).
- August 29, 2014: Christopher Arisman. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Nitric oxide chemistry and velocity slip effects in hypersonic boundary layers (Supervisor: C. Johansen).
- August 28, 2014: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: D. Wood).
- August 25, 2014: Khaled Omar Sebakhy. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: M. Husein).
- July 10, 2014: Adeem Hassan Khan. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Measurement of the physical properties of MacKay bitumen and solvent mixtures (Supervisor: J. Abedi).
- June 16 2014: Mahdieh Shafiee Neistanak. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Kinetics of asphaltene precipitation and flocculation from diluted bitumen (Supervisor: H. Yarranton).
- April 29 2014: Mona Amiri. Department of Civil Engineering, University of Calgary, MSc, final exam. Thesis title: A methodology for estimating greenhouse gas emissions from heavy-duty diesel trucks in construction road transportation (Supervisor: F. Sadeghpour).
- April 17 2014: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- April 16 2014: Virginia Andrade Tovar. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Feasibility study for a small scale integrated on-farm ethanol plant (Supervisor: M. Foley).
- April 8 2014: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- March 27 2014: Ehsan Esmaili Darki. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Modeling and economic assessment of integrated gasification with sorbent CO2 capture (Supervisor: N. Mahinpey).

- January 22 2014: Belal Abu Tarboush. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Adsorption and oxidation of asphaltenes onto in situ prepared and commercial nanoparticles (Supervisor: M. Husein).
- January 10 2014: Xiaojian Wei. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: The effect of varying inlet conditions on the turbulent wake of a fence (Supervisor: D. Rival).
- December 18 2013: Alireza Saidi-Mehrabad. Department of Biological Sciences. MSc, final exam. Thesis title: Characterization of aerobic methane oxidizing bacteria in oil sands tailings ponds (Supervisor: P. Dunfield).
- December 16 2013: Lante Carbognani. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Upgrading of Visbroken vacuum residue by adsorption and catalytic steam gasification of the adsorbed components (Supervisor: P. Pereira Almao).
- December 13 2013: Claudia Bess-Ouko. Department of Civil Engineering, University of Calgary, MSc, final exam. Thesis title: Development of a LCA screening tool: Assessment of biochar in the removal of organic carbon in SAGD produced water (Supervisors: J. Bergerson and G. Achari).
- November 26 2013: Yanghong Liu. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Separation of water-in-heavy oil emulsions using porous particles in coalescence column (Supervisor: M. Dong).
- November 25 2013: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Template-free synthesis and modification of LTY, ZSM-5 and LTL zeolite catalysts and investigation of the catalytic pyrolysis of Saskatchewan Boundary Dam coal (Supervisor: N. Mahinpey).
- November 20 2013: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Mahinpey).
- October 8 2013: Sarah Alamolhoda. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: J. Hill).
- September 20, 2013: Krishna Morgan Panchalingam. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Bioprocessing of human stem cells applied to diseases of the central nervous system. (Supervisor: L. Behie).
- August 15 2013: Santiago Ortiz Ruiz. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Development of a computational tool for low-temperature geothermal-solar power generation plants (Supervisor: A. Mohamad).
- August 1 2013: Rozita Habibi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Co-gasification of biomass and non-biomass feedstocks (Supervisor: J. Hill).
- July 9 2013: Saleh Bawazeer. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Stability and accuracy of Lattice Boltzmann method (Supervisor: A. Mohamad).
- June 20 2013: Upasana Chamoli. Department of Chemistry, University of Calgary, MSc, final exam. Thesis title: Disinfection and self-sensitized degradation of NOM (Natural Organic Matter) by TiO_2 photocatalysis with visible light (Supervisors C. Langford and G. Achari).
- June 18 2013: Mostafa Meibod. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Bio-oil from wheat straw and hydrogen from aqueous phase of bio-oil (Supervisor J. Abedi).

- June 11 2013: Hesham Alhumade. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Reversible reactive flow displacements in porous media (Supervisor J. Azaiez).
- April 23 2013: Jaime McKenzie Graham. Department of Biological Sciences, University of Calgary, MSc, final exam. Thesis title: Effect of Drainage on Carbon Biogeochemistry and Microbiological Communities in Western Canadian Boreal Peatlands (Supervisor: P. Dunfield)
- April 18 2013: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Wet air oxidation of asphaltene particles (Supervisor: P. Pereira)
- January 18 2013: Giuseppe Rosi. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Characterizing coherent structures within the lower log region of the atmospheric boundary layer (Supervisor: D. Rival)
- December 17 2013: Sobhan Iranmesh. Department of Chemical and Petroleum Engineering, University of Calgary, MSc, final exam. Thesis title: Removal of naphthenic acid from water using biomass-based activated carbon.
- December 11, 2012: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Catalytic steam gasification of low grade coal with in situ CO2 capture process: Experimental and modeling approach (Supervisor: N. Mahinpey).
- December 6 2012: Esther Ramos-Padron. Department of Biological Sciencies, University of Calgary, PhD, final exam. Thesis title: Physiology and molecular characterization of microbial communities in oil sands tailings ponds (Supervisors: L. Gieg and G. Voordouw).
- June 28 2012: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, MSc, final exam. Thesis title: Vertical wind speed extrapolation using the k-? turbulence model (Supervisor: D. Wood).
- May 4 2012: Punitkumar Kapadia. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Gasification of Althabasca bitumen: Hydrogen generation, kinetics, and in situ process design (Supervisor: I. Gates).

Zhibin Ye, Professor

Education:

- PhD Chemical Engineering, McMaster University, Hamilton, Ontario 2004
- M. Eng. Chemical Engineering, Zhejiang University, China 1999
- B. Eng. Chemical Engineering, Zhejiang University, China 1996

Positions/Accomplishments/Experience:

- July 2012−present: Full Professor of Chemical Engineering
- Jan. 2011−present: Canada Research Chair (Tier 2) in Polymer Nanomaterials
- Sept. 2010−Feb. 2011: Visiting Associate Professor Department of Chemistry, University of Illinois at Urbana-Champaign
- Jan. 2010−present: Cross-Appointment to Department of Chemistry and Biochemistry
- July 2009−June 2012: Associate Professor (Tenured) of Chemical Engineering

- July 2004−June 2009: Assistant Professor (Tenure Track) of Chemical Engineering, School of Engineering, Laurentian University, Sudbury, Ontario, Canada

Publications: Peer-reviewed journal articles (2012-2017):

- L. Xu, L. Huang, Z. Ye*, Z. Gu, "Polycyclopentene-decorated carbon nanotubes by convenient large-scale in situ polymerization and their lotus leaf-like superhydrophobic films", Macromolecular Rapid Communications 2017, 38, 1600608.
- L. Huang, Z. Ye*, R. Berry, "Modification of cellulose nanocrystals with quaternary ammonium-containing hyperbranched polyethylene ionomers by ionic assembly", ACS Sustainable Chemistry & Engineering 2016, 4, 4937–4950. (Impact Factor: 5.267)
- Z. Dong, P. Xiang, L. Huang, Z. Ye*, "Efficient, robust surface functionalization and stabilization of gold nanorods with quaternary ammonium-containing ionomers as multidentate macromolecular ligands", RSC Advance 2016, 6, 43574–43590 (Impact Factor: 3.289).
- P. Xiang, Z. Ye*, "Hyperbranched polyethylene ionomers containing cationic tetralkylammonium ions synthesized by Pd–diimine-catalyzed direct one-pot ethylene copolymerization with ionic liquid comonomers", Macromolecules 2015, 48, 6096–6107. (Impact Factor: 5.554)
- P. Govindaiah, E. Guerra, Y. Choi, Z. Ye*, "Pressure oxidation leaching of an enargite concentrate in the presence of polytetrafluoroethylene beads", Hydrometallurgy 2015, 157, 340−347. (Impact Factor: 2.290)
- P. Xiang, Z. Ye*, "Homo- and co-polymerization of norbornene and methyl acrylate with Pd–diimine catalysts", Journal of Organometallic Chemistry 2015, 798, 429−436. (Impact Factor: 2.336)
- P. Govindaiah, M. Grundy, E. Guerra*, Y. Choi, Z. Ye*, "Polytetrafluoroethylene/TiO2 composite pellets as sulfur adsorbents for pressure oxidization leaching of chalcopyrite", Metallurgical and Materials Transaction B 2015, 46B, 550−556. (Impact factor: 1.474)
- Z. Dong, Z. Ye*, "Heterogeneous palladium catalyst constructed with cross-linked hyperbranched poly(phenylacetylene) as polymer support: a reusable highly active ppm-level catalyst for multiple cross-coupling reactions", Applied Catalysis A: General 2015, 489, 61−71. (Impact factor: 4.012)
- M. Grundy, Z. Ye*, "Cross-linked polymers of diethynylbenzene and phenylacetylene as new polymer precursors for high-yield synthesis of nanoporous activated carbons of high performance for supercapacitors, hydrogen storage, and CO2 capture", Journal of Materials Chemistry A 2014, 2, 20316−20330. (Impact factor: 8.262) [Invited to be featured on journal back cover]
- Z. Dong, Z. Ye*, "Reusable, highly active heterogeneous Pd catalyst by convenient selfencapsulation cross-linking polymerization for multiple carbon–carbon cross-coupling reactions at ppm to ppb Pd loadings", Advanced Synthesis & Catalysis 2014, 356, 3401−3414. (Impact factor: 5.663)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, "Synthesis of polyethylene and polystyrene miktoarm star copolymers using an 'in-out' strategy", Polymer Chemistry 2014, 5, 5443−5452. (Impact factor: 5.687)
- L. Xu, Z. Ye*, S. Siemann, Z. Gu, "Noncovalent solubilization of multi-walled carbon nanotubes in common low-polarity organic solvents with branched Pd–diimine polyethylenes: effects of polymer chain topology, molecular weight and terminal pyrene group", Polymer 2014, 55, 3120−3129. (Impact factor: 3.586; 2 citations)
- O. Osazuwa, M. Kontopoulou, P. Xiang, Z. Ye, A. Docoslis*, "Electrically conducting polyolefin composites containing electric field-aligned multiwall carbon nanotube structures: the effects of process parameters and filler loading", Carbon 2014, 72, 89−99. (Impact factor: 6.198)

- P. Liu, Z. Dong, Z. Ye*, W.-J. Wang*, B.-G. Li, “A conveniently synthesized polyethylene gel encapsulating palladium nanoparticles as a reusable high-performance catalyst for Heck and Suzuki coupling reactions”, Journal of Materials Chemistry A 2013, 1, 15469−15478. (Impact factor: 8.262)
- L. Xu, Z. Ye*, “A Pd−diimine catalytic inimer for synthesis of polyethylenes of hyperbranchedon-hyperbranched and star architectures”, Chemical Communications 2013, 49, 8800−8802. (Impact factor: 6.567)
- E. Landry, Z. Ye*, “Convenient Pd-catalyzed ‘arm-first’ synthesis of large unimolecular star polyethylene nanoparticles”, Macromolecular Rapid Communications 2013, 34, 1493−1498. (Impact factor: 4.638) [This paper was invited to be featured on the cover page]
- A. A. Vasileiou, A. Docoslis, M. Kontopoulou*, P. Xiang, Z. Ye, “The role of non-covalent functionalization and matrix viscosity on the dispersion and properties of LLDPE/MWCNT nanocomposites”, Polymer 2013, 54, 5230−5240. (Impact factor: 3.586; 2 citations)
- Z. Ye*, L. Xu, Z. Dong, P. Xiang, “Designing polyethylenes of complex chain architectures by Pd–diimine-catalyzed ‘living’ ethylene polymerization”, Chemical Communications 2013, 49, 6235−6255. (Impact factor: 6.567; 3 citations) [Invited feature article]
- L. Xu, J.-W. McGraw, F. Gao, M. Grundy, Z. Ye*, Z. Gu, J. L. Shepherd, “Production of high concentration graphene dispersions in low-boiling-point organic solvents by liquid-phase noncovalent exfoliation of graphite with a hyperbranched polyethylene and formation of graphene/ethylene copolymer composites”, Journal of Physical Chemistry C 2013, 117, 10730−10742. (Impact factor: 4.509; 2 citations)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, “Hyperbranched polyethylenes encapsulating selfsupported palladium (II) species as efficient and recyclable catalysts for Heck reaction”, Macromolecules 2013, 46, 72−82. (Impact factor: 5.554; 3 citations)
- P. Xiang, K. Petrie, M. Kontopoulou, Z. Ye*, R. Subramanian, “Tuning structural parameters of polyethylene brushes in surface-initiated ethylene ‘living’ polymerization from silica nanoparticles and effects on nanocomposite properties”, Polymer Chemistry 2013, 4, 1381−1395. (Impact factor: 5.687; 3 citations) [This paper was invited to be featured on back cover]
- P. Xiang, Z. Ye*, “Alternating, gradient, block, and block-gradient copolymers of ethylene and norbornene by Pd−diimine catalyzed ‘living’ copolymerization”, Journal of Polymer Science, Part A: Polymer Chemistry 2013, 51, 672−686. (Impact factor: 3.11; 2 citations)
- O. Oaszuwa, K. Petrie, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Characterization of non-covalently, non-specifically functionalized multi-wall carbon nanotubes and their melt compounded composites with an ethylene-octene copolymer”, Composite Science and Technology 2012, 73, 27−33. (Impact factor: 3.897; 8 citations)
- O. Osazuwa, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Polymer composites containing non-covalently functionalized carbon nanotubes: a study of their dispersion characteristics and response to AC electric fields”, Procedia Engineering 2012, 42, 1414−1424. (1 citation)
- P. Liu, W. Lu, W.-J. Wang*, B.-G. Li, Z. Ye*, S. Zhu*, “Synthesis and characterization of PE-b-POGEMA copolymers prepared by linear/hyperbranched telechelic polyethylene-initiated ATRP of oligo(ethylene glycol) Methacrylates”, Chapter 4 in ACS Symposium Series 1101, Progress in Controlled Radical Polymerization: Materials and Applications, Edited by K. Matyjaszewski, B. S. Sumerlin, and N. V. Tsarevsky, 2012, pp 39−64.
- Z. Zhang, Z. Ye*, “A ligand exchange strategy for one-pot sequential synthesis of (hyperbranched polyethylene)-b-(linear polyketone) block polymers”, Chemical Communications 2012, 48, 7940−7942. (Impact factor: 6.567; 9 citations)

- Z. Dong, Z. Ye*, "Synthesis of hyperbranched poly(phenylacetylene)s containing pendant alkyne groups by one-pot Pd-catalyzed copolymerization of phenylacetylene with diynes", Macromolecules 2012, 45, 5020−5031. (Impact factor: 5.554; 8 citations) [This paper is one (19th) of top 20 most read articles in the Journal in June 2012; it is also highlighted in ACS Noteworthy Chemistry on August 6, 2012.]
- Z. Dong, Z. Ye*, "Hyperbranched polyethylenes by chain walking polymerization: synthesis, properties, functionalization, and applications", Polymer Chemistry 2012, 3, 286−301. (Impact factor: 5.687; 17 citations)

HQP Supervision (2012-2017):

- Zhe Chen (MASc, Laurentian University) [Research Associate, Nov. 2015–Dec. 2016]
- Junbin Liao (PhD in Chemical Engineeirng, Zhejiang University of Technology) [PDF, August 2015−June 2017]
- Mark Grundy (MASc in Chemical Engineering, Laurentian University) [Research Associate, Jan. 2015−Jan. 2016]
- Patakamuri Govindaiah (PhD in Chemical Engineering, Yonsei University, South Korea) [PDF, June 2013−Dec. 2014]
- Vimal Tiwari (PhD in Polymer Physics, Banaras Hindu University, Inda) [PDF, May 2013−Dec. 2014]
- Zhichao Zhang (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, Oct. 2011−Sept. 2012]
- Zhongmin Dong (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, March 2011−Dec. 2014]
- Lixin Xu (PhD in Polymer Science and Engineering, Zhejiang University, China) [MRI PDF, September 2010−April 2012]
- Syed Atif Haider Zaidi [MEng, Jan. 2017−]
- Hui Su [MASc, Sept. 2014−Oct. 2016]
- Lingqi Huang [PhD, Sept. 2014−]
- Zhe Chen [MASc, Sept. 2013−Oct. 2015]
- Mark Grundy [MASc, May 2012−Oct. 2014]
- Peng Xiang [PhD, May 2011−Aug. 2015]
- Eric Landry [MASc, Sept. 2010−Oct. 2012]
- Pingwei Liu [PhD, 2009−2014]

Participation in thesis juries (2012-2017):

Xiaolei Wang, Assistant Professor

Education:

- PhD in Chemical and Biomolecular Engineering; University of California, Los Angeles (UCLA), USA, 2013
- M.S. in Chemical Engineering; Tianjin University, P.R. China, 2007

- B.S. in Chemical Engineering (Polymer Chemical Engineering); Dalian University of Technology, P.R. China, 2004

Positions/Accomplishments/Experience:

- Nov. 2013-present: Postdoctoral Fellow Researcher (advisor: Prof. Zhongwei Chen); Department of Chemical Engineering, University of Waterloo

Publications: Peer-reviewed journal articles (2012-2017):

- Xiaolei Wang, Ge Li, Min Ho Seo, Gregory Lui, Fathy Hassan, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Carbon-Coated Silicon Nanowires on Carbon Fabric as Self-Supported Electrodes for Flexible Lithium-Ion Batteries. ACS Applied Materials and Interfaces, accepted, 2016. DOI: adfm.10.1021/acsami.6b12080
- Matthew Li, Yining Zhang, Xiaolei Wang, Wook Ahn, Gaopeng Jiang, Gregory Lui, Zhongwei Chen*, Gas Pickering Emulsion Templated Hollow Carbon for High Rate Performance Lithium Sulfur Batteries. Advanced Functional Materials, 2016, 26(46), 8408-8417.
- Xiaolei Wang, Ge Li, Jingde Li, Yining Zhang, Wook Ahn, Aiping Yu, Zhongwei Chen*, Structural and Chemical Synergistic Encapsulation of Polysulfides Enables Ultralong-Life Lithium-Sulfur Batteries. Energy and Environmental Science, 2016, 9, 2533-2538. (Highlighted in inside back cover)
- Xiaolei Wang§, Ge Li§, Yining Zhang, Zhongwei Chen*, Pomegranate-Inspired Rational Design of Highly Active and Durable Bifunctional Electrocatalysts for Rechargeable Metal-Air Batteries. Angewandte Chemie International Edition, 2016, 55(16), 4977-4982. (VIP paper) (co-first author)
- Xiaolei Wang§, Xingye Fan§, Ge Li, Aiping Yu, Zhongwei Chen*, High-Performance Flexible Electrodes Based on Electrodeposited Polypyrrole/MnO2 on Carbon Cloth for Low-Cost Supercapacitors. Journal of Power Sources, 2016, 326, 357-364. (co-first author)
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HQP Mentoring (2012-2017):

- 2016-2018: Yuanli Ding, Postdoctoral Fellow, Chemical Engineering. Advanced Battery Technology beyond Lithium-Ion
- 2016-2017: Wen Lei, exchange PhD student, Chemical Engineering. Novel Phosphorous-based Materials for LIBs and SIBs
- 2016-2018: Steven Sherman, PhD candidate, Chemical Engineering. Scalable Production of Cathode Materials through Spray Drying Process for LIBs
- 2016-2018: Dan Luo, PhD candidate, Chemical Engineering. Cable-Like LIBs and Novel Alkaline Batteries and Supercapacitors
- 2016-2018: Justin Raimbault, MASc candidate, Chemical Engineering. Rational Design of Flexible Cathodes for LIBs
- 2014-2015: Xinlong Ma, PhD candidate, Chemical Engineering. Design of Onion-Like Materials Architecture for LIBs and Supercapacitors
- 2014-2015: Xingye Fan, M.A.Sc candidate, Chemical Engineering. Design and Fabrication of Flexible Electrodes for High-Performance Supercapacitors
- 2009-2010: Xing Zhong, M.A.Sc student, Chemical Engineering. Synthesis of 1D CuInS2 Nanowires and Nanorods for Solar Cell Applications

Appendix 6 Letters of support and list of persons consulted when developing the proposal

This proposal was developed in consultation with the Department of Chemical and Materials Engineering Steering Committee. The members of the Steering Committee are:

- Dr. Amir Aghdam (Electrical and Computer Engineering, Associate Dean SGS)
- Dr. Amir Asif (Electrical and Computer Engineering, Dean ENCS)
- Dr. Christine DeWolf (Chemistry, Arts and Science)
- Dr. Nabil Esmail (Mechanical and Industrial Engineering)
- Dr. Fariborz Haghighat (Building, Civil, and Environmental Engineering)
- Dr. Van Suong Hoa (Mechanical and Industrial Engineering)
- Dr. Paul Joyce (Chemistry, Associate Dean Arts and Science)
- Dr. Muthukumaran Packirisamy (Mechanical and Industrial Engineering)
- Dr. Rolf Wuthrich (Mechanical and Industrial Engineering)

Other persons who have provided advice or who have contributed to this proposal are:

- Frédérica Martin, Manager, Academic Programs and Development, SGS
- Joshua Chalifour, Digital Services & Engineering Librarian

A letter of support from Dr. Amir Asif, Dean of the Faculty of Engineering and Computer Science, and Dr. Graham Carr, Provost, is included on the next page.

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

October 24, 2017

School of Graduate Studies Graduate Curriculum Committee
School of Graduate Studies
GM 930.01

Dear Colleagues,

We write in support of the proposal for establishing graduate programs (Certificate, Diploma, MASc, and PhD) in Chemical Engineering in the recently created Department of Chemical and Materials Engineering.

The proposal is well aligned with the Faculty's strategic planning, touching on many of our strategic directions, especially our commitment to two important ENCS strategic imperatives, namely Enhancing Research Quality and Reputation, and Enhancing Through Innovation in Academic Programs. The proposal being brought forward also demonstrates our commitment to a third Faculty strategic imperative, Embracing Integration across Engineering, Arts, Science, and Business – Dr. De Visscher and his team have worked closely with colleagues in the Faculty of Arts and Science, in particular Dr. Christine De Wolf (Department of Chemistry and Biochemistry) and Dr. Paul Joyce (Associate Dean, Faculty of Arts and Science). Being interdisciplinary and involving faculty members working in physical sciences and engineering, the proposed programs are sufficiently different from existing graduate programs in chemical engineering offered elsewhere in Quebec. In addition, the proposed programs are modular in structure and offer flexibility to the students, allowing for several exit and entry points.

The institutional commitment to the programs is firm at both the Faculty and the University level. Since its establishment in May 01, 2017, three tenure-track/tenured faculty members have been hired in the Department of Chemical and Materials Engineering with one open position advertised in the 2017/18 hiring cycle. The University is committed to hiring two new faculty members in the Department in the 2018/19 hiring cycle and up to two faculty in 2019/20. Renovations for creating research and wet lab space have started in the Hall building. More space would be made available in the extension to the Science and Engineering Pavilion at the Loyola campus.

Interim Chair De Visscher and his team have shown true leadership and vision in proposing these innovative graduate programs, and we are pleased to offer our full support.

Sincerely,

Amir Asif, PhD, PEng
Dean, Engineering and Computer Science

Graham Carr, PhD
Provost and Vice-President, Academic Affairs

1455 De Maisonneuve Blvd. W., EV 2.139, Montreal, Quebec, Canada H3G 1M8
Tel. 514-848-2424 ext. 3109 Fax 514-848-4509 encs.concordia.ca

Appendix 7 Elective Courses Referred to by Subject Areas

List 2

E03 - SYSTEMS AND CONTROL

- ELEC 6041 Large-scale Control Systems
- ELEC 6061 Real-time Computer Control Systems
- ELEC 6091 Discrete Event Systems
- ENGR 6071 Switched and Hybrid Control Systems
- ENGR 6131 Linear Systems (*)
- ENGR 6141 Nonlinear Systems
- ENGR 7121 Analysis and Design of Linear Multivariable Systems
- ENGR 7131 Adaptive Control
- ENGR 7181 Digital Control of Dynamic Systems
- MECH 6681 Dynamics and Control of Nonholonomic Systems

E04 - FLUID MECHANICS

- ENGR 6201 Fluid Mechanics
- ENGR 6221 Microfluidic Systems
- ENGR 6241 Hydrodynamics
- ENGR 6251 The Finite Difference Method in Computational Fluid Dynamics
- ENGR 6261 The Finite Element Method in Computational Fluid Dynamics
- ENGR 6281 Modelling Turbulent Flows
- ENGR 6291 Rheology

E07 - ENERGY CONVERSION

- BLDG 6951 Solar Building Modelling and Design
- ENGR 6601 Principles of Solar Engineering
- ENGR 6611 Equipment Design for Solar Energy Conversion
- ENGR 6661 Solar Energy Materials Science
- ENGR 6811 Energy Resources: Conventional and Renewable

E37 - ENVIRONMENTAL ENGINEERING

- CIVI 6601 Modelling in Building and Environmental Engineering
- CIVI 6611 Environmental Engineering
- CIVI 6621 Engineering Aspects of Biological Treatment for Air and Water
- CIVI 6641 Unit Operations in Environmental Engineering
- CIVI 6651 Water Pollution and Control
- CIVI 6681 Environmental Nanotechnology
- CIVI 6691 Greenhouse Gases and Control
- CIVI 6901 Selected Topics in Civil Engineering I

E52 - THERMODYNAMICS AND HEAT TRANSFER

- MECH 6101 Kinetic Theory of Gases
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 6181 Heating, Air Conditioning and Ventilation (*)
- MECH 6191 Combustion
- MECH 7101 Convection Heat Transfer

E57 - COMPOSITE MATERIALS

- MECH 6501 Advanced Materials
- MECH 6521 Manufacturing of Composites
- MECH 6581 Mechanical Behaviour of Polymer Composite Materials
- MECH 6601 Testing and Evaluation of Polymer Composite Materials and Structures
- MECH 6651 Structural Composites
- MECH 7501 Design Using Composite Materials

List 3

E08 - ACADEMIC COMMUNICATION SKILLS

- ENCS 5721 Composition and Argumentation for Engineers
- ENCS 6721 Technical Writing and Research Methods for Scientists and Engineers

E09 - PROFESSIONAL LEADERSHIP SKILLS

- ENCS 6041 Creativity, Innovation, and Critical Thinking
- ENCS 6042 Communication Techniques for the Innovation Process
- ENCS 6821 Development and Global Engineering

SCHOOL OF GRADUATE STUDIES

US-2018-1-D9

To: Sandra Gabriele, Vice-Provost, Innovation in Teaching and Learning

cc: Olivia Ward, University Curriculum Administrator
Brad Nelson, Associate Dean, School of Graduate Studies

From: Joanne Beaudoin, Secretary, Council of the School of Graduate Studies

Date: November 14, 2017

Re: Graduate Curriculum Changes – CSGS November 13, 2017

This is to confirm that at the Council of the School of Graduate Studies meeting of Monday, November 13, 2017 the following *curriculum changes* were approved:

Faculty of Engineering and Computer Science

- Department of Chemical & Materials Engineering New Program: *Certificate in Chemical Engineering (MECH-101)* — CSGS 1718 2 D4
- Department of Chemical & Materials Engineering New Program: *Diploma in Chemical Engineering (MECH-102)* — CSGS 1718 2 D6
- Department of Chemical & Materials Engineering New Program: *MASc in Chemical Engineering (MECH-103)* — CSGS 1718 2 D8
- Department of Chemical & Materials Engineering New Program: *PhD in Chemical Engineering (MECH-104)* — CSGS 1718 2 D10

The documents can be forwarded to Senate for final approval.

Thank you.

MEMO TO: Paula Wood-Adams, Dean of Graduate Studies

FROM: Brad Nelson, Associate Dean, Academic Programs and Development
School of Graduate Studies

DATE: October 30, 2017

SUBJECT: **GRADUATE CURRICULUM CHANGES (MECH-103)**
(CALENDAR – 2018/2019)
DEPARTEMENT OF CHEMICAL AND MATERIALS ENGINEERING
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

The Graduate Curriculum Committee (GCC) reviewed the curriculum changes approved by the Faculty of Engineering and Computer Science.

The new Department of Chemical and Materials Engineering wishes to introduce a new MASc in Chemical Engineering,

The GCC requested that the department update the following items: the proposal memo, budget table and timetable.

The GCC approved this document with the above inclusions. I therefore recommend that the Council of the School of Graduate Studies approve and recommend to Senate the above-mentioned curriculum changes in their final form.

cc: M. Debbabi, Associate Dean, Graduate Programs and Research, Faculty of Engineering and Computer Science
O. Ward, University Curriculum Administrator, Office of the Provost and Vice-President, Academic Affairs

Concordia University
Engineering and Computer Science

Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Bradley Nelson
Chair, Graduate Curriculum Committee
School of Graduate Studies

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

CC: Ms. Frederica Martin
Academic Programs Analyst
School of Graduate Studies

DATE: September 8, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Faculty of Engineering and Computer Science

At its meetings on May 12th, 2017, the Council of the Faculty of Engineering and Computer Science reviewed and approved, with minor modifications, the creation of the new MASc in Chemical Engineering program from the new Department of Chemical and Materials Engineering (CME).

Details of the new program proposal are indicated and explained in the Department's and Engineering and Computer Science Graduate Studies Committee's (ECSGSC) internal memorandums and Provotrack dossier MECH-103.

We kindly request that this dossier be placed on the next agenda of the Graduate Curriculum Committee.

Thank you for your consideration of this proposal.

Université Concordia University

FACULTY OF ENGINEERING AND COMPUTER SCIENCE
Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Amir Asif
Chair of the Faculty Council
Faculty of Engineering and Computer Science

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

DATE: May 8, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Department of Chemical and Materials Engineering (CME)

At its meeting on May 3, 2017, the Engineering and Computer Science Graduate Studies Committee (ECSGSC) reviewed and approved, with minor modifications, the creation of an MASc program in Chemical Engineering, which is one of the four new programs put forth by the new Department of Chemical and Materials Engineering (CME).

This program could be particularly attractive to Concordia students in the graduate certificate/diploma, as well as to students holding a Bachelor's degree in Chemical Engineering from Quebec or other universities. The new program will be implemented in September 2019.

Details of this proposal are indicated and explained in the Department's internal memorandum and Provotrack dossier MECH-103.

We kindly request that this item be placed on the next agenda of the Faculty Council for approval.

Thank you for your consideration of this proposal.

UNIVERSITÉ Concordia UNIVERSITY

INTERNAL MEMORANDUM

April 19, 2017
Revised October 30, 2017
December 4, 2017

To: Dr. M. Debbabi
Associate Dean Research and Graduate Studies, ENCS

From: Dr. Alex De Visscher

Re.: Proposal for a new Master of Applied Science (MASc) Degree Program in Chemical Engineering

Dear Dr. Debbabi,

Please find attached a proposal for a new MASc program in Chemical Engineering. This program will be offered by the new Department of Chemical and Materials Engineering, to be established this spring. The proposal is one of five proposals for graduate programs in Chemical Engineering currently in development. Four of these (Certificate, Diploma, MASc and PhD) are currently submitted for approval. The fifth (MEng) will be timed to start approximately one year after the MASc and PhD programs.

The MASc program consists of four courses (16 credits) and a thesis (29 credits), consistent with the other MASc degree programs. This program will enable the new department to recruit graduate students and carry out its mandate of developing research excellence in Chemical and Materials Engineering.

The courses offered in the MASc program will also be offered in other programs, such as the Certificate, Diploma, and MEng programs, currently in development. Students who have completed a Certificate or Diploma program will be eligible to transfer up to 16 credits towards their MASc degree, provided they obtain the agreement of their supervisor.

The budget of a MASc program is somewhat arbitrary because resources must be prorated based on the number of students in the program. Based on a prorating of the teaching load by number of students and by course load of the program, it is assumed that 1.15 full-time faculty members correspond with an enrollment of 51 students. This works out to an average class size of approximately 30 students. With this assumption, the program is expected to run a profit of about $100,000 per year. The proposal contains a high-level steady-state budget. A more detailed budget will be provided shortly in a separate document. Also pending are a

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

library study and the results of a survey among senior undergraduate students, which are currently in progress. The reports will be provided as soon as they are available. The curriculum documents in Provotrack are also in development and will be provided as soon as possible.

An overview of course requirements per program is attached to this memo.

It is the intention of the new department to start offering the MASc program in September 2019.

The attached proposal has been vetted by the Steering Committee of the Department of Chemical and Materials Engineering. I would greatly appreciate it if you could put this proposal on the agenda of the next Graduate Studies committee.

Best regards,

Alex De Visscher

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

Table 1 Status of courses per program

Code	Course Title	Certif	Dipl	MEng	MASc	PhD
CHME 6001	Project in Chemical and Materials Engineering	-	-	-	elective	elective
CHME 6011	Advanced Transport Phenomena	core, required	core, required	core, required	core, list	core, list
CHME 6021	Advanced Chemical Engineering Thermodynamics	core, list	core, required	core, required	core, list	core, list
CHME 6031	Chemical Kinetics and Reaction Engineering	core, list	core, required	core, required	core, list	core, list
CHME 6041	Chemical Engineering Process Dynamics and Control	elective	core, required	core, required	core, list	core, list
CHME 6051	Chemical Process Engineering and Design	elective	elective	core, required	core, list	core, list
CHME 6061	Advanced Biochemical Engineering	elective	elective	elective	elective	elective
CHME 6071	Materials Science and Engineering	elective	elective	core, list	core, list	core, list
CHME 6081	Advanced Separation Processes	elective	elective	elective	elective	elective
CHME 6091	Statistics for Chemical Engineering	elective	elective	elective	elective	elective
CHME 6101	Advanced Battery Materials and Technologies	elective	elective	elective	elective	elective
CHME 6111	Polymer Chemistry and Engineering	elective	elective	elective	elective	elective
CHME 6121	Nanomaterials Chemistry and Engineering	elective	elective	core, list	core, list	core, list
CHME 6131	Advanced Colloid and Interface Science and Engineering	elective	elective	elective	elective	elective
-	Capstone Project	-	-	core, required	-	-
CHME 6911	Topics in Chemical Engineering I	elective	elective	elective	elective	elective
CHME 7911	Topics in Chemical Engineering II	-	elective	elective	elective	elective
ENCS 6021	Engineering Analysis	core, required	core, required	core, required	core, list	core, list
	Other List 1 options	elective	elective	elective	elective	elective
	Other List 2 options	-	elective	elective	elective	elective

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	Other List 3 options	-	elective	elective	elective	elective
ENGR 8901	Master of Applied Science Research Thesis	-	-	-	core, required	-
ENCS 8011	PhD Seminar	-	-	-	-	core, required
ENCS 8501	Doctoral Research Proposal	-	-	-	-	core, required
ENCS 8511	Comprehensive Examination	-	-	-	-	core, required
ENGR 8911	Doctoral Research and Thesis	-	-	-	-	core, required

Table 2 Number of courses per category, per program

Type of Course	**Cert**	**Dipl**	**MEng**	**MASc**	**PhD**
Core	3	5	8	2+	1+
List 1	1	1	1+	2-	2-
List 2		1	1+	2-	2-
List 3		1	1+	2-	2-
Total	**4**	**8**	**12**	**4**	**3**

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

PROGRAM CHANGE: MASc in Chemical Engineering

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: MASc
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [ ] Requirements [ ] Regulations [ ] Program Deletion [X] New Program

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	Department of Chemical and Materials Engineering **Chemical Engineering** **Programs** **Master of /Magisteriate in Applied Science (Chemical Engineering)** **Admission Requirements** To be considered for admission to Master-level studies, applicants must hold a bachelor's/ baccalaureate degree (or equivalent) in engineering or the sciences with high standing (e.g., with honours, or the Concordia equivalent of a GPA of at least 3.00 on a scale of 4.30). The Department Graduate Studies Committee will determine the acceptability of an applicant for admission to the program and may require the applicant to do specific remedial coursework, including the bridge course CHME 401 Principles of Chemical Engineering, and/or other course(s) to meet the program requirements. Credible academic references and a statement of purpose are required. **Degree Requirements** Students must complete 45 credits as shown below: 1. **Courses.** 16 credits chosen from the Engineering Courses section, approved by the student's supervisor and either the Graduate Program Director or the Chair of the Department. According to the University regulations on transfer of credits, students who have completed a graduate Certificate or Diploma may have courses transferred into a MASc. Please refer to the Transfer Credits section of the Graduate Calendar for further information.

2. **Thesis**. 29 credits.

Core and elective courses

Core: At least 8 credits (two courses) from the following list:

- CHME 6011 Advanced Transport Phenomena
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control
- CHME 6051 Chemical Process Engineering and Design
- CHME 6071 Materials Science and Engineering
- CHME 6121 Nanomaterials Science and Engineering
- ENCS 6021 Engineering Analysis

Electives: Up to 8 credits (two courses) from lists 1, 2, or 3 (Core and Electives: 16 credits)

Students may take an elective course outside lists 1, 2, or 3 with permission of the Graduate Program Director.

Students who take a three-credit course towards their course requirement of 16 credits must take the one-credit course CHME 6001 Project in Chemical and Materials Engineering to obtain the missing credit.

ENGR 8901 Master of Applied Science Research and Thesis: 29 credits

<u>Elective Course Lists</u>
List 1:

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2:

- CHME 7911 Topics in Chemical Engineering II
- ENGR 6601 Principles of Solar Engineering
- ENGR 6971 Project and Report I
- MECH 6571 Corrosion and Oxidation of Metals

	• All courses in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering or in List 1 List 3: • Any course(s) in Topic Areas E08 and E09

Rationale:
The introduction of the MASc program is part of the new Chemical and Materials Engineering Department's mandate. The development of the Department and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering.

The purpose of the proposed program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future.

According to Engineers Canada (Canadian Engineers for Tomorrow, 2012; 2015), the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292).

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

It is anticipated that the course offerings will start one year ahead of the degree programs.

The existing ENCS, ENGR and MECH courses have available space to accommodate the additional students. One extra course offering per year will be provided for course ENCS 6021, which is a core course in the program.

Resource Implications:
The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

PROGRAM CHANGE: Topic Area E58

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [X] Requirements [ ] Regulations [ ] Program Deletion [ ] New Program

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	Engineering Courses **------** **List of Courses by Topic Areas** **------** **E58 - CHEMICAL PROCESS ENGINEERING** **CHME 6001 Project in Chemical and Materials Engineering** (1 credit) **CHME 6011 Advanced Transport Phenomena** (4 credits) **CHME 6021 Advanced Chemical Engineering Thermodynamics** (4 credits) **CHME 6031 Chemical Kinetics and Reaction Engineering** (4 credits) **CHME 6041 Chemical Engineering Process Dynamics and Control** (4 credits) **CHME 6051 Chemical Process Engineering and Design** (4 credits) **CHME 6061 Advanced Biochemical Engineering** (4 credits) **CHME 6071 Materials Science and Engineering** (4 credits) **CHME 6081 Advanced Separation Processes** (4 credits) **CHME 6091 Statistics for Chemical Engineering** (4 credits) **CHME 6101 Advanced Battery Materials and Technologies** (4 credits) **CHME 6111 Polymer Chemistry and Engineering** (4 credits) **CHME 6121 Nanomaterials Science and Engineering** (4 credits) **CHME 6131 Advanced Colloid and Interface Science and Engineering** (4 credits) **CHME 6911 Topics in Chemical Engineering I** (4 credits) **CHME 7911 Topics in Chemical Engineering II (4 credits)**

Rationale:
The changes reflect the addition of a new topic area and new courses of the proposed new program.

Resource Implications:
The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

COURSE CHANGE: CHME 6001 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6001 Project in Chemical and Materials Engineering (1 credit) The course consists of an individual project in a chosen area of study in the area of Chemical and Materials Engineering under the supervision of a faculty member. This course may be repeated for credit.

Rationale:
The coursework of the PhD program normally consists of three courses of 4 credits each (12 credits). However, students may take courses in programs or universities (with permission of the Graduate Program Director) where courses are 3 credits. To enable this, students will be required to take this one-credit course to meet their course credit requirements.

Resource Implications:
The course will be taught by existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

Other Programs within which course is listed:

None

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6011 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6011 Advanced Transport Phenomena (4 credits) Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6021 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6021 Advanced Chemical Engineering Thermodynamics (4 credits) Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6031 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6031 Chemical Kinetics and Reaction Engineering (4 credits) Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6041 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6041 Chemical Engineering Process Dynamics and Control (4 credits) Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6051 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6051 Chemical Process Engineering and Design (4 credits) Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6061 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6061 Advanced Biochemical Engineering (4 credits) Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6071 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6071 Materials Science and Engineering (4 credits) Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6081 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6081 Advanced Separation Processes (4 credits) Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6091 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6091 Statistics for Chemical Engineering (4 credits) Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6101 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6101 Advanced Battery Materials and Technologies (4 credits) Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6111 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6111 Polymer Chemistry and Engineering (4 credits) Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6121 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number [ ] Course Title [ ] Credit Value [ ] Prerequisite
[ ] Course Description [ ] Editorial [X] New Course
[ ] Course Deletion [ ] Other - Specify:

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6121 Nanomaterials Science and Engineering (4 credits) Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering.

Resource Implications:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6131 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6131 Advanced Colloid and Interface Science and Engineering (4 credits) Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

Rationale:
TThis course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 6911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6911 Topics in Chemical Engineering I (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-103** VERSION: 11

COURSE CHANGE: CHME 7911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 7911 Topics in Chemical Engineering II (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Theory" and "Tools" learning outcomes in the MASc program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

Proposal

Master of Applied Science in Chemical Engineering

Faculty of Engineering and Computer Science

Concordia University

Executive Summary

Concordia University proposes to offer a new MASc program in Chemical Engineering. The proposed MASc program is expected to draw about 50 students at steady state, and graduate about 20 students per year. It will be complementary to existing programs of this nature in Québec. In particular, the program will be embedded in a multidisciplinary department covering the fields of Chemical and Materials Engineering, and this will give the students a unique, multifaceted outlook on the profession of Chemical Engineering. Currently, eighteen universities in Canada offer the MASc or equivalent in Chemical Engineering, four of which are located in the Province of Québec. Concordia University already has extensive research strength in materials engineering, particularly with applications in the aerospace industry, for instance with the Concordia Centre for Composites, which includes 15 faculty members from multiple departments. The new department and the associated programs will build on these strengths.

The proposed MASc program will contain a minimum of 45 credits. It will consist of four graduate courses (16 credits) and a thesis (29 credits). The course requirement is a combination of core courses, to be selected from a limited list, which is focused on deepening core chemical engineering knowledge (e.g., transport phenomena, chemical thermodynamics and kinetics, reactor design, separation processes, etc.), and non-core courses, focused on broadening knowledge. The thesis research will be supervised by members of the Department of Chemical and Materials Engineering.

Chemical Engineering programs in North America have experienced robust growth at all levels in the past decade, from undergraduate to doctoral. This strong performance indicates that there will be a market for the proposed program across the continent.

The development of a Department of Chemical and Materials Engineering and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering. Hence, the Concordia University leadership committed to the success of the proposed MASc program. Chemical Engineering programs also draw a larger proportion of female students than is average for Engineering. Hence, it is expected that the program will help mitigate the gender imbalance in engineering.

The Department of Chemical and Materials Engineering will consist of three regular faculty members, one joint member and two excluded members (Dean of Graduate Studies, VP Research & Grad studies) as of January 2018, and an average of two more faculty recruitments are anticipated per year until the faculty count reaches 15 members. This will ensure that there will be a critical mass for the delivery of the program at the time of its planned start in Fall 2019. The first graduates are anticipated in 2021.

Table of Contents

Section 1 PROGRAM IDENTIFICATION

1.1 Program title, degree title and level

Program title: Master of Applied Science (MASc)
Degree: Chemical Engineering
Level: Graduate

1.2 Areas of specialization

Chemical Engineering; Chemical Thermodynamics; Chemical Kinetics; Transport Phenomena; Chemical Reactor Engineering; Materials Engineering; Polymer Engineering; Electrochemical Engineering.

1.3 Administrative location

University: Concordia University
Faculty: Faculty of Engineering and Computer Science
Department: Department of Chemical and Materials Engineering
Address: 1455 de Maisonneuve Blvd. W
Montreal, Québec, H3G 1M8
Canada

SECTION 2 PROGRAM OBJECTIVES

2.1 Theoretical Foundation and General Academic Aims

Chemical Engineering is the application of chemical and engineering principles to the design and operation of industrial units for the manufacture of chemicals. This includes the manufacture of bulk chemicals (e.g., oil refinery products, fertilizers, plastics), fine chemicals (e.g., pharmaceuticals), metals, etc. It also includes the production of chemicals by micro-organisms (e.g., fermentation, brewing), and the conversion of biomaterials into chemicals (e.g., bio-oil, biodiesel). An emerging field of application for chemical engineers is new materials (nanomaterials, composites). Chemical engineers are responsible for the design and operation of safe and environmentally responsible processes.

Chemical engineers are primarily trained to be designers of chemical processes, but they also work in the operation and control of chemical processes, and in the research and development of new chemical processes.

Chemical engineers are closely related to Materials engineers. However, whereas the materials engineer is mainly focused on the *product*, the chemical engineer is mainly focused on the *process*. The proximity of the fields of chemical and materials engineering provides opportunities for cross-fertilization. The intention of the proposed program is to train chemical engineers with a solid grasp of the materials aspects of their profession. The training will be embedded in a research environment that is strong on materials engineering research.

Industrial chemical processes are generally built from unit operations, i.e., operations that carry out a single step of the overall process. Each unit operation is based on physical and chemical principles. This approach is mirrored in chemical engineering (undergraduate) programs. The program starts with mathematics, physics, and chemistry and then moves on to engineering sciences such as general and chemical thermodynamics, material balances, mass and heat transfer, fluid mechanics, and chemical kinetics. This is followed by the study of unit operations: pumps, compressors, filters, reactors, distillation towers, etc. Next, the dynamics and control of chemical processes is covered, and the program is concluded with chemical process design, where all the obtained knowledge is integrated, and augmented with heuristics for the design of chemical plants. At the graduate level, students deepen their expertise in these areas with additional courses. In the case of a thesis-based graduate program, students deepen their knowledge further in a chosen area of research, and conduct original research in this area.

Chemical engineers are excellent system-wide thinkers. Hence, many chemical engineers find employment in sectors unrelated to chemical industry (management, banking, policy, etc.). Their training and skills often complement those of economists and managers.

Historically, the chemical engineering profession started as a largely empirical endeavor, where the design of chemical processes was mainly based on experience obtained with previous designs. This largely trial-and-error approach made way for a more rigorous, science-based approach in the mid-20th century. This relatively late development is largely owing to the fact that many chemical processes are highly nonlinear, and do not lend themselves well to linear engineering analysis. Hence, a scientific approach to chemical engineering is largely based on computer simulations, and this numerical approach has developed in lockstep with the development of ever faster and more powerful computers since the mid-20th century. Nevertheless, even the most powerful computer systems cannot resolve all aspects of every chemical process, and empiricism (rules of thumb) remains an important aspect of chemical engineering practice. It is the intention of the proposed program to provide contemporary tools of chemical process simulation to the students, without losing sight of the empirical, experience-based aspects of chemical engineering.

The purpose of the proposed MASc program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future. Based on the needs, the proposed MASc program will emphasize the materials engineering aspects of Chemical Engineering.

2.2 Specific knowledge, expertise, skills (learning outcomes) which students will acquire

By the end of this program, successful students will be able to do the following:

- **Research Methods:** Think critically, interpret the literature, plan and apply a range of research methodologies to accomplish research objectives in novel ways.
- **Theory:** Apply and analyze chemical engineering concepts to solve industrially relevant research problems.
- **Tools:** Use and develop chemical engineering tools that are relevant in an industrial setting.
- **Dissemination:** Use oral and written communication to effectively disseminate research and other technical concepts, publishable in high quality journals, conferences, and practitioner events.
- **Original scholarship:** Produce quality original research in an area of chemical engineering.

2.3 Description of how the learning outcomes will be assessed

The learning outcomes that are assessed in the MASc have the following requirements. They are linked in Table 1:

- **Coursework:** Four courses that help the student develop specific skills needed to conduct research and understand industrial software engineering.
- **Master Thesis:** Produce an original piece of chemical engineering scholarship that is publishable in a high quality chemical engineering venue.

Table 1. Mapping Program Requirements with Learning Outcomes

	Program Requirements		
Learning outcomes		Coursework	Master Thesis
	Research Methods	Major	Major
	Theoretical	Major	Major
	Tools	Major	Major
	Dissemination		Major
	Original Scholarship		Major

SECTION 3 RATIONALE FOR PROGRAM PROPOSAL

3.1 Socio-economic or cultural relevance

3.1.1 Detailed needs analysis, including projected student enrolment: Enrolment chart, including graduation and attrition, with justifications and explanations (projected for a five-year period)

According to data from the American Society for Engineering Education (ASEE), the number of students graduating with a Bachelor's degree in Chemical Engineering in the United States has increased from 4452 in 2006 to 9090 in 2015 [Yoder, B.L. *Engineering by the Numbers*. ASEE, 2015], an increase by 104 % in one decade. As a proportion of engineering students graduating with a Bachelor's degree in Chemical Engineering, the Chemical engineering program has gained popularity, from 6.0 % in 2006 to 8.5 % in 2015. In Canada, the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292) during the same time [Engineers Canada, *Canadian Engineers for Tomorrow*, 2012; 2015].

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The number of Master and PhD graduations in Chemical Engineering in the United States has also increased substantially: from 1204 to 1716, or 42 % from 2006 to 2015 for Master students, and from 834 to 1062, or 27 % for PhD students. In Canada, the graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The MASc (and PhD) programs will ramp up slowly because the faculty members who will supervise the students will be recruited over a 6-year time span. For that reason, a time window up to Year 8 is considered in the analysis.

The enrollment projections for the MASc program are given in the table below. Year 1 corresponds with Fall 2019.

Table 2 Graduate enrollment projections for the MASc program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
MASc	5	14	21	28	34	41	48	51

In this projection, a recruitment rate of 1.8 students per faculty member per year, a retention of two years, and an attrition rate of 10 % per year is assumed. These numbers are consistent with other engineering programs at Concordia University. At steady state, there will be 238 students in the various graduate programs in Chemical Engineering (including Certificate and Diploma), of which 208 will be in full degree programs (MEng, MASc, PhD), and 51 in the MASc.

The MASc program is assumed to be a 2-year program for the calculation of the graduation projections, given below.

Table 3 Graduation projections for the MASc program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
MASc			4	7	10	13	16	19

At steady state, there will be 22 graduations per year in the MASc program, out of a total of approximately 100 graduations in Chemical Engineering graduate programs.

3.1.2 Identification of the main prospects for graduates from the program (employment, self-employment, creativity opportunities, career mobility, advanced education)

Chemical Engineers are employed in the chemical industry, in consulting, and in government. Other sectors often require chemical engineers for their specific expertise. Examples are insurance companies, banks, etc.

During their MASc program, students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. They will learn to work independently, and to plan, carry out, and report a research project.

Alumni who have completed the MASc program will have opportunities to find jobs beyond the level available to Bachelor-level engineers. They will find jobs in consulting, and in R&D labs in government and industry. They will take up or grow into positions that require more independence and critical thinking than Bachelor-level engineers, and be involved in innovation in the organizations that employ them.

3.1.3 Importance of the sector affected by the proposed program to professional orders, private or public organizations, or government departments

In Canada, the GDP for chemical manufacturing and related sectors (plastics and rubber, nonmetallic mineral products, paper) amounts to CAN$37 billion, which is over 20 % of all manufacturing sectors in Canada (Statistics Canada).

In Quebec there is a strong presence of chemical industry, in areas such as pharmaceuticals, oil refining, etc.

3.1.4 Existence of similar programs in Canada or elsewhere, their academic success; similarities and differences with the proposed program; how will the proposed program help bring the Province of Québec up to par with the Canadian or International level; or how will the new program help the Province become a leader in this area of specialization

Canada currently offers Chemical Engineering programs at 20 universities (18 at the graduate level). Four of these (McGill University, École Polytechnique, Université Laval and Université de Sherbrooke) are located in the Province of Québec. As a comparison, Ontario offers Chemical Engineering programs at ten universities (eight at the graduate level). Hence, in terms of numbers of universities, Chemical Engineering is currently underrepresented in the Province of Québec. An overview of graduate programs in Chemical Engineering and related fields is given below. The enrollment and graduation numbers are for 2014 [Engineers Canada. *Canadian Engineers for Tomorrow*, 2014].

Where the proposed MASc program will be different from the existing programs in the Province of Québec is in the level of integration between the Chemical Engineering graduate programs and Materials Engineering research as a driver for the program. Concordia University has prior experience with this strategy in the Department of Mechanical, Industrial, and Aerospace Engineering (MIAE), where Materials Engineering is a significant driver of the Mechanical Engineering and Aerospace Engineering programs. Of particular note is the Concordia Centre for Composites (CONCOM), which houses 15 faculty members and a total of 50 members.

Some key members of CONCOM and MIAE who can contribute to the new department are Dr. Suong Van Hoa, director of CONCOM, who conducts research in polymer nanocomposites with applications in the aerospace industry; Dr. Mamoun Medraj, who conducts research in thermodynamic modeling of phase diagrams relevant for composite materials, and Dr. Nabil Esmail, who conducts research in rheology and surface phenomena of fluids. Dr. Paula Wood-Adams, who will transfer to the Department of Chemical and Materials Engineering, is also a member of CONCOM.

In addition, collaborative research is anticipated with faculty members in the Department of Chemistry and Biochemistry. For instance, Dr. John Oh, also a member of CONCOM, conducts research in macromolecular nanoscale biomaterials.

Faculty members in these and other departments who provide significant and lasting contributions to the proposed programs will be appointed as associate members of the Department of Chemical and Materials Engineering. They will augment the research and graduate student supervision of the core members of the Department of Chemical and Materials Engineering. This broad range of expertise will enable the department to provide knowledge from the molecular scale to the scale of the industrial processes to manufacture materials.

Québec

<u>McGill Universtiy</u>

Degrees offered:	PhD MEng (thesis) MEng (non-thesis) Graduate Diploma
Programs offered:	Chemical Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining and Materials Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1
Master graduations:	12
PhD graduations:	11

<u>École Polytechnique</u>

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based

	Diplôme d'études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD, M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD, M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD, M.(rech.), M.(prof.))
	Procédés	(PhD, M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD , M.(rech.), M.(prof.))
	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	
Master graduations:	23	
PhD graduations:	20	

<u>Université Laval</u>

Degrees offered:	Maîtrise avec mémoire (MSc)
	Doctorat
Programs offered:	Génie chimique
	Génie des matériaux et de la métallurgie
Specializations:	-
Full-time enrollment:	68
Part-time enrollment:	0
Master graduations:	8
PhD graduations:	9

<u>Université de Sherbrooke</u>

Degrees offered:	Maîtrise	(thesis-based)
	Maîtrise de type cours	
	Doctorat	
Programs offered:	Génie chimique	
Specializations:	-	
Full-time enrollment:	65	
Part-time enrollment:	0	
Master graduations:	11	
PhD graduations:	7	

Ontario

<u>University of Toronto</u>

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering and Applied Chemistry	(all)
	Materials Science and Engineering (all)	

	Collaborative program in Environmental Studies (all)
	Collaborative program in Biomedical Engineering (MASc, PhD)
	Collaborative program in Cadriovascular Sciences (MASc, PhD)
	Collaborative program in Engineering Education (MASc, PhD)
	Collaborative program in Environmental Engineering (MASc, PhD)
	Collaborative program in Genome Biology and Bioinformatics (MASc, PhD)
	Collaborative program in Global Health (MASc, PhD)
Specializations:	Advanced Water Technologies and Process Design (MEng)
	Entrepreneurship, Leadership, Innovation and Technology in Engineering (MEng)
	Sustainable Energy (all)
	Advanced Manufacturing (MEng)
Full-time enrollment:	217
Part-time enrollment:	12
Master graduations:	50
PhD graduations:	15

<u>Ryerson University</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering
Specializations:	-
Full-time enrollment:	27
Part-time enrollment:	2
Master graduations:	11
PhD graduations:	4

<u>University of Ottawa</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
	Graduate Diploma
Programs offered:	Chemical Engineering (MASc, MEng, and PhD,)
	Advanced Materials and Manufacturing (MASc, MEng, and PhD,)
	Technology Project Management (Diploma)
Specializations:	-
Full-time enrollment:	94
Part-time enrollment:	6
Master graduations:	51
PhD graduations:	5

<u>Queen's University</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering

	Collaborative degree in Applied Sustainability (MEng, MASc)
	Collaborative degree in Biomedical Engineering (MASc, PhD)
Specializations:	-
Full-time enrollment:	78
Part-time enrollment:	1
Master graduations:	19
PhD graduations:	10

<u>Royal Military College</u>

Degrees offered:	Master	(thesis-based)
	PhD	
Programs offered:	Chemical and Materials Engineering	
	Nuclear Engineering	
Specializations:	-	
Full-time enrollment:	28	
Part-time enrollment:	8	
Master graduations:	6	
PhD graduations:	3	

<u>McMaster University</u>

Degrees offered:	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	86	
Part-time enrollment:	2	
Master graduations:	18	
PhD graduations:	2	

<u>University of Waterloo</u>

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	184	
Part-time enrollment:	19	
Master graduations:	57	
PhD graduations:	22	

<u>Western University</u>

Degrees offered:	MEng	(course-based)
	MESc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	

Full-time enrollment: 153
Part-time enrollment: 4
Master graduations: 37
PhD graduations: 15

Laurentian University
No graduate programs in Chemical Engineering. The following are the closest graduate degrees offered:
MEng Natural Resources Engineering
MASc Natural Resources Engineering
PhD Materials Science
PhD Natural Resources Engineering

Lakehead University
No graduate programs in Chemical Engineering. The following is the closest graduate degree offered:
MSc Environmental Engineering

Atlantic Provinces

Dalhousie University

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	19	
Part-time enrollment:	0	
Master graduations:	4	
PhD graduations:	0	

University of New Brunswick

Degrees offered:	MEng	(course-based)
	MScE	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	45	
Part-time enrollment:	7	
Master graduations:	14	
PhD graduations:	4	

Western Canada

University of Saskatchewan

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
Specializations:	-	
Full-time enrollment:	33 (Chemical Engineering)	
Part-time enrollment:	0	
Master graduations:	2	
PhD graduations:	1	

University of Calgary

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Petroleum Engineering	
Specializations:	-	
Full-time enrollment:	246	
Part-time enrollment:	6	
Master graduations:	89	
PhD graduations:	34	

University of Alberta

Degrees offered:	MEng	(course-based)
	MSc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
	Process Control	
Specializations:	-	
Full-time enrollment:	239	
Part-time enrollment:	0	
Master graduations:	51	
PhD graduations:	18	

University of British Columbia

Degrees offered:	MEng	(course-based)
	M.E.L.	(course-based; Master of Engineering Leadership)
	M.Sc.	(thesis-based, for students with a science background)
	MASc	(thesis-based, for students with an engineering background)
	PhD	
Programs offered:	Chemical and Biological Engineering (MEng, MSc, MASc, PhD)	
	Clean Energy Engineering (M.E.L.)	
	Green Bio-Products (M.E.L.)	
	Integrated Water Management (M.E.L.)	

	Materials Engineering (MEng, MSc, MASc, PhD) Advanced Materials Manufacturing (M.E.L.)	
Specializations:	-	
Full-time enrollment:	188	(“Biosystems”; may include programs other than the ones listed)
Part-time enrollment:	0	
Master graduations:	23	
PhD graduations:	15	

3.2 Systemic relevance

3.2.1 Existence of similar programs in the Québec university system, their enrolments; complementarity of this proposed program with other similar programs including those at college level; specific contribution of proposed program within the Quebec context; how it compares to existing programs

An overview of similar programs in the Province of Québec as well as other provinces is shown in Section 3.1.6. Chemical Engineering graduate programs are offered at McGill University, École Polytechnique, Université Laval, and Université de Sherbrooke.

Thesis-based Master programs in Chemical Engineering are offered by McGill University, École Polytechnique, Université Laval, and Université de Sherbrooke.

Research at McGill University focuses on advanced materials and polymers, biomedical engineering and biotechnology, energy, environmental engineering, and plasma science and engineering. Among these areas, biological chemical engineering is the dominant theme.

Research at École Polytechnique focuses on polymers, biopharmaceutical engineering, process engineering, environmental engineering and sustainable development, and pulp and paper.

Research at Université Laval focuses on catalysis, biochemical engineering, environmental engineering, polymer engineering, modeling, computer simulation and process engineering, and rheology.

Research at Université de Sherbrooke has a strong focus on environmental engineering and related areas (biotechnology, fuel cells, water and air treatment, waste management). Other research areas are nanotechnology, and chemical process development.

Biological and environmental chemical engineering are the dominant themes in Chemical Engineering graduate programs in Québec. Materials engineering research is conducted at these department, but is not the dominant theme. The proposed program will be complementary to the existing programs because it will have a stronger focus on materials engineering, not as a separate research area but deeply embedded in chemical engineering. Some of the existing strengths at Concordia University in this area were discussed in Section 3.1.4.

Details of the programs discussed are in Appendix 1.

3.2.2 Foreseeable links to related programs; potential collaborations between professors in the new program and related ones in other institutions

The proximity of McGill University and École Polytechnique to Concordia University creates favorable conditions for collaborations with professors in these institutions. Furthermore, there is a history of collaboration between engineering professors at these three universities.

3.3 Institutional relevance

3.3.1 Status of the discipline at Concordia; how the proposed program fits into the overall set of programs offered by the university (including undergraduate programs); in the same field, related fields, sector of education concerned; enrolment trends and graduates in related programs; impact of enrolments in related fields within the University

The programs most related to the proposed new programs are the Mechanical Engineering program in the Department of Mechanical and Industrial Engineering, and the Environmental Engineering specialization in the Department of Building, Civil, and Environmental Engineering.

Chemical Engineering is the only major engineering discipline that is currently missing in the Engineering program offerings at Concordia University. Hence, the development of Chemical Engineering programs fits in Concordia University's objective to become a more comprehensive university. Nearly all Engineering programs at Concordia University have grown rapidly in recent years. The number of full-time graduate students at Concordia University in all engineering fields combined increased from 1677 in 2012 to 2184 in 2016. Of these, full-time enrollments increased from 355 to 514 in Civil Engineering, and from 295 to 371 in Mechanical Engineering (not including Industrial Engineering). The demand exceeds the enrollments, so it is anticipated that the addition of Chemical Engineering programs will not affect the enrollments in other programs.

3.3.2 Research and development performance of the university in the field of study of the proposed program where advanced degrees are concerned. Research grants obtained and sources of funding

Because the department is new, all faculty members are new, or were transferred from other departments or universities. Table 4 below reflects a recent history of research grants obtained by faculty members in their original department/institution, and the sources of funding

Table 4 Recent research grants obtained by faculty members contributing to the proposed program.

Faculty member	Project Name	Grant/Source
Alex De Visscher	Tier II Canada Research Chair in Air Quality and Pollution Control Engineering ($500,000)	CRC
Alex De Visscher	Ultrasound-assisted Peroxone, a novel air pollution control technique ($145,000)	NSERC Discovery Grant
Alex De Visscher	New modeling algorithms for Eulerian air dispersion models ($30,000)	University of Calgary Faculty Research Grant

Alex De Visscher	Thermodynamic Data Research ($17,000)	Zandmer Fund Research Grant
Alex De Visscher	Photolytic degradation of BTEX from the oil and gas industry (200,000)	Petroleum Technology Alliance of Canada, AUPRF Grant
Zhibin Ye	Tier II Canada Research Chair in Polymer Nanomaterials ($500,000)	CRC
Zhibin Ye	Enhanced characterization infrastructure for Canada Research Chair in Polymer Nanomaterials ($166,224)	CFI John R. Evans Leaders Fund
Zhibin Ye	Developing semicrystalline star polyethylenes and advanced polyethylene ionomers ($200,000+$120,000)	NSERC Discovery Grant and Accelerator Supplement
Zhibin Ye	Developing fluorinated polymer composites for sulfur adsorption in medium temperature pressure oxidation of gold ores and tailings ($223,486)	NSERC CRD Grant
Zhibin Ye	I2I market assessment of a carbon nanosphere technology ($20,000)	NSERC I2I Grant
Zhibin Ye	Developing iron oxide/carbon nanocomposite adsorbents for arsenic removal from gold mine effluents ($54,250)	NSERC ENGAGE and NSERC ENGAGE PLUS
Paula Wood-Adams	The structure and dynamic properties of polymers at interfaces ($170,500)	NSERC Discovery Grant
Paula Wood-Adams	Mechanism of haze formation of LLDPE/LDPE blends and their relationships to fundamental rheological properties ($22,000)	Dow Chemical, Operating Grant
Paula Wood-Adams	Characterization of damage related mechanical properties of thin polymer films on hard substrates ($22,000)	Taiho Kogyo Tribology Research Foundation, Operating Grant
Paula Wood-Adams	Nanoindentation of polymer films on aluminium ($6,090)	Novelis Inc., Contract
Paula Wood-Adams	Rheology and interfacial phenomena of highly filled polypropylene-ethylene co-polymers ($64,000)	NCERC CRD Grant
Paula Wood-Adams	Polymer interfaces: Structures and properties (150,000)	Concordia Research Chair
Rolf Wüthrich	Developing novel electrochemical advanced manufacturing technologies ($50,000)	Special Grant, Concordia University
Rolf Wüthrich	Novel technologies for glass micro-machining by glow discharge electrolysis ($160,000)	Contract, Postalux SA
Rolf Wüthrich	Electrochemical manufacturing technologies for Industry 4.0 ($185,000+$120,000)	NSERC Discovery Grant + Accelerator Supplement
Rolf Wüthrich	Développent de catalyseurs sans platine pour la production électrochimique de l’hydrogène en utilisant des nano-particules de nickels à facettes ayant des index de Miller élevés ($205,000)	FQRNT grant, Recherche partenariat

3.3.3 Collaboration with other departments within Concordia

The newly created Department of Chemical and Materials Engineering was incubated in the Department of Mechanical and Industrial Engineering, and a substantial amount of collaboration is anticipated with this department. Research groups of particular interest are the group of Dr. M. Medraj (phase behavior of materials), Dr. C. Moreau (thermal coating techniques), Dr. M. Packirisamy (MEMS, microfluidics), as well as others. Research groups of potential interest in the Department of Building, Civil, and Environmental Engineering include Dr. S. Rahaman (chemical remediation techniques) and Dr. A. Athienitis (solar energy engineering). At the Centre for Engineering in Society, Dr. K. Schmitt (public policy) is a faculty member of interest. Potential collaborations with the Concordia Centre for Composites (CONCOM) were already discussed in Section 3.1.4.

Outside the Faculty of Engineering and Computer Science, collaborations are anticipated with the Department of Chemistry and Biochemistry, whose Department Chair, Dr. C. DeWolf, has degrees in Chemical Engineering. To foster these collaborations, the new department will be given space in the Loyola campus with the next building project, to be shared with faculty members from the Department of Chemistry and Biochemistry.

The Department of Chemical and Materials Engineering has a steering committee consisting of key faculty members from various departments in the Faculty of Engineering and Computer Science, and the Faculty of Arts and Science. This committee forms the basis for future collaborations between departments. The membership of the steering committee is given in Appendix 6.

3.3.4 Current standing of the department and the discipline in Quebec and the rest of Canada

Because the department is newly created, its standing is the standing of the academics hired or transferred to the department.

The discipline of Chemical Engineering is well established in Quebec and Canada, with 20 academic programs in Canada, and 4 in Quebec.

3.3.5 How does the proposed program align with the Faculty's and University's academic plans

The development of the MASc program in Chemical Engineering is a direct consequence of the establishment of the Department of Chemical and Materials Engineering, and aligns with the Strategic Plan, *Nine Directions for a Next-Generation University*. In particular, the cross-institutional strategy for Direction 1, Double our Research, specifically mentions building research capacity in Chemical and Materials Science and Engineering. To bring this plan to fruition, it is necessary to offer the MASc program proposed here, to draw strong graduate students in this area, and to train them adequately for research in the area.

The program will be embedded in a modular Certificate – Diploma – Master structure that aligns well with the Teach for Tomorrow direction in the Strategic Plan. It is a contemporary approach to graduate studies, more in tune with the ideal of lifelong learning than the traditional program structure, as it allows professionals to return to university, and take on graduate studies at their own pace, while they are professionally employed. It is also a way to “streamline and transform” as expressed in Direction 6: Grow Smartly.

The Montreal area has a large demand for Chemical and Materials Engineers, in the chemical and pharmaceutical industry, food and beverage industry, and in companies supplying the aerospace industry (composites). Hence, the proposal is aligned with Direction 7: Embrace the City, Embrace the World.

Section 4 PROGRAM DESCRIPTION AND REQUIREMENTS

4.1 Admission Requirements

4.1.1 General and specific admission requirements

General requirements

Applicants to Concordia University must meet the minimum university requirements to be considered for admission.

Academic Requirements (to be edited per program)

To be considered for admission to Master-level studies, the applicant must have a bachelor's/baccalaureate degree (or equivalent) in engineering or the sciences with high standing (e.g., with honours, or the Concordia equivalent of a GPA of at least 3.00 on a scale of 4.30).

Language Proficiency Requirements

The language of instruction at Concordia is English.

A student whose primary language is not English must write a pre-admission proficiency test, if not exempted as indicated below. Test results must be reported directly to the Admissions Application Centre by the test centre. Results more than two years old will not be accepted as proof of language proficiency.

Proof of proficiency in English must be provided by achieving the appropriate score on one of the following:

- Test of English as a Foreign Language (TOEFL): The minimum acceptable score for the internet-based TOEFL (TOEFL iBT) is 85 and no part under 20.
- The minimum required score for the paper-based TOEFL is 563.
- International English Language Testing System (IELTS): The minimum band score for IELTS is 6.5 and no part under 6.5.

In all cases, Concordia reserves the right to require proof of English proficiency when such proof is deemed necessary. Concordia will accept test results for the paper-based TOEFL if they are less than 2 years old.

Applicants whose primary language is not English, regardless of citizenship, may be exempted from the proficiency test if they meet one or more of the following requirements:

- A minimum of three full years of study either at the undergraduate or graduate level in an institution where the sole language of instruction is English;
- Quebec applicants, the completion of a Diploma of Collegial Studies (DEC) and a university degree in Quebec

In addition to the general admission requirements, the Faculty may require applicants to write the Engineering Writing Test (EWT) as a condition of admission to all graduate programs in Engineering and Computer Science. Depending on the result, students may be required to complete remedial English language courses in addition to their program requirements.

The Engineering Writing Test examines students' ability to provide reasoned assessment of a short technical composition in English or French, and their ability to provide a qualitative account of quantitative or graphically presented data. The test is offered a number of times throughout the year. Based on their performance in the test, students may be asked to take remedial courses.

Program-specific admission requirements

- An undergraduate degree in engineering or the sciences;
- Students whose undergraduate degree is not chemical engineering will be assessed on a case-by-case basis, and may be required to take additional courses, including the bridge course CHME 401: Principles of Chemical Engineering, and/or others. The Graduate Program Director determines the additional course loads;
- Credible academic reference letters;
- A Statement of Purpose

4.1.2 Selection procedures

The selection is made by the Department Graduate Studies Committee, upon nomination of the prospective supervisor.

4.2 Academic activity

4.2.1 Degree requirements

Credits: Fully qualified students are required to complete a minimum of 45 credits. With permission of the supervisor, students who have completed a Certificate or a Diploma in Chemical Engineering at Concordia University with a GPA of 3.0 or better may be able to complete an MASc in Chemical Engineering by completing a minimum of 29 credits. Only Certificate or Diploma courses where a grade of B or better was obtained can be used for credit in the MASc in Chemical Engineering.

Residence: The minimum residence requirement for the Master's degree is 3 terms (one year) of full-time study, or the equivalent in part-time study. This requirement must be met regardless of the amount of graduate work previously completed in any other program or at any other university.

Time limit: All work for a master's degree for full-time students must be completed within 9 terms (3 years) from the time of initial registration in the program; for part-time students the time limit is 15 terms (5 years).

Students transferring from a PhD to Master's in a similar area of research are granted a time limit based on the expected completion (4 years), less the number of years spent in the PhD program, or 2 years, whichever is greater; or the equivalent for part-time study.

Students transferring from a Diploma to a Master's in a similar area of study are granted a time limit of 3 years, less the number of years in the Diploma; or the equivalent for part-time study.

4.2.2 Program schedule; Core and elective courses

All courses are 4 credits each unless indicated otherwise.

Core: at least 8 credits (two courses) from the following list:

- CHME 6011 Advanced Transport Phenomena
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control
- CHME 6051 Chemical Process Engineering and Design
- CHME 6071 Materials Science and Engineering
- CHME 6121 Nanomaterials Chemistry and Engineering
- ENCS 6021 Engineering Analysis

Electives: up to 8 credits (two courses) from lists 1 or 2 or 3 (Core + Electives 16 credits)

Students may take an elective course outside lists 1, 2, or 3, with permission of the Graduate Program Director.

Students who take a three-credit course towards their course requirement of 16 credits must take course CHME 6001, Project in Chemical and Materials Engineering.

ENGR 8901 Master of Applied Science Research and Thesis: 29 credits

<u>Elective Course Lists</u>

List 1

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2

- CHME 7911 Topics in Chemical Engineering II
- ENGR 6601 Principles of Solar Engineering
- ENGR 6971 Project and Report I
- MECH 6571 Corrosion and Oxidation of Metals
- All courses in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering, or in List 1

List 3

- All courses in Topic Areas E08 and E09

Note: A list of courses in Topic Areas E03, E04, E07, E37, and E57 (List 2), and of Topic Areas E08 and E09 (List 3) is given in Appendix 7.

4.2.3 Number of credits per term (part- and/or full-time) to allow students to meet program objectives; timeline to completion

The normal time to completion for MASc students is six terms (two years). The maximum time to completion is nine terms (three years) for full-time students, and fifteen terms (five years) for part-time students.

The following is the recommended timeline for full-time MASc students:

- Month 1-8: Courses, preparation of research, literature review
- Month 9-20: Full-time research
- Month 21-24: Write-up and defense of thesis

4.2.4 Proposed Chemical Engineering course descriptions

Project course (1 credit, graduate)

CHME 6001 Project in Chemical and Materials Engineering (1 credit)

The course consists of an individual project in a chosen area of study in the area of Chemical and Materials Engineering under the supervision of a faculty member. This course may be repeated for credit.

Core courses (4 credits, graduate)

CHME 6011 Advanced Transport Phenomena

Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

CHME 6021 Advanced Chemical Engineering Thermodynamics

Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

CHME 6031 Chemical Kinetics and Reaction Engineering

Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

CHME 6041 Chemical Engineering Process Dynamics and Control

Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

CHME 6051 Chemical Process Engineering and Design

Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

CHME 6071 Materials Science and Engineering

Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

CHME 6121 Nanomaterials Chemistry and Engineering

Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Elective courses

CHME 6061 Advanced Biochemical Engineering

Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

CHME 6081 Advanced Separation Processes

Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

CHME 6091 Statistics for Chemical Engineering

Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

CHME 6101 Advanced Battery Materials and Technologies

Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

CHME 6111 Polymer Chemistry and Engineering

Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes;

polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

CHME 6131 Advanced Colloid and Interface Science and Engineering

Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

CHME 6911 Topics in Chemical Engineering I

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

CHME 7911 Topics in Chemical Engineering II

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

4.2.5 Intellectual atmosphere (conferences, symposia)

Seminars will be held at least monthly, where leading researchers from across Canada and in all fields of chemical engineering will be invited to present their research. PhD students will be required to attend the seminars, and all other graduate students will be encouraged to attend as well.

Once per year a graduate student symposium will be organized, where students will have the opportunity to present their work in front of their peers, in oral and poster presentations.

Section 5 FACULTY RESOURCES; OTHER HUMAN RESOURCES; MATERIAL RESOURCES: Resource implications of the program

5.1 Faculty Resources (Qualifications and scholarly output)

5.1.1 Qualifications of individual professors: degrees, experience, summary of faculty achievements (previous five years) including: (i) publication in peer-reviewed journals; (ii) experience acquired supervising masters' and doctoral students and post-doctoral fellows, participation on thesis juries

The qualifications of faculty members are summarized below. More detailed CVs are given in Appendix 5. Two additional faculty members will be hired every year during the introduction of this program.

Alex De Visscher, Professor

Dr. De Visscher was trained in Chemical Engineering and Environmental Engineering at Ghent University, Belgium. He obtained his PhD in 2001. He held a faculty position at the University of Calgary from 2005 until 2016. In 2005-2015 he held a Tier II Canada Research Chair in Air Quality and Pollution Control Engineering. From 2014 until 2016 he was Associate Head Graduate (Graduate Program Director) of the Department of Chemical and Petroleum Engineering. During his Sabbatical Leave in 2011-2012 he was Visiting Professor at the Institute of Technical Chemistry in the Technical University Bergakademie Freiberg, where he wrote an academic textbook on Air Dispersion Modeling, which was published by Wiley. He also wrote and self-published an academic textbook on Chemical Engineering Kinetics and Chemical Reactor Design. Dr. De Visscher published over 50 peer-reviewed journal articles, 12 over the past 5 years. He currently supervises four PhD students and has graduated seven graduate students over the past five years. He has participated in more than 100 thesis juries. Over the last five years he was involved in 10 candidacy exams, 13 PhD final exams, and 30 MSc final exams. His areas of research include kinetics and catalysis, transport phenomena, environmental chemical engineering, solution thermodynamics and solubility.

Zhibin Ye, Professor

Dr. Ye obtained his Bachelor and Master degrees in Chemical Engineering at Zhejiang University, China, and his PhD in Chemical Engineering at McMaster University in 2004. He held a faculty position at Laurentian University from 2004 until 2017. From 2011 until 2017 he held a Tier II Canada Research Chair in Polymer Nanomaterials. During his Sabbatical Leave he was a Visiting Associate Professor in the Department of Chemistry at the University of Illinois at Urbana-Champaign. Dr. Ye published 75 peer-reviewed journal papers, 28 in the past five years. He currently supervises two research associates and two graduate students, and he has graduated six graduate students in the past five years. He also supervised several postdoctoral fellows. His areas of research include polymer engineering and polymer reactor engineering, nanotechnology and nanocomposites.

Paula Wood-Adams, Professor

Dr. Wood-Adams obtained her Bachelor's degree in Chemical Engineering at University of Alberta, and her Master's and PhD degrees in Chemical Engineering at McGill University. She has held a faculty position at Concordia University since 2001. She is Dean of the School of Graduate Studies (2013-present), and was Interim Dean in 2012-2013. She was Associate Dean of the School of Graduate Studies in 2010-2012, and Graduate Program Director of Mechanical and Industrial Engineering from 2006 until 2010. In 2006 she was Visiting Professor of Chemical Engineering at Kasetsart University, Bangkok, Thailand. Dr. Wood-Adams holds many other leadership positions, such as Director in the John Abbott College Board of Governors, Director in the Jeanne Sauvé Foundation Board of Directors, and Vice President of L'Association des doyens des études supérieures au Québec. She also held a Director position in the Canadian Association for Graduate Studies Board of Directors from 2013 until 2015. Dr. Wood-Adams published over 50 peer-reviewed journal papers, 17 in 2012-2016. She currently supervises three PhD students and has graduated eight graduate students in the past five years. Her fields of research include polymer engineering, composites and nanocomposites.

Xiaolei Wang, Assistant Professor

Dr. Wang obtained his Bachelor's and Master's degree in Chemical Engineering at Dalian University and Tianjin University, respectively, and his PhD in Chemical and Biomolecular Engineering at the University of California at Los Angeles. He held a postdoctoral fellowship at the University of Waterloo from 2013 until 2017. Dr. Wang published 33 peer-reviewed journal papers, 26 in the past five years. His areas of research include nanotechnology, electrical energy storage materials, electrochemical engineering, electrocatalysis.

Rolf Wüthrich, Associate Professor (joint appointment with Department of Mechanical, Industrial, and Aerospace Engineering)

Dr. Wüthrich obtained his Master's degree in Particle Physics and his PhD in Microtechnology and Manufacturing at the École Polytechnique Fédérale de Lausanne. After two postdoctoral positions at the same insititution, he joined Concordia University in 2006. In 2015 he took a one-year leave to set up the R&D department of Posalux SA. He conducts research in the areas of electrochemistry and advanced manufacturing, particularly in the areas of spark assisted chemical engraving, electropolishing, electrocatalysis, gas evolving electrodes, and plasma electrolysis. Dr. Wüthrich was a member of the steering committee that set up the Department of Chemical and Materials Engineering. Dr. Wüthrich published about 50 peer-reviewed journal papers, 24 in 2012-2016.

Publications in Peer-Reviewed Journals

Faculty Name	2012	2013	2014	2015	2016	Total
Alex De Visscher	3	4	3	0	2	12
Zhibin Ye	6	9	5	5	2	27
Paula Wood-Adams	4	2	5	3	3	17
Xiaolei Wang	4	4	2	9	7	26
Rolf Wüthrich	2	7	4	5	6	24

Supervision of Master and Doctoral Students and Post-Doctoral Fellows

Faculty Name	Student (Degree)	Year
Alex De Visscher	Chongchong Wu (PhD)	In Progress
	Michael Süß (PhD)	In Progress
	Mehrshad Parchei Esfahani (PhD)	In Progress
	Vahid Asili (PhD)	In Progress
	Ali Shafaghat (MEng thesis)	2016
	Farshid Shayganpour (MEng thesis)	2015
	Farzana Haque (PhD)	2014
	Maria Conejo (MSc)	2014
	Vahid Asili (MSc)	2013
	Mahsasadat Atyabi (MSc)	2013
	Kamran Rahnama (MSc)	2012
Zhibin Ye	Zhe Chen (MASc)	2016
	Mark Grundy (MASc)	2016
	Syed Atif Haider Zaidi (MEng)	In Progress
	Hui Su (MASc)	2016
	Lingqi Huang (PhD)	In Progress
	Zhe Chen (MASc)	2015
	Mark Grundy (MASc)	2014
	Peng Xiang (PhD)	2015
	Eric Landry (MASc)	2012
	Pingwei Liu (PhD)	2014
Paula Wood-Adams	Sh. Kwaye-Nimo (PhD)	In Progress
	Keroles Riad (PhD)	In Progress
	Wissam Nakhle (PhD)	In Progress
	Keroles Riad (MSc)	2016
	Niyusha Samadi (PhD)	2016
	Ehsan Rezabeigi (PhD)	2015
	Mostafa Sabzevari (PhD)	2015
	Nithya Subramanian (MASc)	2015
	Wasef Bzeih (MASc)	2014

	Sina Chaeichian (PhD)	2013
	Yuri Yuryev (PhD)	2012
Rolf Wüthrich	Md. Rahman Masiar (PhD)	In Progress
	Lucas Hof (PhD)	In Progress
	Maniya Aghasibeig (PhD)	2015
	Jana Abou Ziki (PhD)	2014
	Andrew Morrison (PhD)	2015
	Hamid Sadabadi (PhD)	2013
	Mohsen Jalali (PhD)	2012
	Vahid Karamzadeh (MASc)	In Progress
	Pantea Fallah (MASc)	In Progress
	Frederic Charbonneau (MASc)	2016
	Keroles Riad (MASc)	2016
	Farzad Jabbari (MASc)	2013
	Zahra Ghorbani (MASc)	2013

5.1.2 Overall faculty characteristics: Ability of faculty to provide adequate supervision and cover all aspects of the discipline or profession; forecast changes in composition of faculty (growth renewal); Chart on present and future workloads and credit breakdown

As of January 2018, the Department of Chemical and Materials Engineering will have three regular members, one joint member, and two excluded members (the Dean of the School of Graduate Studies and the Vice President Research and Graduate Studies), offering expertise in chemical engineering fundamentals (transport phenomena, chemical thermodynamics), catalysis, kinetics, and reactor engineering, polymer engineering, and electrochemical engineering. The main gaps in the expertise currently available are in some of the proposed technical electives. These gaps will be covered with future hires. An additional faculty recruitment is in progress, and there is a commitment from Concordia University to recruit two faculty members in the 2018-19 cycle (see support letter in Appendix 6), and up to two in the 2019-20 cycle. It is anticipated that we will hire an average of two faculty members per year for the three to four years after that, bringing the total to 15 faculty members. In the meantime, the program will be strengthened through collaboration with other departments within Concordia University, with other universities in Montreal, and with local industry professionals.

Table 6 below shows the current and anticipated faculty members, with anticipated course assignments. The table shows that faculty members will generally not teach more than two courses per year in the program until 2021, leaving room for the development of other graduate programs, and an undergraduate program alongside the graduate programs. After 2021, it is anticipated that the course offerings will increase to 24 per year, mostly to accommodate a second offering of the core courses every year. It is expected that the Department of Chemical and Materials Engineering will grow to 15 faculty members during this time. Eight faculty members are sufficient to run all the graduate programs (3 per faculty member per year).

Table 6 Projected course assignments per faculty member for all planned graduate programs in Chemical Engineering

Faculty member	Course	Year	Status
Alex De Visscher	Advanced Chemical Engineering Thermodynamics Advanced Transport Phenomena	F 2018 W 2019	new, core new, core
Zhibin Ye	Principles of Chemical Engineering Polymer Chemistry and Engineering Materials Science and Engineering	F 2018 W 2019 W 2020	new, bridge new, elective new, core
Xiaolei Wang	Advanced Battery Materials and Technologies Chemical Kinetics and Reaction Engineering	F 2018 W 2019	new, elective new, core
Hire 1	Engineering Analysis Chemical Engineering Process Dynamics and Control	F 2018 W 2019	existing, core new, core
Hire 2	Advanced Separation Processes Materials Science and Engineering	F 2019 W 2020	new, elective new, core
Hire 3	Statistics for Chemical Engineering Nanomaterials Science and Engineering	F 2019 W 2020	new, elective new, core
Hire 4	Topics in Chemical Engineering I Chemical Process Engineering and Design	F 2020 W 2021	new, elective new, core

A number of existing electives will be taught outside the Department of Chemical and Materials Engineering. Because this represents no change with the existing condition, these courses are not shown in the table above. However, these courses affect the ability of students to progress their program. Hence, a projection of course offerings per term is given below, starting with Winter 2019. For elective courses, only a sample is given.

Fall 2019

- Principles of Chemical Engineering (Ye) (bridge)
- Engineering Analysis (Hire 1; existing course) (core)
- Advanced Chemical Engineering Thermodynamics (De Visscher) (core)
- Advanced Battery Materials and Technologies (Wang) (elective, list 1)
- Advanced Separation Processes (Hire 1) (elective, list 1)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Statistics for Chemical Engineering (Hire 3) (elective, list 1)
- Linear Systems (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Winter 2020

- Advanced Transport Phenomena (De Visscher) (core)
- Chemical Kinetics and Reaction Engineering (Wang) (core)
- Chemical Engineering Process Dynamics and Control (Hire 1) (core)
- Materials Science and Engineering (Hire 2) (core)
- Nanomaterials Science and Engineering (Hire 3) (core)
- Polymer Chemistry and Engineering (Ye) (elective, list 1)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Summer 2020

- Engineering Analysis (Faculty; existing course) (core)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Principles of Solar Engineering (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

The table shows that all planned graduate programs (the proposed MASc program and four other graduate programs in preparation or proposed) can be offered with a total of 24 course offerings per year. Hence, eight faculty members, teaching three courses per year, can offer the five graduate programs at full deployment. This leaves teaching capacity available for the undergrad program, and the graduate course load can be reduced when additional faculty members are hired. As indicated, the intention is to bring the total number of faculty members in the department to 15.

On average, faculty members in the Faculty of Engineering and Computer Science supervise 7-8 thesis-based graduate students. Assuming that each faculty member supervises 3-4 MASc students and 3-4 PhD students (hiring 2 MASc students and 1 PhD student per year, allowing for attrition), it is anticipated that there will be a critical mass for a viable graduate program by the time it takes effect, with 6-8 faculty members supervising 12-20 graduate students. In addition, faculty members in other departments currently supervise students in areas of chemical engineering. Examples are Dr. R. Wuthrich (Electrochemical engineering), Dr. M. Packirisamy (MEMS, microfluidics), and Dr. F. Haghighat (Environmental chemical engineering).

5.1.3 New faculty required, with specialization; profile of professors to be hired

It is anticipated that two faculty members will be hired per year on average over the next five years. While the recruitment will be flexible to enable us to hire the best people, recruitments in the following areas are desirable:

- Process design, process control, and process simulation
- Advanced separations, bio-separations,
- Surface and coating engineering
- Transport phenomena, microfluidics, microreactors, process intensification
- Catalysis, kinetics, CO_2 conversion
- Biochemical, biomedical and metabolic chemical engineering
- Chemical engineering data, properties, computational chemistry, molecular dynamics
- Any Materials Engineering application domain not covered in the previous hires

The list is not in any particular order.

5.2 Other Human Resources (required and available)

Technical staff is needed to provide technical support with graduate course projects. A technician or an engineer-in-residence will be hired in 2018, to start the process of building setups for graduate research and teaching labs. This recruitment has been approved by the university. Additional technicians will be hired in subsequent years, to be shared between all the graduate programs of the department.

An administrative support staff member will be needed to help program directors with student administration, book appointments, and guide students with their program requirements. It is anticipated that a receptionist/administrative assistant will be hired in 2018, and a graduate program administrator will be hired upon approval of this MASc program, shared between all the graduate programs of the department. Further administrative staff member hires are anticipated as the programs grow.

Depending on the number of registered students, 1-2 teaching assistants per course will be made available. Approximately 20 teaching assistant positions per year would cover the new courses introduced here. As these courses will be shared with other graduate programs, the incremental TA need for the MASc program is estimated at 10.

5.3 Material Resources (Reference materials, computers, equipment and space) (required and available)

A detailed library report outlining quality and quantity of collections, access, reference services and assistance, and interlibrary services is given in Appendix 3.

The program will require students to have access to computers with standard academic computing software (e.g., Matlab), as well as more specific engineering (e.g., Comsol) and chemical engineering (e.g., VMGSim) software. Except for specific chemical engineering software, the resources are already available at Concordia University. Licenses for the remaining software will be obtained.

Laboratory space is currently being renovated on Floor 14 of the Hall building (approx. 150 m^2), and additional renovations (approx. 400 m^2) are in preparation on Floor 10. Floor 14 will be allocated to research space, and will be used by thesis-based graduate students. The labs will host a mix of research and teaching space, and will be used by both course-based and thesis-based students. Graduate courses will use part of the space as project space, where students design and carry out experiments related to their course content. In addition, one floor of a major building expansion at the Loyola campus currently in the design stage will be allocated to the new Department of Chemical and Materials Engineering, with about 700 m^2 of labs, offices, student space, etc.

All courses in the program will be shared with other Chemical Engineering graduate programs. Hence, it is expected that class sizes will be in the 20-50 range at full deployment of the programs. When all graduate programs currently in preparation are in steady state, about 10-12 courses will be taught in each of the Fall and Winter terms, 150 minutes per week. Only half of those are required to offer a viable MASc program. Standard classrooms with blackboard/whiteboard and computer projection will be adequate for these courses.

Some of the courses will need laboratory equipment to create the needed project space. This will consist of piping, connections, thermostatic systems, sensors and data acquisition systems. In addition, some characterization equipment is needed. Concordia University has approved $1 million for academic equipment for the Chemical Engineering programs. Faculty members contributing to the program as supervisors will bring in additional equipment obtained with research funding.

A reception area is available in the office space currently used by the Department of Chemical and Materials Engineering in the VA building.

Some courses have projects that are not linked to the lab, and for these projects some student workspace will be needed. To accommodate this, a maker space is part of the renovation project on Floor 10 of the Hall building. This is in addition to the 400 m^2 dedicated to the Department of Chemical and Materials Engineering in this project. Students will generally work in groups. Proximity to computer labs is needed to ensure that students have access to process simulators (VMGSim, HYSYS) during these group activities.

5.4 Funding for Graduate Students

MASc students will receive scholarships to a minimum of $10,000 per year. These scholarships will be provided in part by research projects of the faculty members supervising the students. Students will have the opportunity to apply for scholarships on their own (e.g., NSERC PGS and CGS; Vanier). The University provides $5,000 per year on scholarships for MASc students for up to two years, provided they meet certain minimum GPA criteria.

5.5 Chart of Expenses and Revenues

The annual budget of the program at steady state is given in the table below.

Table 7 Budget of the MASc program

Revenue	**$751,892**
Cost	
Faculty	$183,569
Staff, admin	$47,888
Staff, tech	$41,502
TA	$14,419
Teaching remissions	$21,400
Part-time faculty	$21,400
Student scholarships	$255,000
Operation	$25,000
Library	$31,589
Total	**$641,767**
Profit	**$110,125**

The faculty budget is based on 1.15 full-time positions at steady state. This number is based on a pro-rating of the teaching needs for each of the graduate programs that will be offered at steady state. It is estimated that the MASc will take up slightly under 15 % of the teaching needs, based on full-time equivalent student counts, counting course-based students double. The total teaching needs for all graduate programs (up to 24 courses per year) is up to 8 faculty members (3 courses per faculty per year). These proportions can be maintained if the average class size is 30 for the MASc courses. Administrative and technical staff costs are based on a half-time position. Ten TAs are assumed. For the operational cost, 20 % of the estimated operational cost of all graduate programs combined is used. Based on these numbers, a profit of about $100,000 is projected. Student scholarship cost is based on the assumption that every MASc student will receive a $5,000 scholarship from the budget, the remainder of their scholarships coming from the supervisors' research grants. This number is fairly sensitive to the costs estimated for the main budget items, but as these numbers scale with the revenues (number of students), the profit is robust.

Below is a more detailed budget table per year, over the first five years of the implementation of the program. The program will be profitable from Year 5 onwards. In that year, the program has not reached steady state yet. This is because of the gradual recruitment of faculty members, and the two-year duration of a typical MASc program.

Cost-revenue template Chemical Engineering (M.A.Sc.)

Concordia University		Year 1	Year 2	Year 3	Year 4	Year 5	5-Year Total
FTEs for Yr 1 students		3.75	6.75	9.75	12.00	15.00	47.25
FTEs for Yr 2 students			3.38	6.08	8.78	10.80	29.03
FTEs for Yr 3 students							-
FTEs for Yr 4 students							-
FTEs for Yr 5 students							-
Student Enrolment		**3.75**	**10.13**	**15.83**	**20.78**	**25.80**	**76.28**
Revenue							
Tuition Revenue ($1,036.01 per term per FTE x 2 terms)	2,072	7,770	20,979	32,790	43,046	53,458	158,043
Teaching grant (base of $3,594.89/FTE x 4.42)	15,889	59,585	160,880	251,450	330,103	409,947	1,211,965
Variable support grant (per raw FTE $1,695.87)	1,696	6,360	17,171	26,837	35,232	43,753	129,352
Total Anticipated University Revenue (Only includes teaching & tuition revenue)		**73,715**	**199,030**	**311,077**	**408,380**	**507,158**	1,499,361
Expenses							
Faculty (steady state = 15)		5	7	9	11	13	
Part-time faculty (2 courses at $10,700 at steady state)	2	7,133	9,987	12,840	15,693	18,547	64,200
Faculty (1.15 FT x $125,000 x 1.277 at steady state)	1.15	61,190	85,665	110,141	134,617	159,093	550,706
Admin (0.5 FT x $75,000 x 1.277 at steady state)	0.5	15,963	22,348	28,733	35,118	41,503	143,663
Technical (0.5 FT x $65,000 x 1.277 at steady state)	0.5	13,834	19,368	24,902	30,435	35,969	124,508
Course sections (GPD remission) From the Provost's Office)	2	7,133	9,987	12,840	15,693	18,547	
Teaching assistantships (10; $1,464 & 1,419 for Master and Ph.D. resp./student)	10	4,805	6,727	8,649	10,571	12,493	43,245
Masters bursaries ($5,000 per student)	5,000	25,000	67,500	105,500	138,500	172,000	508,500
Library costs	31,589	31,589	31,589	31,589	31,589	31,589	157,945
Operation (labs, etc)	25,000	2,451	6,618	10,343	13,578	16,863	49,853
Advertising		3,000	2,000				5,000
Recruitment		3,000	2,000				5,000
Total Anticipated Expenses (ENCS)		**175,098**	**263,795**	**345,545**	**425,806**	**506,615**	**1,652,619**
Anticipated Gain (Loss) for the University		(101,383)	(64,765)	(34,469)	(17,425)	543	(153,258)

Notes:
Attrition rate of 10 % per year assumed
Faculty/staff/TA costs are prorated based on the number of faculty members in a given year assuming 15 faculty members at steady state.
Library cost assumes that the overlapping budgets are prorated based on number of students at steady state

5.6 Implementation Timetable for the Program

A detailed plan of the introduction of courses is given in Section 5.1.2. What follows is a general overview of activities planned for the MASc program.

- Fall 2018
  - First graduate courses in Chemical Engineering offered
- Fall 2019
  - Introduction of MASc program
  - Admission of first students
- Winter 2021
  - Full deployment of all new courses planned for the program
- Summer 2021
  - First graduations in the MASc program

Section 6 APPENDICES

Appendix 1 Related programs in Quebec and the rest of Canada (descriptions, calendar excerpts, etc.)

Québec

McGill Universtiy

Degrees offered:	PhD MEng (thesis) MEng (non-thesis) Graduate Diploma
Programs offered:	Chemical Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining and Materials Engineering (PhD, MEng (thesis), MEng (non-thesis)) Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1
Master graduations:	12
PhD graduations:	11

MEng (thesis) in Chemical Engineering

The "Thesis Option" Master's degree emphasizes independent research. In general, this program requires the completion of an intensive research project performed under the direction of an academic staff member. The research is summarized in a formal thesis submitted at the end of the program. Also required are a research proposal, presentation of a seminar, and twelve (12) credits of graduate-level courses. Most students complete the MEng thesis option requirements in 20 months, earning a Master of Engineering (MEng) degree.

Program Requirement:

Thesis Courses (31 credits)

- CHEE 697 Thesis Proposal 6 Credits
- CHEE 698 Thesis Research 1 12 Credits
- CHEE 699 Thesis Research 2 13 Credits

Required Courses (4 credits)

- CHEE 681 Laboratory Safety 1 1 Credits
- CHEE 682 Laboratory Safety 2 1 Credits
- CHEE 687 Research Skills and Ethics 2 Credits

Complementary Courses (10 credits)

4 credits from the following:

- CHEE 611 Heat and Mass Transfer 4 Credits
- CHEE 621 Thermodynamics 4 Credits

- CHEE 631 Foundations of Fluid Mechanics 4 Credits
- CHEE 641 Chemical Reaction Engineering 4 Credits
- CHEE 651 Adv Biochemical Engineering 4 Credits
- CHEE 662 Computational Methods 4 Credits
- CHEE 672 Process Dynamics and Control 4 Credits

A minimum of 3 credits of Chemical Engineering courses at the 500, 600, or 700 level.

Any remaining complementary course credit requirements may be fulfilled by completing Chemical Engineering or other Engineering or Science courses at the 500, 600, or 700 level.

École Polytechnique

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based
	Diplôme d'études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD , M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD , M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD , M.(rech.), M.(prof.))
	Procédés	(PhD , M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD , M.(rech.), M.(prof.))
	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	
Master graduations:	23	
PhD graduations:	20	

Maîtrise recherche en génie chimique

Le programme de maîtrise a pour but d'approfondir les connaissances technologiques et scientifiques en génie chimique. Le profil recherche favorise le développement de la composante scientifique de la formation du candidat par l'approfondissement des connaissances et l'initiation à la recherche.

Le programme comporte 45 crédits, se répartissant comme suit :

- Cours 15 crédits dont au moins 9 crédits de cycles supérieurs.
- Recherche et rédaction de mémoire 30 crédits

Note : Le cours ING6900 Méthodes de recherche (ou ING6900E) est obligatoire et doit être suivi en début de programme, au plus tard au 3e trimestre suivant la première inscription.

Axes de spécialisation

- **Polymères –** Modélisation et CAO/FAO des procédés de mise en œuvre des polymères. Mise au point de réacteurs et des techniques de mélange. Modification des enchevêtrements dans les matériaux plastiques. Recyclage des déchets de polymères. Étude de la structure et de la morphologie des polymères. Étude des paramètres d'interaction dans les mélanges et les composites. Caractérisation des propriétés mécaniques, viscoélastiques et rhéologiques. Caractérisation des propriétés de surface. Développement de matériaux composites et cellulosiques. Synthèse par émulsion de polymères de haute masse moléculaire.
- **Biopharmaceutique –** Biotechnologies, conception et caractérisation de bioréacteurs pour la culture de microorganismes, de cellules de plante, d'insecte et de mammifère, de cellules souches, pour cellules en suspension et en tissus. Opération, suivi et monitoring de cultures de cellules. Modélisation cinétique et métabolique; analyse de flux métaboliques (MFA), analyse des contrôles métaboliques (MCA). Ingénierie cellulaire et technologie recombinante. Biocapteurs. Production de métabolites, protéines et virus d'intérêt thérapeutique. Commande de bioprocédés de production. Purification, caractérisation et étude de la qualité et de l'efficacité des molécules produites.
- **Procédés –** Conception des procédés à l'aide d'ordinateur (CPAO). Étude cinétique des réactions catalytiques. Modélisation et conception des réacteurs. Simulation et commande par ordinateur des réacteurs catalytiques. Mise en œuvre des catalyseurs pulvérulents : aérogels, cryogels, en couche fluidisée. Mise en œuvre des réacteurs catalytiques à lit circulant et turbulent. Technologies gazières. Incinération des déchets solides et dangereux. Développement de procédés de traitement thermique de solides en lit fluidisé. Chauffage par panneaux radiants catalytiques. Combustion catalytique.
- **Environnement et développement durable –** Traitement des déchets dangereux, des déchets solides, des effluents liquides ou gazeux. Procédés physico-chimiques, biologiques et thermiques. Incinération de sols contaminés et de boues de procédé. Biorémédiation des sites contaminés. Sites d'enfouissement. Dispersion atmosphérique de polluants gazeux ou solides. Études de risques pour la santé. Études d'impact. Analyse du cycle de vie. Développement durable. Conception environnementale.
- **Génie papetier –** Modélisation, analyse et simulation des procédés papetiers. Fermeture des circuits et réduction des effluents, traitement des déchets. Intégration énergétique et matérielle des procédés. Contrôle et dynamique des procédés papetiers, développement de techniques de contrôle avancées. Couchage du papier, modélisation des opérations de couchage, rhéologie des sauces de couchage. Aspects moléculaires de la rhéologie, adhérence, surface et interface des additifs polymériques.

Cours de specialization		crédits
• DDI8003	Analyse du cycle de vie	3
• GCH6101	Chimie physique des polymères	3
• GCH6104A	Rhéologie des polymères	4
• GCH6108	Systèmes polymères multiphasés	3
• GCH6112A	Conc. des opér. d'agitation et de mélange	3

• GCH6113	Identification de syst. et comm. adaptative	3
• GCH6114	Projet de conception de produits polymériques	3
• GCH6201	Catalyse et cinétique appliquées	3
• GCH6210	Ingénierie des pâtes et papiers	3
• GCH6301	Ingénierie des biosystèmes	3
• GCH6302	Culture des cellules	3
• GCH6303	Réacteurs polyphasés	3
• GCH6304	Contrôle de la pollution industrielle	3
• GCH6309	Valorisation énergétique des déchets solides	3
• GCH6313	Modélis. environn. des émissions toxiques	3
• GCH6902	Conception des réacteurs gaz-solide	3
• GCH6903	Phénomènes d'échanges avancés	3
• GCH6905A	Thermodynamique à l'échelle nanométrique	3
• GCH6912A	Compléments de phénomènes d'échanges	4
• GCH6914	Méthode des éléments finis en génie chimique	3
• GCH8102	Mise en forme des polymères	3
• GCH8103	Conversion de la biomasse	3
• GCH8104	Traitement des minerais	3
• GCH8105	Génie brassicole	3
• GCH8107	Procédés pyrométallurgiques	3
• GCH8150	Systèmes de commande de procédés chimiques	3
• GCH8211	Conception et intégration des procédés	3
• GCH8615	Règlementation des procédés propres	3
• GCH8620	Procédés avancés de séparation	3
• GCH8650	Génie biochimique	3
• GCH8660	Opérations unitaires en génie alimentaire	3
• GCH8729	Déchets solides et énergie résiduelle	3
• ENE8210	Efficacité des sources d'énergie	3
• ENE8310	Stockage et intégration des syst. énergéti.	3
• MET8106	Énergie électrochimique	3

Université Laval

Degrees offered:	Maîtrise avec mémoire (M.Sc.)
	Doctorat
Programs offered:	Génie chimique
	Génie des matériaux et de la métallurgie
Specializations:	-
Full-time enrollment:	68
Part-time enrollment:	0
Master graduations:	8
PhD graduations:	9

Maîtrise en génie chimique - avec mémoire

Le but premier de ce programme est la formation de chercheurs. À cette fin, vous atteindrez un niveau élevé de formation par l'approfondissement de connaissances scientifiques et techniques. L'initiation à la recherche est basée sur l'apprentissage des méthodes de recherche afin d'acquérir un esprit de synthèse et de créativité.

Activités de formation communes 12 crédits

- GCH-6000 Communication scientifique orale et écrite I 3 crédits
- RÈGLE 1 - 9 CRÉDITS PARMI : crédits
    - GCH-7000 Mise en oeuvre des polymères 3
    - GCH-7001 Rhéologie des polymères 3
    - GCH-7002 Méthodes numériques en génie chimique 3
    - GCH-7003 Cinétique biochimique 3
    - GCH-7004 Méthodes mathématiques en génie chimique 3
    - GCH-7005 Systèmes réactionnels 3
    - GCH-7006 Méthodologie de recherche 3
    - GCH-7007 Biotechnologie environnementale 3
    - GCH-7008 Mécanique des fluides biphasiques 3
    - GCH-7009 Catalyse hétérogène 3
    - GCH-7010 Sujets spéciaux (génie chimique) 3
    - GCH-7011 Planification et analyse des expériences 3
    - GCH-7012 Nanomatériaux et leur application en catalyse 3
    - GCH-7013 Phénomènes d'échange 3
    - GCH-7014 Technologies de séparation et de capture des gaz à... 3
    - GCH-7015 Génie biomoléculaire 3
    - GCH-7016 Instabilités hydrodynamiques 3
- Recherche
    - GCH-6811 Activité de recherche - mémoire 1 7
    - GCH-6812 Activité de recherche - mémoire 2 8
    - GCH-6813 Activité de recherche - mémoire 3 9
    - GCH-6814 Activité de recherche - mémoire 4 9

<u>Université de Sherbrooke</u>

Degrees offered:	Maîtrise	(thesis-based)
	Maîtrise de type cours	
	Doctorat	
Programs offered:	Génie chimique	
Specializations:	-	
Full-time enrollment:	65	
Part-time enrollment:	0	
Master graduations:	11	
PhD graduations:	7	

Maîtrise en génie chimique

Fort d'une tradition bien établie en recherche, le Département de génie chimique et de génie biotechnologique offre un milieu de formation de qualité et des défis stimulants aux étudiantes et étudiants qui fréquentent ses programmes de maîtrise.

Activités pédagogiques obligatoires (30 crédits)

- GCH 726 Introduction au projet de recherche (1 cr.)
- GCH 727 Définition du projet de recherche (4 cr.)
- GCH 728 Séminaires de recherche (1 cr.)
- SCA 701 Méthodologie de recherche et communication (3 cr.)
- SCA 702 Plan de formation en maîtrise (0 cr.)
- SCA 715 Sécurité dans les laboratoires de recherche (0 cr.)
- SCA 729 Rapport d'avancement en recherche (3 cr.)
- SCA 730 Activités de recherche et mémoire (18 cr.)

Activités pédagogiques à option (6 à 15 crédits)

- GBT 735 Modélisation et commande de systèmes non linéaires (3 cr.)
- GCH 705 Étude spécialisée III (3 cr.)
- GCH 706 Génie des procédés pharmaceutiques (3 cr.)
- GCH 713 Techniques d'optimisation (3 cr.)
- GCH 721 Systèmes réactionnels solide-fluide (3 cr.)
- GCH 722 Phénomènes d'échanges III (3 cr.)
- GCH 732 Génie des pâtes et papiers (3 cr.)
- GCH 733 Traitement de la pollution de l'air (3 cr.)
- GCH 736 Traitement des eaux usées industrielles (3 cr.)
- GCH 737 Électrochimie appliquée (3 cr.)
- GCH 738 Gestion des matières résiduelles (3 cr.)
- GCH 740 Techniques de caractérisation des matériaux (3 cr.)
- GCH 746 Ingénierie des polymères (3 cr.)
- GCH 747 Plans d'expérience et analyse multivariée (3 cr.)
- GCH 760 Technologie des plasmas thermiques (3 cr.)

Activité pédagogique au choix (0 à 9 crédits). Choisies parmi l'ensemble des activités pédagogiques de l'Université ou parmi les activités suivantes, avec l’approbation de sa directrice ou de son directeur de recherche :

- GCH 702 Étude spécialisée I (1 cr.)
- GCH 703 Étude spécialisée II (2 cr.)

Ontario

University of Toronto

Degrees offered: MEng (course-based)
MASc (thesis-based)
PhD

Programs offered:	Chemical Engineering and Applied Chemistry (all)
	Materials Science and Engineering (all)
	Collaborative program in Environmental Studies (all)
	Collaborative program in Biomedical Engineering (MASc, PhD)
	Collaborative program in Cadriovascular Sciences (MASc, PhD)
	Collaborative program in Engineering Education (MASc, PhD)
	Collaborative program in Environmental Engineering (MASc, PhD)
	Collaborative program in Genome Biology and Bioinformatics (MASc, PhD)
	Collaborative program in Global Health (MASc, PhD)
Specializations:	Advanced Water Technologies and Process Design (MEng)
	Entrepreneurship, Leadership, Innovation and Technology in Engineering (MEng)
	Sustainable Energy (all)
	Advanced Manufacturing (MEng)
Full-time enrollment:	217
Part-time enrollment:	12
Master graduations:	50
PhD graduations:	15

MASc in Chemical Engineering and Applied Chemistry

Thesis Requirement

- A research thesis of no more than 70 pages, which gives evidence of mastery of the topic, originality and creativity, and is written and defended in an acceptable manner. It is desirable that the work reported in the thesis be of such a nature and caliber that it can be published.

Academic Course Requirements

- A minimum of 3 half-credit (H) courses – normally taken from Engineering or Physical Science departments – of which:
    - 1 must be Fundamental
        - CHE1100H – Fundamentals of Chemical Engineering
        - CHE1107H – Applied Mathematics
        - CHE1141H – Advanced Chemical Reaction Engineering
        - CHE1142H – Applied Chemical Thermodynamics
        - CHE1143H – Transport Phenomena
        - CHE1310H – Chemical Properties of Polymers
        - JTC1134H – Applied Surface and Interface Science
        - JTC1135H – Applied Surface and Interface Analysis
    - 2 must be Specialized
        - CHE1053H – Electrochemistry
        - CHE1118H – Industrial Catalysis
        - CHE1123H – Liquid Biofuels
        - CHE1125H – Modelling and Optimization of Chemical/ Biomedical Networks
        - CHE1134H – Advances in Bioengineering
        - CHE1146H – Applied Transport Phenomena

        - CHE1147H – Data Mining in Engineering
        - CHE1150H – Industrial Water Technology
        - CHE1213H – Corrosion
        - CHE1435H – Aerosol Physics and Chemistry
        - CHE1533 – Nuclear Chemical Engineering
        - JCC1313H – Environmental Microbiology
        - JCI1503H – Advanced Topics in Computing and Information Systems
        - JCB1349H – Molecular Assemblies
        - JNC2503H- Environmental Pathways
        - JCR1000Y – An Interdisciplinary Approach to Addressing Global Challenges
    - A maximum of 1 half-credit (H) 500-level courses (undergrad courses open to grad students) may count towards the degree.
- Seminar Course Requirements
    - CHE2222H: Safety Training – once, in the first session of study prior to beginning work in the lab
    - JDE1000H: Ethics in Research – once, typically in the first Fall or Winter session of study
    - CHE2011H: Graduate Student Seminars – once, in the first Winter session of study
    - CHE300xH: Seminars in Chemical Engineering & Applied Chemistry – 4 times, i.e. each Fall and Winter session in the first two years of study

<u>Ryerson University</u>

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	27	
Part-time enrollment:	2	
Master graduations:	11	
PhD graduations:	4	

MASc Chemical Engineering

Degree requirements

- Master's Thesis
- Master's Seminar
- Four electives (maximum of one from Group II)
    - Group I
        - CE8139 Prob, Stat and Stochastic Proc
        - CE8140 Statistics for Engineering
        - CE8201 Model and Simulation- Chem Eng

- CE8202 Advanced Process Control
- CE8203 Applied Optimal Control
- CE8204 Advanced Modeling Techniques
- CE8213 Advanced Numerical Methods
- CE8301 Advanced Transport Phenomena
- CE8303 Advanced Fluid Dynamics
- CE8304 Rheology
- CE8401 Ind Catalysis and Biocatalysis
- CE8402 Applied Thermodynamics
- CE8403 Advanced Reactor Engineering
- CE8501 Polymer Science
- CE8502 Polymerization Reaction Engr
- CE8602 Industrial Biotechnology
- CE8603 Advances in Biomaterials
- CE8604 Advances in Porous Materials
- CE8605 Nanobiotechnology
- CE8606 Advanced Topics in Tissue Engineering
- CE8702 Dsgn/Oper Sm Wtr Treat Plants
- CE8703 Adv Water Treatment Tech
- CE8803 Advanced Food Process Engineering
- CE8100 Directed St: Chem Eng (MASc)

- Group II
  - CE8210 Process and Engr Optimization
  - CE8310 Fluidization Engineering
  - CE8331 Membrane Technology
  - CE8510 Plastic Technology
  - CE8710 Air Pollution and Control

University of Ottawa

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
	Graduate Diploma
Programs offered:	Chemical Engineering (MASc, MEng, and Ph.D)
	Advanced Materials and Manufacturing (MASc, MEng, and PhD)
	Technology Project Management (Diploma)
Specializations:	-
Full-time enrollment:	94
Part-time enrollment:	6
Master graduations:	51
PhD graduations:	5

Master of Applied Science Chemical Engineering

The main objective of the master's programs is to refine the skills and research expertise of the students by expanding their specialized knowledge of chemical engineering primarily achieved through course work, research seminars, and technical training.

Compulsory Courses: 12 optional course units in chemical engineering (CHG) at the graduate level

- CHG 8110 Fluid Mechanics (3 units)
- CHG 8115 Heat Transfer I (3 units)
- CHG 8116 Advanced Transport Phenomena (3 units)
- CHG 8120 Rheology and Polymer Processing (3 units)
- CHG 8121 Synthetic Membranes in Biomedical Engineering (3 units)
- CHG 8123 Chemical Engineering Thermodynamics (3 units)
- CHG 8132 Adsorption Separation Processes (3 units)
- CHG 8141 Special Directed Studies I (3 units)
- CHG 8143 Special Directed Studies II (3 units)
- CHG 8145 Special Directed Studies III (3 units)
- CHG 8153 Stat. Model and Cont. Dyna. Proc. (3 units)
- CHG 8157 Strategies for Engineering Process Analysis (3 units)
- CHG 8158 Porous Media (3 units)
- CHG 8161 Chemical Reaction Engineering I (3 units)
- CHG 8175 Material Transport (3 units)
- CHG 8181 Biochemical Engineering (3 units)
- CHG 8186 Modelling of Steady-State Processes (3 units)
- CHG 8187 Introduction to Polymer Reaction Engineering (3 units)
- CHG 8188 Polymer Properties and Characterization (3 units)
- CHG 8189 Chemical Engineering Analysis (3 units)
- CHG 8191 Selected Topics Chemical Engineering (3 units)
- CHG 8192 Membrane Application in Environmental Engineering (3 units)
- CHG 8194 Membrane Separation Processes (3 units)
- CHG 8195 Advanced Numerical Methods in Transport Phenomena (3 units)
- CHG 8196 Interfacial Phenomena in Engineering (3 units)
- CHG 8198 Reverse Osmosis (3 units)

Seminar:

- CHG 8101S Seminar I

Thesis:

- CHG 7999 MASc Thesis

Queen's University

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	

Programs offered:	Chemical Engineering Collaborative degree in Applied Sustainability (MEng, MASc) Collaborative degree in Biomedical Engineering (MASc, PhD)
Specializations:	-
Full-time enrollment:	78
Part-time enrollment:	1
Master graduations:	19
PhD graduations:	10

Master of Applied Science in Chemical Engineering

The minimum requirements to be fulfilled are 4 term courses, a department seminar and a thesis. Two graduate courses must be from within the Department of Chemical Engineering, unless otherwise approved by the research supervisor and departmental graduate coordinator. One course may be selected from 400-series courses in other departments. All students must take CHEM-801*, a non-credit course in laboratory safety, at the first opportunity after their initial registration, and also participate in CHEE-897, the departmental seminar series. All programs of study must be approved by the department.

Courses:

- CHEE-801 Strategies for Process Investigations
- CHEE-803 Transport Phenomena
- CHEE-807 Current Topics in Chemical Engineering
- CHEE-809 Colloid and Surface Phenomena
- CHEE-810 Fuel Cell Systems: Design and Analysis
- CHEE-811 Mathematical Modeling of Chemical Processes
- CHEE-820 Topics in Advanced Process Control
- CHEE-821 Process Control II
- CHEE-822 Model-Based Control
- CHEE-824 Nonlinear Regression Analysis and Applications
- CHEE-825 System Identification
- CHEE-827 System Optimization
- CHEE-828 Polymer Reaction Engineering
- CHEE-835 Turbulent Diffusion in the Environment
- CHEE-837 Transport & Kinetics with Application to Fuel Cells
- CHEE-840 Introduction to Learning and Teaching in Engineering
- CHEE-841 Engineering Education: Theory into Practice
- CHEE-872 Polymeric Biomaterials
- CHEE-874 Tissue Engineering
- CHEE-882 Bioreactor Design
- CHEE-883 Bioseparation Processes
- CHEE-884 Bioremediation
- CHEE-885 Current Topics in Biochemical Engineering
- CHEE-887 Cellular Bioengineering
- CHEE-890 Advanced Polymer Structure, Properties and Processing
- CHEE-901 Principles and Applications of Polymer Rheology

- CHEE-902 Bulk and Solution Polymerisation Processes
- CHEE-903 Polymerisation in Dispersed Media
- CHEE-906 Entrepreneurship for Chemical Engineers
- CHEE-907 Current Topics in Chemical Engineering
- CHEE-908 Green Engineering
- CHEE-909 Colloid and Surface Science Fundamentals
- CHEE-910 Special Topics in Colloid and Surface Phenomena
- CHEE-911 Microscale Transport Phenomena
- CHEE-912 Applied Lab-on-Chip Technologies
- CHEE-927 Global Optimization
- CHEE-990 Structure-Property Relationships of Polymer Materials
- CHEE-991 Introduction to the Processing and Rheology of Polymeric Materials
- CHEE-992 Polymeric Biomaterials

CHEE-897 Seminar

CHEE-899 Master's Thesis Research

<u>Royal Military College</u>

Degrees offered:	Master	(thesis-based)
	PhD	
Programs offered:	Chemical and Materials Engineering	
	Nuclear Engineering	
Specializations:	-	
Full-time enrollment:	28	
Part-time enrollment:	8	
Master graduations:	6	
PhD graduations:	3	

Master of Applied Science in Chemical and Materials Engineering

The Master of Science degree or the Master of Applied Science degree will be awarded to candidates who successfully complete a programme of studies normally comprised of five (5) lecture courses at the graduate level plus a thesis. The degree when pursued full-time in the residential programme normally requires five (5) academic terms or two (2) academic years plus the intervening summer to complete.

- CC501 Chemical And Nuclear Engineering Computations
- CC502 Polymer Welding and Joining
- CC503 Special Topics
- CC504 Seminar
- CC506 Molecular Modelling and Applications to Nanotechnology
- CC508 Sea and Air-Launched Munitions
- CC509 Nuclear Reactor Heat Transfer
- CC510 Ammunition Management

- CC511 Health Physics and Radiation Protection
- CC512 Ground-Launched Munitions
- CC513 Corrosion Engineering - Diagnosis of Corrosion and Corrosion Testing
- CC514 Weapons Systems
- CC515 Nuclear Detection and Measurement
- CC516 Nanotechnology: Theory, Applications and Characterization Methods
- CC517 Shielding for Nuclear Activities
- CC518 Advanced Thermodynamics
- CC520 Transport Phenomena
- CC521 Introduction to Nondestructive Evaluation
- CC522 Applied Experimental Design and Data Analysis
- CC523 Nuclear Reactor Engineering
- CC525 Nuclear Reactor Safety
- CC527 Nuclear Reactor Kinetics and Dynamics
- CC523 Nuclear Reactor Engineering
- CC528 Advanced lnorganic Chemistry
- CC531 Radiological Methods
- CC533 Nuclear Fuels Engineering
- CC537 Site Remediation
- CC539 Applied Analytical Chemistry
- CC541 Environmental Toxicology and Risk Assessment
- CC543 Atmospheric Dispersion and Micrometeorology
- CC545 Advanced Topics in Organic Chemistry
- CC547 Artificial Neural Network Modelling
- CC551 Propulsion in Guns and Rockets
- CC555 Environmental Issues
- CC559 Terminal Ballistics 2 - Impact Mechanics
- CC561 External Ballistics
- CC563 Polymers in Engineering Applications
- CC565 Nuclear and Radiochemistry
- CC567 Nuclear Fuel Management
- CC569 Nuclear, Biological and Chemical Defence
- CC573 Nuclear Waste Management
- CC575 Materials in the Space Environment
- CC577 Explosives and Explosions
- CC579 Chemistry of Energetic Materials
- CC587 Mechanism, Kinetics And Model Development
- CC591 Ceramic Engineering
- CC593 Advanced Nuclear Reactor Physics
- CC595 Nuclear Materials
- CC599 Advanced Topics in Analytical Chemistry
- PR500: Project

TH500: Thesis (Master's Level)

McMaster University

Degrees offered:	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	86	
Part-time enrollment:	2	
Master graduations:	18	
PhD graduations:	2	

Master of Applied Science in Chemical Engineering

Also called the "Research masters", the MASc has a nominal duration of 24 months (6 semesters) after the Bachelor's degree. The MASc program consists of three one-term graduate courses and a dissertation based on research completed under the supervision of a professor. The dissertation must be an original contribution to chemical engineering and must be defended at an oral examination.

Courses:

- ChE 4B03 / ChE 6B03 Polymer Reaction Engineering
- ChE 4E03 / ChE 6E03 Digital Computer Process Control
- ChE 4K03 / ChE 6K03 Reactor Design for Heterogenous Systems
- ChE 4X03 / ChE 6X03 Polymer Processing
- ChE 706 Advanced Heat Transfer
- ChE 707 Analytical Solutions in Transport Phenomena
- ChE 712 Bio-Inspired Engineering
- ChE 740W Advanced PSE Tools and Methods
- ChE 752 Optimization of Chemical Processes
- ChE 767 Foundations of Scientific Computation
- ChE 773 Advanced Concepts of Polymer Extrusion
- ChE 777 Dynamics of Polymers and Complex Fluids
- ChE 4C03 / ChE 6C03 Statistics for Engineers
- ChE 4T03 / ChE 6T03 Applications of Chemical Engineering in Medicine
- ChE 4Z03 / ChE 6Z03 Interfacial Engineering
- ChE 750 Advanced MEMS Fabrication and Microfluidics
- ChE 753 Process Modeling and Optimization
- ChE 756 Mathematical Programming: Theory and Algorithms
- ChE 781 Biomedical Engineering
- ChE 782 Biopharmaceuticals
- ChE 790 Selected Topics in Colloid and Surface Science
- ChE 791 Nanotechnology in Chemical Engineering
- ChE 702 (C01) Ophthalmic Materials and Drug Delivery
- ChE 704 Biological Transport Phenomena

- ChE 742 Membrane Based Bioseparations
- ChE 754 Process Design and Integration for Minimal Environmental Impact
- ChE 757 Optimization Under Uncertainty (Stochastic Optimization)
- ChE 761 Multivariable, Stochastic and Adaptive Control of Chemical Processes
- ChE 762 Time Series Analysis and Process Identification
- ChE 763 Linear Systems: Estimation and Control
- ChE 764 Process Control Design
- ChE 770 Selected Topics in Polymer Science and Engineering
- ChE 772 Polymer Rheology
- ChE 774 Advances in Polymeric Materials
- ChE 776 Soft Matter Thin films & Surface Characterization Techniques
- ChE 784 Gene Therapy for Bioengineers

University of Waterloo

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	Nanotechnology	
	Water	
Full-time enrollment:	184	
Part-time enrollment:	19	
Master graduations:	57	
PhD graduations:	22	

Master of Applied Science in Chemical Engineering

Students with a Chemical Engineering background must complete 4 graduate courses (0.50 unit weight per course). Within these courses:

- At least 2 must be core CHE courses, as listed below.
- No more than 1 may be a 500 level or held with course.
- No more than 2 may be taught by supervisor(s).
- No more than 1 may be a reading course.

Core courses

- CHE 610 Transport Phenomena
- CHE 612 Interfacial Phenomena
- CHE 620 Applied Engineering Mathematics
- CHE 622 Statistics in Engineering
- CHE 630 Chemical Reactor Analysis
- CHE 640 Principles of Polymer Science
- CHE 660 Principles of Biochemical Engineering

- NANO 701 Fundamentals of Nanotechnology (two 0.25 credit NANO 701 modules)
- NANO 702 Nanotechnology Tools (two 0.25 credit NANO 702 modules)

Other courses

- CHE 614 Capillary and Transport Phenomena in Porous Media
- CHE 624 Advanced Process Dynamics and Control
- CHE 632 Introduction to Catalysis
- CHE 641 Physical Properties of Polymers
- CHE 661 Advances in Biochemical Engineering
- CHE 672 Air Pollution Control
- CHE 674 Industrial Waste Treatment
- CHE 710 Special Topics in Transport Phenomena
- CHE 715 Research Topics in Transport Phenomena
- CHE 720 Special Topics in Analysis of Chemical Processes
- CHE 725 Research Topics in Analysis of Chemical Processes
- CHE 730 Special Topics in Chemical Kinetics, Catalysis and Advanced Reactor Engineering
- CHE 735 Research Topics in Chemical Kinetics, Catalysis and Advanced Reactor Engineering
- CHE 740 Special Topics in Polymer Science and Engineering
- CHE 745 Research Topics in Polymer Science and Engineering
- CHE 750 Special Topics in Electrochemical Engineering, Interfacial Engineering & Materials Science
- CHE 755 Research Topics in Electrochemical Engineering, Interfacial Engineering & Materials Science
- CHE 760 Special Topics in Biochemical Engineering
- CHE 765 Research Topics in Biochemical Engineering
- CHE 770 Special Topics in Environmental Engineering and Pollution Control
- CHE 765 Research Topics in Environmental Engineering and Pollution Control

Master's Seminar

Graduate Studies Seminar

Master’s Thesis

<u>Western University</u>

Degrees offered:	MEng	(course-based)
	M.E.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical and Biochemical Engineering	
Specializations:	-	
Full-time enrollment:	153	
Part-time enrollment:	4	

Master graduations: 37
PhD graduations: 15

Master of Engineering Science in Chemical and Biochemical Engineering

Four courses:

Fundamental Courses (minimum 1)

- CBE 9160 Transport Processes (Transport Phenomena)
- CBE 9450 Advanced Reaction Engineering
- CBE 9211 Advanced Biochemical Engineering
- CBE 9150 Advanced Chemical Engineering Thermodynamics
- CBE 9190 Statistical Process Control or CBE 9170 Mathematical Methods in Engineering

Courses Relevant for the Interdisciplinary Work (maximum 2)

- CBE 9550 Advanced Particles and Fluidization Engineering
- CBE 9587 Fine Powder Technologies and Application
- CBE 9561 Advanced High Velocity Fluidization Technology
- CBE 9132 Oil Refining and Processing
- CBE 9424 Computer Process Control
- CBE 9461 Advanced Process Control
- CBE 9190 Statistical Process Control or CBE 9170 Mathematical Methods in Engineering
- CBE 9126 Partial Differential Equations
- CBE 9260 Advanced Bioengineering and Biotechnology
- CBE 9245 Cellular Bioengineering
- CBE 9250 Biomaterials Engineering
- CBE 9241 Nanobiotechnology
- CBE 9544 Pharmaceutical Manufacturing Processes
- CBE 9180 Instrumental Methods for Analysis for Engineers
- CBE 9350 Physical Principles of Environmental Engineering
- CBE 9321 Air Pollution Control
- CBE 9361 Biological Wastewater Treatment
- CBE 9334 Green Fuels and Chemicals
- CBE 9455 Advanced Polymerization Engineering
- CBE 9125 Interfacial Phenomena
- CBE 9265 Microalgal Systems: Biotechnology and Applications

Compulsory Course

- CBE 9100 Advanced Engineering Communications

Atlantic Provinces

Dalhousie University

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	19	
Part-time enrollment:	0	
Master graduations:	4	
PhD graduations:	0	

Master of Applied Science in Chemical Engineering

The Chemical Engineering program prepares students for careers in the chemical and process industries and in a variety of related fields. These encompass, among others, the traditional areas of environmental control, plastics and polymers, pulp and paper, instrumentation and process control, petrochemicals, petroleum and natural gas processing, and energy conversion and utilization, as well as the growing fields of biotechnology, food processing, composite materials, corrosion and protective coatings, and manufacture of microelectronic components.

Courses (4 courses required)

- CHEE 6000 Special Topics in Chemical Engineering I
- CHEE 6701 Loss Prevention and Risk Assessment
- CHEE 6707 Applied Thermodynamics
- CHEE 6714 Polymer Science
- CHEE 6726 Mass Transfer Topics
- CHEE 6730 Kinetics and Catalyses
- CHEE 6732 Transport Phenomena
- CHEE 6734 Chemical Reactor Design
- CHEE 6736 Computer Application in Chemical Engineering
- CHEE 6737 Chemical Process Control
- CHEE 6742 Chemical Process Optimization
- CHEE 6743 Process Synthesis
- CHEE 6744 Radiative Heat Transfer
- CHEE 6750 Combustion Phenomena
- CHEE 6751 Dust Explosion Risk Reduction
- CHEE 6755 Colloids and Interfaces in Petroleum Engineering
- CHEE 6800 Chemical Engineering in Biological Systems
- CHEE 7000 Special Topics in Chemical Engineering II
- Thesis

University of New Brunswick

Degrees offered:	MEng	(course-based)
	MScE	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	45	
Part-time enrollment:	7	
Master graduations:	14	
PhD graduations:	4	

Master of Science in Engineering, Chemical Engineering

The MScE is a research oriented master's degree which normally requires 18 months to two years to complete. The degree requires successful completion approved course program of 15 units, a research thesis and both a Departmental and University oral examination.

The course program must include the following courses:

- ChE 6997 Thesis (Students must register for this every term until they graduate - 0 units)
- ChE 6800 Seminar Course 1 unit
- ChE 6511 Research Proposal Course - 2 units

The remaining course selection must be approved by the candidate's supervisor and may include courses outside of chemical engineering.

Courses:

- CHE 5114 Chemical Reaction Engineering II 3 ch
- CHE 5124 Adsorption and Adsorption Processes 3 ch
- CHE 5224 Applied Petroleum and Reservoir Engineering 3 ch
- CHE 5234 Oil Refining and Natural Gas Processing 3 ch
- CHE 5244 Enhanced Oil Recovery Processes 3 ch
- CHE 5254 Polymer Reaction Engineering and Polymer Processing 3 ch
- CHE 5264 Oil Sands Technology 3 ch
- CHE 5313 Energy and the Environment 3 ch
- CHE 5314 Chemical Process Industries: Overview and Environmental Impact 3 ch
- CHE 5334 Radiative Heat Transfer 3 ch
- CHE 5344 Combustion 3 ch
- CHE 5434 Transport Phenomena 3 ch
- CHE 5524 Mathematical Methods in Chemical Engineering 3 ch
- CHE 5534 Process Identification for Advanced Control 3 ch
- CHE 5614 Process Control 3 ch
- CHE 5714 Electrochemical Engineering 3 ch
- CHE 5744 Steam Supply Systems 3 ch
- CHE 5754 Steam and Gas Turbines 3 ch

• CHE 5764	Special Topics in Power Plant Engineering	3 ch
• CHE 5804	Nuclear Chemical Processes	3 ch
• CHE 5824	Corrosion Processes	3 ch
• CHE 5834	Nuclear Engineering	3 ch
• CHE 5844	Nuclear Safety and Reliability	4 ch
• CHE 5854	Nuclear Heat Removal	3 ch
• CHE 5877	Advanced Nuclear Systems	3 ch
• CHE 5913	Pulp Production	3 ch
• CHE 5923	Papermaking	3 ch
• CHE 5933	Biorefining: Principles. Processes, and Products	3 ch
• CHE 6234	Process Design and Simulation	3 ch
• CHE 6314	Air Pollution Control	3 ch
• CHE 6402	Preliminary Project Report	3 ch
• CHE 6416	Bioseperations Science and Engineering	3 ch
• CHE 6417	Polymer Materials and Reaction Engineering	3 ch
• CHE 6423	Practice School	3 ch
• CHE 6501	Special Topics in Chemical Engineering	3 ch
• CHE 6502	Special Topics in Chemical Engineering	3 ch
• CHE 6503	Nanotechnology	3 ch
• CHE 6511	Introduction to Research Methods	3 ch
• CHE 6515	Advanced Surface Characterization	3 ch
• CHE 6522	Nanoparticle Engineering	3 ch

Western Canada

University of Saskatchewan

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
Specializations:	-	
Full-time enrollment:	33	(Chemical Engineering)
Part-time enrollment:	0	
Master graduations:	2	
PhD graduations:	1	

Master of Science in Chemical Engineering

Degree requirements:

- GPS 960.0 Introduction to Ethics and Integrity
- A minimum of 12 credit units
- GPS 990.0 Seminar
- GPS 994.0 Research

Courses

- CHE 811.3 Principles and Applications of Heterogeneous Catalysis
- CHE 861.3 Fundamental Biochemical Engineering
- CHE 875.3 Reaction Kinetics and Reactor Design
- CHE 881.3 Process Engineering
- CHE 882.3 Design of Industrial Waste Treatment Systems
- CHE 884.3 Corrosion Engineering
- CHE 888.3 Chemicals and Energy from Renewable Resources
- CHE 898.3 Special Topics
- CHE 899 Special Topics

University of Calgary

Degrees offered:	MEng	(course-based)
	MSc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Petroleum Engineering	
Specializations:	-	
Full-time enrollment:	246	
Part-time enrollment:	6	
Master graduations:	89	
PhD graduations:	34	

Master of Science in Chemical and Petroleum Engineering

Requirements:

- Register and participate in the research seminar course (ENCH 601 or equivalent).
- Complete a minimum of four half-courses at the graduate level. At least one of the courses must be ENCH701 or ENCH703. Additional requirements:
- Students intending to have a degree specialization in chemical engineering must also complete at least one course from the list of core courses: ENCH 613, 625, 623, 631, 633.
- Students intending to have a degree specialization in petroleum engineering must also complete at least one course from the list of core courses: ENCH 621, 629, 647, 657, 677.
- Students intending to have a degree specialization in environmental or biomedical engineering should consult with their supervisors for additional requirements.

Courses

- Chemical Engineering 607 Natural Gas Processing Principles
- Chemical Engineering 609 Natural Gas Processing Technology
- Chemical Engineering 613 Advanced Topics in Mass Transfer
- Chemical Engineering 615 Model Predictive Control

- Chemical Engineering 617 Modelling and Identification Advanced Control
- Chemical Engineering 619 Special Problems
- Chemical Engineering 620 Graduate Project
- Chemical Engineering 621 Reservoir Simulation
- Chemical Engineering 623 Chemical Reactor Design
- Chemical Engineering 625 Advanced Topics in Heat Transfer
- Chemical Engineering 627 Chemical Process Simulation
- Chemical Engineering 629 Secondary and Tertiary Recovery
- Chemical Engineering 630 Electrochemical Engineering
- Chemical Engineering 631 Advanced Topics in Fluid Mechanics
- Chemical Engineering 633 Chemical Thermodynamics
- Chemical Engineering 639 Applied Numerical Methods in Engineering
- Chemical Engineering 643 Air Pollution Control Engineering
- Chemical Engineering 645 Industrial and Produced Wastewater Treatment
- Chemical Engineering 647 Thermal Recovery Methods
- Chemical Engineering 649 Naturally Fractured Reservoirs
- Chemical Engineering 653 Horizontal Wells for Petroleum Production
- Chemical Engineering 657 Advanced Reservoir Engineering
- Chemical Engineering 659 Advanced Cell and Tissue Engineering
- Chemical Engineering 661 Geostatistics for Reservoir Characterization
- Chemical Engineering 665 Wastewater Issues for the Oil and Gas Industry
- Chemical Engineering 677 Advanced Topics in Oil and Gas Production
- Chemical Engineering 687 Petroleum Economics
- Chemical Engineering 689 Drilling Advances, Modelling and Simulation
- Chemical Engineering 698 Reservoir Characterization for Field Development
- Chemical Engineering 699 Special Project
- Chemical Engineering 701 Experimental Design and Error Analysis
- Chemical Engineering 703 Advanced Mathematical Methods in Engineering

<u>University of Alberta</u>

Degrees offered:	MEng	(course-based)
	MSc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
	Process Control	
Specializations:	-	
Full-time enrollment:	239	
Part-time enrollment:	0	
Master graduations:	51	
PhD graduations:	18	

Master of Science in Chemical Engineering

MSc programs normally consist of 12 credits in courses, plus ENGG 600, plus seminar attendance, research, and a thesis. Certain core course requirements apply. Details of all programs must be worked out in consultation with the Department.

There is no language requirement for the MSc degree.

The minimum period of residence is two four-month terms of full-time attendance at the University of Alberta.

Courses:

- ENGG 600 - Engineering Ethics and Professionalism
- CH E 610 - Computational Transport Phenomena
- CH E 611 - Advanced Transport Phenomena
- CH E 612 - Advanced Fluid Mechanics
- CH E 617 - Colloids and Interfaces
- CH E 620 - Mixing in the Process Industries
- CH E 624 - Advanced Thermodynamics
- CH E 625 - Surface and Statistical Thermodynamics
- CH E 634 - Advanced Chemical Reactor Design
- CH E 645 - Heterogeneous Catalysis and Reactor Analysis
- CH E 655 - Advanced Biomaterials Science
- CH E 662 - Process Identification
- CH E 674 - Numerical Solutions of Engineering Problems
- CH E 689 - Polymer Properties
- CH E 694 - Advanced Topics in Chemical Engineering
- CH E 696 - Special Topics in Process Dynamics and Control
- CH E 900 - Directed Research Project

University of British Columbia

Degrees offered:	MEng	(course-based)
	M.E.L.	(course-based; Master of Engineering Leadership)
	M.Sc.	(thesis-based, for students with a science background)
	MASc	(thesis-based, for students with an engineering background)
	PhD	
Programs offered:	Chemical and Biological Engineering (MEng, M.Sc., MASc, PhD)	
	Clean Energy Engineering (M.E.L.)	
	Green Bio-Products (M.E.L.)	
	Integrated Water Management (M.E.L.)	
	Materials Engineering (MEng, M.Sc., MASc, PhD)	
	Advanced Materials Manufacturing (M.E.L.)	
Specializations:	-	
Full-time enrollment:	188	(“Biosystems”; may include programs other than the ones listed)
Part-time enrollment:	0	
Master graduations:	23	

PhD graduations: 15

Master of Applied Science in Chemical and Biological Engineering

The MASc requires a 12-credit thesis and 18 credits of coursework, including the seminar course CHBE 598 (1 credit) and the proposal preparation course CHBE 597 (2 credits). Normally, the required 18 credits will consist of 12 credits chosen from graduate courses in chemical and biological engineering and 6 credits of courses from outside or outside the program. Part-time students may enrol in the MASc program.

Fundamental courses:

- CHBE 550 Advanced Reactor Design
- CHBE 551 Advanced Thermodynamics
- CHBE 553 Mathematical Operations
- CHBE 554 Momentum, Heat and Mass Transfer
- CHBE 560 Topics in Biological Engineering
- CHBE 565 Advanced Process Control/Analytics
- CHBE 557 Fluid Mechanics (MECH 502 or equivalent)

Appendix 2 Enrolment surveys and other indicators of student interest in the program and graduate employment opportunities

Introduction

Senior undergraduate students who have completed 60-120 credits were invited to complete the questionnaire below. This survey probed students' intentions to take a certificate, diploma, M.Eng., or M.A.Sc. program in Chemical Engineering. The students probed were in Bachelor's programs in Mechanical Engineering, Industrial Engineering, and Chemistry. The vast majority of respondents were Mechanical Engineering students, so the results mainly reflect the opinions of that group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Bachelor's degree)	40	70.2	70.2	70.2
	Industrial Engineering (Bachelor's degree)	8	14.0	14.0	14.0
	Chemistry (Bachelor's degree)	9	15.8	15.8	15.8
	Total	57	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date April 10, 2017
Survey closing date April 20, 2017

Number of students invited	649
Number of students responded	57
Response rate	8.8%
Margin of error*	± 12.4%

*at a 95% confidence level

In addition, thesis-based Master students in Mechanical Engineering, Civil Engineering, and Chemistry were invited to complete the second questionnaire below. This survey probed students' intentions to take a M.A.Sc. or Ph.D. program in Chemical Engineering. The pool of respondents was fairly evenly spread, with Civil Engineering being the dominant group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Master's)	12	32.4	32.4	32.4
	Civil Engineering (Master's)	19	51.4	51.4	51.4
	Chemistry (Master's)	6	16.2	16.2	16.2
	Total	37	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	193
Number of students responded	37
Response rate	19.2%
Margin of error*	± 14.5%

*at a 95% confidence level

Results – Undergraduate students – M.A.Sc.

The response of the surveyed students is summarized here, followed by the detailed responses in tabular form.

On the question "Based on this description, how likely is it that you would apply to the Master of Applied Science in Chemical Engineering program if it became available?" 8/57 students (14.0 %) responded "likely" or "very likely". About a sixth of the students (9/57 or 15.8 %) would apply in 2018 or 2019.

On the question "How relevant are the proposed program objectives to your academic and professional goals?" 29/57 students (50.9 %) responded "relevant" or "very relevant". For a description of the program objectives as stated in the survey, see below.

On the question "Are the proposed courses relevant to your academic and professional goals?" 31/57 students (54.4 %) responded "relevant" or "very relevant".

On the question "In what ways do you see the Master of Applied Science in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)" 33/57 students (57.9 %) responded "Specialized expertise in Chemical Engineering will increase my career prospects.".

On the question "What drawbacks or disadvantages can you foresee in the proposed Master of Applied Science program with regard to your academic and professional goals? (Please select all that apply.)" 18/57 students (31.6 %) responded "The program is too specialized.", whereas 12/57 students (21.1 %) responded "The program may narrow my employment options."

Overall the survey results are mixed, with about a seventh of the students inclined to pursue the program, but about half of the students evaluating the program as relevant for their careers. Overall, the students selected more advantages than disadvantages in the survey.

Results – Graduate students – M.A.Sc.

The response of the surveyed students is summarized here, followed by the detailed responses in tabular form.

On the question "Based on this description, how likely is it that you would apply to the Master of Applied Science in Chemical Engineering program if it became available?" 12/37 students (32.4 %) responded "likely" or "very likely". About a quarter of the students (10/37 or 27.0 %) would apply in 2018 or 2019.

On the question "How relevant are the proposed program objectives to your academic and professional goals?" 27/37 students (73.0 %) responded "relevant" or "very relevant". For a description of the program objectives as stated in the survey, see below.

On the question "Are the proposed courses relevant to your academic and professional goals?" 29/37 students (78.4 %) responded "relevant" or "very relevant".

On the question "In what ways do you see the Master of Applied Science in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)" 19/37 students (51.4 %) responded "Specialized expertise in Chemical Engineering will increase my career prospects.".

On the question "What drawbacks or disadvantages can you foresee in the proposed Master of Applied Science program with regard to your academic and professional goals? (Please select all that apply.)" 16/37 students (43.2 %) responded "The program may narrow my employment options."

Overall the survey results among Master students are more favorable than among Bachelor students, with about a third of the Master students inclined to pursue the program, and a broad majority of the students evaluating the program as relevant for their careers. Overall, the students selected more advantages than disadvantages in the survey.

Detailed Survey Results – Undergraduate students – M.A.Sc.

Based on this description, how likely is it that you would apply to the Master of Applied Science in Chemical Engineering program if it became available?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very likely	2	3.5	3.6	3.6
	Likely	6	10.5	10.7	10.7
	Somewhat likely	13	22.8	23.2	23.2
	Unlikely	31	54.4	55.4	55.4
	Don't know	4	7.0	7.1	7.1

	Total	56	98.2	100.0	
Missing	System	1	1.8		
Total		57	100.0		

In what year would you most likely expect to apply to the Master of Applied Science in Chemical Engineering program?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	2018	5	8.8	8.8	8.8
	2019	4	7.0	7.0	7.0
	Later than 2019	5	8.8	8.8	8.8
	Don't know	17	29.8	29.8	29.8
	Would not apply	26	45.6	45.6	45.6
	Total	57	100.0	100.0	

How relevant are the proposed program objectives to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	3	5.3	5.4	5.4
	Relevant	26	45.6	46.4	46.4
	Not relevant	19	33.3	33.9	33.9
	Don't know	8	14.0	14.3	14.3
	Total	56	98.2	100.0	
Missing	System	1	1.8		
Total		57	100.0		

Are the proposed courses relevant to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	6	10.5	10.9	10.9
	Relevant	25	43.9	45.5	45.5
	Not relevant	18	31.6	32.7	32.7
	Don't know	6	10.5	10.9	10.9
	Total	55	96.5	100.0	
Missing	System	2	3.5		
Total		57	100.0		

In what ways do you see the Master of Applied Science in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Specialized expertise in Chemical Engineering will increase my career prospects.	33	57.9	57.9	57.9
	I want to pursue a career in Chemical Engineering and this program would allow me to do so.	8	14.0	14.0	14.0
	Other	8	14.0	14.0	14.0
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

What drawbacks or disadvantages can you foresee in the proposed Master of Applied Science program with regard to your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	The program is too specialized.	18	31.6	31.6	31.6
	The program may narrow my employment options.	12	21.1	21.1	21.1
	The program is too general.	3	5.3	5.3	5.3
	Other	8	14.0	14.0	14.0
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

Detailed Survey Results – Graduate students – M.A.Sc.

Based on this description, how likely is it that you would apply to the Master of Applied Science in Chemical Engineering program if it became available?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very likely	7	18.9	18.9	18.9
	Likely	5	13.5	13.5	13.5
	Somewhat likely	8	21.6	21.6	21.6
	Unlikely	16	43.2	43.2	43.2
	Don't know	1	2.7	2.7	2.7
	Total	37	100.0	100.0	

In what year would you most likely expect to apply to the Master of Applied Science in Chemical Engineering program?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	2017	3	8.1	8.1	8.1
	2018	7	18.9	18.9	18.9
	2019	3	8.1	8.1	8.1
	Later than 2019	3	8.1	8.1	8.1
	Don't know	7	18.9	18.9	18.9
	Would not apply	14	37.8	37.8	37.8
	Total	37	100.0	100.0	

How relevant are the proposed program objectives to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	6	16.2	16.2	16.2
	Relevant	21	56.8	56.8	56.8
	Not relevant	9	24.3	24.3	24.3
	Don't know	1	2.7	2.7	2.7
	Total	37	100.0	100.0	

Are the proposed courses relevant to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	10	27.0	27.0	27.0
	Relevant	19	51.4	51.4	51.4
	Not relevant	5	13.5	13.5	13.5
	Don't know	3	8.1	8.1	8.1
	Total	37	100.0	100.0	

In what ways do you see the Master of Applied Science in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Specialized expertise in Chemical Engineering will increase my career prospects.	19	51.4	51.4	51.4

		Frequency	Percent	Valid Percent	Valid Percent
	I want to pursue a career in Chemical Engineering and this program would allow me to do so.	8	21.6	21.6	21.6
	Other	9	24.3	24.3	24.3
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

What drawbacks or disadvantages can you foresee in the proposed Master of Applied Science program with regard to your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	The program is too specialized.	6	16.2	16.2	16.2
	The program may narrow my employment options.	16	43.2	43.2	43.2
	The program is too general.	5	13.5	13.5	13.5
	Other	6	16.2	16.2	16.2
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

Survey Content – Undergraduate

Web Page 1:

Concordia University

New Programs in Chemical Engineering Survey

Welcome to the New Programs in Chemical Engineering Survey

Please copy the survey PIN found in your invitation email and paste it in the space below.

Enter your survey PIN below:

[ ] Start

Web Page 2:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Welcome!

<p>Concordia University's Faculty of Engineering and Computer Science is considering the possibility of offering graduate programs in Chemical Engineering. Chemical Engineering is the application of chemical and engineering principles for the design and operation of industrial processes for the manufacture of chemicals and materials. A total of five programs may potentially be created:</p>

a Graduate Certificate (4 courses, 15 credits);
a Graduate Diploma (8 courses, 30 credits);
a Master of Engineering (12 courses, 45 credits);
a Master of Applied Science (thesis-based); and
a Ph.D. (thesis-based).

<p>We are contacting you to solicit your feedback on some of the proposed programs, and to assess the level of interest in these programs among current Concordia students. The survey should take no longer than 10 minutes to complete. Should you find that your exact situation is not listed as a response to a given question, please select the closest response choice. Your responses will be held in strict confidence and will only be used to produce aggregate results.</p>

<p>Thank you for your participation -- your feedback is important.</p>

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Web Page 3:

New Programs in
Chemical Engineering Survey

Completed

Your Program

Please indicate your current program of study.

- Mechanical Engineering (Bachelor's degree)
- Industrial Engineering (Bachelor's degree)
- Chemistry (Bachelor's degree)

Please indicate the number of credits you have remaining to complete your degree.

<< Back Next >>

Web Page 4:

New Programs in
Chemical Engineering Survey

Completed

The New Certificate Program

The **Certificate in Chemical Engineering** is a course-based program. It consists of four courses: three core courses and one elective. The program provides students with a first exposure to Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the Graduate Diploma and the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Certificate** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Certificate** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 5:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

Objectives of the Certificate Program

The aim of the **Certificate** in Chemical Engineering program is to provide specialized expertise in a limited number of core subjects in Chemical Engineering. It will enable students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

Very relevant
Relevant
Not relevant
Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 6:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

Requirements of the Certificate Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
One of the following two:
Chemical Kinetics and Reaction Engineering (chemical reactor design)
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

Are the proposed courses relevant to your academic and professional goals?

Very relevant
Relevant
Not relevant
Don't know

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Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Certificate** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Graduate Diploma or a Master's degree in Chemical Engineering.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Certificate** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Web Page 8:

Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Diploma Program

The **Diploma in Chemical Engineering** is a course-based program. It consists of eight courses: five core courses and three electives. The program provides students with comprehensive specialized knowledge in Chemical Engineering at the graduate level. It is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.). Students who take the Graduate Certificate will be able to use the course credits towards the M.Eng. degree in Chemical Engineering, and, with approval of the supervisor, towards the M.A.Sc. in Chemical Engineering.

Based on this description, how likely is it that you would apply to the **Diploma** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Diploma** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 9:

New Programs in
Chemical Engineering Survey

Completed

Objectives of the Diploma Program

The aim of the **Diploma** in Chemical Engineering program is to provide specialized expertise in a broad range of core subjects in Chemical Engineering. It will allow students to solve problems from a thorough understanding of the underlying principles, so they can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

Very relevant
Relevant
Not relevant
Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 10:

New Programs in
Chemical Engineering Survey

Completed

Requirements of the Diploma Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control

<p>II. One technical elective course in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One technical elective course outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One complementary course. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

Very relevant
Relevant
Not relevant
Don't know

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Web Page 11:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Diploma** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I can use it as a stepping stone towards a Master's degree.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Diploma** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Web Page 12:

Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Master of Engineering Program

The **Master of Engineering in Chemical Engineering** is a course-based program. It consists of twelve courses: seven core courses and five electives. The program provides students with extensive specialized knowledge in Chemical Engineering at the graduate level. The program is aimed at students with an undergraduate degree in Chemical Engineering or in a related field (e.g., Mechanical & Industrial Engineering, Chemistry, etc.).

Based on this description, how likely is it that you would apply to the **Master of Engineering** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Engineering** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 13:

New Programs in
Chemical Engineering Survey

Completed

Objectives of the Master of Engineering Program

The aim of the **Master of Engineering** in Chemical Engineering program is to provide specialized expertise in all areas of Chemical Engineering, and to solve problems from a thorough understanding of the underlying principles so students can find innovative solutions to new problems. For students whose undergraduate degree is not Chemical Engineering, it will allow them to work in interdisciplinary groups in these areas, because they will understand the concepts.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 14:

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Engineering Program

<p>I. Core courses:</p>
Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
One of the following two courses:
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. One to three technical elective courses in Chemical Engineering. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)

<p>III. One or two technical elective courses outside of Chemical Engineering. Examples:</p>
Principles of Solar Engineering
Linear Systems

<p>IV. One or two complementary courses. Example:</p>
Composition and Argumentation for Engineers

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Web Page 15:

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Engineering** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Engineering** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Web Page 16:

New Programs in Chemical Engineering Survey

Completed

The New Master of Applied Science Program

The **Master of Applied Science in Chemical Engineering** program is a thesis-based program. It consists of four courses and research culminating in the writing of a thesis. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Master of Applied Science** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Applied Science** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 17:

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Applied Science Program

The aim of the **Master of Applied Science** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. Students who complete a Master of Applied Science program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 18:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Applied Science Program

<p>I. Core courses (at least two courses from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A thesis based on academic research in a chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Web Page 19:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Applied Science** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Applied Science** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Web Page 20:

Concordia University

New Programs in Chemical Engineering Survey

Final Comments

If you have any final comments or questions regarding any of the proposed Chemical Engineering programs, please share them below.

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Concordia University

New Programs in Chemical Engineering Survey

Thank you for taking the time to complete this survey.
Your feedback is important.

We have received your responses.

Survey Content – Graduate

Web Page 1:

Concordia University

New Programs in Chemical Engineering Survey

Welcome to the New Programs in Chemical Engineering Survey

Please copy the survey PIN found in your invitation email and paste it in the space below.

Enter your survey PIN below:

[ ] Start

Web Page 2:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Welcome!

<p>Concordia University's Faculty of Engineering and Computer Science is considering the possibility of offering graduate programs in Chemical Engineering. Chemical Engineering is the application of chemical and engineering principles for the design and operation of industrial processes for the manufacture of chemicals and materials. A total of five programs may potentially be created:</p>

a Graduate Certificate (4 courses, 15 credits);
a Graduate Diploma (8 courses, 30 credits);
a Master of Engineering (12 courses, 45 credits);
a Master of Applied Science (thesis-based); and
a Ph.D. (thesis-based).

<p>We are contacting you to solicit your feedback on some of the proposed programs, and to assess the level of interest in these programs among current Concordia students. The survey should take no longer than 10 minutes to complete. Should you find that your exact situation is not listed as a response to a given question, please select the closest response choice. Your responses will be held in strict confidence and will only be used to produce aggregate results.</p>

<p>Thank you for your participation -- your feedback is important.</p>

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Web Page 3:

Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Your Program

Please indicate your current program of study.

- Mechanical Engineering (Master's)
- Civil Engineering (Master's)
- Chemistry (Master's)

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Web Page 4:

Université Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Master of Applied Science Program

The **Master of Applied Science in Chemical Engineering** program is a thesis-based program. It consists of four courses and research culminating in the writing of a thesis. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Master of Applied Science** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Applied Science** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 5:

Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Applied Science Program

The aim of the **Master in Applied Science** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. Students who complete a Master of Applied Science program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 6:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Applied Science Program

<p>I. Core courses (at least two courses from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A thesis based on academic research in a chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Web Page 7:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Applied Science** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Master of Applied Science** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Ph.D. Program

The **Doctor of Philosophy (Ph.D.) in Chemical Engineering** is a thesis-based program. It consists of three courses and extensive research culminating in the writing of a thesis, and typically a number of journal papers as well. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Ph.D.** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Ph.D.** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Web Page 9:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Ph.D. Program

The aim of the **Ph.D.** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will learn to develop their own research ideas, formulate research objectives and develop a strategy for accomplishing the objective. They will conduct research in their chosen field, leading to a thesis. Students who complete a Ph.D. program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 10:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Requirements of the Ph.D. Program

<p>I. Core courses (at least one course from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A comprehensive exam testing your knowledge and ability to collect knowledge in your chosen field.</p>

<p>IV. A thesis proposal exam testing your ability to formulate a research objective and developing a strategy for accomplishing that objective.</p>

<p>V. A thesis based on academic research in the chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Web Page 11:

New Programs in
Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Ph.D.** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Ph.D.** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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New Programs in
Chemical Engineering Survey

Final Comments

If you have any final comments or questions regarding any of the proposed Chemical Engineering programs, please share them below.

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New Programs in
Chemical Engineering Survey

Thank you for taking the time to complete this survey.
Your feedback is important.

We have received your responses.

Appendix 3 Library report

Library Report

For the Proposed

Master of Applied Science (M.A.Sc.) in Chemical Engineering

Joshua Chalifour, Digital Services & Engineering Librarian
Krista Alexander, Biochemistry/Chemistry & Physics Librarian

Created: April 2017

Purpose

The purpose of this report is to assess the adequacy of available library resources to support the proposed Master of Applied Science in Chemical Engineering, in the soon to be established Department of Chemical and Materials Engineering at Concordia University. The Department will be unique in Quebec and is slated to emphasize the development of new processes for producing specialized materials and the application of these materials in industry.

The comparators used throughout this report were identified by the Department of Chemical and Materials Engineering and include McGill University, École Polytechnique Montréal, University of Alberta, Stanford University, University of Houston, and Curtin University. All of the comparators have masters of applied science programs in Chemical Engineering. Considering the number of students and professors, programs, founding dates, and rankings Concordia is most similar to the University of Houston, thus the University of Houston will be used as the main comparator for the purposes of this report.

Monographs

To assess the relative strength of Concordia University Library's monograph collection in terms of the research needs of the proposed Masters program, collection size was measured for a sample of relevant Library of Congress Subject Headings. The results are presented in Table 1.

The following table compares monograph holdings for each of the comparator universities. McGill is excluded from this table because the methods to search its holdings produce different types of results for total print and ebook numbers. It is reasonable to consider McGill's total number is greater than the other comparators except for Stanford.

LC Subject Heading	Number of Monograph Titles					
	Concordia	École Polytechnique	Alberta	Stanford	Houston	Curtin University
Alloys	54	38	198	13724	105	1676
Biochemical engineering	23	52	173	257	54	226
Biotechnology	172	259	862	4749	249	2042
Chemical engineering	88	162	537	1443	225	2128
Chemical industry	26	96	143	1553	81	366
Chemical kinetics	169	124	407	1730	271	239
Chemical processes	21	35	217	673	92	349
Chemical reactions	128	109	425	7304	205	246
Chemical technology	0	0	2	219	0	42
Chemistry	172	253	1356	40191	473	6762
Chemistry, Metallurgic	4	4	30	36	12	34
Composite materials	174	119	444	3530	173	378
Energy transfer	19	34	77	3129	22	40
Fluid mechanics	263	635	602	3864	324	613
Manufacturing processes	187	463	483	1258	174	400
Metals	128	130	341	26718	184	2067
Nanostructured materials	278	856	1513	1774	285	383
Nanotechnology	315	1575	1262	3182	319	1368
Photochemistry Industrial applications	3	1	12	19	5	6
Plasma chemistry Industrial applications	2	1	7	9	3	3
Plastics	100	100	343	5056	207	737
Polymers	237	1915	1016	6482	602	1656
Process control	121	262	365	1617	133	467
Separation technology	46	67	261	281	120	242
Synthetic fuels	14	6	63	1336	46	125
Synthetic products	3	1	28	48	13	18
Total	**2,747**	**7,297**	**11,167**	**130,182**	**4,377**	**22,613**

Table 1: Comparative Size of Monograph Collections for Selected Subject Areas

Concordia's monograph collection in the areas measured is considerably smaller than that of the comparator universities. Some of these universities are older or larger institutions but others are more similar to Concordia. Compared to the University of Houston, Concordia's monograph collection is unsupported by 37%.

While there is no historical data on which to base an assessment of collection growth over time at Concordia, the library materials budget for monographs in Chemistry & Biochemistry, Mechanical and Industrial

Engineering, and Physics is shown for the last six years in Table 2.

Year	Chemistry & Biochemistry Appropriation	Mechanical & Industrial Engineering Appropriation	Physics Appropriation
2011 - 12	$14,636	$26,826	$8,755
2012 - 13	$11,000	$18,778	$6,128
2013 - 14	$6,600	$11,267	$3,677
2014 - 15	$6,600	$11,267	$3,677
2015 - 16	$6,600	$11,267	$3,677
2016 - 17	$6,600	$9,000	$3,700

Table 2: Library Materials Budget for Monographs in Subject Areas

Despite the reduction in monograph funds over the years, the Concordia Library has been able to acquire a number of electronic book collections using some centralized (non-subject specific) funds as well as money from the Academic Plan. Electronic book collections bought using these funds include Springer Ebooks, ScienceDirect, and the IEEE-Wiley Ebooks Library. These collections (normally updated each year with new titles) include monographs relevant to chemical engineering.

One-time monies (known as development funds) are made available each year to support new programs or build specific areas of the library collection in answer to the changing needs of our community. These development funds come from undesignated donations to the library and as such, are not consistent from year to year. They are primarily used to acquire titles to address historical gaps in the monograph or ebook collections.

Finally, students at Concordia University benefit from services that provide access to collections outside of Concordia, including the BCI card, which allows for direct borrowing of books from other Canadian academic libraries, including major Montreal institutions such as McGill University and Montréal Polytechnique. The Library's interlibrary loans service enables users to obtain some books, articles, and conference papers from other institutions worldwide, which are not accessible at Concordia. Books are delivered directly to the Library and users can pick them up at the circulation desk.

Electronic Resources (Databases)

The Concordia University Library's current collection of relevant databases for the fields of chemical and materials engineering is slightly under par with other universities that offer similar programs. Of 67 databases used in relation to chemical and materials engineering programs, Concordia subscribes to 32. On average, libraries subscribe to 34 of these databases. The Concordia Library has key, commonly used databases as identified below but funds ought to be considered for some of the databases that Concordia lacks. The following identifies important databases in Concordia's collection and suggests some options to evaluate for purchase.

In Concordia's collection, the three most important databases for chemical and materials engineering—providing access to indexed abstracts—are the following:

SciFinder
SciFinder searches Chemical Abstracts which indexes a wide range of international literature in chemistry and related fields (biology, engineering, physics, geology and material sciences). SciFinder includes journal articles, patents, dissertations, conference proceedings. It also contains millions of substances (CAS Registry) and reactions (CAS REACT), which can be searched by chemical structure, reactions, formulas or CAS Registry numbers. Commercial and regulated chemical information is included.

Compendex
The Compendex database is the largest source of engineering research literature (over 19 million records). Its coverage spans from 1884 to the present and is updated weekly. Compendex is a bibliographic database with references to engineering journals, conferences, trade publications, and more from over 76 countries. Focusing on just engineering disciplines, a significant portion of the Compendex records (about 13%) covers chemical engineering and a smaller quantity covers materials engineering.

Web of Science
This multidisciplinary database covers the journal literature of the sciences through the Science Citation Index (1979 – onwards), which includes the fields of science and engineering. Coverage also includes conference proceedings from the Conference Proceedings Citation Index (1990 – onwards).

Other important databases in the Library's collection that provide access to chemical engineering literature include:

Scopus
This multidisciplinary database covers journals and conference proceedings in science and technology. Physical sciences records (primarily chemistry, physics, and engineering) comprise 29% of the database's 60 million records. Scopus is updated daily with records from over 5000 publishers worldwide.

ACS Publications (American Chemical Society)
The American Chemical Society Journals covers more than 30 journals published by the ACS. Concordia also has access to the ACS legacy archives.

ScienceDirect
ScienceDirect provides full text of more than 1,800 Elsevier Science journals in the life, physical, medical, technical, and social sciences. ScienceDirect coverage spans from 1995 onward. In addition to some ebooks, the Concordia Library also has extensive backfile packages for journals in the areas of engineering, materials science, and technology prior to 1994.

Royal Society of Chemistry
The Royal Society of Chemistry provides databases, ebooks, and the full text of their journals. The Concordia Library subscribes to some of the databases, including the Merck Index (information on chemicals). Bibliographic databases include Synthetic Reaction Updates and Analytical Abstracts covering 1980 to the present. The Library purchases access to some of the RSC ebooks and has access to the journals archive (1841-2004) through its participation in the CRKN Canadian Site Licensing

Project.

The following recommendation is to evaluate two relevant databases for purchase, which comparator universities have but which Concordia lacks.

Knovel
Knovel is a database from Elsevier that covers chemical properties, corrosion data, and material properties. According to publisher Elsevier, Knovel covers "...chemical processes and product development, including plant design and operation, as well as analytical chemistry, catalysis, separation and synthesis used in the creation of new products." It supports chemical engineers and materials scientists with interactive tools for data analysis and search based on ebook content. It also offers access to premium content for chemical engineering research. All of the comparator universities' libraries subscribe to this database.

ChemicalENGINEERINGnetBASE
Databases on the CRCNetBase platform from Taylor and Francis provide full text to nearly 120 handbooks, references, and monographs published by CRC Press. ChemicalENGINEERINGnetBASE covers topics including bioprocessing, chemical processing & design, mass transfer, and process control.

Journals

The Concordia Library has a substantial collection of electronic journals, which are usually acquired in bundles, either from the publisher or an aggregator. These subscription bundles, generally managed on a provincial or national level through academic library consortia, include journals relevant to chemical engineering. These electronic subscriptions have largely displaced the print journal collections and are available to Concordia researchers on- and off-campus. The relevant subscription bundles for chemical engineering include (but are not limited to): Elsevier (ScienceDirect), American Chemical Society (ACS), Royal Society of Chemistry (RSC), American Physical Society (APS), Sage, Springer, Taylor & Francis, and Wiley-Blackwell.

Below is a list of 25 top chemical engineering journals based on their 5 year impact factor according to Thomson Reuters' *InCites Journal Citation Report*, and the Library's current holdings for these journals, along with holdings at the comparator institutions.

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Progress in Energy and Combustion Science	23.634	1975 - Present	1976 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1976 - Present
Energy & Environmental Science	22.118	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Annual Review of Chemical and Biomolecular Engineering	9.337	2010 - Present	2010 - Present		2010 - Present	2010 - Present	2010 - Present	2010 - Present
Applied Catalysis B - Environmental	8.142	1995 - Present	1992 - Present	1995 - Present	1992 - Present	1992 - Present	1992 - Present	1992 - Present
Journal of Catalysis	7.482	1962 - Present	1962 - Present	1970 - Present	1962 - Present	1962 - Present	1962 - Present	1962 - Present
Applied Energy	6.222	1995 - Present	1975 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1975 - Present
Journal of Membrane Science	5.741	1995 - Present	1976 - Present	1995 - Present	1976 - Present	1976 - Present	1976 - Present	1976 - Present
Chemical Engineering Journal	5.439	1997 - Present	1997 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present
ACS Sustainable Chemistry & Engineering	5.319	2013 - Present	2013 - Present	2013 - Present	1995 - Present	2013 - Present	2013 - Present	2013 - Present
Separation and Purification Reviews	5.050	2003 - Present	1973 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present
Combustion and Flame	4.806	1957 - Present	1957 - Present	1970-1993 1995-Present	1957 - Present	1957 - Present	1957 - Present	1957 - Present
Desalination	4.800	1995 - Present	1966 - Present	1995 - Present	1966 - Present	1966 - Present	1966 - Present	1966 - Present
Journal of CO2 Utilization	4.778	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present
Proceedings of the Combustion Institute	4.303	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present
Fuel	4.140	1995 - Present	1970 - Present	1995 - Present	1965 - Present	1968 - Present	1953 - Present	1970 - Present
Catalysis Today	4.105	1995 - Present	1987 - Present	1995 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Fuel Processing Technology	3.949	1995 - Present	1977 - Present	1995 - Present	1977 - Present	1977 - Present	1977 - Present	1977 - Present
Current Opinion in Chemical Engineering	3.810	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present
Separation and Purification Technology	3.758	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present
Dyes and Pigments	3.708	1980 - Present	1980 - Present	1995 - Present	1980 - Present	1980 - Present	1980 - Present	1980 - Present
Journal of Food Engineering	3.512	1995 - Present	1982 - Present	1995 - Present	1982 - Present	1982 - Present	1982 - Present	1982 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Food and Bioproducts Processing	3.511	1996 - Present	1996 - Present	1996 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present
Journal of Industrial and Engineering Chemistry	3.458	2008 - Present	2008 - Present	2008 - Present	1995 - Present	1995 - Present	2008 - Present	1995 - Present
Energy & Fuels	3.340	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Process Biochemistry	3.067	1995 - Present	1991 - Present	1995 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present

Table 3: The print or electronic holdings of 25 chemical engineering journals for Concordia, McGill, École Polytechnique, University of Alberta, Stanford, University of Houston, and Curtin University.

We have current access to 25 of the 25 titles listed. The following table shows backfile access. Backfile access refers to any titles that are not currently received (whether due to cancellation or a one year publisher embargo) but for which there is complete or partial backfile access.

	Concordia University	McGill	École Polytechnique	U Alberta	U Houston	Curtin University
Current Access	25	25	24	25	25	25
Backfile Access	25	25	24	25	25	25
No access	0	0	1	0	0	0

Table 4: Comparative Access to Select Journals

Concordia University access to these chemical engineering journal titles is strong and very similar to the comparator institutions examined here.

Recurring Library Collection Expenditures

To fully support the proposed Master of Applied Science in Chemical Engineering, certain areas of Concordia Library's collection should be enhanced. In particular, the proposed program is estimated to be unsupported by the monograph collection at 37%.

As per Section 5 of the document ***How to Calculate Revenues & Expenses for New Courses and New Programs***, prepared by the Resources Committee, the weighting grid for Cycle 2 in Engineering is 4.42 and the weighting grid for Cycle 2 in the Pure Sciences is 6.59. The multidisciplinary nature of the proposed program makes it necessary to use each of these values to determine a range of recurring library collection expenditures. Each of these numbers was multiplied by 10,000 (see Section 5 in the document mentioned above) and further multiplied by 37% (the amount by which the collection is considered to be unsupported). The recurring library collection expenditures would then fall between $16,354 and $24,383.

Concordia subscribes to many chemical engineering journals in addition to those listed in table 3 and the current journal collection is adequate to support the proposed program. However adding titles to the collection entails recurring costs estimated at annual rates of $1700 - $4500 (USD) per title depending on its subject. These estimates come from The Library Materials Price Index (LMPI) compiled annually by the American Library Association (ALA), which determines the average price per periodical subscription based on the list price of a sample of periodicals. Please see Table 5 for the estimated recurring cost of purchasing new journal subscriptions to add to the Library's collection.

The database collections are adequate to support the proposed program although adding two to three databases to the collection would improve it to be on par with the comparator institutions. Past estimates on the price of these or similar databases suggest a range of recurring costs between $40,000 to $60,000 (USD).

It is important to note that these figures are all of a recurring nature—additional funds that the library would need **each year**.

The Library will require additional funds of between $24,383 and $116,183 (CAD) each year to support the Master of Applied Science in Chemical Engineering program. Note that obtaining these resources for one program, supports other chemical and materials engineering programs that could use the same resources.

	Average price per title (from LMPI) in USD	Recurring annual total in USD	Estimated USD to CAD currency exchange	Recurring annual total in CAD
Engineering journals (example purchase of 5 new title subscriptions)	1700	8500	1.35	11475
Chemistry journals (example purchase of 2 new title subscriptions)	4500	9000	1.35	12150
Knovel (database)		39500	1.35	53325
CHEMICALENGINEERINGnetBASE (database)		11000	1.35	14850
Monographs/ebooks	-	-	-	24383
Recurring annual total excluding new journal purchases	-	-	-	**92558**
Recurring annual total	**-**	**-**	**-**	**116183**

Table 5: Additional funds needed per year to support the proposed program

Conclusion

In addition to using (one-time) development funds to address historical gaps and using interlibrary loans to supplement our collection, additional funding will be needed. The recommendation is to add recurring funds to establish an appropriate annual monograph allocation, bring the library database collection up to par with comparator institutions, and allow for new journal subscriptions, all of which will enable the Concordia University Library to support a Master of Applied Science program in Chemical Engineering.

Appendix 4 Curriculum documents

Please see the Provotrack sheets starting on p. 6 of the Dossier.

Appendix 5 Abridged curricula vitae of current department members

Alex De Visscher, Professor

Education:

- 2001: PhD Bioscience Engineering. Ghent University, Belgium
- 1993: B.Sc./MSc Chemical Engineering. Ghent University, Belgium

Positions/Accomplishments/Experience:

- 2014-2016: Associate Head Graduate, Department of Chemical and Petroleum Engineering, University of Calgary
- 2015-2016: Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2005-2015: Tier II Canada Research Chair in Air Quality and Pollution Control Engineering, Department of Chemical and Petroleum Engineering, University of Calgary
- 2010-2015: Associate Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2011-2012: Visiting Professor, Technical University Bergakademie Freiberg, Germany; Institute of Technical Chemistry
- 2005-2010: Assistant Professor, Department of Chemical and Petroleum Engineering, University of Calgary

Publications: Books (2012-2017):

- De Visscher A. (2013). Air Dispersion Modeling. Foundations and Applications. J. Wiley & Sons, Hoboken, NJ. 634 pp. ISBN 978-1-1180-7859-4.
- De Visscher A. (2013). Lecture Notes in Chemical Engineering Kinetics and Reactor Design. Self-published through CreateSpace, Charleston, SC. 345 pp. ISBN 9781492792642.

Publications: Peer-reviewed journal articles (2012-2017):

- Mahmoudkhani F., Rezaei M., Asili V., Atyabi M., Vaisman E., Langford C.H., De Visscher A. Benzene degradation in waste gas by photolysis and photolysis-ozonation: Experiments and modeling. Front. Environ. Eng. 10(6), 10 (2016).
- Rahnama K. & De Visscher A. Simplified flare combustion model for flare plume rise calculations. Can. J. Chem. Eng. 94, 1249–1261 (2016).
- Harper L.A., Weaver K.H. & De Visscher A. Dinitrogen and methane gas production during the anaerobic/anoxic decomposition of animal manure. Nutr. Cycl. Agroecosyst. 100, 53–64 (2014).
- Asili V., De Visscher A. Mechanistic model for ultraviolet degradation of H2S and NOx in waste gas. Chem. Eng. J. 244, 597–603 (2014).
- Malekshahian M., De Visscher A., Hill J.M. A non-equimolar mass transfer model for carbon dioxide gasification studies by thermogravimetric analysis. Fuel Proc. Technol. 124, 1–10 (2014).
- Fraser S., Marceau D., De Visscher A., Roth S.H. Estimating exposure by loose-coupling an air dispersion model and a geospatial information system. J. Environ. Informat. 21, 84–92 (2013).
- De Visscher A., Conejo M.S. Solubility phenomena related to CO2 capture and storage. Pure Appl. Chem. 85, 2051–2058 (2013).

- De Visscher A. Response to “Remarks on the paper by A. De Visscher, “What does the g-index really measure?”” J. Am. Soc. Informat. Sci. Technol. 64, 1960–1962 (2013).
- De Visscher A. A new Price’s estimate on the size of scientific specialties based on scientific community structure. Scientometrics 96, 937–940 (2013).
- De Visscher A., Vanderdeelen J. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 2: Ca. J. Phys. Chem. Ref. Data 41, 023105 (137pp) (2012).
- De Visscher A., Vanderdeelen J., Königsberger E., Churgalov B.R., Tsurumi M. & Ichikuni M. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 1: Introduction, Be and Mg. J. Phys. Chem. Ref. Data 41, 013105 (67pp) (2012).
- De Visscher A. The thermodynamics-bibliometrics consilience and the meaning of h-type indices – Reply. J. Am. Soc. Informat. Sci. Technol. 63, 630–631 (2012).

HQP Supervision (2012-2017):

- Chongchong Wu, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Sonochemistry for wastewater treatment. Co-supervisor: Dr. I. Gates.
- Michael Süß, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Environmental Engineering. Thesis: Biofiltration of BTEX.
- Mehrshad Parchei Esfahani, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Ultrasound-assisted peroxone for waste gas treatment.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2013–present), PhD student in Chemical Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of Air Pollutants in waste gas.
- Ali Shafaghat, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2016), MEng (thesis) student in Chemical Engineering, Environmental Engineering Specialization. Thesis: Depressurization Dynamic Modeling and Effect on Flare Flame Distortion. Final exam: 14 March 2016.
- Farshid Shayganpour, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2015), MEng (thesis) student in Chemical and Petroleum Engineering, Petroleum Engineering specialization, Thesis: Comparison of CSS and SAGD in Cold Lake. Final exam: 27 April 2015. Co-supervised, with Dr. Ian Gates as supervisor.
- Farzana Haque, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2008–2014), PhD student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Biofiltration of BTX from Glycol Dehydration Units. Final exam: 8 May 2014.
- Maria Conejo, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2014), MSc student in Chemical and Petroleum Engineering, Energy and Environment Engineering specialization, Thesis: Interactions between carbon dioxide and calcium carbonate in carbon storage conditions. Final exam: 10 March 2014.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2011–2013), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of H2S in waste gas: A comprehensive first-principles model. Final exam: July 2013.
- Mahsasadat Atyabi, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2013), MSc student in Chemical and Petroleum Engineering, Environmental

Engineering specialization, Thesis: Ultraviolet degradation of BTX in waste gas: Effects of photocatalysis and ozone premixing. Final exam: 18 January 2013.

- Kamran Rahnama, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2012), MSc student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Plume dispersion: A new flare combustion and plume rise model. Final exam: December 10, 2012.

Participation in thesis juries (2012-2017):

- March 3, 2017: Deependra Singh. Department of Mechanical and Industrial Engineering, Concordia University, PhD, Comprehensive Exam. Subject: Comprehensive Review of Electro-Chemical Machining (ECM) Process (Supervisor: R. Wuthrich).
- November 24, 2016: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering. PhD, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: P. Pereira Almao).
- September 12, 2016: Marlon Vargas-Ferrer. Department of Chemical and Petroleum Engineering. M.Sc., Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: N. Mahinpey).
- September 1, 2016: Jun Cui. Department of Chemistry, University of Calgary, M.Sc., Final exam. Thesis title: Rapid characterization and degradation of dissolved organic matter for improving the quality of boiler feed water in Steam Assisted Gravity Drainage process (Supervisors: C.H. Langford and G. Achari).
- August 24, 2016: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Processing of Peroxidized Asphaltene in Aqueous Media. (Supervisor: P. Pereira Almao).
- August 9, 2016: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: New Pathways for Asphaltenes Upgrading via Oxy-Cracking in Liquid Phase. (Supervisor: P. Pereira Almao).
- May 13, 2016: Saeed Sampouri. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., Final exam. Thesis title: Catalytic Steam Reforming and Esterification of Bio-Oil. (Supervisor: J. Abedi).
- March 24, 2016: Karen Cañon-Rubio. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., Final exam. Thesis title: Strategies for Improving the Productivity and Cost-Effectiveness of Microalgal Production Systems. (Supervisor: H. De la Hoz Siegler).
- March 23, 2016: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Candidacy exam. (Supervisor: J. Bergerson).
- February 26, 2016: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Sorption-enhanced hydrogen production from catalytic steam gasification of coal. (Supervisor: N. Mahinpey).
- January 18, 2016: An Le. Biomedical Engineering Graduate Program, University of Calgary, M.Sc., Final exam. Thesis title: Computational Fluid Dynamics Modeling of Scalable Stirred Suspension Bioreactors for Pluripotent Stem Cell Expansion. (Supervisors: M. Kallos, I. Gates).
- November 27, 2015: Daniel Lincoln. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development and characterization of an LED-based light source for high-speed schlieren imaging. (Supervisor: C. Johansen).
- November 23, 2015: Masoud Alrmah. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: (Supervisor: A. Mohamad).

- November 4, 2015: Jennifer Pauls. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Simulation of air-steam gasification of woody biomass in Aspen Plus: A comprehensive model including pyrolysis, hydrodynamics and tar production. (Supervisor: N. Mahinpey).
- September 10, 2015: Amir Ahmad Shirazi Manesh. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Thermodynamic modeling of asphaltene precipitation using cubic plus association equation of state. (Supervisor: J. Abedi).
- August 19, 2015: Mohamed Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary. PhD, final exam. Thesis title: Computational modelling of the wind flow over the University of Calgary campus. (Supervisor: D. Wood).
- April 27, 2015: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Comprehensive kinetic study of carbon dioxide and steam gasification: New findings and fundamentals. (Supervisor: N. Mahinpey).
- April 20, 2015: Amjad El-Qanni. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Nassar)
- October 22, 2014: Mahida Khurshid. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Serum-free co-expansion of mesenchymal stem cells and chondrocytesas aggregates in suspension bioreactors. (Supervisor: M. Kallos).
- August 29, 2014: Christopher Arisman. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Nitric oxide chemistry and velocity slip effects in hypersonic boundary layers (Supervisor: C. Johansen).
- August 28, 2014: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: D. Wood).
- August 25, 2014: Khaled Omar Sebakhy. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: M. Husein).
- July 10, 2014: Adeem Hassan Khan. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Measurement of the physical properties of MacKay bitumen and solvent mixtures (Supervisor: J. Abedi).
- June 16 2014: Mahdieh Shafiee Neistanak. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Kinetics of asphaltene precipitation and flocculation from diluted bitumen (Supervisor: H. Yarranton).
- April 29 2014: Mona Amiri. Department of Civil Engineering, University of Calgary, M.Sc., final exam. Thesis title: A methodology for estimating greenhouse gas emissions from heavy-duty diesel trucks in construction road transportation (Supervisor: F. Sadeghpour).
- April 17 2014: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- April 16 2014: Virginia Andrade Tovar. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Feasibility study for a small scale integrated on-farm ethanol plant (Supervisor: M. Foley).
- April 8 2014: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- March 27 2014: Ehsan Esmaili Darki. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Modeling and economic assessment of integrated gasification with sorbent CO2 capture (Supervisor: N. Mahinpey).

- January 22 2014: Belal Abu Tarboush. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Adsorption and oxidation of asphaltenes onto in situ prepared and commercial nanoparticles (Supervisor: M. Husein).
- January 10 2014: Xiaojian Wei. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: The effect of varying inlet conditions on the turbulent wake of a fence (Supervisor: D. Rival).
- December 18 2013: Alireza Saidi-Mehrabad. Department of Biological Sciences. M.Sc., final exam. Thesis title: Characterization of aerobic methane oxidizing bacteria in oil sands tailings ponds (Supervisor: P. Dunfield).
- December 16 2013: Lante Carbognani. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Upgrading of Visbroken vacuum residue by adsorption and catalytic steam gasification of the adsorbed components (Supervisor: P. Pereira Almao).
- December 13 2013: Claudia Bess-Ouko. Department of Civil Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development of a LCA screening tool: Assessment of biochar in the removal of organic carbon in SAGD produced water (Supervisors: J. Bergerson and G. Achari).
- November 26 2013: Yanghong Liu. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Separation of water-in-heavy oil emulsions using porous particles in coalescence column (Supervisor: M. Dong).
- November 25 2013: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Template-free synthesis and modification of LTY, ZSM-5 and LTL zeolite catalysts and investigation of the catalytic pyrolysis of Saskatchewan Boundary Dam coal (Supervisor: N. Mahinpey).
- November 20 2013: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Mahinpey).
- October 8 2013: Sarah Alamolhoda. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: J. Hill).
- September 20, 2013: Krishna Morgan Panchalingam. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Bioprocessing of human stem cells applied to diseases of the central nervous system. (Supervisor: L. Behie).
- August 15 2013: Santiago Ortiz Ruiz. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development of a computational tool for low-temperature geothermal-solar power generation plants (Supervisor: A. Mohamad).
- August 1 2013: Rozita Habibi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Co-gasification of biomass and non-biomass feedstocks (Supervisor: J. Hill).
- July 9 2013: Saleh Bawazeer. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Stability and accuracy of Lattice Boltzmann method (Supervisor: A. Mohamad).
- June 20 2013: Upasana Chamoli. Department of Chemistry, University of Calgary, M.Sc., final exam. Thesis title: Disinfection and self-sensitized degradation of NOM (Natural Organic Matter) by TiO_2 photocatalysis with visible light (Supervisors C. Langford and G. Achari).
- June 18 2013: Mostafa Meibod. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Bio-oil from wheat straw and hydrogen from aqueous phase of bio-oil (Supervisor J. Abedi).

- June 11 2013: Hesham Alhumade. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Reversible reactive flow displacements in porous media (Supervisor J. Azaiez).
- April 23 2013: Jaime McKenzie Graham. Department of Biological Sciences, University of Calgary, M.Sc., final exam. Thesis title: Effect of Drainage on Carbon Biogeochemistry and Microbiological Communities in Western Canadian Boreal Peatlands (Supervisor: P. Dunfield)
- April 18 2013: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Wet air oxidation of asphaltene particles (Supervisor: P. Pereira)
- January 18 2013: Giuseppe Rosi. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Characterizing coherent structures within the lower log region of the atmospheric boundary layer (Supervisor: D. Rival)
- December 17 2013: Sobhan Iranmesh. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Removal of naphthenic acid from water using biomass-based activated carbon.
- December 11, 2012: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Catalytic steam gasification of low grade coal with in situ CO2 capture process: Experimental and modeling approach (Supervisor: N. Mahinpey).
- December 6 2012: Esther Ramos-Padron. Department of Biological Sciencies, University of Calgary, PhD, final exam. Thesis title: Physiology and molecular characterization of microbial communities in oil sands tailings ponds (Supervisors: L. Gieg and G. Voordouw).
- June 28 2012: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Vertical wind speed extrapolation using the k-? turbulence model (Supervisor: D. Wood).
- May 4 2012: Punitkumar Kapadia. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Gasification of Althabasca bitumen: Hydrogen generation, kinetics, and in situ process design (Supervisor: I. Gates).

Zhibin Ye, Professor

Education:

- PhD Chemical Engineering, McMaster University, Hamilton, Ontario 2004
- MEng Chemical Engineering, Zhejiang University, China 1999
- BEng Chemical Engineering, Zhejiang University, China 1996

Positions/Accomplishments/Experience:

- July 2012−present: Full Professor of Chemical Engineering
- Jan. 2011−present: Canada Research Chair (Tier 2) in Polymer Nanomaterials
- Sept. 2010−Feb. 2011: Visiting Associate Professor Department of Chemistry, University of Illinois at Urbana-Champaign
- Jan. 2010−present: Cross-Appointment to Department of Chemistry and Biochemistry
- July 2009−June 2012: Associate Professor (Tenured) of Chemical Engineering

- July 2004−June 2009: Assistant Professor (Tenure Track) of Chemical Engineering, School of Engineering, Laurentian University, Sudbury, Ontario, Canada

Publications: Peer-reviewed journal articles (2012-2017):

- L. Xu, L. Huang, Z. Ye*, Z. Gu, "Polycyclopentene-decorated carbon nanotubes by convenient large-scale in situ polymerization and their lotus leaf-like superhydrophobic films", Macromolecular Rapid Communications 2017, 38, 1600608.
- L. Huang, Z. Ye*, R. Berry, "Modification of cellulose nanocrystals with quaternary ammonium-containing hyperbranched polyethylene ionomers by ionic assembly", ACS Sustainable Chemistry & Engineering 2016, 4, 4937–4950. (Impact Factor: 5.267)
- Z. Dong, P. Xiang, L. Huang, Z. Ye*, "Efficient, robust surface functionalization and stabilization of gold nanorods with quaternary ammonium-containing ionomers as multidentate macromolecular ligands", RSC Advance 2016, 6, 43574–43590 (Impact Factor: 3.289).
- P. Xiang, Z. Ye*, "Hyperbranched polyethylene ionomers containing cationic tetralkylammonium ions synthesized by Pd–diimine-catalyzed direct one-pot ethylene copolymerization with ionic liquid comonomers", Macromolecules 2015, 48, 6096–6107. (Impact Factor: 5.554)
- P. Govindaiah, E. Guerra, Y. Choi, Z. Ye*, "Pressure oxidation leaching of an enargite concentrate in the presence of polytetrafluoroethylene beads", Hydrometallurgy 2015, 157, 340−347. (Impact Factor: 2.290)
- P. Xiang, Z. Ye*, "Homo- and co-polymerization of norbornene and methyl acrylate with Pd–diimine catalysts", Journal of Organometallic Chemistry 2015, 798, 429−436. (Impact Factor: 2.336)
- P. Govindaiah, M. Grundy, E. Guerra*, Y. Choi, Z. Ye*, "Polytetrafluoroethylene/TiO2 composite pellets as sulfur adsorbents for pressure oxidization leaching of chalcopyrite", Metallurgical and Materials Transaction B 2015, 46B, 550−556. (Impact factor: 1.474)
- Z. Dong, Z. Ye*, "Heterogeneous palladium catalyst constructed with cross-linked hyperbranched poly(phenylacetylene) as polymer support: a reusable highly active ppm-level catalyst for multiple cross-coupling reactions", Applied Catalysis A: General 2015, 489, 61−71. (Impact factor: 4.012)
- M. Grundy, Z. Ye*, "Cross-linked polymers of diethynylbenzene and phenylacetylene as new polymer precursors for high-yield synthesis of nanoporous activated carbons of high performance for supercapacitors, hydrogen storage, and CO2 capture", Journal of Materials Chemistry A 2014, 2, 20316−20330. (Impact factor: 8.262) [Invited to be featured on journal back cover]
- Z. Dong, Z. Ye*, "Reusable, highly active heterogeneous Pd catalyst by convenient selfencapsulation cross-linking polymerization for multiple carbon–carbon cross-coupling reactions at ppm to ppb Pd loadings", Advanced Synthesis & Catalysis 2014, 356, 3401−3414. (Impact factor: 5.663)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, "Synthesis of polyethylene and polystyrene miktoarm star copolymers using an 'in-out' strategy", Polymer Chemistry 2014, 5, 5443−5452. (Impact factor: 5.687)
- L. Xu, Z. Ye*, S. Siemann, Z. Gu, "Noncovalent solubilization of multi-walled carbon nanotubes in common low-polarity organic solvents with branched Pd–diimine polyethylenes: effects of polymer chain topology, molecular weight and terminal pyrene group", Polymer 2014, 55, 3120−3129. (Impact factor: 3.586; 2 citations)
- O. Osazuwa, M. Kontopoulou, P. Xiang, Z. Ye, A. Docoslis*, "Electrically conducting polyolefin composites containing electric field-aligned multiwall carbon nanotube structures: the effects of process parameters and filler loading", Carbon 2014, 72, 89−99. (Impact factor: 6.198)

- P. Liu, Z. Dong, Z. Ye*, W.-J. Wang*, B.-G. Li, “A conveniently synthesized polyethylene gel encapsulating palladium nanoparticles as a reusable high-performance catalyst for Heck and Suzuki coupling reactions”, Journal of Materials Chemistry A 2013, 1, 15469−15478. (Impact factor: 8.262)
- L. Xu, Z. Ye*, “A Pd−diimine catalytic inimer for synthesis of polyethylenes of hyperbranchedon-hyperbranched and star architectures”, Chemical Communications 2013, 49, 8800−8802. (Impact factor: 6.567)
- E. Landry, Z. Ye*, “Convenient Pd-catalyzed ‘arm-first’ synthesis of large unimolecular star polyethylene nanoparticles”, Macromolecular Rapid Communications 2013, 34, 1493−1498. (Impact factor: 4.638) [This paper was invited to be featured on the cover page]
- A. A. Vasileiou, A. Docoslis, M. Kontopoulou*, P. Xiang, Z. Ye, “The role of non-covalent functionalization and matrix viscosity on the dispersion and properties of LLDPE/MWCNT nanocomposites”, Polymer 2013, 54, 5230−5240. (Impact factor: 3.586; 2 citations)
- Z. Ye*, L. Xu, Z. Dong, P. Xiang, “Designing polyethylenes of complex chain architectures by Pd–diimine-catalyzed ‘living’ ethylene polymerization”, Chemical Communications 2013, 49, 6235−6255. (Impact factor: 6.567; 3 citations) [Invited feature article]
- L. Xu, J.-W. McGraw, F. Gao, M. Grundy, Z. Ye*, Z. Gu, J. L. Shepherd, “Production of high concentration graphene dispersions in low-boiling-point organic solvents by liquid-phase noncovalent exfoliation of graphite with a hyperbranched polyethylene and formation of graphene/ethylene copolymer composites”, Journal of Physical Chemistry C 2013, 117, 10730−10742. (Impact factor: 4.509; 2 citations)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, “Hyperbranched polyethylenes encapsulating selfsupported palladium (II) species as efficient and recyclable catalysts for Heck reaction”, Macromolecules 2013, 46, 72−82. (Impact factor: 5.554; 3 citations)
- P. Xiang, K. Petrie, M. Kontopoulou, Z. Ye*, R. Subramanian, “Tuning structural parameters of polyethylene brushes in surface-initiated ethylene ‘living’ polymerization from silica nanoparticles and effects on nanocomposite properties”, Polymer Chemistry 2013, 4, 1381−1395. (Impact factor: 5.687; 3 citations) [This paper was invited to be featured on back cover]
- P. Xiang, Z. Ye*, “Alternating, gradient, block, and block-gradient copolymers of ethylene and norbornene by Pd−diimine catalyzed ‘living’ copolymerization”, Journal of Polymer Science, Part A: Polymer Chemistry 2013, 51, 672−686. (Impact factor: 3.11; 2 citations)
- O. Oaszuwa, K. Petrie, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Characterization of non-covalently, non-specifically functionalized multi-wall carbon nanotubes and their melt compounded composites with an ethylene-octene copolymer”, Composite Science and Technology 2012, 73, 27−33. (Impact factor: 3.897; 8 citations)
- O. Osazuwa, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Polymer composites containing non-covalently functionalized carbon nanotubes: a study of their dispersion characteristics and response to AC electric fields”, Procedia Engineering 2012, 42, 1414−1424. (1 citation)
- P. Liu, W. Lu, W.-J. Wang*, B.-G. Li, Z. Ye*, S. Zhu*, “Synthesis and characterization of PE-b-POGEMA copolymers prepared by linear/hyperbranched telechelic polyethylene-initiated ATRP of oligo(ethylene glycol) Methacrylates”, Chapter 4 in ACS Symposium Series 1101, Progress in Controlled Radical Polymerization: Materials and Applications, Edited by K. Matyjaszewski, B. S. Sumerlin, and N. V. Tsarevsky, 2012, pp 39−64.
- Z. Zhang, Z. Ye*, “A ligand exchange strategy for one-pot sequential synthesis of (hyperbranched polyethylene)-b-(linear polyketone) block polymers”, Chemical Communications 2012, 48, 7940−7942. (Impact factor: 6.567; 9 citations)

- Z. Dong, Z. Ye*, “Synthesis of hyperbranched poly(phenylacetylene)s containing pendant alkyne groups by one-pot Pd-catalyzed copolymerization of phenylacetylene with diynes”, Macromolecules 2012, 45, 5020−5031. (Impact factor: 5.554; 8 citations) [This paper is one (19th) of top 20 most read articles in the Journal in June 2012; it is also highlighted in ACS Noteworthy Chemistry on August 6, 2012.]
- Z. Dong, Z. Ye*, “Hyperbranched polyethylenes by chain walking polymerization: synthesis, properties, functionalization, and applications”, Polymer Chemistry 2012, 3, 286−301. (Impact factor: 5.687; 17 citations)

HQP Supervision (2012-2017):

- Zhe Chen (MASc, Laurentian University) [Research Associate, Nov. 2015–Dec. 2016]
- Junbin Liao (PhD in Chemical Engineeirng, Zhejiang University of Technology) [PDF, August 2015−June 2017]
- Mark Grundy (MASc in Chemical Engineering, Laurentian University) [Research Associate, Jan. 2015−Jan. 2016]
- Patakamuri Govindaiah (PhD in Chemical Engineering, Yonsei University, South Korea) [PDF, June 2013−Dec. 2014]
- Vimal Tiwari (PhD in Polymer Physics, Banaras Hindu University, Inda) [PDF, May 2013−Dec. 2014]
- Zhichao Zhang (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, Oct. 2011−Sept. 2012]
- Zhongmin Dong (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, March 2011−Dec. 2014]
- Lixin Xu (PhD in Polymer Science and Engineering, Zhejiang University, China) [MRI PDF, September 2010−April 2012]
- Syed Atif Haider Zaidi [MEng, Jan. 2017−]
- Hui Su [MASc, Sept. 2014−Oct. 2016]
- Lingqi Huang [PhD, Sept. 2014−]
- Zhe Chen [MASc, Sept. 2013−Oct. 2015]
- Mark Grundy [MASc, May 2012−Oct. 2014]
- Peng Xiang [PhD, May 2011−Aug. 2015]
- Eric Landry [MASc, Sept. 2010−Oct. 2012]
- Pingwei Liu [PhD, 2009−2014]

Participation in thesis juries (2012-2017):

Paula Wood-Adams, Professor

Education:

- 1999: PhD, Chemical Engineering, McGill University
- 1995: MEng in Chemical Engineering (Dean’s Honor List) McGill University
- 1991: B.Sc. in Chemical Engineering with Distinction, University of Alberta

Positions/Accomplishments/Experience:

- 2016- : John Abbott College Board of Governors, Director
- 2013- : Concordia University, Montreal, Quebec, Dean of Graduate Studies.
- 2013- : Concordia University, Montreal, Quebec, Professor of mechanical engineering.
- 2013- : Jeanne Sauvé Foundation Board of Directors, Director
- 2012- : L'Association des doyens des études supérieures au Québec (Vice-President since 2015)
- 2002- : Member of the editorial board of the Journal of Applied Polymer Science
- 2013-2015: Canadian Association for Graduate Studies Board of Directors, Director
- 2006-2016: Concordia University Research Chair
- 2012-2013: Concordia University, Montreal, Quebec, Interim Dean of Graduate Studies.
- 2010-2012: Concordia University, Montreal, Quebec, Associate Dean of School of Graduate Studies.
- 2006-2013: Concordia University, Montreal, Quebec, Associate Professor of mechanical engineering.
- 2006-2010: Concordia University, Montreal, Quebec, Graduate Program Director of mechanical and industrial engineering
- 2006: Kasetsart University, Bangkok, Thailand, Visiting Professor of chemical engineering
- 2001-2006: NSERC University Faculty Award
- 2005: Petro Canada Young Innovator Award
- 2001-2006: Concordia University, Montreal, Quebec, Assistant Professor of mechanical engineering
- 1998-2001: McGill University, Montreal, Quebec, Assistant Professor of chemical engineering (3 year ETA)

Publications: Peer-reviewed journal articles (2012-2017):

- E Rezabeigi*, PM Wood-Adams, RAL Drew, "Crystallization of polylactic acid under in situ deformation during nonsolvent induced phase separation", in press, Journal of Polymer Science Part B: Polymer Physics, 2017.
- A Arias; M-C Heuzey*; M Huneault; P Wood-Adams, "Rheological study of crystallization behavior of polylactide and its flax fiber composites", 24:46 DOI 10.1007/s10965-017-1210-y, Journal of Polymer Research, 2017.
- E. Rezabeigi*, M Sta, M Swain, N.R. Demarquette, R.A.L. Drew, P.M. Wood-Adams, "Electrospinning of porous polylactic acid fibers during nonsolvent induced phase separation" 134, 44862, J. Applied Polymer Science, 2017.
- KB Riad; R Schmidt; AA Arnold; R Wuthrich; PM Wood-Adams* "Characterizing the structural formation of epoxy-amine networks: the effect of monomer geometry", 104, 83-90, Polymer, 2016.
- S. Mostafa Sabzevari, Joshua D. McGraw, Paula M. Wood-Adams*, "Short Chains Enhance Slip of Highly Entangled Polystyrenes During Thin Film Dewetting", 6, 91163 - 91170, RSC Advances, 2016.
- E Rezabeigi, PM Wood-Adams*, RAL Drew, "Morphological examination of highly porous polylactic acid/Bioglass® scaffolds produced via nonsolvent induced phase separation", DOI: 10.1002/jbm.b.33784, Journal of Biomedical Materials Research Part B, 2016.
- S. Mostafa Sabzevari, Joshua D. McGraw, Karin Jacobs, Paula M. Wood-Adams, "Sacrificial Mica Substrates Influence the Slip Boundary Condition of Dewetting Polymer Films" 78, 202-207 Polymer, 2015.

- S. Chaeichian, PM Wood-Adams*, SV Hoa, "Effect of morphology on fracture toughness of unsaturated polyester-based hybrid nanocomposites" Polymer, 72, 154-164, 2015.
- S. Chaeichian, PM Wood-Adams*, SV Hoa, "Fracture of unsaturated polyester and the limitation of layered silicates" Polymer Engineering and Science, 55, 1303-1309 2015.
- E Rezabeigi, PM Wood-Adams*, RAL Drew, Production of porous polylactic acid monoliths via nonsolvent induced phase separation" Polymer, 55 (26), 6743-6753, 2014
- S.M. Sabzevari, PM Wood-Adams*, I. Cohen, "Wall Slip of Tridisperse Polymer Melts and the Effect of Un-Entangled versus Weakly-Entangled Chains" 47, 8033-8040, Macromolecules, 2014.
- E. Rezabeigi, P.M. Wood-Adams* and Robin A.L. Drew, "Isothermal ternary phase diagram of the polylactic acid-dichloromethane-hexane system"] 55, 3100-3106, Polymer, 2014.
- S.M. Sabzevari, PM Wood-Adams*, I. Cohen, "Wall Slip of Bidisperse Linear Polymer Melts" 47, 3154-3160, Macromolecules, 2014.
- E. Rezabeigi, P.M. Wood-Adams*, R.A.L. Drew, "Synthesis of 45S5 Bioglass® via a straightforward organic, nitrate-free sol-gel process" 40, 248-252, Materials Science and Engineering C, 2014.
- J-S Hébert, PM Wood-Adams, M-C Heuzey, C Dubois and J Brisson*, "Morphology of Polylactic Acid Crystallized during Uniaxial Deformation", 51, 430-440, J. of Polymer Science, Polymer Physics, 2013.
- S. Chaeichian, PM Wood-Adams*, SV Hoa, "In situ polymerization of polyester-based hybrid systems for the preparation of clay nanocomposites", 54, 1512-1523, Polymer, 2013.
- Satu Strandman, David G. Lessard, Dagmar van Dusschoten, Manfred Wilhelm, Paula M. Wood-Adams, Hans W. Spiess, X.X. Zhu*, "Two-dimensional Fourier Transform Rheological Study on Thermosensitivity of Poly(N,N-Diethylacrylamide) in Aqueous Solutions", Polymer, 53, 4800-4805, 2012.
- V. Shaayegan, PM Wood-Adams*, NR Demarquette "Linear Viscoelasticity of Immiscible Blends: The Application of Creep", Journal of Rheology, 56, 1039-1056, 2012.
- NC. Najafi, M-C. Heuzey*, P.J. Carreau, P.M. Wood-Adams, "Control of thermal degradation of polylactic acid (PLA)-clay nanocomposites using chain extenders", Polymer Degradation and Stability, 97, 554-565, 2012.
- Y. Yuryev, PM. Wood-Adams*, "Crystallization of poly(L-/D-lactide) in the presence of electric fields", Macromolecular Chemistry and Physics, 213, 635?642, 2012.

HQP Supervision (2012-2017):

- Sh. Kwaye-Nimo, PhD (in progress). “Slip and die drool in polymer processing”.
- Keroles Riad, PhD (in progress). “3D printable graphene” (co-supervised).
- Wissam Nakhle, PhD (in progress). “Diffusion in polymer melts”.
- Keroles Riad, MSc (Graduated 2016). “Photo-stable, photo-curable epoxies” (co-supervised).
- Niyusha Samadi, PhD (Graduated 2016). “Electrowetting of biological polymer solutions” (co-supervised).
- Ehsan Rezabeigi, PhD (Graduated 2015). “Nanocomposite scaffolds for bone healing” (co-supervised).
- Mostafa Sabzevari, PhD (Graduated 2015). “Effect of MWD on slip of polymers”.
- Nithya Subramamian, MASc (Graduated 2015). “Switchable surface development” (co-supervised).
- Wasef Bzeih, MASc (Graduated 2014). “SFG studies of polystyrene”.

- Sina Chaeichian, PhD (Graduated 2013). “Hybrid thermoset/thermoplastic based nanocomposites” (co-supervised).
- Yury Yuryev, PhD (Graduated 2012). “Crystallization of polylactide”.

Xiaolei Wang, Assistant Professor

Education:

- PhD in Chemical and Biomolecular Engineering; University of California, Los Angeles (UCLA), USA, 2013
- MS in Chemical Engineering; Tianjin University, P.R. China, 2007
- BS in Chemical Engineering (Polymer Chemical Engineering); Dalian University of Technology, P.R. China, 2004

Positions/Accomplishments/Experience:

- Nov. 2013-present: Postdoctoral Fellow Researcher (advisor: Prof. Zhongwei Chen); Department of Chemical Engineering, University of Waterloo

Publications: Peer-reviewed journal articles (2012-2017):

- Xiaolei Wang, Ge Li, Min Ho Seo, Gregory Lui, Fathy Hassan, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Carbon-Coated Silicon Nanowires on Carbon Fabric as Self-Supported Electrodes for Flexible Lithium-Ion Batteries. ACS Applied Materials and Interfaces, accepted, 2016. DOI: adfm.10.1021/acsami.6b12080
- Matthew Li, Yining Zhang, Xiaolei Wang, Wook Ahn, Gaopeng Jiang, Gregory Lui, Zhongwei Chen*, Gas Pickering Emulsion Templated Hollow Carbon for High Rate Performance Lithium Sulfur Batteries. Advanced Functional Materials, 2016, 26(46), 8408-8417.
- Xiaolei Wang, Ge Li, Jingde Li, Yining Zhang, Wook Ahn, Aiping Yu, Zhongwei Chen*, Structural and Chemical Synergistic Encapsulation of Polysulfides Enables Ultralong-Life Lithium-Sulfur Batteries. Energy and Environmental Science, 2016, 9, 2533-2538. (Highlighted in inside back cover)
- Xiaolei Wang§, Ge Li§, Yining Zhang, Zhongwei Chen*, Pomegranate-Inspired Rational Design of Highly Active and Durable Bifunctional Electrocatalysts for Rechargeable Metal-Air Batteries. Angewandte Chemie International Edition, 2016, 55(16), 4977-4982. (VIP paper) (co-first author)
- Xiaolei Wang§, Xingye Fan§, Ge Li, Aiping Yu, Zhongwei Chen*, High-Performance Flexible Electrodes Based on Electrodeposited Polypyrrole/MnO2 on Carbon Cloth for Low-Cost Supercapacitors. Journal of Power Sources, 2016, 326, 357-364. (co-first author)
- Gregory Lui, Ge Li, Xiaolei Wang, Aiping Yu, Zhongwei Chen*, Flexible, 3D Ordered Macroporous TiO2 Electrode with Enhanced Electrode-Electrolyte Interaction in High-Power Li-Ion Batteries. Nano Energy, 2016, 24, 72-77.
- Xiaolei Wang, Ge Li, Min Ho Seo, Fathy M. Hassan, Md Ariful Hoque, Zhongwei Chen*, Sulfur Atoms Bridging Few-layered MoS2 with S-doped Graphene Enables Highly Robust Anode for Lithium-ion Batteries. Advanced Energy Materials, 2015, 5(23), 1501106.
- Xiaolei Wang, Ge Li, Fathy M. Hassan, Jingde Li, Xingye Fan, Rasim Batmaz, Xingcheng Xiao, Zhongwei Chen*, Sulfur Covalently Bonded Graphene with Large Capacity and High Rate for High- Performance Sodium-ion Batteries Anodes. Nano Energy, 2015, 15, 746-754.

- Xiaolei Wang, Xingye Fan, Ge Li, Matthew Li, Xingcheng Xiao, Aiping Yu*, Zhongwei Chen*, Composites of MnO2 Nanocrystals/Partially Graphitized Hierarchically Porous Carbon Spheres with Enhanced Rate Capability for High-performance Supercapacitors. Carbon, 2015, 93, 258-265.
- Xiaolei Wang, Ge Li, Fathy M Hassan, Matthew Li, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Building Sponge-like Robust Architecture of CNT-Graphene-Si Composites with Enhanced Rate and Cycling Performance for Lithium-Ion Batteries. Journal of Materials Chemistry A, 2015, 3, 3962-3967.
- Xiaolei Wang, Ge Li, Fathy M. Hassan, Rasim Batmaz, Xingcheng Xiao, Aiping Yu*, Fast Lithium-ion Storage of Nb2O5 Nanocrystals in-situ Grown on Carbon Nanotube for High-performance Asymmetric Supercapacitors. RSC Advances, 2015, 5, 41179-41185.
- Ge Li, Xiaolei Wang, Fathy M. Hassan, Matthew Li, Rasim Batmaz, Xingcheng Xiao, Aiping Yu*, Vanadium Pentoxide Nanorods Anchored to and Wrapped with Graphene Nanosheets for High-Performance Asymmetric Supercapacitors. ChemElectroChem, 2015, 2(9), 1264-1269.
- Fathy M. Hassan, Rasim Batmaz, Jingde Li, Xiaolei Wang, Aiping Yu, Xingcheng Xiao*, Zhongwei Chen*, Covalent Synergy of Silicon-Sulfur-Graphene as Peculiar Material Design for Cutting-edge Lithium-ion Battery. Nature Communications, 2015, 6, 8597.
- Wook Ahn, Min Ho Seo, Yun-Seok Jun, Dong Un Lee, Xiaolei Wang, Aiping Yu, Zhongwei Chen*, Sulfur Nanofilm Coated Three-Dimensional Graphene Sponge based High Power Lithium Sulfur Battery. ACS Applied Materials & Interfaces, 2016, 8(3), 1984-1991.
- Dong Un Lee, Moon Gyu Park, Hey Woong Park, Min Ho Seo, Xiaolei Wang, Zhongwei Chen, Highly Active and Durable Nanocrystals-Decorated Bifunctional Electrocatalyst for Rechargeable Zinc-Air Batteries. ChemSusChem, 2015, 8(18), 3129-3138.
- Kun Feng, Wook Ahn, Gregory Lui, Hey Woong, Ali Ghorbani Kashkooli, Gaopeng Jiang, Xiaolei Wang, Zhongwei Chen*, Implementing an in-situ carbon network in Si/reduced graphene oxide for high performance lithium-ion battery anodes. Nano Energy, 2015, 19, 187-197.
- Chao Lei, Zheng Chen, Hiesang Sohn, Xiaolei Wang, Ding Weng, Meiqing Shen*, Yunfeng Lu*, Better Lithium-Ion Storage Materials Made through Hierarchical Assemblies of Active Nanorods and Nanocrystals. Journal of Materials Chemistry A, 2014, 2, 17536-17544.
- Kun Feng, Hey Woong Park, Xiaolei Wang, Dong Un Lee, Zhongwei Chen*, High Performance Porous Anode Based on Template-Free Synthesis of Co3O4 Nanowires for Lithium-Ion Batteries. Electrochimica Acta, 2014, 109, 145-151.
- Ge Li, Xiaolei Wang*, Xueming Ma, Nb2O5-Carbon Core-Shell Nanocomposite as Anode Material for Lithium Ion Battery. Journal of Energy Chemistry, 2013, 22(3), 357-362.
- Ge Li, Xiaolei Wang*, Xueming Ma*, Tetragonal VNb9O24.9-based Nanorods: A Novel Form of Lithium Battery Anode with Superior Cyclability. Journal of Materials Chemistry A, 2013, 1, 12409-12412.
- Ge Li, Xiaolei Wang, Zheng Chen, Xueming Ma*, Yunfeng Lu*, Characterization of Niobium and Vanadium Oxide Nanocomposites with Improved Rate Performance and Cycling Stability. Electrochimica Acta, 2013, 102, 351-357.
- Zheng Chen, Yin Yuan, Huihui Zhou, Xiaolei Wang, Zhihua Gan, Fosong Wang*, Yunfeng Lu*, 3D Nanocomposite Architectures from Carbon-Nanotube-Threaded Nanocrystals for High-Performance Electrochemical Energy Storage. Advanced Materials, 2013 36(2), 339-345.
- Xilai Jia, Zheng Chen, Xia Cui, Yiting Peng, Xiaolei Wang, Fei Wei*, Yunfeng Lu*, Building Robust Architectures of Carbon and Metal Oxide Nanocrystals towards High-Performance Anodes for Lithium Ion Batteries. ACS Nano, 2012, 6(11), 9911-9919.

- Zheng Chen, Dieqing Zhang, Xiaolei Wang, Xilai Jia, Fei Wei, Hexing Li, Yunfeng Lu*, High-Performance Energy Storage Architectures from Carbon Nanotubes and Nanocrystal Building Blocks. Advanced Materials, 2012, 24(15), 2030-2036.
- Zheng Chen, Ding Weng, Xiaolei Wang, Yanhua Cheng, Ge Wang, Yunfeng Lu*, Ready fabrication of thin-film electrodes from building nanocrystals for micro-supercapacitors. Chemical Communications, 2012, 48, 3736-3738.
- Xilai Jia, Zheng Chen, Arnold Suwarnasarn, Xiaolei Wang, Hiesang Sohn, Qiang Zhang, Fei Wei, Yunfeng Lu*, High-performance flexible lithium-ion electrodes based on robust network architecture. Energy and Environmental Science, 2012, 5, 6845-6849.

HQP Mentoring (2012-2017):

- 2016-2018: Yuanli Ding, Postdoctoral Fellow, Chemical Engineering. Advanced Battery Technology beyond Lithium-Ion
- 2016-2017: Wen Lei, exchange PhD student, Chemical Engineering. Novel Phosphorous-based Materials for LIBs and SIBs
- 2016-2018: Steven Sherman, PhD candidate, Chemical Engineering. Scalable Production of Cathode Materials through Spray Drying Process for LIBs
- 2016-2018: Dan Luo, PhD candidate, Chemical Engineering. Cable-Like LIBs and Novel Alkaline Batteries and Supercapacitors
- 2016-2018: Justin Raimbault, MASc candidate, Chemical Engineering. Rational Design of Flexible Cathodes for LIBs
- 2014-2015: Xinlong Ma, PhD candidate, Chemical Engineering. Design of Onion-Like Materials Architecture for LIBs and Supercapacitors
- 2014-2015: Xingye Fan, M.A.Sc candidate, Chemical Engineering. Design and Fabrication of Flexible Electrodes for High-Performance Supercapacitors
- 2009-2010: Xing Zhong, M.A.Sc student, Chemical Engineering. Synthesis of 1D CuInS2 Nanowires and Nanorods for Solar Cell Applications

Rolf Wüthrich, Associate Professor (joint appointment with the Department of Mechanical, Industrial, and Aerospace Engineering)

Education:

- 2003: Doctorate, Microtechnology and Manufacturing, École Polytechnique fédérale de Lausanne (EPFL)
- 1998: Master's Equivalent, Particle physics, École Polytechnique fédérale de Lausanne (EPFL)

Positions/Accomplishments/Experience:

- 2015: Technology manager and Head R&D, Posalux SA
- 2009-: Associate Professor, Department of Mechanical and Industrial Engineering, Concordia University
- 2006-2009: Assistant Professor, Department of Mechanical and Industrial Engineering, Concordia University
- 2003-2006: Lecturer Microtechnique, Ecole Polytechnique Federal de Lausanne

Publications: Books (2012-2017):

- R. Wüthrich and J.D. Abou Ziki. (2015). Micro-machining using electrochemical discharge phenomenon - Fundaments and application of Spark Assisted Chemical Engraving. Second Eddition. Elsevier.

Publications: Peer-reviewed journal articles (2012-2017):

- R.T.A. Morrison*, S.S. Hosseiny*, R Wüthrich. (2016). Platinum-like oxidation of nickel surfaces by rapidly switching voltage to generate highly active bifunctional catalysts. Electrochemistry Communications. 67: 22-25.
- Riad KB*, Schmidt R, Arnold AA, Wüthrich R, Wood-Adams PM. (2016). Characterizing the structural formation of epoxy-amine networks: the effect of monomer geometry. Polymer. In Press.
- Morrison A*, Juillac L*, Guyomart S*, Wüthrich R. (2016). Optimization of the Nickel Square Wave Treatment to Produce Highly Active Bifunctional Alkaline Hydrogen Evolution Catalysts. Journal of The Electrochemical Society. Accepted.
- Aghasibeig M*, Moreau C, Dolatabadi A, Wuthrich R. (2016). Engineered Three-Dimensional Electrodes by HVOF Process for Hydrogen Production. Journal of thermal spray technology. In Press.
- Wüthrich R, Wingerter D. (2016). Glass processing with precision and efficiency. Mikroproduktion.
- Aghasibeig M*, Moreau C, Dolatabadi A, Wuthrich R. (2016). Fabrication of Nickel Electrode Coatings by Combined Atmospheric and Suspension Plasma Spray Processes. Surface and Coatings Technology. 285: 68-76.
- Abou Ziki J*, Hof L*, Wüthrich R. (2015). The machining temperature during Spark Assisted Chemical Engraving of glass. Manufacturing Letters. 3: 9-13.
- Abou Ziki J*, Wüthrich R. (2015). The machining gap during constant velocity-feed glass micro-drilling by Spark Assisted Chemical Engraving. Journal of Manufacturing Processes. 19: 87-94.
- Allagui A, Wüthrich R. (2015). Nonequilibrium Thermodynamics for the Stability Study of Contact Glow Discharge Electrolysis. Plasma Processes and Polymers. 12: 691-697.
- Aghasibeig M*, Dolatabadi A, Wüthrich R, Moreau C. (2015). Cold Spray as a Novel Method for Production of Nickel Electrode Coatings for Hydrogen Evolution. International Journal of Hydrogen Energy.
- Abou Ziki J*, Wüthrich R. (2015). Nature of drilling forces during Spark Assisted Chemical Engraving. Manufacturing Letters. 4: 10-13.
- Jabbari F*, Jadidi M*, Wuthrich R, Dolatabadi A. (2014). A Numerical Study of Suspension Injection in Plasma-Spraying Process. Journal of Thermal Spray Technology. 23
- Allagui A*, Alami A, Baranova E, Wüthrich R. (2014). Size-dependent capacitance of NiO nanoparticles synthesized with cathodic contact glow discharge electrolysis. Journal of Power Sources. 262: 178-182.
- Aghasibeig M*, Mousavi M, Ben Ettouill F, Moreau C, Wüthrich R, Dolatabadi A. (2014). Electrocatalytically Active Nickel-Based Electrode Coatings Formed by Atmospheric and Suspension Plasma Spraying. Journal of Thermal Spray Technology. 23
- Mandin P, Derhoumi Z*, Roustan H, Wüthrich R. (2014). Bubble Over-Potential During Two-Phase Alkaline Water Electrolysis. Electrochimica Acta. 128: 248-258.

- SadAbadi H*, Muthukumaran P, Wüthrich R. (2013). High performance cascaded PDMS micromixer based on split-and-recombination flows for lab-on-a-chip applications. RSC Advances. 3
- SadAbadi H*, Badilescu S, Muthukumaran P, Wüthrich R. (2013). Integration of gold nanoparticles in PDMS microfluidics for lab-on-a-chip plasmonic biosensing of growth hormones. Biosensors & Bioelectronics. 44: 77-84.
- Jalali M*, Molière T*, Michaud A, Wüthrich R. (2013). Multidisciplinary Characterization of New Shield with Metallic Nanoparticles for Composite Aircrafts. Composites Part B: Engineering. 50: 309-317.
- Allagui A*, Baranova E, Wüthrich R. (2013). Synthesis of Ni and Pt nanomaterials by cathodic contact glow discharge electrolysis in acidic and alkaline media. Electrochimica Acta. 93: 137-142.
- Baranova E, Cally A*, Allagui A*, Wüthrich R. (2013). Nickel particles with increased catalytic activity towards hydrogen evolution reaction. Comptes Rendus Chimie. 16: 28-33.
- Derhoumi Z*, Mandin P, Roustan H, Wüthrich R. (2013). Experimental investigation of two-phase electrolysis processes: comparison with or without gravity. Journal of Applied Electrochemistry. 43: 1145-1161.
- Abou Ziki JD*, Wüthrich R. (2013). Forces exerted on the tool-electrode during constant-feed glass microdrilling by spark assisted chemical engraving. International Journal of Machine Tools and Manufacture. 73: 47-54.
- SadAbadi H*, Badilescu S, Packirisamy M, Wüthrich R. (2012). PDMS-Gold Nanocomposite Platforms with Enhanced Sensing Properties. Journal of Biomedical Nanotechnology. 8: 539-549.
- Abou Ziki JD*, Fatanat Didar T*, Wüthrich R. (2012). Micro-Texturing Channel Surfaces on Glass with Spark Assisted Chemical Engraving. International Journal of Machine Tools and Manufacture. 57: 66-72.

HQP Supervision (2012-2017):

- Karamzadeh, Vahid (In Progress), MASc student, Concordia University. Thesis/Project Title: Manufacturing of ultra-customized glass parts (2015-present)
- Fallah, Pantea (In Progress), MASc student, Concordia University. Thesis/Project Title: Electrodedeposition of Titanium on Additively Manufactured Parts (2016-present)
- Charbonneau, Frederic (In Progress), MASc student, Concordia University. Thesis/Project Title: Building high precision mechanism in Glass by Spark Assisted Chemical Engraving (2014-2016)
- Riad, Keroles (Completed), MASc student, Concordia University. Thesis/Project Title: Developping novel type of photo-curable polymers using quantum dots for additive manufacturing (2013-2016)
- Jabbari, Farzad (Completed), MASc student, Concordia University. Thesis/Project Title: Simulation on suspension plasma spraying (SPS) (2011-2013)
- Ghorbani, Zahra (Completed), MASc student, Concordia University. Thesis/Project Title: Study of Gas Evolving Electrodes Under Extreme Current Densities (2010-2013)
- Md Masiar, Rahman (In Progress), PhD student, Concordia University. Thesis/Project Title: Electropolishing of Titanium Parts Produced by Selective Laser Sintering (2014-present)
- Hof, Lucas (In Progress), PhD student, Concordia University. Thesis/Project Title: Additive manufacturing by glow discharge electrolysis (2014-present)
- Aghasibeig, Maniya (Completed), PhD student, Concordia University. Thesis/Project Title: Building highly active Nickel electrode for the hydrogen evolution reaction by thermal spraying technologies (2011-2015)

- Ziki, Jana Abou (Completed), PhD student, Concordia University. Thesis/Project Title: Spark Assisted Chemical Engraving: A Novel Approach for Quantifying the Machining Zone Parameters Using Drilling Forces (2011-2014)
- Morrison, Andrew (Completed), PhD student, Concordia University. Thesis/Project Title: A novel highly active and stable Ni(OH)x surface structure as bifunction electrocatalyst for the hydrogen evolution reaction (2010-2015)
- Sadabadi, Hamid (Completed), PhD student, Concordia University. Thesis/Project Title: Nano-integrated Polymeric Suspended Microfluidic Platform for Ultra-Sensitive Bio-Molecular Recognition (2009-2013)
- Jalali, Moshen (Completed), PhD student, Concordia University. Thesis/Project Title: Improving Electromagnetic Shielding with Metallic Nanoparticles (2007-2012)
- Hosseiny, Schwan (Completed), Postdoctoral fellow, Concordia University. Thesis/Project Title: Developing new generation of electrocatalysts for the hydrogen and oxygen evolution reaction (2012-2013)

Appendix 6 Letters of support and list of persons consulted when developing the proposal

This proposal was developed in consultation with the Department of Chemical and Materials Engineering Steering Committee. The members of the Steering Committee are:

- Dr. Amir Aghdam (Electrical and Computer Engineering, Associate Dean SGS)
- Dr. Amir Asif (Electrical and Computer Engineering, Dean ENCS)
- Dr. Christine DeWolf (Chemistry, Arts and Science)
- Dr. Nabil Esmail (Mechanical and Industrial Engineering)
- Dr. Fariborz Haghighat (Building, Civil, and Environmental Engineering)
- Dr. Van Suong Hoa (Mechanical and Industrial Engineering)
- Dr. Paul Joyce (Chemistry, Associate Dean Arts and Science)
- Dr. Muthukumaran Packirisamy (Mechanical and Industrial Engineering)
- Dr. Rolf Wuthrich (Mechanical and Industrial Engineering)

Other persons who have provided advice or who have contributed to this proposal are:

- Frédérica Martin, Manager, Academic Programs and Development, SGS
- Joshua Chalifour, Digital Services & Engineering Librarian

A letter of support from Dr. Amir Asif, Dean of the Faculty of Engineering and Computer Science, and Dr. Graham Carr, Provost, is included on the next page.

Concordia University

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

October 24, 2017

School of Graduate Studies Graduate Curriculum Committee
School of Graduate Studies
GM 930.01

Dear Colleagues,

We write in support of the proposal for establishing graduate programs (Certificate, Diploma, MASc, and PhD) in Chemical Engineering in the recently created Department of Chemical and Materials Engineering.

The proposal is well aligned with the Faculty's strategic planning, touching on many of our strategic directions, especially our commitment to two important ENCS strategic imperatives, namely Enhancing Research Quality and Reputation, and Enhancing Through Innovation in Academic Programs. The proposal being brought forward also demonstrates our commitment to a third Faculty strategic imperative, Embracing Integration across Engineering, Arts, Science, and Business – Dr. De Visscher and his team have worked closely with colleagues in the Faculty of Arts and Science, in particular Dr. Christine De Wolf (Department of Chemistry and Biochemistry) and Dr. Paul Joyce (Associate Dean, Faculty of Arts and Science). Being interdisciplinary and involving faculty members working in physical sciences and engineering, the proposed programs are sufficiently different from existing graduate programs in chemical engineering offered elsewhere in Quebec. In addition, the proposed programs are modular in structure and offer flexibility to the students, allowing for several exit and entry points.

The institutional commitment to the programs is firm at both the Faculty and the University level. Since its establishment in May 01, 2017, three tenure-track/tenured faculty members have been hired in the Department of Chemical and Materials Engineering with one open position advertised in the 2017/18 hiring cycle. The University is committed to hiring two new faculty members in the Department in the 2018/19 hiring cycle and up to two faculty in 2019/20. Renovations for creating research and wet lab space have started in the Hall building. More space would be made available in the extension to the Science and Engineering Pavilion at the Loyola campus.

Interim Chair De Visscher and his team have shown true leadership and vision in proposing these innovative graduate programs, and we are pleased to offer our full support.

Sincerely,

Amir Asif, PhD, PEng
Dean, Engineering and Computer Science

Graham Carr, PhD
Provost and Vice-President, Academic Affairs

1455 De Maisonneuve Blvd. W., EV 2.139, Montreal, Quebec, Canada H3G 1M8
Tel. 514-848-2424 ext. 3109 Fax 514-848-4509 encs.concordia.ca

Appendix 7 Elective Courses Referred to by Subject Areas

List 2

E03 - SYSTEMS AND CONTROL

- ELEC 6041 Large-scale Control Systems
- ELEC 6061 Real-time Computer Control Systems
- ELEC 6091 Discrete Event Systems
- ENGR 6071 Switched and Hybrid Control Systems
- ENGR 6131 Linear Systems (*)
- ENGR 6141 Nonlinear Systems
- ENGR 7121 Analysis and Design of Linear Multivariable Systems
- ENGR 7131 Adaptive Control
- ENGR 7181 Digital Control of Dynamic Systems
- MECH 6681 Dynamics and Control of Nonholonomic Systems

E04 - FLUID MECHANICS

- ENGR 6201 Fluid Mechanics
- ENGR 6221 Microfluidic Systems
- ENGR 6241 Hydrodynamics
- ENGR 6251 The Finite Difference Method in Computational Fluid Dynamics
- ENGR 6261 The Finite Element Method in Computational Fluid Dynamics
- ENGR 6281 Modelling Turbulent Flows
- ENGR 6291 Rheology

E07 - ENERGY CONVERSION

- BLDG 6951 Solar Building Modelling and Design
- ENGR 6601 Principles of Solar Engineering
- ENGR 6611 Equipment Design for Solar Energy Conversion
- ENGR 6661 Solar Energy Materials Science
- ENGR 6811 Energy Resources: Conventional and Renewable

E37 - ENVIRONMENTAL ENGINEERING

- CIVI 6601 Modelling in Building and Environmental Engineering
- CIVI 6611 Environmental Engineering
- CIVI 6621 Engineering Aspects of Biological Treatment for Air and Water
- CIVI 6641 Unit Operations in Environmental Engineering
- CIVI 6651 Water Pollution and Control
- CIVI 6681 Environmental Nanotechnology
- CIVI 6691 Greenhouse Gases and Control
- CIVI 6901 Selected Topics in Civil Engineering I

E52 - THERMODYNAMICS AND HEAT TRANSFER

- MECH 6101 Kinetic Theory of Gases
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 6181 Heating, Air Conditioning and Ventilation (*)
- MECH 6191 Combustion
- MECH 7101 Convection Heat Transfer

E57 - COMPOSITE MATERIALS

- MECH 6501 Advanced Materials
- MECH 6521 Manufacturing of Composites
- MECH 6581 Mechanical Behaviour of Polymer Composite Materials
- MECH 6601 Testing and Evaluation of Polymer Composite Materials and Structures
- MECH 6651 Structural Composites
- MECH 7501 Design Using Composite Materials

List 3

E08 - ACADEMIC COMMUNICATION SKILLS

- ENCS 5721 Composition and Argumentation for Engineers
- ENCS 6721 Technical Writing and Research Methods for Scientists and Engineers

E09 - PROFESSIONAL LEADERSHIP SKILLS

- ENCS 6041 Creativity, Innovation, and Critical Thinking
- ENCS 6042 Communication Techniques for the Innovation Process
- ENCS 6821 Development and Global Engineering

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SCHOOL OF GRADUATE STUDIES

To: Sandra Gabriele, Vice-Provost, Innovation in Teaching and Learning

cc: Olivia Ward, University Curriculum Administrator
Brad Nelson, Associate Dean, School of Graduate Studies

From: Joanne Beaudoin, Secretary, Council of the School of Graduate Studies

Date: November 14, 2017

Re: Graduate Curriculum Changes – CSGS November 13, 2017

This is to confirm that at the Council of the School of Graduate Studies meeting of Monday, November 13, 2017 the following *curriculum changes* were approved:

Faculty of Engineering and Computer Science

- Department of Chemical & Materials Engineering New Program: *Certificate in Chemical Engineering (MECH-101)* CSGS 1718 2 D4
- Department of Chemical & Materials Engineering New Program: *Diploma in Chemical Engineering (MECH-102)* CSGS 1718 2 D6
- Department of Chemical & Materials Engineering New Program: *MASc in Chemical Engineering (MECH-103)* CSGS 1718 2 D8
- Department of Chemical & Materials Engineering New Program: *PhD in Chemical Engineering (MECH-104)* CSGS 1718 2 D10

The documents can be forwarded to Senate for final approval.

Thank you.

Concordia University
School of
Graduate Studies

MEMO TO: Paula Wood-Adams, Dean of Graduate Studies

FROM: Brad Nelson, Associate Dean, Academic Programs and Development
School of Graduate Studies

DATE: October 30, 2017

SUBJECT: **GRADUATE CURRICULUM CHANGES (MECH-104)**
(CALENDAR – 2018/2019)
DEPARTEMENT OF CHEMICAL AND MATERIALS ENGINEERING
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

The Graduate Curriculum Committee (GCC) reviewed the curriculum changes approved by the Faculty of Engineering and Computer Science.

The new Department of Chemical and Materials Engineering wishes to introduce a new PhD in Chemical Engineering.

The GCC requested that the department update the following items: the proposal memo, budget table and timetable along with some editorial changes.

The GCC approved this document with the above inclusions. I therefore recommend that the Council of the School of Graduate Studies approve and recommend to Senate the above-mentioned curriculum changes in their final form.

cc: M. Debbabi, Associate Dean, Graduate Programs and Research, Faculty of Engineering and Computer Science
O. Ward, University Curriculum Administrator, Office of the Provost and Vice-President, Academic Affairs

Concordia University
Engineering and Computer Science

Office of the Dean

INTERNAL MEMORANDUM

TO: Dr. Bradley Nelson
Chair, Graduate Curriculum Committee
School of Graduate Studies

FROM: Dr. M. Debbabi
Associate Dean, Graduate Programs and Research
Faculty of Engineering and Computer Science

CC: Ms. Frederica Martin
Academic Programs Analyst
School of Graduate Studies

DATE: September 8, 2017

RE: **Graduate Curriculum Proposal for the 2018-19 Academic Year**
Faculty of Engineering and Computer Science

At its meetings on May 12th, 2017, the Council of the Faculty of Engineering and Computer Science reviewed and approved, with minor modifications, the creation of the new PhD in Chemical Engineering program from the new Department of Chemical and Materials Engineering (CME).

Details of the new program proposal are indicated and explained in the Department's and Engineering and Computer Science Graduate Studies Committee's (ECSGSC) internal memorandums and Provotrack dossier MECH-104.

We kindly request that this dossier be placed on the next agenda of the Graduate Curriculum Committee.

Thank you for your consideration of this proposal.

Concordia University

FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

INTERNAL MEMORANDUM

TO:	Dr. Amir Asif Chair of the Faculty Council Faculty of Engineering and Computer Science
FROM:	Dr. M. Debbabi Associate Dean, Graduate Programs and Research Faculty of Engineering and Computer Science
DATE:	May 8, 2017
RE:	**Graduate Curriculum Proposal for the 2018-19 Academic Year** **Department of Chemical and Materials Engineering (CME)**

At its meeting on May 3, 2017, the Engineering and Computer Science Graduate Studies Committee (ECSGSC) reviewed and approved, with minor modifications, the creation of a PhD program in Chemical Engineering, which is one of the four new programs put forth by the new Department of Chemical and Materials Engineering (CME).

This program will be complementary to existing programs in Quebec. The uniqueness of this program lies in its multidisciplinary nature drawn from the fields of chemical engineering and materials science. The new program will be implemented in September 2019.

Details of this proposal are indicated and explained in the Department's internal memorandum and Provotrack dossier MECH-104.

We kindly request that this item be placed on the next agenda of the Faculty Council for approval.

Thank you for your consideration of this proposal.

Université Concordia University

INTERNAL MEMORANDUM

April 19, 2017
Revised October 30, 2017
December 4, 2017

To: Dr. M. Debbabi
Associate Dean Research and Graduate Studies, ENCS

From: Dr. Alex De Visscher

Re.: Proposal for a new Doctor of Philosophy (PhD) Degree Program in Chemical Engineering

Dear Dr. Debbabi,

Please find attached a proposal for a new PhD program in Chemical Engineering. This program will be offered by the new Department of Chemical and Materials Engineering, to be established this spring. The proposal is one of five proposals for graduate programs in Chemical Engineering currently in development. Four of these (Certificate, Diploma, MASc and PhD) are currently submitted for approval. The fifth (MEng) will be timed to start approximately one year after the MASc and PhD programs.

The PhD program consists of three courses (12 credits), a comprehensive exam, a doctoral research proposal (6 credits), a seminar (2 credits) and a thesis (70 credits), consistent with the other PhD degree programs. This program will enable the new department to recruit graduate students and carry out its mandate of developing research excellence in Chemical and Materials Engineering.

The courses offered in the PhD program will also be offered in other programs, such as the Certificate, Diploma, MEng, and MASc programs, currently in development.

The budget of a PhD program is somewhat arbitrary because resources must be prorated based on the number of students in the program. Based on a prorating of the teaching load by number of students and by course load of the program, it is assumed that 1.45 full-time faculty members correspond with an enrollment of 62 students. This works out to an average class size of approximately 30 students. With this assumption, the program is expected run a profit of over $600,000 per year. The proposal contains a high-level steady-state budget. A more detailed budget will be provided shortly in a separate document. Also pending are a library study and the results of a survey among senior undergraduate students, which are

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

currently in progress. The reports will be provided as soon as they are available. The curriculum documents in Provotrack are also in development and will be provided as soon as possible.

An overview of course requirements per program is attached to this memo.

It is the intention of the new department to start offering the PhD program in September 2019.

The attached proposal has been vetted by the Steering Committee of the Department of Chemical and Materials Engineering. I would greatly appreciate it if you could put this proposal on the agenda of the next Graduate Studies committee.

Best regards,

Alex De Visscher

1455 De Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8 www.concordia.ca

Tel.: (514) 848-2424 ext. 3488 E-mail: alex.devisscher@concordia.ca

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Table 1 Status of courses per program

Code	Course Title	Certif	Dipl	MEng	MASc	PhD
CHME 6001	Project in Chemical and Materials Engineering	-	-	-	elective	elective
CHME 6011	Advanced Transport Phenomena	core, required	core, required	core, required	core, list	core, list
CHME 6021	Advanced Chemical Engineering Thermodynamics	core, list	core, required	core, required	core, list	core, list
CHME 6031	Chemical Kinetics and Reaction Engineering	core, list	core, required	core, required	core, list	core, list
CHME 6041	Chemical Engineering Process Dynamics and Control	elective	core, required	core, required	core, list	core, list
CHME 6051	Chemical Process Engineering and Design	elective	elective	core, required	core, list	core, list
CHME 6061	Advanced Biochemical Engineering	elective	elective	elective	elective	elective
CHME 6071	Materials Science and Engineering	elective	elective	core, list	core, list	core, list
CHME 6081	Advanced Separation Processes	elective	elective	elective	elective	elective
CHME 6091	Statistics for Chemical Engineering	elective	elective	elective	elective	elective
CHME 6101	Advanced Battery Materials and Technologies	elective	elective	elective	elective	elective
CHME 6111	Polymer Chemistry and Engineering	elective	elective	elective	elective	elective
CHME 6121	Nanomaterials Chemistry and Engineering	elective	elective	core, list	core, list	core, list
CHME 6131	Advanced Colloid and Interface Science and Engineering	elective	elective	elective	elective	elective
-	Capstone Project	-	-	core, required	-	-
CHME 6911	Topics in Chemical Engineering I	elective	elective	elective	elective	elective
CHME 7911	Topics in Chemical Engineering II	-	elective	elective	elective	elective
ENCS 6021	Engineering Analysis	core, required	core, required	core, required	core, list	core, list
	Other List 1 options	elective	elective	elective	elective	elective
	Other List 2 options	-	elective	elective	elective	elective

	Other List 3 options	-	elective	elective	elective	elective
ENGR 8901	Master of Applied Science Research Thesis	-	-	-	core, required	-
ENCS 8011	PhD Seminar	-	-	-	-	core, required
ENCS 8501	Doctoral Research Proposal	-	-	-	-	core, required
ENCS 8511	Comprehensive Examination	-	-	-	-	core, required
ENGR 8911	Doctoral Research and Thesis	-	-	-	-	core, required

Table 2 Number of courses per category, per program

Type of Course	**Cert**	**Dipl**	**MEng**	**MASc**	**PhD**
Core	3	5	8	2+	1+
List 1	1	1	1+	2-	2-
List 2		1	1+	2-	2-
List 3		1	1+	2-	2-
Total	**4**	**8**	**12**	**4**	**3**

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

PROGRAM CHANGE: PhD in Chemical Engineering

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [ ] Requirements [ ] Regulations [ ] Program Deletion [X] New Program

Present Text (from 20xx/20xx) calendar	Proposed Text
	Department of Chemical and Materials Engineering **Chemical Engineering** **Programs** **Doctor of / Doctorate in Philosophy (Chemical Engineering)** **Admission Requirements** To be considered for admission on a full-time basis, applicants normally must hold a master's degree or equivalent with high standing in engineering or the sciences. Holders of a bachelor's degree will, in general, be considered for admission to a master's program only. After completion of a minimum of two terms of full- time study, they may, upon application, be considered by the Faculty Graduate Studies Committee for admission to a PhD program (please see Graduate Calendar regulations on accelerated admission to PhD programs). The Department Graduate Studies Committee will determine the acceptability of an applicant for admission to the program and may require the applicant to do specific remedial course work, including the bridge course CHME 401 Principles of Chemical Engineering, and/or other course(s) to meet the program requirements. Credible academic references and a statement of purpose are required. **Degree Requirements** See the description of the Doctor of/Doctorate in Philosophy requirements in the general section on the Faculty of Engineering and Computer Science. **Core and elective courses**

Core: At least 4 credits (one course) from the following list:

- CHME 6011 Advanced Transport Phenomena
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control
- CHME 6051 Chemical Process Engineering and Design
- CHME 6071 Materials Science and Engineering
- CHME 6121 Nanomaterials Chemistry and Engineering
- ENCS 6021 Engineering Analysis

Electives: Up to 8 credits (two courses) from lists 1, 2, or 3 (Core and Electives: 12 credits).
Students may take an elective course outside lists 1, 2, or 3 with permission of the Graduate Program Director.

Students who take a three-credit course towards their course requirement of 12 credits must take course CHME 6001 Project in Chemical and Materials Engineering to obtain the missing credit.

Students who are permitted to fast-track to the PhD program (please see Graduate Calendar regulations on accelerated admission to PhD programs) must complete a total of 28 course credits, at least 12 of which should be from the core course list, and the remainder of which should come from lists 1, 2, or 3, not including Topic Area E08 or ENGR 6971.

ENCS 8011 Ph.D. Seminar: 2 credits
ENCS 8501 Comprehensive Examination: no credit value
ENCS 8511 Doctoral Research Proposal: 6 credits
ENGR 8911 Doctoral Research and Thesis: 70 credits

<u>Elective Course Lists</u>
List 1:

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I
- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2:

- CHME 7911 Topics in Chemical Engineering II

	• ENGR 6601 Principles of Solar Engineering • ENGR 6971 Project and Report I • MECH 6571 Corrosion and Oxidation of Metals • All courses in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering or in List 1 List 3: • Any course(s) in Topic Areas E08 and E09

Rationale:

The introduction of the PhD program is part of the new Chemical and Materials Engineering Department's mandate. The development of the Department and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering.

The purpose of the proposed program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future.

According to Engineers Canada (Canadian Engineers for Tomorrow, 2012; 2015), the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292).

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The proportion of female students is typically about 33 % in Chemical Engineering, higher than in other engineering programs. Hence, introducing Chemical Engineering programs will help mitigate the gender imbalance among engineering students at Concordia University.

It is anticipated that the course offerings will start one year ahead of the degree programs.

There is adequate space in the ENCS, ENGR, and MECH courses to accommodate the additional students.

Resource Implications:

The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

PROGRAM CHANGE: Topic Area E58

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:
[ ] Editorial [X] Requirements [ ] Regulations [ ] Program Deletion [ ] New Program

Present Text (from 20xx/20xx) calendar	Proposed Text
	Engineering Courses ------ **List of Courses by Topic Areas** ------ **E58 - CHEMICAL PROCESS ENGINEERING** **CHME 6001 Project in Chemical and Materials Engineering** (1 credit) **CHME 6011 Advanced Transport Phenomena** (4 credits) **CHME 6021 Advanced Chemical Engineering Thermodynamics** (4 credits) **CHME 6031 Chemical Kinetics and Reaction Engineering** (4 credits) **CHME 6041 Chemical Engineering Process Dynamics and Control** (4 credits) **CHME 6051 Chemical Process Engineering and Design** (4 credits) **CHME 6061 Advanced Biochemical Engineering** (4 credits) **CHME 6071 Materials Science and Engineering** (4 credits) **CHME 6081 Advanced Separation Processes** (4 credits) **CHME 6091 Statistics for Chemical Engineering** (4 credits) **CHME 6101 Advanced Battery Materials and Technologies** (4 credits) **CHME 6111 Polymer Chemistry and Engineering** (4 credits) **CHME 6121 Nanomaterials Science and Engineering** (4 credits) **CHME 6131 Advanced Colloid and Interface Science and Engineering** (4 credits) **CHME 6911 Topics in Chemical Engineering I** (4 credits) **CHME 7911 Topics in Chemical Engineering II** (4 credits)

Rationale:
The changes reflect the addition of a new topic area and new courses of the proposed new program.

Resource Implications:
The program can be run with the existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6001 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6001 Project in Chemical and Materials Engineering (1 credit) The course consists of an individual project in a chosen area of study in the area of Chemical and Materials Engineering under the supervision of a faculty member. This course may be repeated for credit.

Rationale:
The coursework of the PhD program normally consists of three courses of 4 credits each (12 credits). However, students may take courses in programs or universities (with permission of the Graduate Program Director) where courses are 3 credits. To enable this, students will be required to take this one-credit course to meet their course credit requirements.

Resource Implications:
The course will be taught by existing faculty and new faculty members foreseen in the hiring plan for the Department of Chemical and Materials Engineering.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6011 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6011 Advanced Transport Phenomena (4 credits) Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6021 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6021 Advanced Chemical Engineering Thermodynamics (4 credits) Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6031 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	**Proposed Text**
	CHME 6031 Chemical Kinetics and Reaction Engineering (4 credits) Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6041 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6041 Chemical Engineering Process Dynamics and Control (4 credits) Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Research Methods", "Theory", and "Tools" learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6051 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6051 Chemical Process Engineering and Design (4 credits) Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6061 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6061 Advanced Biochemical Engineering (4 credits) Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the "Research Methods", "Theory", and "Tools" learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6071 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6071 Materials Science and Engineering (4 credits) Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6081 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6081 Advanced Separation Processes (4 credits) Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6091 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6091 Statistics for Chemical Engineering (4 credits) Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6101 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6101 Advanced Battery Materials and Technologies (4 credits) Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6111 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6111 Polymer Chemistry and Engineering (4 credits) Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6121 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6121 Nanomaterials Science and Engineering (4 credits) Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 6131 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6131 Advanced Colloid and Interface Science and Engineering (4 credits) Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Research Methods”, “Theory”, and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

COURSE CHANGE: CHME 6911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Certificate, Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 6911 Topics in Chemical Engineering I (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

PROGRAM AND COURSES CHANGE FORMS FOR DOCUMENT: **MECH-104** VERSION: 10

COURSE CHANGE: CHME 7911 New Course Number:

Proposed [ ] Undergraduate or [X] Graduate Curriculum Changes

Calendar for academic year: 20xx/20xx
Implementation Month/Year: TBD 20xx

Faculty/School: Engineering and Computer Science
Department: Chemical and Materials Engineering
Program: Chemical Engineering
Degree: Diploma, MEng, MASc, PhD
Calendar Section/Graduate Page Number: Fall 2017

Type of Change:

[ ] Course Number	[ ] Course Title	[ ] Credit Value	[ ] Prerequisite
[ ] Course Description	[ ] Editorial	[X] New Course	
[ ] Course Deletion	[ ] Other - Specify:		

Present Text (from 20xx/20xx) calendar	Proposed Text
	CHME 7911 Topics in Chemical Engineering II (4 credits) Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

Rationale:
This course is part of the introduction of new graduate programs in Chemical Engineering. This course contributes to the “Theory” and “Tools” learning outcomes in the PhD program.

Resource Implications:
This course will be part of the teaching load of recently hired faculty members.

Other Programs within which course is listed:

None.

Proposal

Doctor of Philosophy in Chemical Engineering

Faculty of Engineering and Computer Science

Concordia University

Executive Summary

Concordia University proposes to offer a new PhD program in Chemical Engineering. The PhD program is expected to draw about 60 students at steady state, and graduate about 12 students per year. It will be complementary to existing programs of this nature in Québec. In particular, the program will be embedded in a multidisciplinary department covering the fields of Chemical and Materials Engineering, and this will give the students a unique, multifaceted outlook on the profession of Chemical Engineering. Currently, eighteen universities in Canada offer the PhD in Chemical Engineering, four of which are located in the Province of Québec. Concordia University already has extensive research strength in materials engineering, particularly with applications in the aerospace industry, for instance with the Concordia Centre for Composites, which includes 15 faculty members from multiple departments. The new department and the associated programs will build on these strengths.

The proposed PhD program will contain a minimum of 90 credits. It will consist of three graduate courses (12 credits), a seminar (2 credits), a research proposal (6 credits), a comprehensive exam and a thesis (70 credits). The course requirement is a combination of core courses, to be selected from a limited list, which is focused on deepening core chemical engineering knowledge (e.g., transport phenomena, chemical thermodynamics and kinetics, reactor design, separation processes, etc.), and non-core courses, focused on broadening knowledge. The thesis research will be supervised by members of the Department of Chemical and Materials Engineering.

Chemical Engineering programs in North America have experienced robust growth at all levels in the past decade, from undergraduate to doctoral. This strong performance indicates that there will be a market for the proposed program across the continent.

The development of a Department of Chemical and Materials Engineering and its programs is a key part of Concordia's strategy, which specifically includes building research capacity in Chemical and Materials Engineering. Hence, the Concordia University leadership committed to the success of the proposed PhD program. Chemical Engineering programs also draw a larger proportion of female students than is average for Engineering. Hence, it is expected that the program will help mitigate the gender imbalance in engineering.

The Department of Chemical and Materials Engineering will consist of three regular faculty members, one joint member and two excluded members (Dean of Graduate Studies, VP Research & Grad studies) as of January 2018, and two more faculty recruitments are anticipated every year until the faculty count reaches 15 members. This will ensure that there will be a critical mass for the delivery of the program at the time of its planned start in Fall 2019. The first graduates are anticipated in 2023.

Table of Contents

Section 1 PROGRAM IDENTIFICATION

1.1 Program title, degree title and level

Program title:	Doctor of Philosophy (PhD)
Degree:	Chemical Engineering
Level:	Graduate

1.2 Areas of specialization

Chemical Engineering; Chemical Thermodynamics; Chemical Kinetics; Transport Phenomena; Chemical Reactor Engineering; Materials Engineering; Polymer Engineering; Electrochemical Engineering.

1.3 Administrative location

University:	Concordia University
Faculty:	Faculty of Engineering and Computer Science
Department:	Department of Chemical and Materials Engineering
Address:	1455 de Maisonneuve Blvd. W
	Montreal, Québec, H3G 1M8
	Canada

SECTION 2 PROGRAM OBJECTIVES

2.1 Theoretical Foundation and General Academic Aims

Chemical Engineering is the application of chemical and engineering principles to the design and operation of industrial units for the manufacture of chemicals. This includes the manufacture of bulk chemicals (e.g., oil refinery products, fertilizers, plastics), fine chemicals (e.g., pharmaceuticals), metals, etc. It also includes the production of chemicals by micro-organisms (e.g., fermentation, brewing), and the conversion of biomaterials into chemicals (e.g., bio-oil, biodiesel). An emerging field of application for chemical engineers is new materials (nanomaterials, composites). Chemical engineers are responsible for the design and operation of safe and environmentally responsible processes.

Chemical engineers are primarily trained to be designers of chemical processes, but they also work in the operation and control of chemical processes, and in the research and development of new chemical processes.

Chemical engineers are closely related to Materials engineers. However, whereas the materials engineer is mainly focused on the *product*, the chemical engineer is mainly focused on the *process*. The proximity of the fields of chemical and materials engineering provides opportunities for cross-fertilization. The intention of the proposed program is to train chemical engineers with a solid grasp of the materials aspects of their profession. The training will be embedded in a research environment that is strong on materials engineering research.

Industrial chemical processes are generally built from unit operations, i.e., operations that carry out a single step of the overall process. Each unit operation is based on physical and chemical principles. This approach is mirrored in chemical engineering (undergraduate) programs. The program starts with mathematics, physics, and chemistry and then moves on to engineering sciences such as general and chemical thermodynamics, material balances, mass and heat transfer, fluid mechanics, and chemical kinetics. This is followed by the study of unit operations: pumps, compressors, filters, reactors, distillation towers, etc. Next, the dynamics and control of chemical processes is covered, and the program is concluded with chemical process design, where all the obtained knowledge is integrated, and augmented with heuristics for the design of chemical plants. At the graduate level, students deepen their expertise in these areas with additional courses. In the case of a thesis-based graduate program, students deepen their knowledge further in a chosen area of research, and conduct original research in this area.

Chemical engineers are excellent system-wide thinkers. Hence, many chemical engineers find employment in sectors unrelated to chemical industry (management, banking, policy, etc.). Their training and skills often complement those of economists and managers.

Historically, the chemical engineering profession started as a largely empirical endeavor, where the design of chemical processes was mainly based on experience obtained with previous designs. This largely trial-and-error approach made way for a more rigorous, science-based approach in the mid-20th century. This relatively late development is largely owing to the fact that many chemical processes are highly nonlinear, and do not lend themselves well to linear engineering analysis. Hence, a scientific approach to chemical engineering is largely based on computer simulations, and this numerical approach has developed in lockstep with the development of ever faster and more powerful computers since the mid-20th century. Nevertheless, even the most powerful computer systems cannot resolve all aspects of every chemical process, and empiricism (rules of thumb) remains an important aspect of chemical engineering practice. It is the intention of the proposed program to provide contemporary tools of chemical process simulation to the students, without losing sight of the empirical, experience-based aspects of chemical engineering.

The purpose of the proposed PhD program in Chemical Engineering is to train engineers with valuable skills for a broad range of industrial sectors in Quebec and worldwide, who will drive economic growth by manufacturing the materials needed for the economy of the future. Based on the needs, the proposed PhD program will emphasize the materials engineering aspects of Chemical Engineering.

2.2 Specific knowledge, expertise, skills (learning outcomes) which students will acquire

By the end of this program, successful students will be able to do the following:

- **Research Methods:** Think critically, interpret the literature, develop, plan, and apply a range of research methodologies to accomplish research objectives in novel ways.
- **Theory:** Apply, analyze and evaluate chemical engineering concepts to solve industrially relevant research problems.
- **Tools:** Use and develop chemical engineering tools that are relevant in an industrial setting.
- **Dissemination:** Use oral and written communication to effectively disseminate research and other technical concepts in high quality journals, conferences, and practitioner events.
- **Original scholarship:** Produce high quality, original research and create new knowledge in an area of chemical engineering.

2.3 Description of how the learning outcomes will be assessed

The learning outcomes that are assessed in the PhD program have the following requirements. They are linked in Table 1:

- **Coursework:** Three courses that help the student develop specific skills needed to conduct research and understand chemical engineering.
- **Comprehensive Exam:** Survey literature and demonstrate the ability to understand, criticize, abstract and summarize research.
- **Proposal:** Create a realistic research plan grounded in the literature and chemical engineering problems that makes a novel contribution to chemical engineering knowledge.
- **Doctoral Thesis:** Produce an original piece of chemical engineering scholarship that is usually composed of a cohesive series of published papers in top chemical engineering venues.

Table 1. Mapping Program Requirements with Learning Outcomes

	Program Requirements				
Learning outcomes		Coursework	Comprehensive Exam	Proposal	Doctoral Thesis
	Research Methods	Major	Minor	Major	Major
	Theoretical	Major	Major	Minor	Major
	Tools	Major		Minor	Major
	Dissemination			Major	Major
	Original Scholarship			Major	Major

SECTION 3 RATIONALE FOR PROGRAM PROPOSAL

3.1 Socio-economic or cultural relevance

3.1.1 Detailed needs analysis, including projected student enrolment: Enrolment chart, including graduation and attrition, with justifications and explanations (projected for a five-year period)

According to data from the American Society for Engineering Education (ASEE), the number of students graduating with a Bachelor's degree in Chemical Engineering in the United States has increased from 4452 in 2006 to 9090 in 2015 [Yoder, B.L. *Engineering by the Numbers*. ASEE, 2015], an increase by 104 % in one decade. As a proportion of engineering students graduating with a Bachelor's degree in Chemical Engineering, the Chemical engineering program has gained popularity, from 6.0 % in 2006 to 8.5 % in 2015. In Canada, the overall enrollment in Bachelor's programs in Chemical Engineering has increased by 38 % between 2008 and 2014 (from 4379 to 6076), and the number of graduations increased by 25 % (from 1030 to 1292) during the same time [Engineers Canada, *Canadian Engineers for Tomorrow*, 2012; 2015].

These numbers indicate that there is a potential for increased inflow of students into graduate programs. The number of Master and PhD graduations in Chemical Engineering in the United States has also increased substantially: from 1204 to 1716, or 42 % from 2006 to 2015 for Master students, and from 834 to 1062, or 27 % for PhD students. In Canada, the graduate enrollment of Master students in Chemical Engineering has increased by 28 % between 2008 and 2014 (from 708 to 910), and the enrollment of PhD students has increased by 41 % during that time (from 679 to 958).

The PhD (and MASc) programs will ramp up slowly because the faculty members who will supervise the students will be recruited over a 6-year time span. For that reason, a time window up to Year 8 is considered in the analysis.

The enrollment projections for the PhD program are given in the table below. Year 1 corresponds with Fall 2019.

Table 2 Graduate enrollment projections for the PhD program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
PhD	4	9	17	26	34	42	51	56

In this projection, a recruitment rate of 1.2 students per faculty member per year, a retention of four years, and an attrition rate of 10 % per year is assumed. These numbers are consistent with other engineering programs at Concordia University. At steady state, there will be 238 students in the various graduate programs in Chemical Engineering (including Certificate and Diploma), of which 208 will be in full degree programs (MEng, MASc, PhD), and 62 in the PhD.

The PhD program is assumed to be a 4-year program for the calculation of the graduation projections, given below.

Table 3 Graduation projections for the PhD program in Chemical Engineering

Program	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
PhD					2	4	6	7

At steady state, there will be 12 graduations per year in the PhD program, out of a total of approximately 100 graduations in Chemical Engineering graduate programs.

3.1.2 Identification of the main prospects for graduates from the program (employment, self-employment, creativity opportunities, career mobility, advanced education)

Chemical Engineers are employed in the chemical industry, in consulting, and in government. Other sectors often require chemical engineers for their specific expertise. Examples are insurance companies, banks, etc.

During their PhD program, students will immerse themselves deeply in a specialized field within chemical engineering, beyond the boundaries of current knowledge and/or current engineering practice. They will conduct research in their chosen field, leading to a thesis. They will learn to develop and carry out a substantial, innovative research project independently. They will learn to formulate a research problem or research question, develop a research strategy that is appropriate for the stated problem, considering the problem from multiple angles, plan and carry out their work, and draw conclusions from their results. They will report and publish their results.

Alumni who have completed a PhD program have opportunities to find jobs beyond the level available to Bachelor and Master-level engineers. They will find jobs in consulting, and in R&D labs in government and industry. They will take up or grow into senior positions that require a substantial amount of independence and critical thinking. They will be the drivers of innovation in the organizations that employ them.

The PhD program will also prepare students for an academic career.

3.1.3 Importance of the sector affected by the proposed program to professional orders, private or public organizations, or government departments

In Canada, the GDP for chemical manufacturing and related sectors (plastics and rubber, nonmetallic mineral products, paper) amounts to CAN$37 billion, which is over 20 % of all manufacturing sectors in Canada (Statistics Canada).

In Quebec there is a strong presence of chemical industry, in areas such as pharmaceuticals, oil refining, etc.

3.1.4 Existence of similar programs in Canada or elsewhere, their academic success; similarities and differences with the proposed program; how will the proposed program help bring the Province of Québec up to par with the Canadian or International level; or how will the new program help the Province become a leader in this area of specialization

Canada currently offers Chemical Engineering programs at 20 universities (18 at the graduate level). Four of these (McGill University, École Polytechnique, Université Laval and Université de Sherbrooke) are located in the Province of Québec. As a comparison, Ontario offers Chemical Engineering programs at ten universities (eight at the graduate level). Hence, in terms of numbers of universities, Chemical Engineering is currently underrepresented in the Province of Québec. An overview of graduate programs in Chemical Engineering and related fields is given below. The enrollment and graduation numbers are for 2014 [Engineers Canada. *Canadian Engineers for Tomorrow*, 2014].

Where the proposed PhD program will be different from the existing programs in the Province of Québec is in the level of integration between the Chemical Engineering graduate programs and Materials Engineering research as a driver for the program. Concordia University has prior experience with this strategy in the Department of Mechanical, Industrial, and Aerospace Engineering (MIAE), where Materials Engineering is a significant driver of the Mechanical Engineering and Aerospace Engineering programs. Of particular note is the Concordia Centre for Composites (CONCOM), which houses 15 faculty members and a total of 50 members.

Some key members of CONCOM and MIAE who can contribute to the new department are Dr. Suong Van Hoa, director of CONCOM, who conducts research in polymer nanocomposites with applications in the aerospace industry; Dr. Mamoun Medraj, who conducts research in thermodynamic modeling of phase diagrams relevant for composite materials, and Dr. Nabil Esmail, who conducts research in rheology and surface phenomena of fluids. Dr. Paula Wood-Adams, who will transfer to the Department of Chemical and Materials Engineering, is also a member of CONCOM.

In addition, collaborative research is anticipated with faculty members in the Department of Chemistry and Biochemistry. For instance, Dr. John Oh, also a member of CONCOM, conducts research in macromolecular nanoscale biomaterials.

Faculty members in these and other departments who provide significant and lasting contributions to the proposed programs will be appointed as associate members of the Department of Chemical and Materials Engineering. They will augment the research and graduate student supervision of the core members of the Department of Chemical and Materials Engineering. This broad range of expertise will enable the department to provide knowledge from the molecular scale to the scale of the industrial processes to manufacture materials.

Québec

McGill Universtiy

Degrees offered:	PhD
	MEng (thesis)
	MEng (non-thesis)
	Graduate Diploma
Programs offered:	Chemical Engineering (PhD, MEng (thesis), MEng (non-thesis))
	Mining and Materials Engineering (PhD, MEng (thesis), MEng (non-thesis))
	Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1
Master graduations:	12

PhD graduations:	11	

<u>École Polytechnique</u>

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based
	Diplôme d'études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD, M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD, M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD, M.(rech.), M.(prof.))
	Procédés	(PhD, M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD, M.(rech.), M.(prof.))
	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	
Master graduations:	23	
PhD graduations:	20	

<u>Université Laval</u>

Degrees offered:	Maîtrise avec mémoire (MSc)
	Doctorat
Programs offered:	Génie chimique
	Génie des matériaux et de la métallurgie
Specializations:	-
Full-time enrollment:	68
Part-time enrollment:	0
Master graduations:	8
PhD graduations:	9

<u>Université de Sherbrooke</u>

Degrees offered:	Maîtrise	(thesis-based)
	Maîtrise de type cours	
	Doctorat	
Programs offered:	Génie chimique	
Specializations:	-	
Full-time enrollment:	65	
Part-time enrollment:	0	
Master graduations:	11	
PhD graduations:	7	

Ontario

<u>University of Toronto</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering and Applied Chemistry (all)
	Materials Science and Engineering (all)
	Collaborative program in Environmental Studies (all)
	Collaborative program in Biomedical Engineering (MASc, PhD)
	Collaborative program in Cadriovascular Sciences (MASc, PhD)
	Collaborative program in Engineering Education (MASc, PhD)
	Collaborative program in Environmental Engineering (MASc, PhD)
	Collaborative program in Genome Biology and Bioinformatics (MASc, PhD)
	Collaborative program in Global Health (MASc, PhD)
Specializations:	Advanced Water Technologies and Process Design (MEng)
	Entrepreneurship, Leadership, Innovation and Technology in Engineering (MEng)
	Sustainable Energy (all)
	Advanced Manufacturing (MEng)
Full-time enrollment:	217
Part-time enrollment:	12
Master graduations:	50
PhD graduations:	15

<u>Ryerson University</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering
Specializations:	-
Full-time enrollment:	27
Part-time enrollment:	2
Master graduations:	11
PhD graduations:	4

<u>University of Ottawa</u>

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
	Graduate Diploma
Programs offered:	Chemical Engineering (MASc, MEng, and PhD)
	Advanced Materials and Manufacturing (MASc, MEng, and PhD)
	Technology Project Management (Diploma)
Specializations:	-
Full-time enrollment:	94
Part-time enrollment:	6

Master graduations:	51
PhD graduations:	5

Queen's University

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering
	Collaborative degree in Applied Sustainability (MEng, MASc)
	Collaborative degree in Biomedical Engineering (MASc, PhD)
Specializations:	-
Full-time enrollment:	78
Part-time enrollment:	1
Master graduations:	19
PhD graduations:	10

Royal Military College

Degrees offered:	Master (thesis-based)
	PhD
Programs offered:	Chemical and Materials Engineering
	Nuclear Engineering
Specializations:	-
Full-time enrollment:	28
Part-time enrollment:	8
Master graduations:	6
PhD graduations:	3

McMaster University

Degrees offered:	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering
	Materials Engineering
Specializations:	-
Full-time enrollment:	86
Part-time enrollment:	2
Master graduations:	18
PhD graduations:	2

University of Waterloo

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering
Specializations:	-
Full-time enrollment:	184
Part-time enrollment:	19
Master graduations:	57

PhD graduations: 22

Western University

Degrees offered:	MEng	(course-based)
	MESc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	153	
Part-time enrollment:	4	
Master graduations:	37	
PhD graduations:	15	

Laurentian University

No graduate programs in Chemical Engineering. The following are the closest graduate degrees offered:

MEng Natural Resources Engineering
MASc Natural Resources Engineering
PhD Materials Science
PhD Natural Resources Engineering

Lakehead University

No graduate programs in Chemical Engineering. The following is the closest graduate degree offered:

M.Sc. Environmental Engineering

Atlantic Provinces

Dalhousie University

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	19	
Part-time enrollment:	0	
Master graduations:	4	
PhD graduations:	0	

University of New Brunswick

Degrees offered:	MEng	(course-based)
	MScE	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	45	

Part-time enrollment:	7	
Master graduations:	14	
PhD graduations:	4	

Western Canada

University of Saskatchewan

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
Specializations:	-	
Full-time enrollment:	33 (Chemical Engineering)	
Part-time enrollment:	0	
Master graduations:	2	
PhD graduations:	1	

University of Calgary

Degrees offered:	MEng	(course-based)
	MSc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Petroleum Engineering	
Specializations:	-	
Full-time enrollment:	246	
Part-time enrollment:	6	
Master graduations:	89	
PhD graduations:	34	

University of Alberta

Degrees offered:	MEng	(course-based)
	MSc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
	Process Control	
Specializations:	-	
Full-time enrollment:	239	
Part-time enrollment:	0	
Master graduations:	51	
PhD graduations:	18	

University of British Columbia

Degrees offered:	MEng	(course-based)
	MEL	(course-based; Master of Engineering Leadership)

	MSc	(thesis-based, for students with a science background)
	MASc	(thesis-based, for students with an engineering background)
	PhD	
Programs offered:	Chemical and Biological Engineering (MEng, MSc, MASc, PhD)	
	Clean Energy Engineering (MEL)	
	Green Bio-Products (MEL)	
	Integrated Water Management (MEL)	
	Materials Engineering (MEng, MSc, MASc, PhD)	
	Advanced Materials Manufacturing (MEL)	
Specializations:	-	
Full-time enrollment:	188	(“Biosystems”; may include programs other than the ones listed)
Part-time enrollment:	0	
Master graduations:	23	
PhD graduations:	15	

3.2 Systemic relevance

3.2.1 Existence of similar programs in the Québec university system, their enrolments; complementarity of this proposed program with other similar programs including those at college level; specific contribution of proposed program within the Quebec context; how it compares to existing programs

An overview of similar programs in the Province of Québec as well as other provinces is shown in Section 3.1.6. Chemical Engineering graduate programs are offered at McGill University, École Polytechnique, Université Laval, and Université de Sherbrooke.

PhD programs in Chemical Engineering are offered by McGill University, École Polytechnique, Université Laval, and Université de Sherbrooke.

Research at McGill University focuses on advanced materials and polymers, biomedical engineering and biotechnology, energy, environmental engineering, and plasma science and engineering. Among these areas, biological chemical engineering is the dominant theme.

Research at École Polytechnique focuses on polymers, biopharmaceutical engineering, process engineering, environmental engineering and sustainable development, and pulp and paper.

Research at Université Laval focuses on catalysis, biochemical engineering, environmental engineering, polymer engineering, modeling, computer simulation and process engineering, and rheology.

Research at Université de Sherbrooke has a strong focus on environmental engineering and related areas (biotechnology, fuel cells, water and air treatment, waste management). Other research areas are nanotechnology, and chemical process development.

Biological and environmental chemical engineering are the dominant themes in Chemical Engineering graduate programs in Québec. Materials engineering research is conducted at these departments, but is not the dominant theme. The proposed program will be complementary to the existing programs because it will have a stronger focus on materials engineering, not as a separate research area but deeply embedded in chemical engineering. Some of the existing strengths at Concordia University in this area were discussed in Section 3.1.4.

Details of the programs discussed are given in Appendix 1.

3.2.2 Foreseeable links to related programs; potential collaborations between professors in the new program and related ones in other institutions

The proximity of McGill University and École Polytechnique to Concordia University creates favorable conditions for collaborations with professors in these institutions. Furthermore, there is a history of collaboration between engineering professors at these three universities.

3.3 Institutional relevance

3.3.1 Status of the discipline at Concordia; how the proposed program fits into the overall set of programs offered by the university (including undergraduate programs); in the same field, related fields, sector of education concerned; enrolment trends and graduates in related programs; impact of enrolments in related fields within the University

The programs most related to the proposed new programs are the Mechanical Engineering program in the Department of Mechanical and Industrial Engineering, and the Environmental Engineering specialization in the Department of Building, Civil, and Environmental Engineering.

Chemical Engineering is the only major engineering discipline that is currently missing in the Engineering program offerings at Concordia University. Hence, the development of Chemical Engineering programs fits in Concordia University's objective to become a more comprehensive university. Nearly all Engineering programs at Concordia University have grown rapidly in recent years. The number of full-time graduate students at Concordia University in all engineering fields combined increased from 1677 in 2012 to 2184 in 2016. Of these, full-time enrollments increased from 355 to 514 in Civil Engineering, and from 295 to 371 in Mechanical Engineering (not including Industrial Engineering). The demand exceeds the enrollments, so it is anticipated that the addition of Chemical Engineering programs will not affect the enrollments in other programs.

3.3.2 Research and development performance of the university in the field of study of the proposed program where advanced degrees are concerned. Research grants obtained and sources of funding

Because the department is new, all faculty members are new, or were transferred from other departments or universities. Table 4 below reflects a recent history of research grants obtained by faculty members in their original department/institution, and the sources of funding

Table 4 Recent research grants obtained by faculty members contributing to the proposed program.

Faculty member	Project Name	Grant/Source

Alex De Visscher	Tier II Canada Research Chair in Air Quality and Pollution Control Engineering ($500,000)	CRC
Alex De Visscher	Ultrasound-assisted Peroxone, a novel air pollution control technique ($145,000)	NSERC Discovery Grant
Alex De Visscher	New modeling algorithms for Eulerian air dispersion models ($30,000)	University of Calgary Faculty Research Grant
Alex De Visscher	Thermodynamic Data Research ($17,000)	Zandmer Fund Research Grant
Alex De Visscher	Photolytic degradation of BTEX from the oil and gas industry (200,000)	Petroleum Technology Alliance of Canada, AUPRF Grant
Zhibin Ye	Tier II Canada Research Chair in Polymer Nanomaterials ($500,000)	CRC
Zhibin Ye	Enhanced characterization infrastructure for Canada Research Chair in Polymer Nanomaterials ($166,224)	CFI John R. Evans Leaders Fund
Zhibin Ye	Developing semicrystalline star polyethylenes and advanced polyethylene ionomers ($200,000+$120,000)	NSERC Discovery Grant and Accelerator Supplement
Zhibin Ye	Developing fluorinated polymer composites for sulfur adsorption in medium temperature pressure oxidation of gold ores and tailings ($223,486)	NSERC CRD Grant
Zhibin Ye	I2I market assessment of a carbon nanosphere technology ($20,000)	NSERC I2I Grant
Zhibin Ye	Developing iron oxide/carbon nanocomposite adsorbents for arsenic removal from gold mine effluents ($54,250)	NSERC ENGAGE and NSERC ENGAGE PLUS
Paula Wood-Adams	The structure and dynamic properties of polymers at interfaces ($170,500)	NSERC Discovery Grant
Paula Wood-Adams	Mechanism of haze formation of LLDPE/LDPE blends and their relationships to fundamental rheological properties ($22,000)	Dow Chemical, Operating Grant
Paula Wood-Adams	Characterization of damage related mechanical properties of thin polymer films on hard substrates ($22,000)	Taiho Kogyo Tribology Research Foundation, Operating Grant
Paula Wood-Adams	Nanoindentation of polymer films on aluminium ($6,090)	Novelis Inc., Contract
Paula Wood-Adams	Rheology and interfacial phenomena of highly filled polypropylene-ethylene co-polymers ($64,000)	NCERC CRD Grant
Paula Wood-Adams	Polymer interfaces: Structures and properties ($150,000)	Concordia Research Chair
Rolf Wüthrich	Developing novel electrochemical advanced manufacturing technologies ($50,000)	Special Grant, Concordia University
Rolf Wüthrich	Novel technologies for glass micro-machining by glow discharge electrolysis ($160,000)	Contract, Postalux SA
Rolf Wüthrich	Electrochemical manufacturing technologies for Industry 4.0 ($185,000+$120,000)	NSERC Discovery Grant + Accelerator Supplement

Rolf Wüthrich	Développent de catalyseurs sans platine pour la production électrochimique de l'hydrogène en utilisant des nano-particules de nickels à facettes ayant des index de Miller élevés ($205,000)	FQRNT grant, Recherche partenariat

3.3.3 Collaboration with other departments within Concordia

The newly created Department of Chemical and Materials Engineering was incubated in the Department of Mechanical and Industrial Engineering, and a substantial amount of collaboration is anticipated with this department. Research groups of particular interest are the group of Dr. M. Medraj (phase behavior of materials), Dr. C. Moreau (thermal coating techniques), Dr. M. Packirisamy (MEMS, microfluidics), as well as others. Research groups of potential interest in the Department of Building, Civil, and Environmental Engineering include Dr. S. Rahaman (chemical remediation techniques) and Dr. A. Athienitis (solar energy engineering). At the Centre for Engineering in Society, Dr. K. Schmitt (public policy) is a faculty member of interest. Potential collaborations with the Concordia Centre for Composites (CONCOM) were already discussed in Section 3.1.4.

Outside the Faculty of Engineering and Computer Science, collaborations are anticipated with the Department of Chemistry and Biochemistry, whose Department Chair, Dr. C. DeWolf, has degrees in Chemical Engineering. To foster these collaborations, the new department will be given space in the Loyola campus with the next building project, to be shared with faculty members from the Department of Chemistry and Biochemistry.

The Department of Chemical and Materials Engineering has a steering committee consisting of key faculty members from various departments in the Faculty of Engineering and Computer Science, and the Faculty of Arts and Science. This committee forms the basis for future collaborations between departments. The membership of the steering committee is given in Appendix 6.

3.3.4 Current standing of the department and the discipline in Quebec and the rest of Canada

Because the department is newly created, its standing is the standing of the academics hired or transferred to the department.

The discipline of Chemical Engineering is well established in Quebec and Canada, with 20 academic programs in Canada, and 4 in Quebec.

3.3.5 How does the proposed program align with the Faculty's and University's academic plans

The development of the PhD program in Chemical Engineering is a direct consequence of the establishment of the Department of Chemical and Materials Engineering, and aligns with the Strategic Plan, *Nine Directions for a Next-Generation University*. In particular, the cross-institutional strategy for Direction 1, Double our Research, specifically mentions building research capacity in Chemical and Materials Science and Engineering. To bring this plan to fruition, it is necessary to offer the PhD program proposed here, to draw strong graduate students in this area, and to train them adequately for research in the area.

The Montreal area has a large demand for Chemical and Materials Engineers, in the chemical and pharmaceutical industry, food and beverage industry, and in companies supplying the aerospace industry (composites). Hence, the proposal is aligned with Direction 7: Embrace the City, Embrace the World.

Section 4 PROGRAM DESCRIPTION AND REQUIREMENTS

4.1 Admission Requirements

4.1.1 General and specific admission requirements

General requirements

Applicants to Concordia University must meet the minimum university requirements to be considered for admission.

Academic Requirements (to be edited per program)

To be considered for admission on a full-time basis, applicants normally must hold a master's degree or equivalent with high standing in engineering or the sciences. Holders of a bachelor's degree will, in general, be considered for admission to a master's program only. After completion of a minimum of two terms of full-time study, they may, upon application, be considered by the Faculty Graduate Studies Committee for admission to a PhD program.

Language Proficiency Requirements

The language of instruction at Concordia is English.

A student whose primary language is not English must write a pre-admission proficiency test, if not exempted as indicated below. Test results must be reported directly to the Admissions Application Centre by the test centre. Results more than two years old will not be accepted as proof of language proficiency.

Proof of proficiency in English must be provided by achieving the appropriate score on one of the following:

- Test of English as a Foreign Language (TOEFL): The minimum acceptable score for the internet-based TOEFL (TOEFL iBT) is 85 and no part under 20.
- The minimum required score for the paper-based TOEFL is 563.
- International English Language Testing System (IELTS): The minimum band score for IELTS is 6.5 and no part under 6.5.

In all cases, Concordia reserves the right to require proof of English proficiency when such proof is deemed necessary. Concordia will accept test results for the paper-based TOEFL if they are less than 2 years old.

Applicants whose primary language is not English, regardless of citizenship, may be exempted from the proficiency test if they meet one or more of the following requirements:

- A minimum of three full years of study either at the undergraduate or graduate level in an institution where the sole language of instruction is English;

- Quebec applicants, the completion of a Diploma of Collegial Studies (DEC) and a university degree in Quebec

In addition to the general admission requirements, the Faculty may require applicants to write the Engineering Writing Test (EWT) as a condition of admission to all graduate programs in Engineering and Computer Science. Depending on the result, students may be required to complete remedial English language courses in addition to their program requirements.

The Engineering Writing Test examines students' ability to provide reasoned assessment of a short technical composition in English or French, and their ability to provide a qualitative account of quantitative or graphically presented data. The test is offered a number of times throughout the year. Based on their performance in the test, students may be asked to take remedial courses.

Program-specific admission requirements

- A Master degree in engineering or the sciences;
- Students whose undergraduate or Master degree is not chemical engineering will be assessed on a case-by-case basis, and may be required to take additional courses, including the bridge course CHME 401: Principles of Chemical Engineering, and/or others. The Graduate Program Director determines the additional course loads;
- Credible academic reference letters;
- A Statement of Purpose

Students admitted to the PhD program without a Master's degree (fast-tracking) are required to fulfill the MASc course requirements in chemical engineering in addition to their course requirements for the PhD program.

4.1.2 Selection procedures

The selection is made by the Department Graduate Studies Committee, upon nomination of the prospective supervisor.

4.2 Academic activity

4.2.1 Degree requirements

Credits: Fully qualified students must complete 90 credits to complete a PhD in Chemical Engineering. Students who did not complete a Master's degree must complete 106 credits to complete a PhD in Chemical Engineering.

Residence: The minimum residence requirement for a doctoral degree is 6 terms (two years) of full-time graduate study beyond the master's degree, or the equivalent in part-time study, or 9 terms (3 years) of full-time graduate study beyond the bachelor's degree for those students who are permitted to enroll for doctoral studies without completing a master's degree.

Time limit: All work for a doctoral degree must be completed within 18 terms (6 years) of full-time study or 24 terms (8 years) of part-time study from the time of original registration in the program.

4.2.2 Program schedule; Core and elective courses

All courses are 4 credits each unless indicated otherwise.

Core: at least 4 credits (one course) from the following list:

- CHME 6011 Advanced Transport Phenomena
- CHME 6021 Advanced Chemical Engineering Thermodynamics
- CHME 6031 Chemical Kinetics and Reaction Engineering
- CHME 6041 Chemical Engineering Process Dynamics and Control
- CHME 6051 Chemical Process Engineering and Design
- CHME 6071 Materials Science and Engineering
- CHME 6121 Nanomaterials Chemistry and Engineering
- ENCS 6021 Engineering Analysis

Electives: up to 8 credits (two courses) from lists 1 or 2 or 3 (Core + Electives: 12 credits).

Students may take an elective course outside lists 1, 2, or 3 with permission of the Graduate Program Director.

Students who take a three-credit course towards their course requirement of 12 credits must take course CHME 6001, Project in Chemical and Materials Engineering.

Students who have not completed a Master's program must complete a total of 28 course credits, at least 12 of which should be from the core course list, and the remainder of which should come from lists 1, 2, or 3, not including Topic Area E08 or ENGR 6971.

ENCS 8011 Ph.D. Seminar: 2 credits

ENCS 8511 Doctoral Research Proposal: 6 credits

ENCS 8501 Comprehensive Examination

ENGR 8911 Doctoral Research and Thesis: 70 credits

<u>Elective Course Lists</u>

List 1

- CHME 6061 Advanced Biochemical Engineering
- CHME 6081 Advanced Separation Processes
- CHME 6091 Statistics for Chemical Engineering
- CHME 6101 Advanced Battery Materials and Technologies
- CHME 6111 Polymer Chemistry and Engineering
- CHME 6131 Advanced Colloid and Interface Science and Engineering
- CHME 6911 Topics in Chemical Engineering I

- ENCS 6111 Numerical Methods
- ENGR 6201 Fluid Mechanics
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 7101 Convection Heat Transfer

List 2

- CHME 7911 Topics in Chemical Engineering II
- ENGR 6601 Principles of Solar Engineering
- ENGR 6971 Project and Report I
- MECH 6571 Corrosion and Oxidation of Metals
- All courses in Topic Areas E03, E04, E07, E37, E52, and E57 not included in the core course list of the MEng program in Chemical Engineering, or in List 1

List 3

- All courses in Topic Areas E08 and E09

Note: A list of courses in Topic Areas E03, E04, E07, E37, E52 and E57 (List 2), and of Topic Areas E08 and E09 (List 3) is given in Appendix 7.

4.2.3 Number of credits per term (part- and/or full-time) to allow students to meet program objectives; timeline to completion

The normal time to completion for PhD students is twelve terms (four years). The maximum time to completion is eighteen terms (six years) for full-time students, and twenty-four terms (eight years) for part-time students.

The following is the recommended timeline for full-time MASc students:

- Month 1-4: Courses, preparation of research, literature review
- Month 5-8: Continuation of courses, preparation of research proposal
- Month 9-12: Research proposal exam; preparation of comprehensive exam
- Month 13-16: Comprehensive exam; research
- Month 17-40: Full-time research, seminar
- Month 41-48: Write-up and defense of thesis

4.2.4 Describe the nature and content expected of the comprehensive or pre-doctoral examinations, and theses; the respective grading system, comprehensive examinations or exhibitions

ENCS 8501 Comprehensive Exam (Pass/Fail)

Components of the exam

1. By the end of the first month in the program, the supervisor must provide the student with a written statement of the general area of the thesis research and a list of at least three key journal articles to get the student started. The student is responsible for identifying any other pertinent literature.

2. The supervisor and student may decide to take the comprehensive exam after the first semester or the second semester of the program. The student must inform the GPD of the decision by the end of the first month in the program.

3. In the middle of the second month of the chosen semester, the student must attend a seminar on how to write a critical literature review. (This seminar will be organized by the GPD and offered once per semester in October, February and June).

4. By the end of the third month of the chosen semester, the student must submit a critical literature review paper to the GPD. The paper will be 10 to 15 pages in length (not including the list of references), font size 12, and margins of 2 cm and spacing of 1.5. The literature reviewed in the paper should consist of journal articles from a range of sources and should be focused rather than broad in scope. Note that the review paper can be used as a component of the proposal later on although it is possible that it may need to be broadened for that purpose. The paper should consist of the following components:

- Abstract
- Introduction
- Literature Review Results (answering the following questions:
- What is the current state of the art in the reviewed field?
- What is (are) the main problem(s) researchers in this field are currently trying to solve?
- What is (are) the main open question(s) in the reviewed field?)
- Conclusion and potential future work

5. Before the end of the first month in the following semester, the student must complete an oral exam of the review paper which will be given by the supervisory committee. The student will be examined on the content of the review paper and related topics including any relevant fundamentals. The committee will judge if the review paper is a critical literature review and if it is of appropriate level for a doctoral candidate.

The potential grades of the oral exam are pass or fail.

<u>ENCS 8011 PhD Seminar (2 credits)</u>

Purpose of the seminar is:

- To develop scientific communication skills
- To assess progress in research

Components:

- Students must submit an extended abstract of their research progress
- In-class presentation
- Participation in other students’ presentations

The members of the students' thesis committee will be invited to attend the presentation to assess the students' progress.

4.2.5 Thesis or Research proposal (link between research/thesis interests and teaching activities should be apparent)

ENCS 8511 Doctoral Research Proposal (6 credits)

Upon successful completion of the comprehensive examination, students must pass the doctoral research proposal ENCS 8511 (6 credits), within 18 (36) months after the initial registration as a full-time (part-time) student in a PhD program, before they are admitted to candidacy for the PhD degree. Students will be assessed on the basis of written and oral presentations that must include: (i) a critical review of previous work relevant to the subject of the thesis, and (ii) a detailed research plan of action and expected milestones. Students are required to defend their doctoral research proposal before a committee that will normally be comprised of the same members as the Comprehensive Examination Committee. Students must demonstrate the viability of their project and their capacity to undertake doctoral thesis research. The proposal may be accepted, returned for modifications, or rejected. The rejection of a proposal will result in the student's withdrawal from the program. A student whose proposal is accepted will be admitted to candidacy for the PhD.

ENGR 8911 Doctoral Research and Thesis (70 credits)

Students are required to plan and carry out a suitable research, development, or design project, which leads to an advance in knowledge. The student must submit a thesis based upon this work and defend it in an oral examination. For purposes of registration, this work will be designated ENGR 8911 or COMP 8901: Doctoral Research and Thesis (70 credits). The thesis will be examined by a committee consisting of the student's supervisory committee, an external examiner, and other examiners as approved by the Faculty Graduate Studies Committee and the Dean of Graduate Studies.

4.2.6 Proposed Chemical Engineering course descriptions

Project course (1 credit, graduate)

CHME 6001 Project in Chemical and Materials Engineering (1 credit)

The course consists of an individual project in a chosen area of study in the area of Chemical and Materials Engineering under the supervision of a faculty member. This course may be repeated for credit.

Core courses (4 credits, graduate)

CHME 6011 Advanced Transport Phenomena

Topics include equations of heat, mass, and momentum transfer; viscosity, thermal conductivity and diffusivity in laminar and turbulent conditions; velocity, temperature, and concentration distributions in selected systems; Navier-Stokes equations: direct simulation and turbulence modelling – Reynolds-averaged Navier-Stokes (RANS); turbulence near surfaces and interphase transport; multicomponent mass transfer; transport in porous media; effects of narrow pore size; and the dusty-gas model (DGM). A project is required.

CHME 6021 Advanced Chemical Engineering Thermodynamics

Topics include principles, concepts, and laws/postulates of classical and statistical thermodynamics and their link to applications that require quantitative knowledge of thermodynamic properties from a macroscopic to a molecular level; basic postulates of classical thermodynamics and their application; criteria of stability and equilibria; constitutive property models of pure materials and mixtures, including molecular-level effects using statistical mechanics; equations of state; phase and chemical equilibria of multicomponent systems; and thermodynamics of polymers. Applications are emphasized through extensive problem work relating to practical cases. A project is required.

CHME 6031 Chemical Kinetics and Reaction Engineering

Topics include applied chemical kinetics and their use in chemical reactor design and chemical plant operation where both homogeneous and heterogeneous kinetics, including catalysis, are considered; residence time distribution; dispersed plug flow reactors; radial mass and heat transfer limitation; mass and heat transfer limitation in and around catalyst pellets; and multiphase reactors. A project is required.

CHME 6041 Chemical Engineering Process Dynamics and Control

Topics include principles of process dynamics and control; step response curves; PID control; strategies for chemical process control; process model identification; dynamic chemical process simulation; model-predictive control algorithms; and assessment of controller performance. A project is required.

CHME 6051 Chemical Process Engineering and Design

Topics include a review of the concepts of industrial chemical process design, engineering economics, process optimization, process simulation and plant safety; the use of fundamental knowledge in science and mathematics to design practical chemical engineering facilities. Special emphasis is placed on safety, hazards, sustainability and loss prevention issues in chemical plants. A project is required.

CHME 6071 Materials Science and Engineering

Topics include structure, behaviour and properties of engineering materials – metals, ceramics, polymers and composites; effects of crystalline structure and imperfections; and methods of observing, measuring and interpreting properties of materials. A project is required.

CHME 6121 Nanomaterials Chemistry and Engineering

Topics include chemical and engineering aspects of nanomaterials. The course covers synthesis, characterization, properties, and applications of a variety of nanomaterials, with a focus on representative inorganic nanomaterials, as well as carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene. A project is required.

Elective courses

CHME 6061 Advanced Biochemical Engineering

Topics include the interaction of chemical engineering, biochemistry, and microbiology; mathematical representations of microbial systems. Kinetics of growth, death, and metabolism are also covered, as well as studies of continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology. A project is required.

CHME 6081 Advanced Separation Processes

Topics include a review of basic chemical and mechanical separations; multicomponent separations; membrane separations; adsorption; chromatographic separations; and ion exchange. A project is required.

CHME 6091 Statistics for Chemical Engineering

Topics include a review of basic statistics; hypothesis testing; multivariate statistics; linear and nonlinear regression; chemical process model calibration; and response surface methodology. A project is required.

CHME 6101 Advanced Battery Materials and Technologies

Topics include a review of the principles of batteries, fuel cells, and supercapacitors; electrodes and electrolytes; thermodynamics, reaction kinetics, transport phenomena, electrostatics and phase transformations of various energy storage materials, particularly lithium-ion batteries, supercapacitors, and fuel cells; and experimental methods to study key parameters of energy storage materials, focusing on a materials science approach. A project is required.

CHME 6111 Polymer Chemistry and Engineering

Topics include the advanced theory and industrial practice of polymers, polymer chemistry, and polymer reactor engineering. The course covers polymer chemistry and polymerization kinetics for various types of polymerization including condensation, free radical, cationic, anionic, and coordination polymerization; polymerization processes including bulk, solution, emulsion, dispersion, gas phase, and slurry processes; polymer reactor engineering, polymer materials structure and property characterization, and recent developments in the field are included. A project is required.

CHME 6131 Advanced Colloid and Interface Science and Engineering

Topics include properties of colloids and surfactants; physical and chemical interactions between colloidal particles: attraction and repulsion; stability of colloidal dispersions; coagulation and flocculation; surface and interface tension – wettability; characterization methods of colloidal particles; the relation between interface energy and adsorption; adsorption of surfactants on interfaces; micelles; surfactants in nanotechnology; adsorption in porous media; and surface characterization methods. A project is required.

CHME 6911 Topics in Chemical Engineering I

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

CHME 7911 Topics in Chemical Engineering II

Note: Subject matter will vary from term to term and from year to year. Students may re-register for these courses providing that the course content has changed. Changes in content will be indicated by the title of the topic. A project is required.

4.2.7 Intellectual atmosphere (conferences, symposia)

Seminars will be held at least monthly, where leading researchers from across Canada and in all fields of chemical engineering will be invited to present their research. PhD students will be required to attend the seminars, and all other graduate students will be encouraged to attend as well.

Once per year a graduate student symposium will be organized, where students will have the opportunity to present their work in front of their peers, in oral and poster presentations.

Section 5 FACULTY RESOURCES; OTHER HUMAN RESOURCES; MATERIAL RESOURCES: Resource implications of the program

5.1 Faculty Resources (Qualifications and scholarly output)

5.1.1 Qualifications of individual professors: degrees, experience, summary of faculty achievements (previous five years) including: (i) publication in peer-reviewed journals; (ii) experience acquired supervising masters' and doctoral students and post-doctoral fellows, participation on thesis juries

The qualifications of faculty members are summarized below. More detailed CVs are given in Appendix 5. Two additional faculty members will be hired every year during the introduction of this program.

Alex De Visscher, Professor

Dr. De Visscher was trained in Chemical Engineering and Environmental Engineering at Ghent University, Belgium. He obtained his PhD in 2001. He held a faculty position at the University of Calgary from 2005 until 2016. In 2005-2015 he held a Tier II Canada Research Chair in Air Quality and Pollution Control Engineering. From 2014 until 2016 he was Associate Head Graduate (Graduate Program Director) of the Department of Chemical and Petroleum Engineering. During his Sabbatical Leave in 2011-2012 he was Visiting Professor at the Institute of Technical Chemistry in the Technical University Bergakademie Freiberg, where he wrote an academic textbook on Air Dispersion Modeling, which was published by Wiley. He also wrote and self-published an academic textbook on Chemical Engineering Kinetics and Chemical Reactor Design. Dr. De Visscher published over 50 peer-reviewed journal articles, 12 over the past 5 years. He currently supervises four PhD students and has graduated seven graduate students over the past five years. He has participated in more than 100 thesis juries. Over the last five years he was involved in 10 candidacy exams, 13 PhD final exams, and 30 MSc final exams. His areas of research include kinetics and catalysis, transport phenomena, environmental chemical engineering, solution thermodynamics and solubility.

Zhibin Ye, Professor

Dr. Ye obtained his Bachelor and Master degrees in Chemical Engineering at Zhejiang University, China, and his PhD in Chemical Engineering at McMaster University in 2004. He held a faculty position at Laurentian University from 2004 until 2017. From 2011 until 2017 he held a Tier II Canada Research Chair in Polymer Nanomaterials. During his Sabbatical Leave he was a Visiting Associate Professor in the Department of Chemistry at the University of Illinois at Urbana-Champaign. Dr. Ye published 75 peer-reviewed journal papers, 28 in the past five years. He currently supervises two research associates and two graduate students, and he has graduated six graduate students in the past five years. He also supervised several postdoctoral fellows. His areas of research include polymer engineering and polymer reactor engineering, nanotechnology and nanocomposites.

Paula Wood-Adams, Professor

Dr. Wood-Adams obtained her Bachelor's degree in Chemical Engineering at University of Alberta, and her Master's and PhD degrees in Chemical Engineering at McGill University. She has held a faculty position at Concordia University since 2001. She is Dean of the School of Graduate Studies (2013-present), and was Interim Dean in 2012-2013. She was Associate Dean of the School of Graduate Studies in 2010-2012, and Graduate Program Director of Mechanical and Industrial Engineering from 2006 until 2010. In 2006 she was Visiting Professor of Chemical Engineering at Kasetsart University, Bangkok, Thailand. Dr. Wood-Adams holds many other leadership positions, such as Director in the John Abbott College Board of Governors, Director in the Jeanne Sauvé Foundation Board of Directors, and Vice President of L'Association des doyens des études supérieures au Québec. She also held a Director position in the Canadian Association for Graduate Studies Board of Directors from 2013 until 2015. Dr. Wood-Adams published over 50 peer-reviewed journal papers, 17 in 2012-2016. She currently supervises three PhD students and has graduated eight graduate students in the past five years. Her fields of research include polymer engineering, composites and nanocomposites.

Xiaolei Wang, Assistant Professor

Dr. Wang obtained his Bachelor's and Master's degree in Chemical Engineering at Dalian University and Tianjin University, respectively, and his PhD in Chemical and Biomolecular Engineering at the University of California at Los Angeles. He held a postdoctoral fellowship at the University of Waterloo from 2013 until 2017. Dr. Wang published 33 peer-reviewed journal papers, 26 in the past five years. His areas of research include nanotechnology, electrical energy storage materials, electrochemical engineering, electrocatalysis.

Rolf Wüthrich, Associate Professor (joint appointment with Department of Mechanical, Industrial, and Aerospace Engineering)

Dr. Wüthrich obtained his Master's degree in Particle Physics and his PhD in Microtechnology and Manufacturing at the École Polytechnique Fédérale de Lausanne. After two postdoctoral positions at the same insititution, he joined Concordia University in 2006. In 2015 he took a one-year leave to set up the R&D department of Posalux SA. He conducts research in the areas of electrochemistry and advanced manufacturing, particularly in the areas of spark assisted chemical engraving, electropolishing, electrocatalysis, gas evolving electrodes, and plasma electrolysis. Dr. Wüthrich was a member of the steering committee that set up the Department of Chemical and Materials Engineering. Dr. Wüthrich published about 50 peer-reviewed journal papers, 24 in 2012-2016.

Publications in Peer-Reviewed Journals

Faculty Name	2012	2013	2014	2015	2016	Total
Alex De Visscher	3	4	3	0	2	12
Zhibin Ye	6	9	5	5	2	27
Paula Wood-Adams	4	2	5	3	3	17
Xiaolei Wang	4	4	2	9	7	26
Rolf Wüthrich	2	7	4	5	6	24

Supervision of Master and Doctoral Students and Post-Doctoral Fellows

Faculty Name	Student (Degree)	Year
Alex De Visscher	Chongchong Wu (PhD)	In Progress
	Michael Süß (PhD)	In Progress
	Mehrshad Parchei Esfahani (PhD)	In Progress
	Vahid Asili (PhD)	In Progress
	Ali Shafaghat (MEng thesis)	2016
	Farshid Shayganpour (MEng thesis)	2015
	Farzana Haque (PhD)	2014
	Maria Conejo (MSc)	2014
	Vahid Asili (MSc)	2013
	Mahsasadat Atyabi (MSc)	2013
	Kamran Rahnama (MSc)	2012
Zhibin Ye	Zhe Chen (MASc)	2016
	Mark Grundy (MASc)	2016
	Syed Atif Haider Zaidi (MEng)	In Progress
	Hui Su (MASc)	2016
	Lingqi Huang (PhD)	In Progress
	Zhe Chen (MASc)	2015
	Mark Grundy (MASc)	2014
	Peng Xiang (PhD)	2015
	Eric Landry (MASc)	2012
	Pingwei Liu (PhD)	2014
Paula Wood-Adams	Sh. Kwaye-Nimo (PhD)	In Progress
	Keroles Riad (PhD)	In Progress
	Wissam Nakhle (PhD)	In Progress
	Keroles Riad (MSc)	2016
	Niyusha Samadi (PhD)	2016
	Ehsan Rezabeigi (PhD)	2015
	Mostafa Sabzevari (PhD)	2015
	Nithya Subramanian (MASc)	2015
	Wasef Bzeih (MASc)	2014

	Sina Chaeichian (PhD)	2013
	Yuri Yuryev (PhD)	2012
Rolf Wüthrich	Md. Rahman Masiar (PhD)	In Progress
	Lucas Hof (PhD)	In Progress
	Maniya Aghasibeig (PhD)	2015
	Jana Abou Ziki (PhD)	2014
	Andrew Morrison (PhD)	2015
	Hamid Sadabadi (PhD)	2013
	Mohsen Jalali (PhD)	2012
	Vahid Karamzadeh (MASc)	In Progress
	Pantea Fallah (MASc)	In Progress
	Frederic Charbonneau (MASc)	2016
	Keroles Riad (MASc)	2016
	Farzad Jabbari (MASc)	2013
	Zahra Ghorbani (MASc)	2013

5.1.2 Overall faculty characteristics: Ability of faculty to provide adequate supervision and cover all aspects of the discipline or profession; forecast changes in composition of faculty (growth renewal); Chart on present and future workloads and credit breakdown

As of January 2018, the Department of Chemical and Materials Engineering will have three regular members, one joint member, and two excluded members (the Dean of the School of Graduate Studies and the Vice President Research and Graduate Studies), offering expertise in chemical engineering fundamentals (transport phenomena, chemical thermodynamics), catalysis, kinetics, and reactor engineering, polymer engineering, and electrochemical engineering. The main gaps in the expertise currently available are in some of the proposed technical electives. These gaps will be covered with future hires. An additional faculty recruitment is in progress, and there is a commitment from Concordia University to recruit two faculty members in the 2018-19 cycle (see support letter in Appendix 6), and up to two in the 2019-20 cycle. It is anticipated that we will hire an average of two faculty members per year for the three to four years after that, bringing the total to 15 faculty members. In the meantime, the program will be strengthened through collaboration with other departments within Concordia University, with other universities in Montreal, and with local industry professionals.

Table 6 below shows the current and anticipated faculty members, with anticipated course assignments. The table shows that faculty members will generally not teach more than two courses per year in the program until 2021, leaving room for the development of other graduate programs, and an undergraduate program alongside the graduate programs. After 2021, it is anticipated that the course offerings will increase to 24 per year, mostly to accommodate a second offering of the core courses every year. It is expected that the Department of Chemical and Materials Engineering will grow to 15 faculty members during this time. Eight faculty members are sufficient to run all the graduate programs (3 per faculty member per year).

Table 6 Projected course assignments per faculty member for all planned graduate programs in Chemical Engineering

Faculty member	Course	Year	Status
Alex De Visscher	Advanced Chemical Engineering Thermodynamics Advanced Transport Phenomena	F 2018 W 2019	new, core new, core
Zhibin Ye	Principles of Chemical Engineering Polymer Chemistry and Engineering Materials Science and Engineering	F 2018 W 2019 W 2020	new, bridge new, elective new, core
Xiaolei Wang	Advanced Battery Materials and Technologies Chemical Kinetics and Reactor Engineering	F 2018 W 2019	new, elective new, core
Hire 1	Engineering Analysis Chemical Engineering Process Dynamics and Control	F 2018 W 2019	existing, core new, core
Hire 2	Advanced Separation Processes Materials Science and Engineering	F 2019 W 2020	new, elective new, core
Hire 3	Statistics for Chemical Engineering Nanomaterials Science and Engineering	F 2019 W 2020	new, elective new, core
Hire 4	Topics in Chemical Engineering I Chemical Process Engineering and Design	F 2020 W 2021	new, elective new, core

A number of existing electives will be taught outside the Department of Chemical and Materials Engineering. Because this represents no change with the existing condition, these courses are not shown in the table above. However, these courses affect the ability of students to progress their program. Hence, a projection of course offerings per term is given below, starting with Fall 2019. For elective courses, only a sample is given.

Fall 2019

- Principles of Chemical Engineering (Ye) (bridge)
- Engineering Analysis (Hire 1; existing course) (core)
- Advanced Chemical Engineering Thermodynamics (De Visscher) (core)
- Advanced Battery Materials and Technologies (Wang) (elective, list 1)
- Advanced Separation Processes (Hire 1) (elective, list 1)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Statistics for Chemical Engineering (Hire 3) (elective, list 1)
- Linear Systems (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Winter 2020

- Advanced Transport Phenomena (De Visscher) (core)
- Chemical Kinetics and Reaction Engineering (Wang) (core)
- Chemical Engineering Process Dynamics and Control (Hire 1) (core)
- Materials Science and Engineering (Hire 2) (core)
- Nanomaterials Science and Engineering (Hire 3) (core)
- Polymer Chemistry and Engineering (Ye) (elective, list 1)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

Summer 2020

- Engineering Analysis (Faculty; existing course) (core)
- Fluid Mechanics (Faculty; existing course) (elective, list 1)
- Principles of Solar Engineering (Faculty; existing course) (elective, list 2)
- Composition and Argumentation for Engineers (Faculty; existing course) (elective, list 3)

It is anticipated that all planned graduate programs (the proposed PhD program and four other graduate programs in preparation or proposed) can be offered with a total of 24 course offerings per year. Hence, eight faculty members, teaching three courses per year, can offer the five graduate programs at full deployment. This leaves teaching capacity available for the undergrad program, and the graduate course load can be reduced when additional faculty members are hired. As indicated, the intention is to bring the total number of faculty members in the department to 15.

On average, faculty members in the Faculty of Engineering and Computer Science supervise 7-8 thesis-based graduate students. Assuming that each faculty member supervises 3-4 MASc students and 3-4 PhD students (hiring 2 MASc students and 1 PhD student per year, allowing for attrition), it is anticipated that there will be a critical mass for a viable graduate program by the time it takes effect, with 6-8 faculty members supervising 12-20 graduate students. In addition, faculty members in other departments currently supervise students in areas of chemical engineering. Examples are Dr. R. Wuthrich (Electrochemical engineering), Dr. M. Packirisamy (MEMS, microfluidics), and Dr. F. Haghighat (Environmental chemical engineering).

5.1.3 New faculty required, with specialization; profile of professors to be hired

It is anticipated that two faculty members will be hired per year on average over the next five years. While the recruitment will be flexible to enable us to hire the best people, recruitments in the following areas are desirable:

- Process design, process control, and process simulation
- Advanced separations, bio-separations,
- Surface and coating engineering
- Transport phenomena, microfluidics, microreactors, process intensification
- Catalysis, kinetics, CO_2 conversion
- Biochemical, biomedical and metabolic chemical engineering
- Chemical engineering data, properties, computational chemistry, molecular dynamics
- Any Materials Engineering application domain not covered in the previous hires

The list is not in any particular order.

5.2 Other Human Resources (required and available)

Technical staff is needed to provide technical support with graduate course projects. A technician or an engineer-in-residence will be hired in 2018, to start the process of building setups for graduate research and teaching labs. This recruitment has been approved by the university. Additional technicians will be hired in subsequent years, to be shared between all the graduate programs of the department.

An administrative support staff member will be needed to help program directors with student administration, book appointments, and guide students with their program requirements. It is anticipated that a receptionist/administrative assistant will be hired in 2018, and a graduate program administrator will be hired upon approval of this PhD program, shared between all the graduate programs of the department. Further administrative staff member hires are anticipated as the programs grow.

Depending on the number of registered students, 1-2 teaching assistants per course will be made available. Approximately 20 teaching assistant positions per year would cover the new courses introduced here. As these courses will be shared with other graduate programs, the incremental TA need for the PhD program is estimated at 10.

5.3 Material Resources (Reference materials, computers, equipment and space) (required and available)

A detailed library report outlining quality and quantity of collections, access, reference services and assistance, and interlibrary services is given in Appendix 3.

The program will require students to have access to computers with standard academic computing software (e.g., Matlab), as well as more specific engineering (e.g., Comsol) and chemical engineering (e.g., VMGSim) software. Except for specific chemical engineering software, the resources are already available at Concordia University. Licenses for the remaining software will be obtained.

Laboratory space is currently being renovated on Floor 14 of the Hall building (approx. 150 m^2), and additional renovations (approx. 400 m^2) are in preparation on Floor 10. Floor 14 will be allocated to research space, and will be used by thesis-based graduate students. The labs will host a mix of research and teaching space, and will be used by both course-based and thesis-based students. Graduate courses will use part of the space as project space, where students design and carry out experiments related to their course content. In addition, one floor of a major building expansion at the Loyola campus currently in the design stage will be allocated to the new Department of Chemical and Materials Engineering, with about 700 m^2 of labs, offices, student space, etc.

All courses in the program will be shared with other Chemical Engineering graduate programs. Hence, it is expected that class sizes will be in the 20-50 range at full deployment of the programs. When all graduate programs currently in preparation are in steady state, about 10-12 courses will be taught in each of the Fall and Winter terms, 150 minutes per week. Only half of those are required to offer a viable PhD program. Standard classrooms with blackboard/whiteboard and computer projection will be adequate for these courses.

Some of the courses will need laboratory equipment to create the needed project space. This will consist of piping, connections, thermostatic systems, sensors and data acquisition systems. In addition, some characterization equipment is needed. Concordia University has approved $1 million for academic equipment for the Chemical Engineering programs. Faculty members contributing to the program as supervisors will bring in additional equipment obtained with research funding.

A reception area is available in the office space currently used by the Department of Chemical and Materials Engineering in the VA building.

Some courses have projects that are not linked to the lab, and for these projects some student workspace will be needed. To accommodate this, a maker space is part of the renovation project on Floor 10 of the Hall building. This is in addition to the 400 m^2 dedicated to the Department of Chemical and Materials Engineering in this project. Students will generally work in groups. Proximity to computer labs is needed to ensure that students have access to process simulators (VMGSim, HYSYS) during these group activities.

5.4 Funding for Graduate Students

PhD students will receive scholarships to a minimum of $17,500 per year. These scholarships will be provided in part by research projects of the faculty members supervising the students. Students will have the opportunity to apply for scholarships on their own (e.g., NSERC PGS and CGS; Vanier). The University provides $10,000 per year on scholarships for PhD students for up to three years, provided they meet certain minimum GPA criteria.

5.5 Chart of Expenses and Revenues

The annual budget of the program at steady state is given in the table below.

Table 7 Budget of the PhD program

Revenue	**$1,749,876**
Cost	
Faculty	$231,456
Staff, admin	$47,888
Staff, tech	$41,502
TA	$14,419
Teaching remissions	$21,400
Part-time faculty	$21,400
Student scholarships	$620,000
Operation	$25,000
Library	$43,988
Total	**$1,067,053**
Profit	**$682,823**

The faculty budget is based on 1.45 full-time positions at steady state. This number is based on a pro-rating of the teaching needs for each of the graduate programs that will be offered at steady state. It is estimated that the PhD will take up about 18 % of the teaching needs, based on full-time equivalent student counts, counting course-based students double. The total teaching needs for all graduate programs (up to 24 courses per year) is up to 8 faculty members (3 courses per faculty per year). These proportions can be maintained if the average class size is 30 for the PhD courses. Administrative and technical staff costs are based on a half-time position. Ten TAs are assumed. For the operational cost, 20 % of the estimated operational cost of all graduate programs combined is used. Based on these numbers, a profit of over $600,000 is projected at steady state. Student scholarship cost is based on the assumption that every PhD student will receive a $10,000 scholarship from the budget in the first three years of their program, the remainder of their scholarships coming from the supervisors' research grants. This number is fairly sensitive to the costs estimated for the main budget items, but as these numbers scale with the revenues (number of students), the profit is robust.

Below is a more detailed budget table per year, over the first five years of the implementation of the program. The program will be profitable from Year 3 onwards. In Year 5 the program has not reached steady state yet. This is because of the gradual recruitment of faculty members, and the four-year duration of a typical PhD program.

Cost-revenue template Chemical Engineering (Ph.D.)

Concordia University		Year 1	Year 2	Year 3	Year 4	Year 5	5-Year Total
FTEs for Yr 1 students		3.00	4.50	6.00	8.25	9.75	31.50
FTEs for Yr 2 students			2.70	4.05	5.40	7.43	19.58
FTEs for Yr 3 students				2.43	3.65	4.86	10.94
FTEs for Yr 4 students					2.19	3.28	5.47
FTEs for Yr 5 students							-
Student Enrolment		**3.00**	**7.20**	**12.48**	**19.48**	**25.32**	**67.48**
Funded students		3.00	7.20	12.48	19.48	25.32	
Revenue							
Tuition Revenue ($1,036.01 per term per FTE x 2 terms)	2,072	6,216	14,919	25,859	40,367	52,454	139,815
Teaching grant (base of $3,594.89/FTE x 9.42)	33,864	101,592	243,820	422,621	659,736	857,281	2,285,049
Variable support grant (per raw FTE $1,695.87)	1,696	5,088	12,210	21,164	33,039	42,932	114,433
Total Anticipated University Revenue (Only includes teaching & tuition revenue)		**112,895**	**270,949**	**469,644**	**733,142**	**952,667**	2,539,297
Expenses							
Faculty (steady state = 15)		5	7	9	11	13	
Part-time faculty (2 courses at $10,700 at steady state)	**2**	7,133	9,987	12,840	15,693	18,547	64,200
Faculty (1.45 FT x $125,000 x 1.277 at steady state)	**1.45**	77,152	108,013	138,874	169,735	200,595	694,369
Admin (0.5 FT x $75,000 x 1.277 at steady state)	**0.5**	15,963	22,348	28,733	35,118	41,503	143,663
Technical (0.5 FT x $65,000 x 1.277 at steady state)	**0.5**	13,834	19,368	24,902	30,435	35,969	124,508
Course sections (GPD remission) From the Provost's Office)	**2**	7,133	9,987	12,840	15,693	18,547	
Teaching assistantships (10; $1,464 & 1,419 for Master and Ph.D. resp./student)	**10**	4,805	6,727	8,649	10,571	12,493	43,245
Doctoral bursaries ($10,000 per student in the first three years)	**10,000**	40,000	96,000	166,400	230,600	293,800	826,800
Library costs	**43,988**	43,988	43,988	43,988	43,988	43,988	219,940
Operation (labs, etc)	**25,000**	1,613	3,871	6,710	10,474	13,610	36,278
Advertising		3,000	2,000				5,000
Recruitment		3,000	2,000				5,000
Total Anticipated Expenses (ENCS)		**217,621**	**324,295**	**443,943**	**562,318**	**679,065**	**2,163,002**
		(104,726)	(53,346)	25,701	170,824	273,602	376,295
Anticipated Gain (Loss) for the University							

Notes:
Attrition rate of 10 % per year assumed
Faculty/staff/TA costs are prorated based on the number of faculty members in a given year assuming 15 faculty members at steady state.
Library cost assumes that the overlapping budgets are prorated based on number of students at steady state

5.6 Implementation Timetable for the Program

A detailed plan of the introduction of courses is given in Section 5.1.2. What follows is a general overview of activities planned for the PhD program.

- Fall 2018
  - First graduate courses in Chemical Engineering offered
- Fall 2019
  - Anticipated introduction of PhD program
  - Admission of first students
- Winter 2021
  - Full deployment of all new courses planned for the program
- Summer 2023

- First graduations in the PhD program

Section 6 APPENDICES

<u>Appendix 1 Related programs in Quebec and the rest of Canada (descriptions, calendar excerpts, etc.)</u>

Québec

<u>McGill Universtiy</u>

Degrees offered:	PhD MEng (thesis) MEng (non-thesis) Graduate Diploma
Programs offered:	Chemical Engineering (PhD, M.Eng (thesis), MEng (non-thesis)) Mining and Materials Engineering (PhD, M.Eng (thesis), MEng (non-thesis)) Mining Engineering (Dipl.)
Specializations:	-
Full-time enrollment:	90
Part-time enrollment:	1
Master graduations:	12
PhD graduations:	11

PhD in Chemical Engineering

Those with a Master's degree in chemical engineering from a recognized institution are admitted to the PhD program. This requires the completion of several graduate courses and a research thesis. Those holding a Master's degree with minimal course requirements or in a field other than chemical engineering may be required to take additional courses. The residence requirement is 3 years, with most students completing the PhD in 4-5 years. Successful candidates are awarded a Doctor of Philosophy (PhD) degree.

Program Requirement:

Thesis

A thesis for the doctoral degree must constitute original scholarship and must be a distinct contribution to knowledge. It must show familiarity with previous work in the field and must demonstrate ability to plan and carry out research, organize results, and defend the approach and conclusions in a scholarly manner. The research presented must meet current standards of the discipline; as well, the thesis must clearly demonstrate how the research advances knowledge in the field. Finally, the thesis must be written in compliance with norms for academic and scholarly expression and for publication in the public domain.

Required Courses

- CHEE 681 Laboratory Safety 1 1 Credits
- CHEE 682 Laboratory Safety 2 1 Credits
- CHEE 687 Research Skills and Ethics 2 Credits
- CHEE 795 PhD Thesis Proposal

- CHEE 796 PhD Proposal Defence
- CHEE 797 PhD Seminar

Complementary Courses (6-12 credits)

6-8 credits of Chemical Engineering courses (two courses) at the 500, 600, or 700 level.

12 credits (three courses) from the following list must be taken during the MEng and/or PhD program:

- CHEE 611 Heat and Mass Transfer — 4 Credits
- CHEE 621 Thermodynamics — 4 Credits
- CHEE 631 Foundations of Fluid Mechanics — 4 Credits
- CHEE 641 Chemical Reaction Engineering — 4 Credits
- CHEE 651 Adv Biochemical Engineering — 4 Credits
- CHEE 662 Computational Methods — 4 Credits
- CHEE 672 Process Dynamics and Control — 4 Credits

<u>École Polytechnique</u>

Degrees offered:	Doctorat	
	Maîtrise recherche	thesis-based
	Maîtrise professionelle	course-based
	Diplôme d'études supérieures spécialisées	
	Microprogramme de 2e cycle	
Programs offered:	Génie chimique	(PhD , M.(rech.), M.(prof.))
Specializations:	Polymères	(PhD , M.(rech.), M.(prof.))
	Biopharmaceutique	(PhD , M.(rech.), M.(prof.))
	Procédés	(PhD , M.(rech.), M.(prof.))
	Environnement et développement durable	(all)
	Génie papetier	(PhD , M.(rech.), M.(prof.))
	Matériaux	(Dipl., Microprogr.)
	Procédés et environnement	(Dipl., Microprogr.)
Full-time enrollment:	132	
Part-time enrollment:	4	
Master graduations:	23	
PhD graduations:	20	

Doctorat en génie chimique

Le programme de doctorat en génie chimique a pour but de développer chez le candidat un haut niveau de connaissances, de rigueur intellectuelle, de curiosité scientifique et de créativité nécessaires tant dans les activités professionnelles de pointe que dans la recherche scientifique et l'enseignement universitaire.

Le doctorat en génie chimique comporte 90 crédits se répartissant comme suit :

- Cours de cycles supérieurs — 15 crédits (minimum)
- Recherche et réaction de thèse — 75 crédits

Exigence du programme: Afin de compléter le programme, la réussite avec une note minimale de B à l’un des cours suivantsest exigée: le cours de 1ercycle de Phénomènes d’échanges GCH3515, ou le cours Compléments de phénomènes d’échanges GCH6912A, ou le cours Phénomènes d’échanges avancés GCH6903, ou un cours jugé équivalent. Ce cours devra être suivi durant la première année au doctorat s’il n’a pas été réussi auparavant avec une note minimale de B.

Le cours GCH7918 Planification d’un projet doctoral est obligatoire et doit être suivi en début de programme, au plus tard au 3etrimestre suivant la première inscription. La réussite avec une note minimale de B pour le cours est exigée.

Axes de spécialisation et liste des cours

- **Polymères –** Modélisation et CAO/FAO des procédés de mise en œuvre des polymères. Mise au point de réacteurs et des techniques de mélange. Modification des enchevêtrements dans les matériaux plastiques. Recyclage des déchets de polymères. Étude de la structure et de la morphologie des polymères. Étude des paramètres d'interaction dans les mélanges et les composites. Caractérisation des propriétés mécaniques, viscoélastiques et rhéologiques. Caractérisation des propriétés de surface. Développement de matériaux composites et cellulosiques. Synthèse par émulsion de polymères de haute masse moléculaire.
- **Biopharmaceutique –** Biotechnologies, conception et caractérisation de bioréacteurs pour la culture de microorganismes, de cellules de plante, d'insecte et de mammifère, de cellules souches, pour cellules en suspension et en tissus. Opération, suivi et monitoring de cultures de cellules. Modélisation cinétique et métabolique; analyse de flux métaboliques (MFA), analyse des contrôles métaboliques (MCA). Ingénierie cellulaire et technologie recombinante. Biocapteurs. Production de métabolites, protéines et virus d'intérêt thérapeutique. Commande de bioprocédés de production. Purification, caractérisation et étude de la qualité et de l'efficacité des molécules produites.
- **Procédés –** Conception des procédés à l'aide d'ordinateur (CPAO). Étude cinétique des réactions catalytiques. Modélisation et conception des réacteurs. Simulation et commande par ordinateur des réacteurs catalytiques. Mise en œuvre des catalyseurs pulvérulents : aérogels, cryogels, en couche fluidisée. Mise en œuvre des réacteurs catalytiques à lit circulant et turbulent. Technologies gazières. Incinération des déchets solides et dangereux Développement de procédés de traitement thermique de solides en lit fluidisé. Chauffage par panneaux radiants catalytiques. Combustion catalytique.
- **Environnement et développement durable –** Traitement des déchets dangereux, des déchets solides, des effluents liquides ou gazeux. Procédés physico-chimiques, biologiques et thermiques. Incinération de sols contaminés et de boues de procédé. Biorémédiation des sites contaminés. Sites d'enfouissement. Dispersion atmosphérique de polluants gazeux ou solides. Études de risques pour la santé. Études d'impact. Analyse du cycle de vie. Développement durable. Conception environnementale.
- **Génie papetier –** Modélisation, analyse et simulation des procédés papetiers. Fermeture des circuits et réduction des effluents, traitement des déchets. Intégration énergétique et matérielle des procédés. Contrôle et dynamique des

procédés papetiers, développement de techniques de contrôle avancées. Couchage du papier, modélisation des opérations de couchage, rhéologie des sauces de couchage. Aspects moléculaires de la rhéologie, adhérence, surface et interface des additifs polymériques.

Ateliers obligatoires

- CAP7001 Réussir au doctorat (1 cr.)
  - Suivi préférablement au 1er ou 2e trimestre suivant l’inscription
- CAP7005 Traitement de l’information scientifique et technique (1 cr.)
  - Suivi préférablement au 2e ou 3e trimestre suivant l’inscription
- CAP7010 La créativité à votre portée (1 cr.)
  - Suivi préférablement au 3e ou 4e trimestre suivant l’inscription
- CAP7015 Conduire un projet de recherche (1 cr.)
  - Suivi préférablement au 3e ou 4e trimestre suivant l’inscription

Examen de synthèse

Cours de specialization		crédits
• DDI8003	Analyse du cycle de vie	3
• GCH6101	Chimie physique des polymères	3
• GCH6104A	Rhéologie des polymères	4
• GCH6108	Systèmes polymères multiphasés	3
• GCH6112A	Conc. des opér. d'agitation et de mélange	3
• GCH6113	Identification de syst. et comm. adaptative	3
• GCH6114	Projet de conception de produits polymériques	3
• GCH6201	Catalyse et cinétique appliquées	3
• GCH6210	Ingénierie des pâtes et papiers	3
• GCH6301	Ingénierie des biosystèmes	3
• GCH6302	Culture des cellules	3
• GCH6303	Réacteurs polyphasés	3
• GCH6304	Contrôle de la pollution industrielle	3
• GCH6309	Valorisation énergétique des déchets solides	3
• GCH6313	Modélis. environn. des émissions toxiques	3
• GCH6902	Conception des réacteurs gaz-solide	3
• GCH6903	Phénomènes d'échanges avancés	3
• GCH6905A	Thermodynamique à l'échelle nanométrique	3
• GCH6912A	Compléments de phénomènes d'échanges	4
• GCH6914	Méthode des éléments finis en génie chimique	3
• GCH7918	Planification d'un projet doctoral	3
• GCH8102	Mise en forme des polymers	3
• GCH8103	Conversion de la biomasse	3
• GCH8104	Traitement des minerais	3
• GCH8105	Génie brassicole	3
• GCH8106	Ingénierie des emballages polymères	3
• GCH8107	Procédés pyrométallurgiques	3

- GCH8150 Systèmes de commande de procédés chimiques 3
- GCH8211 Conception et intégration des procédés 3
- GCH8615 Règlementation des procédés propres 3
- GCH8620 Procédés avancés de séparation 3
- GCH8650 Génie biochimique 3
- GCH8660 Opérations unitaires en génie alimentaire 3
- GCH8729 Déchets solides et énergie résiduelle 3
- ENE8210 Efficacité des sources d'énergie 3
- ENE8310 Stockage et intégration des syst. énergéti. 3
- MET8106 Énergie électrochimique 3

Séminaires et cours spéciaux

- GCH6908 Séminaires 1
- GCH6951# C. SPÉC. : « titre du cours spécial » 1
- GCH6952# C. SPÉC. : « titre du cours spécial » 2
- GCH6953# C. SPÉC. : « titre du cours spécial » 3

Stages doctoraux pour étudiant étranger en codirection inscrit dans une autre institution

- GCH791X Stage doctoral X (X = 1 à 6) 9

<u>Université Laval</u>

Degrees offered:	Maîtrise avec mémoire (M.Sc.) Doctorat
Programs offered:	Génie chimique Génie des matériaux et de la métallurgie
Specializations:	-
Full-time enrollment:	68
Part-time enrollment:	0
Master graduations:	8
PhD graduations:	9

Doctorat en génie chimique

Vous serez apte à réaliser des recherches originales de façon autonome. Vous vous perfectionnerez dans un des champs du génie chimique et vous contribuerez, par le résultat de vos recherches, au progrès de la science.

Activités de formation communes 8 crédits

- GCH-8000 Projet complémentaire de doctorat 1 crédit
- GCH-8001 Communication scientifique orale et écrite II 1 crédit
- RÈGLE 1 - 6 CRÉDITS PARMI : credits
  - GCH-7000 Mise en oeuvre des polymères 3
  - GCH-7001 Rhéologie des polymères 3
  - GCH-7002 Méthodes numériques en génie chimique 3

- GCH-7003 Cinétique biochimique 3
- GCH-7004 Méthodes mathématiques en génie chimique 3
- GCH-7005 Systèmes réactionnels 3
- GCH-7006 Méthodologie de recherche 3
- GCH-7007 Biotechnologie environnementale 3
- GCH-7008 Mécanique des fluides biphasiques 3
- GCH-7009 Catalyse hétérogène 3
- GCH-7010 Sujets spéciaux (génie chimique) 3
- GCH-7011 Planification et analyse des expériences 3
- GCH-7012 Nanomatériaux et leur application en catalyse 3
- GCH-7013 Phénomènes d'échange 3
- GCH-7014 Technologies de séparation et de capture des gaz à... 3
- GCH-7015 Génie biomoléculaire 3
- GCH-7016 Instabilités hydrodynamiques 3

- Recherche
  - GCH-8801 Activité de recherche - thèse 1 11
  - GCH-8802 Activité de recherche - thèse 2 11
  - GCH-8803 Activité de recherche - thèse 3 11
  - GCH-8804 Activité de recherche - thèse 4 11
  - GCH-8805 Activité de recherche - thèse 5 11
  - GCH-8806 Activité de recherche - thèse 6 11
  - GCH-8807 Activité de recherche - thèse 7 11
  - GCH-8808 Activité de recherche - thèse 8 11

Université de Sherbrooke

Degrees offered:	Maîtrise	(thesis-based)
	Maîtrise de type cours	
	Doctorat	
Programs offered:	Génie chimique	
Specializations:	-	
Full-time enrollment:	65	
Part-time enrollment:	0	
Master graduations:	11	
PhD graduations:	7	

Doctorat en génie chimique

Fort d'une tradition bien établie en recherche, le Département de génie chimique et de génie biotechnologique offre un milieu de formation de qualité et des défis stimulants aux étudiantes et étudiants qui fréquentent ses programmes de doctorat.

Activités pédagogiques obligatoires (84 crédits)

- SCA 715 Sécurité dans les laboratoires de recherche (0 cr.)
- SCA 770 Plan de formation aux études de doctorat (1 cr.)

- SCA 772 Définition du projet de recherche au doctorat (6 cr.)
- SCA 775 Examen de synthèse (9 cr.)
- SCA 777 Séminaire et communication (2 cr.)
- SCA 778 Activités de recherche au doctorat I (9 cr.)
- SCA 779 Activités de recherche au doctorat II (9 cr.)
- SCA 790 Thèse de doctorat et soutenance (48 cr.)

Activités pédagogiques à option (3 crédits). Choisie parmi les activités suivantes :

- EFD 901 Construire un projet de recherche, Réflexives® (3 cr.)
- SCA 701 Méthodologie de recherche et communication (3 cr.)

Activités pédagogiques au choix (3 crédits). Trois crédits d'activités pédagogiques choisies parmi les activités de 2e ou de 3e cycle de l'Université ou l'activité pédagogique suivante, avec l'approbation de sa directrice ou de son directeur de recherche :

- SCA 781 Études spécialisées au doctorat (3 cr.)

Ontario

University of Toronto

Degrees offered:	MEng (course-based)
	MASc (thesis-based)
	PhD
Programs offered:	Chemical Engineering and Applied Chemistry (all)
	Materials Science and Engineering (all)
	Collaborative program in Environmental Studies (all)
	Collaborative program in Biomedical Engineering (MASc, PhD)
	Collaborative program in Cadriovascular Sciences (MASc, PhD)
	Collaborative program in Engineering Education (MASc, PhD)
	Collaborative program in Environmental Engineering (MASc, PhD)
	Collaborative program in Genome Biology and Bioinformatics (MASc, PhD)
	Collaborative program in Global Health (MASc, PhD)
Specializations:	Advanced Water Technologies and Process Design (MEng)
	Entrepreneurship, Leadership, Innovation and Technology in Engineering (MEng)
	Sustainable Energy (all)
	Advanced Manufacturing (MEng)
Full-time enrollment:	217
Part-time enrollment:	12
Master graduations:	50
PhD graduations:	15

PhD in Chemical Engineering and Applied Chemistry

Thesis Requirement

- A research thesis of no more than 200 pages, which involves an original contribution to knowledge, written and defended in an acceptable manner.

Academic Course Requirements

- A minimum of 4 half-credit (H) courses – normally taken from Engineering or Physical Science departments.
        - CHE1100H – Fundamentals of Chemical Engineering
        - CHE1107H – Applied Mathematics
        - CHE1141H – Advanced Chemical Reaction Engineering
        - CHE1142H – Applied Chemical Thermodynamics
        - CHE1143H – Transport Phenomena
        - CHE1310H – Chemical Properties of Polymers
        - JTC1134H – Applied Surface and Interface Science
        - JTC1135H – Applied Surface and Interface Analysis
        - CHE1053H - Electrochemistry
        - CHE1118H - Industrial Catalysis
        - CHE1123H - Liquid Biofuels
        - CHE1125H - Modelling and Optimization of Chemical/ Biomedical Networks
        - CHE1134H - Advances in Bioengineering
        - CHE1146H - Applied Transport Phenomena
        - CHE1147H - Data Mining in Engineering
        - CHE1150H - Industrial Water Technology
        - CHE1213H - Corrosion
        - CHE1435H - Aerosol Physics and Chemistry
        - CHE1533 - Nuclear Chemical Engineering
        - JCC1313H - Environmental Microbiology
        - JCI1503H - Advanced Topics in Computing and Information Systems
        - JCB1349H - Molecular Assemblies
        - JNC2503H- Environmental Pathways
        - JCR1000Y - An Interdisciplinary Approach to Addressing Global Challenges
    - A maximum of 1 half-credit (H) course in the Faculty of Management Studies or Engineering Management (ELITE) may be taken.
    - No 500-level courses may be taken without pre-approval by both the Supervisor and Graduate Coordinator
- Seminar Course Requirements
    - CHE2222H: Safety Training – once, in the first session of study prior to beginning work in the lab
    - JDE1000H: Ethics in Research – once, typically in the first Fall or Winter session of study
    - CHE2011H: Graduate Student Seminars – twice, typically in the first and third year of study
    - CHE300xH: Seminars in Chemical Engineering & Applied Chemistry – 8 times, i.e., each Fall and Winter session in the first four years of study

Ryerson University

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	27	
Part-time enrollment:	2	
Master graduations:	11	
PhD graduations:	4	

PhD Chemical Engineering

Degree requirements

- Dissertation
- Doctoral Seminar
- Four elective credits (from Group I)
  - CE8139 Prob, Stat and Stochastic Proc
  - CE8140 Statistics for Engineering
  - CE8202 Advanced Process Control
  - CE8203 Applied Optimal Control
  - CE8204 Advanced Modeling Techniques
  - CE8213 Advanced Numerical Methods
  - CE8301 Advanced Transport Phenomena
  - CE8303 Advanced Fluid Dynamics
  - CE8304 Rheology
  - CE8401 Ind Catalysis and Biocatalysis
  - CE8402 Applied Thermodynamics
  - CE8403 Advanced Reactor Engineering
  - CE8501 Polymer Science
  - CE8502 Polymerization Reaction Engr
  - CE8602 Industrial Biotechnology
  - CE8603 Advances in Biomaterials
  - CE8604 Advances in Porous Materials
  - CE8605 Nanobiotechnology
  - CE8606 Advanced Topics in Tissue Engineering
  - CE8702 Dsgn/Oper Sm Wtr Treat Plants
  - CE8703 Adv Water Treatment Tech
  - CE8803 Advanced Food Process Engineering
  - CE9100 Directed St: Chem Eng (PhD)

University of Ottawa

Degrees offered:	MEng	(course-based)

	MASc	(thesis-based)
	PhD	
	Graduate Diploma	
Programs offered:	Chemical Engineering (MA.Sc., MEng, and Ph.D,)	
	Advanced Materials and Manufacturing (MA.Sc., MEng, and Ph.D,)	
	Technology Project Management (Diploma)	
Specializations:	-	
Full-time enrollment:	94	
Part-time enrollment:	6	
Master graduations:	51	
PhD graduations:	5	

Doctorate in Philosophy Chemical Engineering

The PhD program prepares candidates for a career in teaching, research and/or development. Graduates are expected to have acquired autonomy in conducting research, preparing scholarly publications, and promoting chemical engineering.

Compulsory Courses: 9 optional course units above the level of the master of applied science

- CHG 8110 Fluid Mechanics (3 units)
- CHG 8115 Heat Transfer I (3 units)
- CHG 8116 Advanced Transport Phenomena (3 units)
- CHG 8120 Rheology and Polymer Processing (3 units)
- CHG 8121 Synthetic Membranes in Biomedical Engineering (3 units)
- CHG 8123 Chemical Engineering Thermodynamics (3 units)
- CHG 8132 Adsorption Separation Processes (3 units)
- CHG 8141 Special Directed Studies I (3 units)
- CHG 8143 Special Directed Studies II (3 units)
- CHG 8145 Special Directed Studies III (3 units)
- CHG 8153 Stat. Model and Cont. Dyna. Proc. (3 units)
- CHG 8157 Strategies for Engineering Process Analysis (3 units)
- CHG 8158 Porous Media (3 units)
- CHG 8161 Chemical Reaction Engineering I (3 units)
- CHG 8175 Material Transport (3 units)
- CHG 8181 Biochemical Engineering (3 units)
- CHG 8186 Modelling of Steady-State Processes (3 units)
- CHG 8187 Introduction to Polymer Reaction Engineering (3 units)
- CHG 8188 Polymer Properties and Characterization (3 units)
- CHG 8189 Chemical Engineering Analysis (3 units)
- CHG 8191 Selected Topics Chemical Engineering (3 units)
- CHG 8192 Membrane Application in Environmental Engineering (3 units)
- CHG 8194 Membrane Separation Processes (3 units)
- CHG 8195 Advanced Numerical Methods in Transport Phenomena (3 units)
- CHG 8196 Interfacial Phenomena in Engineering (3 units)
- CHG 8198 Reverse Osmosis (3 units)

Seminar:

- CHG 8102S Seminar II

Comprehensive Examination:

- CHG 9998 Comprehensive Examination (PhD)

Thesis:

- CHG 9999 PhD Thesis

<u>Queen's University</u>

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Collaborative degree in Applied Sustainability (MEng, MASc)	
	Collaborative degree in Biomedical Engineering (MASc, PhD)	
Specializations:	-	
Full-time enrollment:	78	
Part-time enrollment:	1	
Master graduations:	19	
PhD graduations:	10	

Doctor of Philosophy in Chemical Engineering

Requirements additional to those in the general regulations are as follows. The minimum course requirement for the PhD beyond the B.Sc. is 7 term length courses. Six must be graduate courses. The list of graduate courses taken will be evaluated by the supervisory committee on an ongoing basis and will be reviewed at the time of the oral comprehensive examination. One course may be selected from 400-series undergraduate courses in other departments. All students must take CHEM-801*, a non-credit course in laboratory safety, at the first opportunity after their initial registration, and also participate in CHEE-897, the departmental seminar series.

Courses:

- CHEE-801 Strategies for Process Investigations
- CHEE-803 Transport Phenomena
- CHEE-807 Current Topics in Chemical Engineering
- CHEE-809 Colloid and Surface Phenomena
- CHEE-810 Fuel Cell Systems: Design and Analysis
- CHEE-811 Mathematical Modeling of Chemical Processes
- CHEE-820 Topics in Advanced Process Control
- CHEE-821 Process Control II
- CHEE-822 Model-Based Control
- CHEE-824 Nonlinear Regression Analysis and Applications

- CHEE-825 System Identification
- CHEE-827 System Optimization
- CHEE-828 Polymer Reaction Engineering
- CHEE-835 Turbulent Diffusion in the Environment
- CHEE-837 Transport & Kinetics with Application to Fuel Cells
- CHEE-840 Introduction to Learning and Teaching in Engineering
- CHEE-841 Engineering Education: Theory into Practice
- CHEE-872 Polymeric Biomaterials
- CHEE-874 Tissue Engineering
- CHEE-882 Bioreactor Design
- CHEE-883 Bioseparation Processes
- CHEE-884 Bioremediation
- CHEE-885 Current Topics in Biochemical Engineering
- CHEE-887 Cellular Bioengineering
- CHEE-890 Advanced Polymer Structure, Properties and Processing
- CHEE-901 Principles and Applications of Polymer Rheology
- CHEE-902 Bulk and Solution Polymerisation Processes
- CHEE-903 Polymerisation in Dispersed Media
- CHEE-906 Entrepreneurship for Chemical Engineers
- CHEE-907 Current Topics in Chemical Engineering
- CHEE-908 Green Engineering
- CHEE-909 Colloid and Surface Science Fundamentals
- CHEE-910 Special Topics in Colloid and Surface Phenomena
- CHEE-911 Microscale Transport Phenomena
- CHEE-912 Applied Lab-on-Chip Technologies
- CHEE-927 Global Optimization
- CHEE-990 Structure-Property Relationships of Polymer Materials
- CHEE-991 Introduction to the Processing and Rheology of Polymeric Materials
- CHEE-992 Polymeric Biomaterials

CHEE-897 Seminar

CHEE-999 PhD Thesis Research

Royal Military College

Degrees offered:	Master	(thesis-based)
	PhD	
Programs offered:	Chemical and Materials Engineering	
	Nuclear Engineering	
Specializations:	-	
Full-time enrollment:	28	
Part-time enrollment:	8	
Master graduations:	6	
PhD graduations:	3	

Doctor of Philosophy in Chemical and Materials Engineering

The Doctor of Philosophy in Environmental, Nuclear, and Chemical and Materials Science or Engineering, will be awarded to candidates who successfully complete a programme of studies normally comprised of at least eight (8) lecture courses, at the graduate level, plus a thesis.

- CC501 Chemical And Nuclear Engineering Computations
- CC502 Polymer Welding and Joining
- CC503 Special Topics
- CC506 Molecular Modelling and Applications to Nanotechnology
- CC508 Sea and Air-Launched Munitions
- CC509 Nuclear Reactor Heat Transfer
- CC510 Ammunition Management
- CC511 Health Physics and Radiation Protection
- CC512 Ground-Launched Munitions
- CC513 Corrosion Engineering - Diagnosis of Corrosion and Corrosion Testing
- CC514 Weapons Systems
- CC515 Nuclear Detection and Measurement
- CC516 Nanotechnology: Theory, Applications and Characterization Methods
- CC517 Shielding for Nuclear Activities
- CC518 Advanced Thermodynamics
- CC520 Transport Phenomena
- CC521 Introduction to Nondestructive Evaluation
- CC522 Applied Experimental Design and Data Analysis
- CC523 Nuclear Reactor Engineering
- CC525 Nuclear Reactor Safety
- CC527 Nuclear Reactor Kinetics and Dynamics
- CC523 Nuclear Reactor Engineering
- CC528 Advanced lnorganic Chemistry
- CC531 Radiological Methods
- CC533 Nuclear Fuels Engineering
- CC537 Site Remediation
- CC539 Applied Analytical Chemistry
- CC541 Environmental Toxicology and Risk Assessment
- CC543 Atmospheric Dispersion and Micrometeorology
- CC545 Advanced Topics in Organic Chemistry
- CC547 Artificial Neural Network Modelling
- CC551 Propulsion in Guns and Rockets
- CC555 Environmental Issues
- CC559 Terminal Ballistics 2 - Impact Mechanics
- CC561 External Ballistics
- CC563 Polymers in Engineering Applications
- CC565 Nuclear and Radiochemistry
- CC567 Nuclear Fuel Management

- CC569 Nuclear, Biological and Chemical Defence
- CC573 Nuclear Waste Management
- CC575 Materials in the Space Environment
- CC577 Explosives and Explosions
- CC579 Chemistry of Energetic Materials
- CC587 Mechanism, Kinetics And Model Development
- CC591 Ceramic Engineering
- CC593 Advanced Nuclear Reactor Physics
- CC595 Nuclear Materials
- CC599 Advanced Topics in Analytical Chemistry
- CC604 Seminar
- PR500: Project

TH600: Thesis (Doctoral Level)

CP600: Comprehensive Examination (Doctoral Level)

<u>McMaster University</u>

Degrees offered:	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
Specializations:	-	
Full-time enrollment:	86	
Part-time enrollment:	2	
Master graduations:	18	
PhD graduations:	2	

Doctor of Philosophy in Chemical Engineering

Duration: nominally four years (12 semesters) after the Master's degree. the PhD program consists of seven one-term graduate courses beyond the Bachelor's Degree or three courses beyond the Master's degree and a more extensive research program leading to a dissertation. The dissertation must be an original contribution to chemical engineering and must also be defended at an oral examination. A candidate is also required to take the PhD comprehensive examination which is designed to test the breadth of knowledge and the ability to synthesize ideas from within the peripheral to the candidate's research area.

Courses:

- ChE 4B03 / ChE 6B03 Polymer Reaction Engineering
- ChE 4E03 / ChE 6E03 Digital Computer Process Control
- ChE 4K03 / ChE 6K03 Reactor Design for Heterogenous Systems
- ChE 4X03 / ChE 6X03 Polymer Processing
- ChE 706 Advanced Heat Transfer
- ChE 707 Analytical Solutions in Transport Phenomena

- ChE 712 Bio-Inspired Engineering
- ChE 740W Advanced PSE Tools and Methods
- ChE 752 Optimization of Chemical Processes
- ChE 767 Foundations of Scientific Computation
- ChE 773 Advanced Concepts of Polymer Extrusion
- ChE 777 Dynamics of Polymers and Complex Fluids
- ChE 4C03 / ChE 6C03 Statistics for Engineers
- ChE 4T03 / ChE 6T03 Applications of Chemical Engineering in Medicine
- ChE 4Z03 / ChE 6Z03 Interfacial Engineering
- ChE 750 Advanced MEMS Fabrication and Microfluidics
- ChE 753 Process Modeling and Optimization
- ChE 756 Mathematical Programming: Theory and Algorithms
- ChE 781 Biomedical Engineering
- ChE 782 Biopharmaceuticals
- ChE 790 Selected Topics in Colloid and Surface Science
- ChE 791 Nanotechnology in Chemical Engineering
- ChE 702 (C01) Ophthalmic Materials and Drug Delivery
- ChE 704 Biological Transport Phenomena
- ChE 742 Membrane Based Bioseparations
- ChE 754 Process Design and Integration for Minimal Environmental Impact
- ChE 757 Optimization Under Uncertainty (Stochastic Optimization)
- ChE 761 Multivariable, Stochastic and Adaptive Control of Chemical Processes
- ChE 762 Time Series Analysis and Process Identification
- ChE 763 Linear Systems: Estimation and Control
- ChE 764 Process Control Design
- ChE 770 Selected Topics in Polymer Science and Engineering
- ChE 772 Polymer Rheology
- ChE 774 Advances in Polymeric Materials
- ChE 776 Soft Matter Thin films & Surface Characterization Techniques
- ChE 784 Gene Therapy for Bioengineers

<u>University of Waterloo</u>

Degrees offered:	MEng	(course-based)
	MASc	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	Nanotechnology	
	Water	
Full-time enrollment:	184	
Part-time enrollment:	19	
Master graduations:	57	
PhD graduations:	22	

Doctor of Philosophy in Chemical Engineering

Students with a Chemical Engineering background with a MASc degree must complete 3 graduate courses (0.50 unit weight per course). Within these courses:

- At least 2 must be core CHE courses, as listed below.
- 3 must be 600 or 700 level graduate courses.
- No more than 1 may be a held with course.
- No more than 1 may be taught by supervisor(s).
- No more than 1 may be a reading course.

Core courses

- CHE 610 Transport Phenomena
- CHE 612 Interfacial Phenomena
- CHE 620 Applied Engineering Mathematics
- CHE 622 Statistics in Engineering
- CHE 630 Chemical Reactor Analysis
- CHE 640 Principles of Polymer Science
- CHE 660 Principles of Biochemical Engineering
- NANO 701 Fundamentals of Nanotechnology (two 0.25 credit NANO 701 modules)
- NANO 702 Nanotechnology Tools (two 0.25 credit NANO 702 modules)

Other courses

- CHE 614 Capillary and Transport Phenomena in Porous Media
- CHE 624 Advanced Process Dynamics and Control
- CHE 632 Introduction to Catalysis
- CHE 641 Physical Properties of Polymers
- CHE 661 Advances in Biochemical Engineering
- CHE 672 Air Pollution Control
- CHE 674 Industrial Waste Treatment
- CHE 710 Special Topics in Transport Phenomena
- CHE 715 Research Topics in Transport Phenomena
- CHE 720 Special Topics in Analysis of Chemical Processes
- CHE 725 Research Topics in Analysis of Chemical Processes
- CHE 730 Special Topics in Chemical Kinetics, Catalysis and Advanced Reactor Engineering
- CHE 735 Research Topics in Chemical Kinetics, Catalysis and Advanced Reactor Engineering
- CHE 740 Special Topics in Polymer Science and Engineering
- CHE 745 Research Topics in Polymer Science and Engineering
- CHE 750 Special Topics in Electrochemical Engineering, Interfacial Engineering & Materials Science
- CHE 755 Research Topics in Electrochemical Engineering, Interfacial Engineering & Materials Science

- CHE 760 Special Topics in Biochemical Engineering
- CHE 765 Research Topics in Biochemical Engineering
- CHE 770 Special Topics in Environmental Engineering and Pollution Control
- CHE 765 Research Topics in Environmental Engineering and Pollution Control

Graduate Studies Seminar

PhD Comprehensive Examination

PhD Thesis

Western University

Degrees offered:	MEng	(course-based)
	M.E.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical and Biochemical Engineering	
Specializations:	-	
Full-time enrollment:	153	
Part-time enrollment:	4	
Master graduations:	37	
PhD graduations:	15	

Doctor of Philosophy in Chemical and Biochemical Engineering

Eight courses (including up to four course transfers):

Fundamental Courses (0-3 depending on transfer credits)

- CBE 9160 Transport Processes (Transport Phenomena)
- CBE 9450 Advanced Reaction Engineering
- CBE 9211 Advanced Biochemical Engineering
- CBE 9150 Advanced Chemical Engineering Thermodynamics
- CBE 9190 Statistical Process Control or CBE 9170 Mathematical Methods in Engineering

Courses Relevant for the Interdisciplinary Work (0-4 depending on transfer credits)

- CBE 9550 Advanced Particles and Fluidization Engineering
- CBE 9587 Fine Powder Technologies and Application
- CBE 9561 Advanced High Velocity Fluidization Technology
- CBE 9132 Oil Refining and Processing
- CBE 9424 Computer Process Control
- CBE 9461 Advanced Process Control
- CBE 9190 Statistical Process Control or CBE 9170 Mathematical Methods in Engineering
- CBE 9126 Partial Differential Equations
- CBE 9260 Advanced Bioengineering and Biotechnology
- CBE 9245 Cellular Bioengineering

- CBE 9250 Biomaterials Engineering
- CBE 9241 Nanobiotechnology
- CBE 9544 Pharmaceutical Manufacturing Processes
- CBE 9180 Instrumental Methods for Analysis for Engineers
- CBE 9350 Physical Principles of Environmental Engineering
- CBE 9321 Air Pollution Control
- CBE 9361 Biological Wastewater Treatment
- CBE 9334 Green Fuels and Chemicals
- CBE 9455 Advanced Polymerization Engineering
- CBE 9125 Interfacial Phenomena
- CBE 9265 Microalgal Systems: Biotechnology and Applications

Compulsory Course

- CBE 9100 Advanced Engineering Communications

Atlantic Provinces

Dalhousie University

Degrees offered:	MEng (course-based) MASc (thesis-based) PhD
Programs offered:	Chemical Engineering Biological Engineering Materials Engineering
Specializations:	-
Full-time enrollment:	19
Part-time enrollment:	0
Master graduations:	4
PhD graduations:	0

Doctor of Philosophy in Chemical Engineering

The Chemical Engineering program prepares students for careers in the chemical and process industries and in a variety of related fields. These encompass, among others, the traditional areas of environmental control, plastics and polymers, pulp and paper, instrumentation and process control, petrochemicals, petroleum and natural gas processing, and energy conversion and utilization, as well as the growing fields of biotechnology, food processing, composite materials, corrosion and protective coatings, and manufacture of microelectronic components.

Courses (3 courses required)

- CHEE 6000 Special Topics in Chemical Engineering I
- CHEE 6701 Loss Prevention and Risk Assessment
- CHEE 6707 Applied Thermodynamics
- CHEE 6714 Polymer Science

- CHEE 6726 Mass Transfer Topics
- CHEE 6730 Kinetics and Catalyses
- CHEE 6732 Transport Phenomena
- CHEE 6734 Chemical Reactor Design
- CHEE 6736 Computer Application in Chemical Engineering
- CHEE 6737 Chemical Process Control
- CHEE 6742 Chemical Process Optimization
- CHEE 6743 Process Synthesis
- CHEE 6744 Radiative Heat Transfer
- CHEE 6750 Combustion Phenomena
- CHEE 6751 Dust Explosion Risk Reduction
- CHEE 6755 Colloids and Interfaces in Petroleum Engineering
- CHEE 6800 Chemical Engineering in Biological Systems
- CHEE 7000 Special Topics in Chemical Engineering II

Thesis

University of New Brunswick

Degrees offered:	MEng	(course-based)
	M.Sc.E.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
Specializations:	-	
Full-time enrollment:	45	
Part-time enrollment:	7	
Master graduations:	14	
PhD graduations:	4	

PhD, Chemical Engineering

Students are required to present a research proposal and successfully complete the research proposal course (CHE 6511). Candidates must also pass a comprehensive examination covering the major areas of chemical engineering within the first year of study. Candidates entering on or after Fall 2009 are required to give an oral research proposal within their first year of study to a committee of three reviewers set by their supervisor. A candidate who has completed their Master's degree at UNB will not be required to complete CHE6511. Normally, candidates for the PhD should hold a Master's degree in Chemical Engineering or in an appropriate related discipline.

PhD candidates are required to take three courses (9ch) at the 5000 or 6000 level in addition to ChE6511 and ChE 6800. The courses must be approved by the students' supervisor and may include courses outside of Chemical Engineering.

Courses:

- CHE 5114 Chemical Reaction Engineering II 3 ch
- CHE 5124 Adsorption and Adsorption Processes 3 ch

- CHE 5224 Applied Petroleum and Reservoir Engineering 3 ch
- CHE 5234 Oil Refining and Natural Gas Processing 3 ch
- CHE 5244 Enhanced Oil Recovery Processes 3 ch
- CHE 5254 Polymer Reaction Engineering and Polymer Processing 3 ch
- CHE 5264 Oil Sands Technology 3 ch
- CHE 5313 Energy and the Environment 3 ch
- CHE 5314 Chemical Process Industries: Overview and Environmental Impact 3 ch
- CHE 5334 Radiative Heat Transfer 3 ch
- CHE 5344 Combustion 3 ch
- CHE 5434 Transport Phenomena 3 ch
- CHE 5524 Mathematical Methods in Chemical Engineering 3 ch
- CHE 5534 Process Identification for Advanced Control 3 ch
- CHE 5614 Process Control 3 ch
- CHE 5714 Electrochemical Engineering 3 ch
- CHE 5744 Steam Supply Systems 3 ch
- CHE 5754 Steam and Gas Turbines 3 ch
- CHE 5764 Special Topics in Power Plant Engineering 3 ch
- CHE 5804 Nuclear Chemical Processes 3 ch
- CHE 5824 Corrosion Processes 3 ch
- CHE 5834 Nuclear Engineering 3 ch
- CHE 5844 Nuclear Safety and Reliability 4 ch
- CHE 5854 Nuclear Heat Removal 3 ch
- CHE 5877 Advanced Nuclear Systems 3 ch
- CHE 5913 Pulp Production 3 ch
- CHE 5923 Papermaking 3 ch
- CHE 5933 Biorefining: Principles. Processes, and Products 3 ch
- CHE 6234 Process Design and Simulation 3 ch
- CHE 6314 Air Pollution Control 3 ch
- CHE 6402 Preliminary Project Report 3 ch
- CHE 6416 Bioseperations Science and Engineering 3 ch
- CHE 6417 Polymer Materials and Reaction Engineering 3 ch
- CHE 6423 Practice School 3 ch
- CHE 6501 Special Topics in Chemical Engineering 3 ch
- CHE 6502 Special Topics in Chemical Engineering 3 ch
- CHE 6503 Nanotechnology 3 ch
- CHE 6511 Introduction to Research Methods 3 ch
- CHE 6515 Advanced Surface Characterization 3 ch
- CHE 6522 Nanoparticle Engineering 3 ch

Western Canada

University of Saskatchewan

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Biological Engineering	
Specializations:	-	
Full-time enrollment:	33 (Chemical Engineering)	
Part-time enrollment:	0	
Master graduations:	2	
PhD graduations:	1	

PhD in Chemical Engineering

Degree requirements:

- GPS 960.0 Introduction to Ethics and Integrity
- A minimum of 12 credit units
- GPS 990.0 Seminar
- GPS 996.0 Research
- Qualifying exam
- Comprehensive exam

Courses

- CHE 811.3 Principles and Applications of Heterogeneous Catalysis
- CHE 861.3 Fundamental Biochemical Engineering
- CHE 875.3 Reaction Kinetics and Reactor Design
- CHE 881.3 Process Engineering
- CHE 882.3 Design of Industrial Waste Treatment Systems
- CHE 884.3 Corrosion Engineering
- CHE 888.3 Chemicals and Energy from Renewable Resources
- CHE 898.3 Special Topics
- CHE 899 Special Topics

<u>University of Calgary</u>

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Petroleum Engineering	
Specializations:	-	
Full-time enrollment:	246	
Part-time enrollment:	6	
Master graduations:	89	
PhD graduations:	34	

Doctor of Philosophy in Chemical and Petroleum Engineering

Requirements:

- Register and participate in the research seminar course (ENCH 601 or equivalent).
- Complete a minimum of two half-courses at the graduate level.
- Before proceeding to the candidacy examination, all students must complete both ENCH701 and ENCH703, or equivalents.
- Students with a specialization in chemical engineering or petroleum engineering must also take at least two courses from the list of core courses for their specialization, or equivalents. For other specializations, students should consult with their supervisors for the additional requirements.
- Pass the candidacy exam.
- Submit and successfully defend a thesis on an original research topic.

Courses

- Chemical Engineering 607 Natural Gas Processing Principles
- Chemical Engineering 609 Natural Gas Processing Technology
- Chemical Engineering 613 Advanced Topics in Mass Transfer
- Chemical Engineering 615 Model Predictive Control
- Chemical Engineering 617 Modelling and Identification Advanced Control
- Chemical Engineering 619 Special Problems
- Chemical Engineering 620 Graduate Project
- Chemical Engineering 621 Reservoir Simulation
- Chemical Engineering 623 Chemical Reactor Design
- Chemical Engineering 625 Advanced Topics in Heat Transfer
- Chemical Engineering 627 Chemical Process Simulation
- Chemical Engineering 629 Secondary and Tertiary Recovery
- Chemical Engineering 630 Electrochemical Engineering
- Chemical Engineering 631 Advanced Topics in Fluid Mechanics
- Chemical Engineering 633 Chemical Thermodynamics
- Chemical Engineering 639 Applied Numerical Methods in Engineering
- Chemical Engineering 643 Air Pollution Control Engineering
- Chemical Engineering 645 Industrial and Produced Wastewater Treatment
- Chemical Engineering 647 Thermal Recovery Methods
- Chemical Engineering 649 Naturally Fractured Reservoirs
- Chemical Engineering 653 Horizontal Wells for Petroleum Production
- Chemical Engineering 657 Advanced Reservoir Engineering
- Chemical Engineering 659 Advanced Cell and Tissue Engineering
- Chemical Engineering 661 Geostatistics for Reservoir Characterization
- Chemical Engineering 665 Wastewater Issues for the Oil and Gas Industry
- Chemical Engineering 677 Advanced Topics in Oil and Gas Production
- Chemical Engineering 687 Petroleum Economics
- Chemical Engineering 689 Drilling Advances, Modelling and Simulation
- Chemical Engineering 698 Reservoir Characterization for Field Development

- Chemical Engineering 699 — Special Project
- Chemical Engineering 701 — Experimental Design and Error Analysis
- Chemical Engineering 703 — Advanced Mathematical Methods in Engineering

University of Alberta

Degrees offered:	MEng	(course-based)
	M.Sc.	(thesis-based)
	PhD	
Programs offered:	Chemical Engineering	
	Materials Engineering	
	Process Control	
Specializations:	-	
Full-time enrollment:	239	
Part-time enrollment:	0	
Master graduations:	51	
PhD graduations:	18	

Doctor of Philosophy in Chemical Engineering

For the PhD program, in addition to the requirements of the Faculty of Graduate Studies and Research, the Department normally requires the candidate to complete satisfactorily at least 18 credits in courses and ENGG 600 and attend specified seminars. Certain core course requirements apply. Details of all programs must be worked out in consultation with the Department.

There is no language requirement for the PhD degree.

The minimum period of residence is two academic years of full-time attendance at the University of Alberta.

Courses:

- ENGG 600 - Engineering Ethics and Professionalism
- CH E 610 - Computational Transport Phenomena
- CH E 611 - Advanced Transport Phenomena
- CH E 612 - Advanced Fluid Mechanics
- CH E 617 - Colloids and Interfaces
- CH E 620 - Mixing in the Process Industries
- CH E 624 - Advanced Thermodynamics
- CH E 625 - Surface and Statistical Thermodynamics
- CH E 634 - Advanced Chemical Reactor Design
- CH E 645 - Heterogeneous Catalysis and Reactor Analysis
- CH E 655 - Advanced Biomaterials Science
- CH E 662 - Process Identification
- CH E 674 - Numerical Solutions of Engineering Problems
- CH E 689 - Polymer Properties

- CH E 694 - Advanced Topics in Chemical Engineering
- CH E 696 - Special Topics in Process Dynamics and Control
- CH E 900 - Directed Research Project

<u>University of British Columbia</u>

Degrees offered:	MEng	(course-based)
	MEL	(course-based; Master of Engineering Leadership)
	M.Sc.	(thesis-based, for students with a science background)
	MASc	(thesis-based, for students with an engineering background)
	PhD	
Programs offered:	Chemical and Biological Engineering (MEng, MSc, MASc, PhD)	
	Clean Energy Engineering (MEL)	
	Green Bio-Products (MEL)	
	Integrated Water Management (MEL)	
	Materials Engineering (MEng, MSc, MASc, PhD)	
	Advanced Materials Manufacturing (MEL)	
Specializations:	-	
Full-time enrollment:	188	("Biosystems"; may include programs other than the ones listed)
Part-time enrollment:	0	
Master graduations:	23	
PhD graduations:	15	

Doctro of Philosophy in Chemical and Biological Engineering

All doctoral students are required to complete a comprehensive examination successfully. The major requirement for the PhD is completion of a research dissertation meeting the Faculty of Graduate and Postdoctoral Studies requirements.

The PhD is for superior students who wish to acquire the knowledge, techniques, and skills required for advanced research. The program is based on a dissertation, at least 3 credits of coursework suitable to the student's research interests, the seminar course CHBE 598, and a proposal preparation course CHBE 697.

Fundamental courses:

- CHBE 550 Advanced Reactor Design
- CHBE 551 Advanced Thermodynamics
- CHBE 553 Mathematical Operations
- CHBE 554 Momentum, Heat and Mass Transfer
- CHBE 560 Topics in Biological Engineering
- CHBE 565 Advanced Process Control/Analytics
- CHBE 557 Fluid Mechanics (MECH 502 or equivalent)

Appendix 2 Enrolment surveys and other indicators of student interest in the program and graduate employment opportunities

Introduction

Senior undergraduate students who have completed 60-120 credits were invited to complete the questionnaire below. This survey probed students' intentions to take a certificate, diploma, M.Eng., or M.A.Sc. program in Chemical Engineering. The students probed were in Bachelor's programs in Mechanical Engineering, Industrial Engineering, and Chemistry. The vast majority of respondents were Mechanical Engineering students, so the results mainly reflect the opinions of that group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Bachelor's degree)	40	70.2	70.2	70.2
	Industrial Engineering (Bachelor's degree)	8	14.0	14.0	14.0
	Chemistry (Bachelor's degree)	9	15.8	15.8	15.8
	Total	57	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	649
Number of students responded	57
Response rate	8.8%
Margin of error*	± 12.4%

*at a 95% confidence level

In addition, thesis-based Master students in Mechanical Engineering, Civil Engineering, and Chemistry were invited to complete the second questionnaire below. This survey probed students' intentions to take a M.A.Sc. or Ph.D. program in Chemical Engineering. The pool of respondents was fairly evenly spread, with Civil Engineering being the dominant group.

Please indicate your current program of study.

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Mechanical Engineering (Master's)	12	32.4	32.4	32.4
	Civil Engineering (Master's)	19	51.4	51.4	51.4
	Chemistry (Master's)	6	16.2	16.2	16.2
	Total	37	100.0	100.0	

The overall response rate and the resulting margin of error is as follows:

Survey launch date	April 10, 2017
Survey closing date	April 20, 2017

Number of students invited	193
Number of students responded	37
Response rate	19.2%
Margin of error*	± 14.5%

*at a 95% confidence level

Results – Graduate students – Ph.D.

The response of the surveyed students is summarized here, followed by the detailed responses in tabular form.

On the question “Based on this description, how likely is it that you would apply to the Ph.D. in Chemical Engineering program if it became available?” 14/37 students (37.8 %) responded “likely” or “very likely”. About a quarter of the students (10/37 or 27.0 %) would apply in 2018 or 2019.

On the question “How relevant are the proposed program objectives to your academic and professional goals?” 23/37 students (62.2 %) responded “relevant” or “very relevant”. For a description of the program objectives as stated in the survey, see below.

On the question “Are the proposed courses relevant to your academic and professional goals?” 25/37 students (67.6 %) responded “relevant” or “very relevant”.

On the question “In what ways do you see the Ph.D. in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)” 17/37 students (45.9 %) responded “Specialized expertise in Chemical Engineering will increase my career prospects.”.

On the question “What drawbacks or disadvantages can you foresee in the proposed Ph.D. program with regard to your academic and professional goals? (Please select all that apply.)” 15/37 students (40.5 %) responded “The program may narrow my employment options.”

Overall the survey results among Master students are favorable, with about a third of the students inclined to pursue the program, and a broad majority of the students evaluating the program as relevant for their careers. Overall, the students selected the same number of advantages as disadvantages in the survey.

Detailed Survey Results – Graduate students – Ph.D.

Based on this description, how likely is it that you would apply to the Ph.D. in Chemical Engineering program if it became available?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very likely	5	13.5	13.9	13.9
	Likely	9	24.3	25.0	25.0
	Somewhat likely	4	10.8	11.1	11.1
	Unlikely	17	45.9	47.2	47.2
	Don't know	1	2.7	2.8	2.8
	Total	36	97.3	100.0	
Missing	System	1	2.7		
Total		37	100.0		

In what year would you most likely expect to apply to the Ph.D. in Chemical Engineering program?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	2017	4	10.8	11.1	11.1
	2018	4	10.8	11.1	11.1
	2019	6	16.2	16.7	16.7
	Later than 2019	3	8.1	8.3	8.3
	Don't know	6	16.2	16.7	16.7
	Would not apply	13	35.1	36.1	36.1
	Total	36	97.3	100.0	
Missing	System	1	2.7		
Total		37	100.0		

How relevant are the proposed program objectives to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent

Valid	Very relevant	11	29.7	31.4	31.4
	Relevant	12	32.4	34.3	34.3
	Not relevant	10	27.0	28.6	28.6
	Don't know	2	5.4	5.7	5.7
	Total	35	94.6	100.0	
Missing	System	2	5.4		
Total		37	100.0		

Are the proposed courses relevant to your academic and professional goals?

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Very relevant	9	24.3	25.0	25.0
	Relevant	16	43.2	44.4	44.4
	Not relevant	9	24.3	25.0	25.0
	Don't know	2	5.4	5.6	5.6
	Total	36	97.3	100.0	
Missing	System	1	2.7		
Total		37	100.0		

In what ways do you see the Ph.D. in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	Specialized expertise in Chemical Engineering will increase my career prospects.	17	45.9	45.9	45.9
	I want to pursue a career in Chemical Engineering and this program would allow me to do so.	8	21.6	21.6	21.6
	Other	7	18.9	18.9	18.9
Total		*	*	*	

*Multiple answer percentage-count totals not meaningful

What drawbacks or disadvantages can you foresee in the proposed Ph.D. program with regard to your academic and professional goals? (Please select all that apply.)

		Frequency	Percent	Valid Percent	Valid Percent
Valid	The program is too specialized.	7	18.9	18.9	18.9
	The program may narrow my employment options.	15	40.5	40.5	40.5
	The program is too general.	5	13.5	13.5	13.5

Other	5	13.5	13.5	13.5
Total	*	*	*	

*Multiple answer percentage-count totals not meaningful

Survey Content – Graduate

Web Page 1:

Concordia University

New Programs in Chemical Engineering Survey

Welcome to the New Programs in Chemical Engineering Survey

Please copy the survey PIN found in your invitation email and paste it in the space below.

Enter your survey PIN below:

[ ] Start

Web Page 2:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Welcome!

<p>Concordia University's Faculty of Engineering and Computer Science is considering the possibility of offering graduate programs in Chemical Engineering. Chemical Engineering is the application of chemical and engineering principles for the design and operation of industrial processes for the manufacture of chemicals and materials. A total of five programs may potentially be created:</p>

a Graduate Certificate (4 courses, 15 credits);
a Graduate Diploma (8 courses, 30 credits);
a Master of Engineering (12 courses, 45 credits);
a Master of Applied Science (thesis-based); and
a Ph.D. (thesis-based).

<p>We are contacting you to solicit your feedback on some of the proposed programs, and to assess the level of interest in these programs among current Concordia students. The survey should take no longer than 10 minutes to complete. Should you find that your exact situation is not listed as a response to a given question, please select the closest response choice. Your responses will be held in strict confidence and will only be used to produce aggregate results.</p>

<p>Thank you for your participation -- your feedback is important.</p>

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Web Page 3:

Concordia University

New Programs in Chemical Engineering Survey

Completed

Your Program

Please indicate your current program of study.

- Mechanical Engineering (Master's)
- Civil Engineering (Master's)
- Chemistry (Master's)

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Web Page 4:

Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Master of Applied Science Program

The **Master of Applied Science in Chemical Engineering** program is a thesis-based program. It consists of four courses and research culminating in the writing of a thesis. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Master of Applied Science** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Master of Applied Science** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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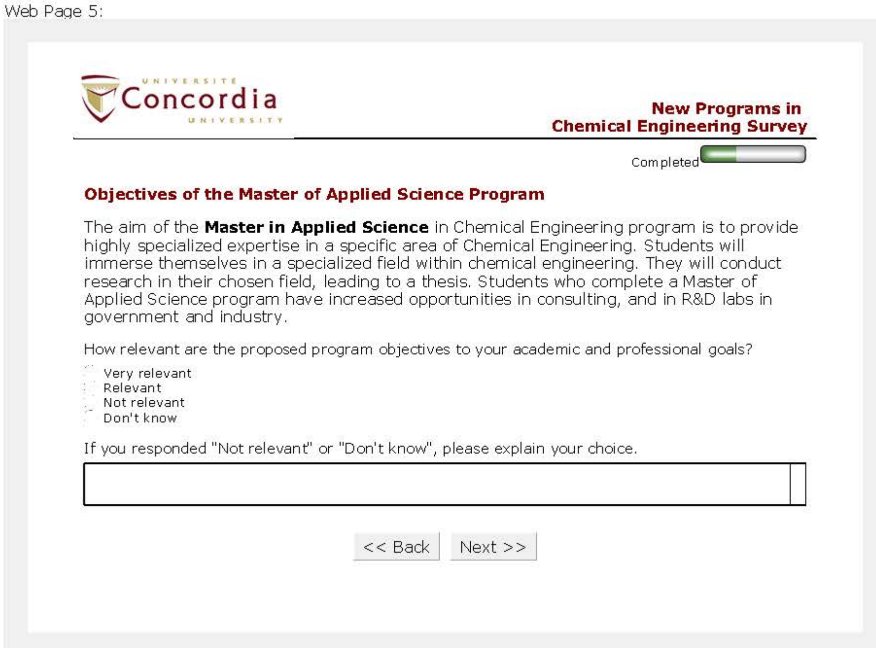
Web Page 5:


Université Concordia University

New Programs in Chemical Engineering Survey

Completed

Objectives of the Master of Applied Science Program

The aim of the **Master in Applied Science** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will conduct research in their chosen field, leading to a thesis. Students who complete a Master of Applied Science program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Web Page 6:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

Requirements of the Master of Applied Science Program

<p>I. Core courses (at least two courses from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A thesis based on academic research in a chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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Web Page 7:

UNIVERSITÉ Concordia UNIVERSITY

New Programs in Chemical Engineering Survey

Completed

Goals

In what ways do you see the **Master of Applied Science** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other: ____________

What drawbacks or disadvantages can you foresee in the proposed **Master of Applied Science** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other: ____________

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Web Page 8:

Concordia University

New Programs in Chemical Engineering Survey

Completed

The New Ph.D. Program

The **Doctor of Philosophy (Ph.D.) in Chemical Engineering** is a thesis-based program. It consists of three courses and extensive research culminating in the writing of a thesis, and typically a number of journal papers as well. The program provides students with highly specialized knowledge in Chemical Engineering at the graduate level, an ability to work independently on a research topic, and the ability to report these findings at the academic level.

Based on this description, how likely is it that you would apply to the **Ph.D.** in Chemical Engineering program if it became available?

- Very likely
- Likely
- Somewhat likely
- Unlikely
- Don't know

In what year would you most likely expect to apply to the **Ph.D.** in Chemical Engineering program?

- 2017
- 2018
- 2019
- Later than 2019
- Don't know
- Would not apply

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Objectives of the Ph.D. Program

The aim of the **Ph.D.** in Chemical Engineering program is to provide highly specialized expertise in a specific area of Chemical Engineering. Students will immerse themselves in a specialized field within chemical engineering. They will learn to develop their own research ideas, formulate research objectives and develop a strategy for accomplishing the objective. They will conduct research in their chosen field, leading to a thesis. Students who complete a Ph.D. program have increased opportunities in consulting, and in R&D labs in government and industry.

How relevant are the proposed program objectives to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

If you responded "Not relevant" or "Don't know", please explain your choice.

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Requirements of the Ph.D. Program

<p>I. Core courses (at least one course from the following list):</p>

Engineering Analysis (calculus)
Advanced Transport Phenomena (integrated study of heat, mass, and momentum transfer, as they may occur in a complex chemical process such as a chemical reactor)
Chemical Kinetics and Reaction Engineering (chemical reactor design
Advanced Chemical Engineering Thermodynamics (chemical equilibrium, phase equilibrium predictions)
Chemical Engineering Process Dynamics and Control
Chemical Process Engineering and Design (design of chemical plants)
Advanced Biochemical Engineering
Materials Science and Engineering

<p>II. Up to two courses from an extensive list. Examples:</p>
Polymer Chemistry and Engineering
Advanced Separation Processes (chemical separations, e.g., distillation, membrane separations)
Electrochemistry for Engineers (e.g., battery technology)
Principles of Solar Engineering
Linear Systems
Composition and Argumentation for Engineers

<p>III. A comprehensive exam testing your knowledge and ability to collect knowledge in your chosen field.</p>

<p>IV. A thesis proposal exam testing your ability to formulate a research objective and developing a strategy for accomplishing that objective.</p>

<p>V. A thesis based on academic research in the chosen area.</p>

Are the proposed courses relevant to your academic and professional goals?

- Very relevant
- Relevant
- Not relevant
- Don't know

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New Programs in Chemical Engineering Survey

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Goals

In what ways do you see the **Ph.D.** in Chemical Engineering program advancing your academic and professional goals? (Please select all that apply.)

- Specialized expertise in Chemical Engineering will increase my career prospects.
- I want to pursue a career in Chemical Engineering and this program would allow me to do so.
- Other:

What drawbacks or disadvantages can you foresee in the proposed **Ph.D.** program with regard to your academic and professional goals? (Please select all that apply.)

- The program is too specialized.
- The program may narrow my employment options.
- The program is too general.
- Other:

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New Programs in Chemical Engineering Survey

Final Comments

If you have any final comments or questions regarding any of the proposed Chemical Engineering programs, please share them below.

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New Programs in Chemical Engineering Survey

Thank you for taking the time to complete this survey. Your feedback is important.

We have received your responses.

Appendix 3 Library report

Library Report

For the Proposed

Doctor of Philosophy (Ph.D.) in Chemical Engineering

Joshua Chalifour, Digital Services & Engineering Librarian
Krista Alexander, Biochemistry/Chemistry & Physics Librarian

Created: April 2017

Purpose

The purpose of this report is to assess the adequacy of available library resources to support the proposed Doctor of Philosophy in Chemical Engineering, in the soon to be established Department of Chemical and Materials Engineering at Concordia University. The Department will be unique in Quebec and is slated to emphasize the development of new processes for producing specialized materials and the application of these materials in industry.

The comparators used throughout this report were identified by the Department of Chemical and Materials Engineering and include McGill University, École Polytechnique Montréal, University of Alberta, Stanford University, University of Houston, and Curtin University. All of the comparators have a PhD in Chemical Engineering program. Considering the number of students and professors, programs, founding dates, and rankings Concordia is most similar to the University of Houston, thus the University of Houston will be used as the main comparator for the purposes of this report.

Monographs

To assess the relative strength of Concordia University Library's monograph collection in terms of the research needs of the proposed doctoral program, collection size was measured for a sample of relevant Library of Congress Subject Headings. The results are presented in Table 1.

The following table compares monograph holdings for each of the comparator universities. McGill is excluded from this table because the methods to search its holdings produce different types of results for total print and ebook numbers. It is reasonable to consider McGill's total number is greater than the other comparators except for Stanford.

LC Subject Heading	Number of Monograph Titles					
	Concordia	École Polytechnique	Alberta	Stanford	Houston	Curtin University
Alloys	54	38	198	13724	105	1676
Biochemical engineering	23	52	173	257	54	226
Biotechnology	172	259	862	4749	249	2042
Chemical engineering	88	162	537	1443	225	2128
Chemical industry	26	96	143	1553	81	366
Chemical kinetics	169	124	407	1730	271	239
Chemical processes	21	35	217	673	92	349
Chemical reactions	128	109	425	7304	205	246
Chemical technology	0	0	2	219	0	42
Chemistry	172	253	1356	40191	473	6762
Chemistry, Metallurgic	4	4	30	36	12	34
Composite materials	174	119	444	3530	173	378
Energy transfer	19	34	77	3129	22	40
Fluid mechanics	263	635	602	3864	324	613
Manufacturing processes	187	463	483	1258	174	400
Metals	128	130	341	26718	184	2067
Nanostructured materials	278	856	1513	1774	285	383
Nanotechnology	315	1575	1262	3182	319	1368
Photochemistry Industrial applications	3	1	12	19	5	6
Plasma chemistry Industrial applications	2	1	7	9	3	3
Plastics	100	100	343	5056	207	737
Polymers	237	1915	1016	6482	602	1656
Process control	121	262	365	1617	133	467
Separation technology	46	67	261	281	120	242
Synthetic fuels	14	6	63	1336	46	125
Synthetic products	3	1	28	48	13	18
Total	**2,747**	**7,297**	**11,167**	**130,182**	**4,377**	**22,613**

Table 1: Comparative Size of Monograph Collections for Selected Subject Areas

Concordia's monograph collection in the areas measured is considerably smaller than that of the comparator universities. Some of these universities are older or larger institutions but others are more similar to Concordia. Compared to the University of Houston, Concordia's monograph collection is unsupported by 37%.

While there is no historical data on which to base an assessment of collection growth over time at Concordia, the library materials budget for monographs in Chemistry & Biochemistry, Mechanical and Industrial

Engineering, and Physics is shown for the last six years in Table 2.

Year	Chemistry & Biochemistry Appropriation	Mechanical & Industrial Engineering Appropriation	Physics Appropriation
2011 - 12	$14,636	$26,826	$8,755
2012 - 13	$11,000	$18,778	$6,128
2013 - 14	$6,600	$11,267	$3,677
2014 - 15	$6,600	$11,267	$3,677
2015 - 16	$6,600	$11,267	$3,677
2016 - 17	$6,600	$9,000	$3,700

Table 2: Library Materials Budget for Monographs in Subject Areas

Despite the reduction in monograph funds over the years, the Concordia Library has been able to acquire a number of electronic book collections using some centralized (non-subject specific) funds as well as money from the Academic Plan. Electronic book collections bought using these funds include Springer Ebooks, ScienceDirect, and the IEEE-Wiley Ebooks Library. These collections (normally updated each year with new titles) include monographs relevant to chemical engineering.

One-time monies (known as development funds) are made available each year to support new programs or build specific areas of the library collection in answer to the changing needs of our community. These development funds come from undesignated donations to the library and as such, are not consistent from year to year. They are primarily used to acquire titles to address historical gaps in the monograph or ebook collections.

Finally, students at Concordia University benefit from services that provide access to collections outside of Concordia, including the BCI card, which allows for direct borrowing of books from other Canadian academic libraries, including major Montreal institutions such as McGill University and Montréal Polytechnique. The Library's interlibrary loans service enables users to obtain some books, articles, and conference papers from other institutions worldwide, which are not accessible at Concordia. Books are delivered directly to the Library and users can pick them up at the circulation desk.

Electronic Resources (Databases)

The Concordia University Library's current collection of relevant databases for the fields of chemical and materials engineering is slightly under par with other universities that offer similar programs. Of 67 databases used in relation to chemical and materials engineering programs, Concordia subscribes to 32. On average, libraries subscribe to 34 of these databases. The Concordia Library has key, commonly used databases as identified below but funds ought to be considered for some of the databases that Concordia lacks. The following identifies important databases in Concordia's collection and suggests some options to evaluate for purchase.

In Concordia's collection, the three most important databases for chemical and materials engineering—providing access to indexed abstracts—are the following:

SciFinder
SciFinder searches Chemical Abstracts which indexes a wide range of international literature in chemistry and related fields (biology, engineering, physics, geology and material sciences). SciFinder includes journal articles, patents, dissertations, conference proceedings. It also contains millions of substances (CAS Registry) and reactions (CAS REACT), which can be searched by chemical structure, reactions, formulas or CAS Registry numbers. Commercial and regulated chemical information is included.

Compendex
The Compendex database is the largest source of engineering research literature (over 19 million records). Its coverage spans from 1884 to the present and is updated weekly. Compendex is a bibliographic database with references to engineering journals, conferences, trade publications, and more from over 76 countries. Focusing on just engineering disciplines, a significant portion of the Compendex records (about 13%) covers chemical engineering and a smaller quantity covers materials engineering.

Web of Science
This multidisciplinary database covers the journal literature of the sciences through the Science Citation Index (1979 – onwards), which includes the fields of science and engineering. Coverage also includes conference proceedings from the Conference Proceedings Citation Index (1990 – onwards).

Other important databases in the Library's collection that provide access to chemical engineering literature include:

Scopus
This multidisciplinary database covers journals and conference proceedings in science and technology. Physical sciences records (primarily chemistry, physics, and engineering) comprise 29% of the database's 60 million records. Scopus is updated daily with records from over 5000 publishers worldwide.

ACS Publications (American Chemical Society)
The American Chemical Society Journals covers more than 30 journals published by the ACS. Concordia also has access to the ACS legacy archives.

ScienceDirect
ScienceDirect provides full text of more than 1,800 Elsevier Science journals in the life, physical, medical, technical, and social sciences. ScienceDirect coverage spans from 1995 onward. In addition to some ebooks, the Concordia Library also has extensive backfile packages for journals in the areas of engineering, materials science, and technology prior to 1994.

Royal Society of Chemistry
The Royal Society of Chemistry provides databases, ebooks, and the full text of their journals. The Concordia Library subscribes to some of the databases, including the Merck Index (information on chemicals). Bibliographic databases include Synthetic Reaction Updates and Analytical Abstracts covering 1980 to the present. The Library purchases access to some of the RSC ebooks and has access to the journals archive (1841-2004) through its participation in the CRKN Canadian Site Licensing

Project.

The following recommendation is to evaluate two relevant databases for purchase, which comparator universities have but which Concordia lacks.

Knovel
Knovel is a database from Elsevier that covers chemical properties, corrosion data, and material properties. According to publisher Elsevier, Knovel covers "...chemical processes and product development, including plant design and operation, as well as analytical chemistry, catalysis, separation and synthesis used in the creation of new products." It supports chemical engineers and materials scientists with interactive tools for data analysis and search based on ebook content. It also offers access to premium content for chemical engineering research. All of the comparator universities' libraries subscribe to this database.

ChemicalENGINEERINGnetBASE
Databases on the CRCNetBase platform from Taylor and Francis provide full text to nearly 120 handbooks, references, and monographs published by CRC Press. ChemicalENGINEERINGnetBASE covers topics including bioprocessing, chemical processing & design, mass transfer, and process control.

Journals

The Concordia Library has a substantial collection of electronic journals, which are usually acquired in bundles, either from the publisher or an aggregator. These subscription bundles, generally managed on a provincial or national level through academic library consortia, include journals relevant to chemical engineering. These electronic subscriptions have largely displaced the print journal collections and are available to Concordia researchers on- and off-campus. The relevant subscription bundles for chemical engineering include (but are not limited to): Elsevier (ScienceDirect), American Chemical Society (ACS), Royal Society of Chemistry (RSC), American Physical Society (APS), Sage, Springer, Taylor & Francis, and Wiley-Blackwell.

Below is a list of 25 top chemical engineering journals based on 5 year impact factor, according to Thomson Reuters' *InCites Journal Citation Report*, and the Library's current holdings for these journals, along with holdings at the comparator institutions.

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Progress in Energy and Combustion Science	23.634	1975 - Present	1976 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1976 - Present
Energy & Environmental Science	22.118	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present	2008 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Annual Review of Chemical and Biomolecular Engineering	9.337	2010 - Present	2010 - Present		2010 - Present	2010 - Present	2010 - Present	2010 - Present
Applied Catalysis B - Environmental	8.142	1995 - Present	1992 - Present	1995 - Present	1992 - Present	1992 - Present	1992 - Present	1992 - Present
Journal of Catalysis	7.482	1962 - Present	1962 - Present	1970 - Present	1962 - Present	1962 - Present	1962 - Present	1962 - Present
Applied Energy	6.222	1995 - Present	1975 - Present	1995 - Present	1975 - Present	1975 - Present	1975 - Present	1975 - Present
Journal of Membrane Science	5.741	1995 - Present	1976 - Present	1995 - Present	1976 - Present	1976 - Present	1976 - Present	1976 - Present
Chemical Engineering Journal	5.439	1997 - Present	1997 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present	1996 - Present
ACS Sustainable Chemistry & Engineering	5.319	2013 - Present	2013 - Present	2013 - Present	1995 - Present	2013 - Present	2013 - Present	2013 - Present
Separation and Purification Reviews	5.050	2003 - Present	1973 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present	2003 - Present
Combustion and Flame	4.806	1957 - Present	1957 - Present	1970-1993 1995-Present	1957 - Present	1957 - Present	1957 - Present	1957 - Present
Desalination	4.800	1995 - Present	1966 - Present	1995 - Present	1966 - Present	1966 - Present	1966 - Present	1966 - Present
Journal of CO2 Utilization	4.778	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present	2013 - Present
Proceedings of the Combustion Institute	4.303	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present	2000 - Present
Fuel	4.140	1995 - Present	1970 - Present	1995 - Present	1965 - Present	1968 - Present	1953 - Present	1970 - Present
Catalysis Today	4.105	1995 - Present	1987 - Present	1995 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Fuel Processing Technology	3.949	1995 - Present	1977 - Present	1995 - Present	1977 - Present	1977 - Present	1977 - Present	1977 - Present
Current Opinion in Chemical Engineering	3.810	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present	2011 - Present
Separation and Purification Technology	3.758	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present	1997 - Present
Dyes and Pigments	3.708	1980 - Present	1980 - Present	1995 - Present	1980 - Present	1980 - Present	1980 - Present	1980 - Present
Journal of Food Engineering	3.512	1995 - Present	1982 - Present	1995 - Present	1982 - Present	1982 - Present	1982 - Present	1982 - Present

Title (publisher or aggregator)	5-year impact factor	Concordia	McGill	École Polytechnique	Alberta	Stanford	Houston	Curtin
Food and Bioproducts Processing	3.511	1996 - Present	1996 - Present	1996 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present
Journal of Industrial and Engineering Chemistry	3.458	2008 - Present	2008 - Present	2008 - Present	1995 - Present	1995 - Present	2008 - Present	1995 - Present
Energy & Fuels	3.340	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present	1987 - Present
Process Biochemistry	3.067	1995 - Present	1991 - Present	1995 - Present	1991 - Present	1991 - Present	1991 - Present	1991 - Present

Table 3: The print or electronic holdings of 25 chemical engineering journals for Concordia, McGill, École Polytechnique, University of Alberta, Stanford, University of Houston, and Curtin University.

We have current access to 25 of the 25 titles listed. The following table shows backfile access. Backfile access refers to any titles that are not currently received (whether due to cancellation or a one year publisher embargo) but for which there is complete or partial backfile access.

	Concordia University	McGill	École Polytechnique	U Alberta	U Houston	Curtin University
Current Access	25	25	24	25	25	25
Backfile Access	25	25	24	25	25	25
No access	0	0	1	0	0	0

Table 4: Comparative Access to Select Journals

Concordia University access to these chemical engineering journal titles is strong and very similar to the comparator institutions examined here.

Recurring Library Collection Expenditures

To fully support the proposed Doctor of Philosophy in Chemical Engineering, certain areas of Concordia Library's collection should be enhanced. In particular, the proposed program is estimated to be unsupported by the monograph collection at 37%.

As per Section 5 of the document ***How to Calculate Revenues & Expenses for New Courses and New Programs***, prepared by the Resources Committee, the weighting grid for Cycle 3 in Engineering is 9.42 and the weighting grid for Cycle 3 in the Pure Sciences is 10.69. The multidisciplinary nature of the proposed program makes it necessary to use each of these values to determine a range of recurring library collection expenditures. Each of these numbers was multiplied by 10,000 (see Section 5 in the document mentioned above) and further multiplied by 37% (the amount by which the collection is considered to be unsupported). The recurring library collection expenditures would then fall between $34,854 and $39,553.

Concordia subscribes to many chemical engineering journals in addition to those listed in table 3 and the current journal collection is adequate to support the proposed program. However adding titles to the collection entails recurring costs estimated at annual rates of $1700 - $4500 (USD) per title depending on its subject. These estimates come from The Library Materials Price Index (LMPI) compiled annually by the American Library Association (ALA), which determines the average price per periodical subscription based on the list price of a sample of periodicals. Please see Table 5 for the estimated recurring cost of purchasing new journal subscriptions to add to the Library's collection.

The database collections are adequate to support the proposed program although adding two to three databases to the collection would improve it to be on par with the comparator institutions. Past estimates on the price of these or similar databases suggest a range of recurring costs between $40,000 to $60,000 (USD).

It is important to note that these figures are all of a recurring nature—additional funds that the library would need **each year**.

The Library will require additional funds of between $107,728 and $131,353 (CAD) each year to support the Doctor of Philosophy in Chemical Engineering program. Note that obtaining these resources for one program, supports other chemical and materials engineering programs that could use the same resources.

	Average price per title (LMPI) USD	Recurring annual total in USD	Estimated USD to CAD currency exchange	Recurring annual total in CAD
Engineering journals (example purchase of 5 new title subscriptions)	1700	8500	1.35	11475
Chemistry journals (example purchase of 2 new title subscriptions)	4500	9000	1.35	12150
Knovel (database)		39500	1.35	53325
CHEMICALENGINEERINGnetBASE (database)		11000	1.35	14850
Monographs/ebooks	-	-	-	39553
Recurring annual total excluding new journal purchases	-	-	-	**107728**
Recurring annual total	-	-	-	**131353**

Table 5: Additional funds needed per year to support the proposed program

Conclusion

In addition to using (one-time) development funds to address historical gaps and using interlibrary loans to supplement our collection, additional funding will be needed. The recommendation is to add recurring funds to establish an appropriate annual monograph allocation, bring the library database collection up to par with comparator institutions, and allow for new journal subscriptions, all of which will enable the Concordia University Library to support a Doctor of Philosophy in Chemical Engineering program.

Appendix 4 Curriculum documents

Please see the Provotrack sheets starting on p. 6 of the Dossier.

Appendix 5 Abridged curricula vitae of current department members

Alex De Visscher, Professor

Education:

- 2001: PhD Bioscience Engineering. Ghent University, Belgium
- 1993: B.Sc./M.Sc. Chemical Engineering. Ghent University, Belgium

Positions/Accomplishments/Experience:

- 2014-2016: Associate Head Graduate, Department of Chemical and Petroleum Engineering, University of Calgary
- 2015-2016: Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2005-2015: Tier II Canada Research Chair in Air Quality and Pollution Control Engineering, Department of Chemical and Petroleum Engineering, University of Calgary
- 2010-2015: Associate Professor, Department of Chemical and Petroleum Engineering, University of Calgary
- 2011-2012: Visiting Professor, Technical University Bergakademie Freiberg, Germany; Institute of Technical Chemistry
- 2005-2010: Assistant Professor, Department of Chemical and Petroleum Engineering, University of Calgary

Publications: Books (2012-2017):

- De Visscher A. (2013). Air Dispersion Modeling. Foundations and Applications. J. Wiley & Sons, Hoboken, NJ. 634 pp. ISBN 978-1-1180-7859-4.
- De Visscher A. (2013). Lecture Notes in Chemical Engineering Kinetics and Reactor Design. Self-published through CreateSpace, Charleston, SC. 345 pp. ISBN 9781492792642.

Publications: Peer-reviewed journal articles (2012-2017):

- Mahmoudkhani F., Rezaei M., Asili V., Atyabi M., Vaisman E., Langford C.H., De Visscher A. Benzene degradation in waste gas by photolysis and photolysis-ozonation: Experiments and modeling. Front. Environ. Eng. 10(6), 10 (2016).
- Rahnama K. & De Visscher A. Simplified flare combustion model for flare plume rise calculations. Can. J. Chem. Eng. 94, 1249–1261 (2016).
- Harper L.A., Weaver K.H. & De Visscher A. Dinitrogen and methane gas production during the anaerobic/anoxic decomposition of animal manure. Nutr. Cycl. Agroecosyst. 100, 53–64 (2014).
- Asili V., De Visscher A. Mechanistic model for ultraviolet degradation of H2S and NOx in waste gas. Chem. Eng. J. 244, 597–603 (2014).
- Malekshahian M., De Visscher A., Hill J.M. A non-equimolar mass transfer model for carbon dioxide gasification studies by thermogravimetric analysis. Fuel Proc. Technol. 124, 1–10 (2014).
- Fraser S., Marceau D., De Visscher A., Roth S.H. Estimating exposure by loose-coupling an air dispersion model and a geospatial information system. J. Environ. Informat. 21, 84–92 (2013).
- De Visscher A., Conejo M.S. Solubility phenomena related to CO2 capture and storage. Pure Appl. Chem. 85, 2051–2058 (2013).

- De Visscher A. Response to “Remarks on the paper by A. De Visscher, “What does the g-index really measure?”” J. Am. Soc. Informat. Sci. Technol. 64, 1960–1962 (2013).
- De Visscher A. A new Price’s estimate on the size of scientific specialties based on scientific community structure. Scientometrics 96, 937–940 (2013).
- De Visscher A., Vanderdeelen J. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 2: Ca. J. Phys. Chem. Ref. Data 41, 023105 (137pp) (2012).
- De Visscher A., Vanderdeelen J., Königsberger E., Churgalov B.R., Tsurumi M. & Ichikuni M. IUPAC-NIST Solubility Data Series. 95. Alkaline earth carbonates in aqueous systems. Part 1: Introduction, Be and Mg. J. Phys. Chem. Ref. Data 41, 013105 (67pp) (2012).
- De Visscher A. The thermodynamics-bibliometrics consilience and the meaning of h-type indices – Reply. J. Am. Soc. Informat. Sci. Technol. 63, 630–631 (2012).

HQP Supervision (2012-2017):

- Chongchong Wu, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Sonochemistry for wastewater treatment. Co-supervisor: Dr. I. Gates.
- Michael Süß, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Environmental Engineering. Thesis: Biofiltration of BTEX.
- Mehrshad Parchei Esfahani, Department of Chemical and Petroleum Engineering, University of Calgary (2015–present), PhD student in Chemical Engineering. Thesis: Ultrasound-assisted peroxone for waste gas treatment.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2013–present), PhD student in Chemical Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of Air Pollutants in waste gas.
- Ali Shafaghat, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2016), MEng (thesis) student in Chemical Engineering, Environmental Engineering Specialization. Thesis: Depressurization Dynamic Modeling and Effect on Flare Flame Distortion. Final exam: 14 March 2016.
- Farshid Shayganpour, Department of Chemical and Petroleum Engineering, University of Calgary (2014–2015), MEng (thesis) student in Chemical and Petroleum Engineering, Petroleum Engineering specialization, Thesis: Comparison of CSS and SAGD in Cold Lake. Final exam: 27 April 2015. Co-supervised, with Dr. Ian Gates as supervisor.
- Farzana Haque, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2008–2014), PhD student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Biofiltration of BTX from Glycol Dehydration Units. Final exam: 8 May 2014.
- Maria Conejo, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2014), M.Sc. student in Chemical and Petroleum Engineering, Energy and Environment Engineering specialization, Thesis: Interactions between carbon dioxide and calcium carbonate in carbon storage conditions. Final exam: 10 March 2014.
- Vahid Asili, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2011–2013), M.Sc. student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Ultraviolet degradation of H2S in waste gas: A comprehensive first-principles model. Final exam: July 2013.
- Mahsasadat Atyabi, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2013), M.Sc. student in Chemical and Petroleum Engineering, Environmental

Engineering specialization, Thesis: Ultraviolet degradation of BTX in waste gas: Effects of photocatalysis and ozone premixing. Final exam: 18 January 2013.

- Kamran Rahnama, Department of Chemical and Petroleum Engineering and CEERE, University of Calgary (2010–2012), M.Sc. student in Chemical and Petroleum Engineering, Environmental Engineering specialization, Thesis: Plume dispersion: A new flare combustion and plume rise model. Final exam: December 10, 2012.

Participation in thesis juries (2012-2017):

- March 3, 2017: Deependra Singh. Department of Mechanical and Industrial Engineering, Concordia University, PhD, Comprehensive Exam. Subject: Comprehensive Review of Electro-Chemical Machining (ECM) Process (Supervisor: R. Wuthrich).
- November 24, 2016: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering. PhD, Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: P. Pereira Almao).
- September 12, 2016: Marlon Vargas-Ferrer. Department of Chemical and Petroleum Engineering. M.Sc., Final exam. Thesis title: Study of semi-industrial polymeric vapor permeation modules (Supervisor: N. Mahinpey).
- September 1, 2016: Jun Cui. Department of Chemistry, University of Calgary, M.Sc., Final exam. Thesis title: Rapid characterization and degradation of dissolved organic matter for improving the quality of boiler feed water in Steam Assisted Gravity Drainage process (Supervisors: C.H. Langford and G. Achari).
- August 24, 2016: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Processing of Peroxidized Asphaltene in Aqueous Media. (Supervisor: P. Pereira Almao).
- August 9, 2016: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: New Pathways for Asphaltenes Upgrading via Oxy-Cracking in Liquid Phase. (Supervisor: P. Pereira Almao).
- May 13, 2016: Saeed Sampouri. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., Final exam. Thesis title: Catalytic Steam Reforming and Esterification of Bio-Oil. (Supervisor: J. Abedi).
- March 24, 2016: Karen Cañon-Rubio. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., Final exam. Thesis title: Strategies for Improving the Productivity and Cost-Effectiveness of Microalgal Production Systems. (Supervisor: H. De la Hoz Siegler).
- March 23, 2016: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Candidacy exam. (Supervisor: J. Bergerson).
- February 26, 2016: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, Final exam. Thesis title: Sorption-enhanced hydrogen production from catalytic steam gasification of coal. (Supervisor: N. Mahinpey).
- January 18, 2016: An Le. Biomedical Engineering Graduate Program, University of Calgary, M.Sc., Final exam. Thesis title: Computational Fluid Dynamics Modeling of Scalable Stirred Suspension Bioreactors for Pluripotent Stem Cell Expansion. (Supervisors: M. Kallos, I. Gates).
- November 27, 2015: Daniel Lincoln. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development and characterization of an LED-based light source for high-speed schlieren imaging. (Supervisor: C. Johansen).
- November 23, 2015: Masoud Alrmah. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: (Supervisor: A. Mohamad).

- November 4, 2015: Jennifer Pauls. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Simulation of air-steam gasification of woody biomass in Aspen Plus: A comprehensive model including pyrolysis, hydrodynamics and tar production. (Supervisor: N. Mahinpey).
- September 10, 2015: Amir Ahmad Shirazi Manesh. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Thermodynamic modeling of asphaltene precipitation using cubic plus association equation of state. (Supervisor: J. Abedi).
- August 19, 2015: Mohamed Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary. PhD, final exam. Thesis title: Computational modelling of the wind flow over the University of Calgary campus. (Supervisor: D. Wood).
- April 27, 2015: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Comprehensive kinetic study of carbon dioxide and steam gasification: New findings and fundamentals. (Supervisor: N. Mahinpey).
- April 20, 2015: Amjad El-Qanni. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Nassar)
- October 22, 2014: Mahida Khurshid. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Serum-free co-expansion of mesenchymal stem cells and chondrocytesas aggregates in suspension bioreactors. (Supervisor: M. Kallos).
- August 29, 2014: Christopher Arisman. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Nitric oxide chemistry and velocity slip effects in hypersonic boundary layers (Supervisor: C. Johansen).
- August 28, 2014: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: D. Wood).
- August 25, 2014: Khaled Omar Sebakhy. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. (Supervisor: M. Husein).
- July 10, 2014: Adeem Hassan Khan. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Measurement of the physical properties of MacKay bitumen and solvent mixtures (Supervisor: J. Abedi).
- June 16 2014: Mahdieh Shafiee Neistanak. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Kinetics of asphaltene precipitation and flocculation from diluted bitumen (Supervisor: H. Yarranton).
- April 29 2014: Mona Amiri. Department of Civil Engineering, University of Calgary, M.Sc., final exam. Thesis title: A methodology for estimating greenhouse gas emissions from heavy-duty diesel trucks in construction road transportation (Supervisor: F. Sadeghpour).
- April 17 2014: Fredy Cabrales Navarro. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- April 16 2014: Virginia Andrade Tovar. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Feasibility study for a small scale integrated on-farm ethanol plant (Supervisor: M. Foley).
- April 8 2014: Parsa Haghighat. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: P. Pereira Almao).
- March 27 2014: Ehsan Esmaili Darki. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Modeling and economic assessment of integrated gasification with sorbent CO2 capture (Supervisor: N. Mahinpey).

- January 22 2014: Belal Abu Tarboush. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Adsorption and oxidation of asphaltenes onto in situ prepared and commercial nanoparticles (Supervisor: M. Husein).
- January 10 2014: Xiaojian Wei. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: The effect of varying inlet conditions on the turbulent wake of a fence (Supervisor: D. Rival).
- December 18 2013: Alireza Saidi-Mehrabad. Department of Biological Sciences. M.Sc., final exam. Thesis title: Characterization of aerobic methane oxidizing bacteria in oil sands tailings ponds (Supervisor: P. Dunfield).
- December 16 2013: Lante Carbognani. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Upgrading of Visbroken vacuum residue by adsorption and catalytic steam gasification of the adsorbed components (Supervisor: P. Pereira Almao).
- December 13 2013: Claudia Bess-Ouko. Department of Civil Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development of a LCA screening tool: Assessment of biochar in the removal of organic carbon in SAGD produced water (Supervisors: J. Bergerson and G. Achari).
- November 26 2013: Yanghong Liu. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Separation of water-in-heavy oil emulsions using porous particles in coalescence column (Supervisor: M. Dong).
- November 25 2013: Kavan Motazedi. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Template-free synthesis and modification of LTY, ZSM-5 and LTL zeolite catalysts and investigation of the catalytic pyrolysis of Saskatchewan Boundary Dam coal (Supervisor: N. Mahinpey).
- November 20 2013: Ramon Arturo Gomez Quevedo. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: N. Mahinpey).
- October 8 2013: Sarah Alamolhoda. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam (Supervisor: J. Hill).
- September 20, 2013: Krishna Morgan Panchalingam. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Bioprocessing of human stem cells applied to diseases of the central nervous system. (Supervisor: L. Behie).
- August 15 2013: Santiago Ortiz Ruiz. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Development of a computational tool for low-temperature geothermal-solar power generation plants (Supervisor: A. Mohamad).
- August 1 2013: Rozita Habibi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Co-gasification of biomass and non-biomass feedstocks (Supervisor: J. Hill).
- July 9 2013: Saleh Bawazeer. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Stability and accuracy of Lattice Boltzmann method (Supervisor: A. Mohamad).
- June 20 2013: Upasana Chamoli. Department of Chemistry, University of Calgary, M.Sc., final exam. Thesis title: Disinfection and self-sensitized degradation of NOM (Natural Organic Matter) by TiO_2 photocatalysis with visible light (Supervisors C. Langford and G. Achari).
- June 18 2013: Mostafa Meibod. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Bio-oil from wheat straw and hydrogen from aqueous phase of bio-oil (Supervisor J. Abedi).

- June 11 2013: Hesham Alhumade. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Reversible reactive flow displacements in porous media (Supervisor J. Azaiez).
- April 23 2013: Jaime McKenzie Graham. Department of Biological Sciences, University of Calgary, M.Sc., final exam. Thesis title: Effect of Drainage on Carbon Biogeochemistry and Microbiological Communities in Western Canadian Boreal Peatlands (Supervisor: P. Dunfield)
- April 18 2013: Maryam Ashtari. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Wet air oxidation of asphaltene particles (Supervisor: P. Pereira)
- January 18 2013: Giuseppe Rosi. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Characterizing coherent structures within the lower log region of the atmospheric boundary layer (Supervisor: D. Rival)
- December 17 2013: Sobhan Iranmesh. Department of Chemical and Petroleum Engineering, University of Calgary, M.Sc., final exam. Thesis title: Removal of naphthenic acid from water using biomass-based activated carbon.
- December 11, 2012: Ehsan Mostafavi. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, candidacy exam. Subject: Catalytic steam gasification of low grade coal with in situ CO2 capture process: Experimental and modeling approach (Supervisor: N. Mahinpey).
- December 6 2012: Esther Ramos-Padron. Department of Biological Sciencies, University of Calgary, PhD, final exam. Thesis title: Physiology and molecular characterization of microbial communities in oil sands tailings ponds (Supervisors: L. Gieg and G. Voordouw).
- June 28 2012: Arif Mohamed. Department of Mechanical and Manufacturing Engineering, University of Calgary, M.Sc., final exam. Thesis title: Vertical wind speed extrapolation using the k-? turbulence model (Supervisor: D. Wood).
- May 4 2012: Punitkumar Kapadia. Department of Chemical and Petroleum Engineering, University of Calgary, PhD, final exam. Thesis title: Gasification of Althabasca bitumen: Hydrogen generation, kinetics, and in situ process design (Supervisor: I. Gates).

Zhibin Ye, Professor

Education:

- PhD Chemical Engineering, McMaster University, Hamilton, Ontario 2004
- M. Eng. Chemical Engineering, Zhejiang University, China 1999
- B. Eng. Chemical Engineering, Zhejiang University, China 1996

Positions/Accomplishments/Experience:

- July 2012−present: Full Professor of Chemical Engineering
- Jan. 2011−present: Canada Research Chair (Tier 2) in Polymer Nanomaterials
- Sept. 2010−Feb. 2011: Visiting Associate Professor Department of Chemistry, University of Illinois at Urbana-Champaign
- Jan. 2010−present: Cross-Appointment to Department of Chemistry and Biochemistry
- July 2009−June 2012: Associate Professor (Tenured) of Chemical Engineering

- July 2004−June 2009: Assistant Professor (Tenure Track) of Chemical Engineering, School of Engineering, Laurentian University, Sudbury, Ontario, Canada

Publications: Peer-reviewed journal articles (2012-2017):

- L. Xu, L. Huang, Z. Ye*, Z. Gu, "Polycyclopentene-decorated carbon nanotubes by convenient large-scale in situ polymerization and their lotus leaf-like superhydrophobic films", Macromolecular Rapid Communications 2017, 38, 1600608.
- L. Huang, Z. Ye*, R. Berry, "Modification of cellulose nanocrystals with quaternary ammonium-containing hyperbranched polyethylene ionomers by ionic assembly", ACS Sustainable Chemistry & Engineering 2016, 4, 4937–4950. (Impact Factor: 5.267)
- Z. Dong, P. Xiang, L. Huang, Z. Ye*, "Efficient, robust surface functionalization and stabilization of gold nanorods with quaternary ammonium-containing ionomers as multidentate macromolecular ligands", RSC Advance 2016, 6, 43574–43590 (Impact Factor: 3.289).
- P. Xiang, Z. Ye*, "Hyperbranched polyethylene ionomers containing cationic tetralkylammonium ions synthesized by Pd–diimine-catalyzed direct one-pot ethylene copolymerization with ionic liquid comonomers", Macromolecules 2015, 48, 6096–6107. (Impact Factor: 5.554)
- P. Govindaiah, E. Guerra, Y. Choi, Z. Ye*, "Pressure oxidation leaching of an enargite concentrate in the presence of polytetrafluoroethylene beads", Hydrometallurgy 2015, 157, 340−347. (Impact Factor: 2.290)
- P. Xiang, Z. Ye*, "Homo- and co-polymerization of norbornene and methyl acrylate with Pd–diimine catalysts", Journal of Organometallic Chemistry 2015, 798, 429−436. (Impact Factor: 2.336)
- P. Govindaiah, M. Grundy, E. Guerra*, Y. Choi, Z. Ye*, "Polytetrafluoroethylene/TiO2 composite pellets as sulfur adsorbents for pressure oxidization leaching of chalcopyrite", Metallurgical and Materials Transaction B 2015, 46B, 550−556. (Impact factor: 1.474)
- Z. Dong, Z. Ye*, "Heterogeneous palladium catalyst constructed with cross-linked hyperbranched poly(phenylacetylene) as polymer support: a reusable highly active ppm-level catalyst for multiple cross-coupling reactions", Applied Catalysis A: General 2015, 489, 61−71. (Impact factor: 4.012)
- M. Grundy, Z. Ye*, "Cross-linked polymers of diethynylbenzene and phenylacetylene as new polymer precursors for high-yield synthesis of nanoporous activated carbons of high performance for supercapacitors, hydrogen storage, and CO2 capture", Journal of Materials Chemistry A 2014, 2, 20316−20330. (Impact factor: 8.262) [Invited to be featured on journal back cover]
- Z. Dong, Z. Ye*, "Reusable, highly active heterogeneous Pd catalyst by convenient selfencapsulation cross-linking polymerization for multiple carbon–carbon cross-coupling reactions at ppm to ppb Pd loadings", Advanced Synthesis & Catalysis 2014, 356, 3401−3414. (Impact factor: 5.663)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, "Synthesis of polyethylene and polystyrene miktoarm star copolymers using an 'in-out' strategy", Polymer Chemistry 2014, 5, 5443−5452. (Impact factor: 5.687)
- L. Xu, Z. Ye*, S. Siemann, Z. Gu, "Noncovalent solubilization of multi-walled carbon nanotubes in common low-polarity organic solvents with branched Pd–diimine polyethylenes: effects of polymer chain topology, molecular weight and terminal pyrene group", Polymer 2014, 55, 3120−3129. (Impact factor: 3.586; 2 citations)
- O. Osazuwa, M. Kontopoulou, P. Xiang, Z. Ye, A. Docoslis*, "Electrically conducting polyolefin composites containing electric field-aligned multiwall carbon nanotube structures: the effects of process parameters and filler loading", Carbon 2014, 72, 89−99. (Impact factor: 6.198)

- P. Liu, Z. Dong, Z. Ye*, W.-J. Wang*, B.-G. Li, “A conveniently synthesized polyethylene gel encapsulating palladium nanoparticles as a reusable high-performance catalyst for Heck and Suzuki coupling reactions”, Journal of Materials Chemistry A 2013, 1, 15469−15478. (Impact factor: 8.262)
- L. Xu, Z. Ye*, “A Pd−diimine catalytic inimer for synthesis of polyethylenes of hyperbranchedon-hyperbranched and star architectures”, Chemical Communications 2013, 49, 8800−8802. (Impact factor: 6.567)
- E. Landry, Z. Ye*, “Convenient Pd-catalyzed ‘arm-first’ synthesis of large unimolecular star polyethylene nanoparticles”, Macromolecular Rapid Communications 2013, 34, 1493−1498. (Impact factor: 4.638) [This paper was invited to be featured on the cover page]
- A. A. Vasileiou, A. Docoslis, M. Kontopoulou*, P. Xiang, Z. Ye, “The role of non-covalent functionalization and matrix viscosity on the dispersion and properties of LLDPE/MWCNT nanocomposites”, Polymer 2013, 54, 5230−5240. (Impact factor: 3.586; 2 citations)
- Z. Ye*, L. Xu, Z. Dong, P. Xiang, “Designing polyethylenes of complex chain architectures by Pd–diimine-catalyzed ‘living’ ethylene polymerization”, Chemical Communications 2013, 49, 6235−6255. (Impact factor: 6.567; 3 citations) [Invited feature article]
- L. Xu, J.-W. McGraw, F. Gao, M. Grundy, Z. Ye*, Z. Gu, J. L. Shepherd, “Production of high concentration graphene dispersions in low-boiling-point organic solvents by liquid-phase noncovalent exfoliation of graphite with a hyperbranched polyethylene and formation of graphene/ethylene copolymer composites”, Journal of Physical Chemistry C 2013, 117, 10730−10742. (Impact factor: 4.509; 2 citations)
- P. Liu, Z. Ye*, W.-J. Wang*, B.-G. Li, “Hyperbranched polyethylenes encapsulating selfsupported palladium (II) species as efficient and recyclable catalysts for Heck reaction”, Macromolecules 2013, 46, 72−82. (Impact factor: 5.554; 3 citations)
- P. Xiang, K. Petrie, M. Kontopoulou, Z. Ye*, R. Subramanian, “Tuning structural parameters of polyethylene brushes in surface-initiated ethylene ‘living’ polymerization from silica nanoparticles and effects on nanocomposite properties”, Polymer Chemistry 2013, 4, 1381−1395. (Impact factor: 5.687; 3 citations) [This paper was invited to be featured on back cover]
- P. Xiang, Z. Ye*, “Alternating, gradient, block, and block-gradient copolymers of ethylene and norbornene by Pd−diimine catalyzed ‘living’ copolymerization”, Journal of Polymer Science, Part A: Polymer Chemistry 2013, 51, 672−686. (Impact factor: 3.11; 2 citations)
- O. Oaszuwa, K. Petrie, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Characterization of non-covalently, non-specifically functionalized multi-wall carbon nanotubes and their melt compounded composites with an ethylene-octene copolymer”, Composite Science and Technology 2012, 73, 27−33. (Impact factor: 3.897; 8 citations)
- O. Osazuwa, M. Kontopoulou*, P. Xiang, Z. Ye, A. Docoslis, “Polymer composites containing non-covalently functionalized carbon nanotubes: a study of their dispersion characteristics and response to AC electric fields”, Procedia Engineering 2012, 42, 1414−1424. (1 citation)
- P. Liu, W. Lu, W.-J. Wang*, B.-G. Li, Z. Ye*, S. Zhu*, “Synthesis and characterization of PE-b-POGEMA copolymers prepared by linear/hyperbranched telechelic polyethylene-initiated ATRP of oligo(ethylene glycol) Methacrylates”, Chapter 4 in ACS Symposium Series 1101, Progress in Controlled Radical Polymerization: Materials and Applications, Edited by K. Matyjaszewski, B. S. Sumerlin, and N. V. Tsarevsky, 2012, pp 39−64.
- Z. Zhang, Z. Ye*, “A ligand exchange strategy for one-pot sequential synthesis of (hyperbranched polyethylene)-b-(linear polyketone) block polymers”, Chemical Communications 2012, 48, 7940−7942. (Impact factor: 6.567; 9 citations)

- Z. Dong, Z. Ye*, "Synthesis of hyperbranched poly(phenylacetylene)s containing pendant alkyne groups by one-pot Pd-catalyzed copolymerization of phenylacetylene with diynes", Macromolecules 2012, 45, 5020−5031. (Impact factor: 5.554; 8 citations) [This paper is one (19th) of top 20 most read articles in the Journal in June 2012; it is also highlighted in ACS Noteworthy Chemistry on August 6, 2012.]
- Z. Dong, Z. Ye*, "Hyperbranched polyethylenes by chain walking polymerization: synthesis, properties, functionalization, and applications", Polymer Chemistry 2012, 3, 286−301. (Impact factor: 5.687; 17 citations)

HQP Supervision (2012-2017):

- Zhe Chen (MASc, Laurentian University) [Research Associate, Nov. 2015–Dec. 2016]
- Junbin Liao (PhD in Chemical Engineeirng, Zhejiang University of Technology) [PDF, August 2015−June 2017]
- Mark Grundy (MASc in Chemical Engineering, Laurentian University) [Research Associate, Jan. 2015−Jan. 2016]
- Patakamuri Govindaiah (PhD in Chemical Engineering, Yonsei University, South Korea) [PDF, June 2013−Dec. 2014]
- Vimal Tiwari (PhD in Polymer Physics, Banaras Hindu University, Inda) [PDF, May 2013−Dec. 2014]
- Zhichao Zhang (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, Oct. 2011−Sept. 2012]
- Zhongmin Dong (PhD in Polymer Science and Engineering, Changchun Institute of Applied Chemistry, Chinese Academy of Science) [PDF, March 2011−Dec. 2014]
- Lixin Xu (PhD in Polymer Science and Engineering, Zhejiang University, China) [MRI PDF, September 2010−April 2012]
- Syed Atif Haider Zaidi [MEng, Jan. 2017−]
- Hui Su [MASc, Sept. 2014−Oct. 2016]
- Lingqi Huang [PhD, Sept. 2014−]
- Zhe Chen [MASc, Sept. 2013−Oct. 2015]
- Mark Grundy [MASc, May 2012−Oct. 2014]
- Peng Xiang [PhD, May 2011−Aug. 2015]
- Eric Landry [MASc, Sept. 2010−Oct. 2012]
- Pingwei Liu [PhD, 2009−2014]

Participation in thesis juries (2012-2017):

Paula Wood-Adams, Professor

Education:

- 1999: PhD, Chemical Engineering, McGill University
- 1995: MEng in Chemical Engineering (Dean's Honor List) McGill University
- 1991: B.Sc. in Chemical Engineering with Distinction, University of Alberta

Positions/Accomplishments/Experience:

- 2016- : John Abbott College Board of Governors, Director
- 2013- : Concordia University, Montreal, Quebec, Dean of Graduate Studies.
- 2013- : Concordia University, Montreal, Quebec, Professor of mechanical engineering.
- 2013- : Jeanne Sauvé Foundation Board of Directors, Director
- 2012- : L'Association des doyens des études supérieures au Québec (Vice-President since 2015)
- 2002- : Member of the editorial board of the Journal of Applied Polymer Science
- 2013-2015: Canadian Association for Graduate Studies Board of Directors, Director
- 2006-2016: Concordia University Research Chair
- 2012-2013: Concordia University, Montreal, Quebec, Interim Dean of Graduate Studies.
- 2010-2012: Concordia University, Montreal, Quebec, Associate Dean of School of Graduate Studies.
- 2006-2013: Concordia University, Montreal, Quebec, Associate Professor of mechanical engineering.
- 2006-2010: Concordia University, Montreal, Quebec, Graduate Program Director of mechanical and industrial engineering
- 2006: Kasetsart University, Bangkok, Thailand, Visiting Professor of chemical engineering
- 2001-2006: NSERC University Faculty Award
- 2005: Petro Canada Young Innovator Award
- 2001-2006: Concordia University, Montreal, Quebec, Assistant Professor of mechanical engineering
- 1998-2001: McGill University, Montreal, Quebec, Assistant Professor of chemical engineering (3 year ETA)

Publications: Peer-reviewed journal articles (2012-2017):

- E Rezabeigi*, PM Wood-Adams, RAL Drew, "Crystallization of polylactic acid under in situ deformation during nonsolvent induced phase separation", in press, Journal of Polymer Science Part B: Polymer Physics, 2017.
- A Arias; M-C Heuzey*; M Huneault; P Wood-Adams, "Rheological study of crystallization behavior of polylactide and its flax fiber composites", 24:46 DOI 10.1007/s10965-017-1210-y, Journal of Polymer Research, 2017.
- E. Rezabeigi*, M Sta, M Swain, N.R. Demarquette, R.A.L. Drew, P.M. Wood-Adams, "Electrospinning of porous polylactic acid fibers during nonsolvent induced phase separation" 134, 44862, J. Applied Polymer Science, 2017.
- KB Riad; R Schmidt; AA Arnold; R Wuthrich; PM Wood-Adams* "Characterizing the structural formation of epoxy-amine networks: the effect of monomer geometry", 104, 83-90, Polymer, 2016.
- S. Mostafa Sabzevari, Joshua D. McGraw, Paula M. Wood-Adams*, "Short Chains Enhance Slip of Highly Entangled Polystyrenes During Thin Film Dewetting", 6, 91163 - 91170, RSC Advances, 2016.
- E Rezabeigi, PM Wood-Adams*, RAL Drew, "Morphological examination of highly porous polylactic acid/Bioglass® scaffolds produced via nonsolvent induced phase separation", DOI: 10.1002/jbm.b.33784, Journal of Biomedical Materials Research Part B, 2016.
- S. Mostafa Sabzevari, Joshua D. McGraw, Karin Jacobs, Paula M. Wood-Adams, "Sacrificial Mica Substrates Influence the Slip Boundary Condition of Dewetting Polymer Films" 78, 202-207 Polymer, 2015.

- S. Chaeichian, PM Wood-Adams*, SV Hoa, "Effect of morphology on fracture toughness of unsaturated polyester-based hybrid nanocomposites" Polymer, 72, 154-164, 2015.
- S. Chaeichian, PM Wood-Adams*, SV Hoa, "Fracture of unsaturated polyester and the limitation of layered silicates" Polymer Engineering and Science, 55, 1303-1309 2015.
- E Rezabeigi, PM Wood-Adams*, RAL Drew, Production of porous polylactic acid monoliths via nonsolvent induced phase separation" Polymer, 55 (26), 6743-6753, 2014
- S.M. Sabzevari, PM Wood-Adams*, I. Cohen, "Wall Slip of Tridisperse Polymer Melts and the Effect of Un-Entangled versus Weakly-Entangled Chains" 47, 8033-8040, Macromolecules, 2014.
- E. Rezabeigi, P.M. Wood-Adams* and Robin A.L. Drew, "Isothermal ternary phase diagram of the polylactic acid-dichloromethane-hexane system"] 55, 3100-3106, Polymer, 2014.
- S.M. Sabzevari, PM Wood-Adams*, I. Cohen, "Wall Slip of Bidisperse Linear Polymer Melts" 47, 3154-3160, Macromolecules, 2014.
- E. Rezabeigi, P.M. Wood-Adams*, R.A.L. Drew, "Synthesis of 45S5 Bioglass® via a straightforward organic, nitrate-free sol-gel process" 40, 248-252, Materials Science and Engineering C, 2014.
- J-S Hébert, PM Wood-Adams, M-C Heuzey, C Dubois and J Brisson*, "Morphology of Polylactic Acid Crystallized during Uniaxial Deformation", 51, 430-440, J. of Polymer Science, Polymer Physics, 2013.
- S. Chaeichian, PM Wood-Adams*, SV Hoa, "In situ polymerization of polyester-based hybrid systems for the preparation of clay nanocomposites", 54, 1512-1523, Polymer, 2013.
- Satu Strandman, David G. Lessard, Dagmar van Dusschoten, Manfred Wilhelm, Paula M. Wood-Adams, Hans W. Spiess, X.X. Zhu*, "Two-dimensional Fourier Transform Rheological Study on Thermosensitivity of Poly(N,N-Diethylacrylamide) in Aqueous Solutions", Polymer, 53, 4800-4805, 2012.
- V. Shaayegan, PM Wood-Adams*, NR Demarquette "Linear Viscoelasticity of Immiscible Blends: The Application of Creep", Journal of Rheology, 56, 1039-1056, 2012.
- NC. Najafi, M-C. Heuzey*, P.J. Carreau, P.M. Wood-Adams, "Control of thermal degradation of polylactic acid (PLA)-clay nanocomposites using chain extenders", Polymer Degradation and Stability, 97, 554-565, 2012.
- Y. Yuryev, PM. Wood-Adams*, "Crystallization of poly(L-/D-lactide) in the presence of electric fields", Macromolecular Chemistry and Physics, 213, 635?642, 2012.

HQP Supervision (2012-2017):

- Sh. Kwaye-Nimo, PhD (in progress). “Slip and die drool in polymer processing”.
- Keroles Riad, PhD (in progress). “3D printable graphene” (co-supervised).
- Wissam Nakhle, PhD (in progress). “Diffusion in polymer melts”.
- Keroles Riad, M.Sc. (Graduated 2016). “Photo-stable, photo-curable epoxies” (co-supervised).
- Niyusha Samadi, PhD (Graduated 2016). “Electrowetting of biological polymer solutions” (co-supervised).
- Ehsan Rezabeigi, PhD (Graduated 2015). “Nanocomposite scaffolds for bone healing” (co-supervised).
- Mostafa Sabzevari, PhD (Graduated 2015). “Effect of MWD on slip of polymers”.
- Nithya Subramamian, MASc (Graduated 2015). “Switchable surface development” (co-supervised).
- Wasef Bzeih, MASc (Graduated 2014). “SFG studies of polystyrene”.

- Sina Chaeichian, PhD (Graduated 2013). “Hybrid thermoset/thermoplastic based nanocomposites” (co-supervised).
- Yury Yuryev, PhD (Graduated 2012). “Crystallization of polylactide”.

Xiaolei Wang, Assistant Professor

Education:

- PhD in Chemical and Biomolecular Engineering; University of California, Los Angeles (UCLA), USA, 2013
- M.S. in Chemical Engineering; Tianjin University, P.R. China, 2007
- B.S. in Chemical Engineering (Polymer Chemical Engineering); Dalian University of Technology, P.R. China, 2004

Positions/Accomplishments/Experience:

- Nov. 2013-present: Postdoctoral Fellow Researcher (advisor: Prof. Zhongwei Chen); Department of Chemical Engineering, University of Waterloo

Publications: Peer-reviewed journal articles (2012-2017):

- Xiaolei Wang, Ge Li, Min Ho Seo, Gregory Lui, Fathy Hassan, Kun Feng, Xingcheng Xiao*, Zhongwei Chen*, Carbon-Coated Silicon Nanowires on Carbon Fabric as Self-Supported Electrodes for Flexible Lithium-Ion Batteries. ACS Applied Materials and Interfaces, accepted, 2016. DOI: adfm.10.1021/acsami.6b12080
- Matthew Li, Yining Zhang, Xiaolei Wang, Wook Ahn, Gaopeng Jiang, Gregory Lui, Zhongwei Chen*, Gas Pickering Emulsion Templated Hollow Carbon for High Rate Performance Lithium Sulfur Batteries. Advanced Functional Materials, 2016, 26(46), 8408-8417.
- Xiaolei Wang, Ge Li, Jingde Li, Yining Zhang, Wook Ahn, Aiping Yu, Zhongwei Chen*, Structural and Chemical Synergistic Encapsulation of Polysulfides Enables Ultralong-Life Lithium-Sulfur Batteries. Energy and Environmental Science, 2016, 9, 2533-2538. (Highlighted in inside back cover)
- Xiaolei Wang§, Ge Li§, Yining Zhang, Zhongwei Chen*, Pomegranate-Inspired Rational Design of Highly Active and Durable Bifunctional Electrocatalysts for Rechargeable Metal-Air Batteries. Angewandte Chemie International Edition, 2016, 55(16), 4977-4982. (VIP paper) (co-first author)
- Xiaolei Wang§, Xingye Fan§, Ge Li, Aiping Yu, Zhongwei Chen*, High-Performance Flexible Electrodes Based on Electrodeposited Polypyrrole/MnO2 on Carbon Cloth for Low-Cost Supercapacitors. Journal of Power Sources, 2016, 326, 357-364. (co-first author)
- Gregory Lui, Ge Li, Xiaolei Wang, Aiping Yu, Zhongwei Chen*, Flexible, 3D Ordered Macroporous TiO2 Electrode with Enhanced Electrode-Electrolyte Interaction in High-Power Li-Ion Batteries. Nano Energy, 2016, 24, 72-77.
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- Ge Li, Xiaolei Wang*, Xueming Ma, Nb2O5-Carbon Core-Shell Nanocomposite as Anode Material for Lithium Ion Battery. Journal of Energy Chemistry, 2013, 22(3), 357-362.
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- Xilai Jia, Zheng Chen, Arnold Suwarnasarn, Xiaolei Wang, Hiesang Sohn, Qiang Zhang, Fei Wei, Yunfeng Lu*, High-performance flexible lithium-ion electrodes based on robust network architecture. Energy and Environmental Science, 2012, 5, 6845-6849.

HQP Mentoring (2012-2017):

- 2016-2018: Yuanli Ding, Postdoctoral Fellow, Chemical Engineering. Advanced Battery Technology beyond Lithium-Ion
- 2016-2017: Wen Lei, exchange PhD student, Chemical Engineering. Novel Phosphorous-based Materials for LIBs and SIBs
- 2016-2018: Steven Sherman, PhD candidate, Chemical Engineering. Scalable Production of Cathode Materials through Spray Drying Process for LIBs
- 2016-2018: Dan Luo, PhD candidate, Chemical Engineering. Cable-Like LIBs and Novel Alkaline Batteries and Supercapacitors
- 2016-2018: Justin Raimbault, MASc candidate, Chemical Engineering. Rational Design of Flexible Cathodes for LIBs
- 2014-2015: Xinlong Ma, PhD candidate, Chemical Engineering. Design of Onion-Like Materials Architecture for LIBs and Supercapacitors
- 2014-2015: Xingye Fan, M.A.Sc candidate, Chemical Engineering. Design and Fabrication of Flexible Electrodes for High-Performance Supercapacitors
- 2009-2010: Xing Zhong, M.A.Sc student, Chemical Engineering. Synthesis of 1D CuInS2 Nanowires and Nanorods for Solar Cell Applications

Rolf Wüthrich, Associate Professor (joint appointment with the Department of Mechanical, Industrial, and Aerospace Engineering)

Education:

- 2003: Doctorate, Microtechnology and Manufacturing, École Polytechnique fédérale de Lausanne (EPFL)
- 1998: Master's Equivalent, Particle physics, École Polytechnique fédérale de Lausanne (EPFL)

Positions/Accomplishments/Experience:

- 2015: Technology manager and Head R&D, Posalux SA
- 2009-: Associate Professor, Department of Mechanical and Industrial Engineering, Concordia University
- 2006-2009: Assistant Professor, Department of Mechanical and Industrial Engineering, Concordia University
- 2003-2006: Lecturer Microtechnique, Ecole Polytechnique Federal de Lausanne

Publications: Books (2012-2017):

- R. Wüthrich and J.D. Abou Ziki. (2015). Micro-machining using electrochemical discharge phenomenon - Fundaments and application of Spark Assisted Chemical Engraving. Second Eddition. Elsevier.

Publications: Peer-reviewed journal articles (2012-2017):

- R.T.A. Morrison*, S.S. Hosseiny*, R Wüthrich. (2016). Platinum-like oxidation of nickel surfaces by rapidly switching voltage to generate highly active bifunctional catalysts. Electrochemistry Communications. 67: 22-25.
- Riad KB*, Schmidt R, Arnold AA, Wüthrich R, Wood-Adams PM. (2016). Characterizing the structural formation of epoxy-amine networks: the effect of monomer geometry. Polymer. In Press.
- Morrison A*, Juillac L*, Guyomart S*, Wüthrich R. (2016). Optimization of the Nickel Square Wave Treatment to Produce Highly Active Bifunctional Alkaline Hydrogen Evolution Catalysts. Journal of The Electrochemical Society. Accepted.
- Aghasibeig M*, Moreau C, Dolatabadi A, Wuthrich R. (2016). Engineered Three-Dimensional Electrodes by HVOF Process for Hydrogen Production. Journal of thermal spray technology. In Press.
- Wüthrich R, Wingerter D. (2016). Glass processing with precision and efficiency. Mikroproduktion.
- Aghasibeig M*, Moreau C, Dolatabadi A, Wuthrich R. (2016). Fabrication of Nickel Electrode Coatings by Combined Atmospheric and Suspension Plasma Spray Processes. Surface and Coatings Technology. 285: 68-76.
- Abou Ziki J*, Hof L*, Wüthrich R. (2015). The machining temperature during Spark Assisted Chemical Engraving of glass. Manufacturing Letters. 3: 9-13.
- Abou Ziki J*, Wüthrich R. (2015). The machining gap during constant velocity-feed glass micro-drilling by Spark Assisted Chemical Engraving. Journal of Manufacturing Processes. 19: 87-94.
- Allagui A, Wüthrich R. (2015). Nonequilibrium Thermodynamics for the Stability Study of Contact Glow Discharge Electrolysis. Plasma Processes and Polymers. 12: 691-697.
- Aghasibeig M*, Dolatabadi A, Wüthrich R, Moreau C. (2015). Cold Spray as a Novel Method for Production of Nickel Electrode Coatings for Hydrogen Evolution. International Journal of Hydrogen Energy.
- Abou Ziki J*, Wüthrich R. (2015). Nature of drilling forces during Spark Assisted Chemical Engraving. Manufacturing Letters. 4: 10-13.
- Jabbari F*, Jadidi M*, Wuthrich R, Dolatabadi A. (2014). A Numerical Study of Suspension Injection in Plasma-Spraying Process. Journal of Thermal Spray Technology. 23
- Allagui A*, Alami A, Baranova E, Wüthrich R. (2014). Size-dependent capacitance of NiO nanoparticles synthesized with cathodic contact glow discharge electrolysis. Journal of Power Sources. 262: 178-182.
- Aghasibeig M*, Mousavi M, Ben Ettouill F, Moreau C, Wüthrich R, Dolatabadi A. (2014). Electrocatalytically Active Nickel-Based Electrode Coatings Formed by Atmospheric and Suspension Plasma Spraying. Journal of Thermal Spray Technology. 23
- Mandin P, Derhoumi Z*, Roustan H, Wüthrich R. (2014). Bubble Over-Potential During Two-Phase Alkaline Water Electrolysis. Electrochimica Acta. 128: 248-258.

- SadAbadi H*, Muthukumaran P, Wüthrich R. (2013). High performance cascaded PDMS micromixer based on split-and-recombination flows for lab-on-a-chip applications. RSC Advances. 3
- SadAbadi H*, Badilescu S, Muthukumaran P, Wüthrich R. (2013). Integration of gold nanoparticles in PDMS microfluidics for lab-on-a-chip plasmonic biosensing of growth hormones. Biosensors & Bioelectronics. 44: 77-84.
- Jalali M*, Molière T*, Michaud A, Wüthrich R. (2013). Multidisciplinary Characterization of New Shield with Metallic Nanoparticles for Composite Aircrafts. Composites Part B: Engineering. 50: 309-317.
- Allagui A*, Baranova E, Wüthrich R. (2013). Synthesis of Ni and Pt nanomaterials by cathodic contact glow discharge electrolysis in acidic and alkaline media. Electrochimica Acta. 93: 137-142.
- Baranova E, Cally A*, Allagui A*, Wüthrich R. (2013). Nickel particles with increased catalytic activity towards hydrogen evolution reaction. Comptes Rendus Chimie. 16: 28-33.
- Derhoumi Z*, Mandin P, Roustan H, Wüthrich R. (2013). Experimental investigation of two-phase electrolysis processes: comparison with or without gravity. Journal of Applied Electrochemistry. 43: 1145-1161.
- Abou Ziki JD*, Wüthrich R. (2013). Forces exerted on the tool-electrode during constant-feed glass microdrilling by spark assisted chemical engraving. International Journal of Machine Tools and Manufacture. 73: 47-54.
- SadAbadi H*, Badilescu S, Packirisamy M, Wüthrich R. (2012). PDMS-Gold Nanocomposite Platforms with Enhanced Sensing Properties. Journal of Biomedical Nanotechnology. 8: 539-549.
- Abou Ziki JD*, Fatanat Didar T*, Wüthrich R. (2012). Micro-Texturing Channel Surfaces on Glass with Spark Assisted Chemical Engraving. International Journal of Machine Tools and Manufacture. 57: 66-72.

HQP Supervision (2012-2017):

- Karamzadeh, Vahid (In Progress), MASc student, Concordia University. Thesis/Project Title: Manufacturing of ultra-customized glass parts (2015-present)
- Fallah, Pantea (In Progress), MASc student, Concordia University. Thesis/Project Title: Electrodedeposition of Titanium on Additively Manufactured Parts (2016-present)
- Charbonneau, Frederic (In Progress), MASc student, Concordia University. Thesis/Project Title: Building high precision mechanism in Glass by Spark Assisted Chemical Engraving (2014-2016)
- Riad, Keroles (Completed), MASc student, Concordia University. Thesis/Project Title: Developping novel type of photo-curable polymers using quantum dots for additive manufacturing (2013-2016)
- Jabbari, Farzad (Completed), MASc student, Concordia University. Thesis/Project Title: Simulation on suspension plasma spraying (SPS) (2011-2013)
- Ghorbani, Zahra (Completed), MASc student, Concordia University. Thesis/Project Title: Study of Gas Evolving Electrodes Under Extreme Current Densities (2010-2013)
- Md Masiar, Rahman (In Progress), PhD student, Concordia University. Thesis/Project Title: Electropolishing of Titanium Parts Produced by Selective Laser Sintering (2014-present)
- Hof, Lucas (In Progress), PhD student, Concordia University. Thesis/Project Title: Additive manufacturing by glow discharge electrolysis (2014-present)
- Aghasibeig, Maniya (Completed), PhD student, Concordia University. Thesis/Project Title: Building highly active Nickel electrode for the hydrogen evolution reaction by thermal spraying technologies (2011-2015)

- Ziki, Jana Abou (Completed), PhD student, Concordia University. Thesis/Project Title: Spark Assisted Chemical Engraving: A Novel Approach for Quantifying the Machining Zone Parameters Using Drilling Forces (2011-2014)
- Morrison, Andrew (Completed), PhD student, Concordia University. Thesis/Project Title: A novel highly active and stable Ni(OH)x surface structure as bifunction electrocatalyst for the hydrogen evolution reaction (2010-2015)
- Sadabadi, Hamid (Completed), PhD student, Concordia University. Thesis/Project Title: Nano-integrated Polymeric Suspended Microfluidic Platform for Ultra-Sensitive Bio-Molecular Recognition (2009-2013)
- Jalali, Moshen (Completed), PhD student, Concordia University. Thesis/Project Title: Improving Electromagnetic Shielding with Metallic Nanoparticles (2007-2012)
- Hosseiny, Schwan (Completed), Postdoctoral fellow, Concordia University. Thesis/Project Title: Developing new generation of electrocatalysts for the hydrogen and oxygen evolution reaction (2012-2013)

Appendix 6 Letters of support and list of persons consulted when developing the proposal

This proposal was developed in consultation with the Department of Chemical and Materials Engineering Steering Committee. The members of the Steering Committee are:

- Dr. Amir Aghdam (Electrical and Computer Engineering, Associate Dean SGS)
- Dr. Amir Asif (Electrical and Computer Engineering, Dean ENCS)
- Dr. Christine DeWolf (Chemistry, Arts and Science)
- Dr. Nabil Esmail (Mechanical and Industrial Engineering)
- Dr. Fariborz Haghighat (Building, Civil, and Environmental Engineering)
- Dr. Van Suong Hoa (Mechanical and Industrial Engineering)
- Dr. Paul Joyce (Chemistry, Associate Dean Arts and Science)
- Dr. Muthukumaran Packirisamy (Mechanical and Industrial Engineering)
- Dr. Rolf Wuthrich (Mechanical and Industrial Engineering)

Other persons who have provided advice or who have contributed to this proposal are:

- Frédérica Martin, Manager, Academic Programs and Development, SGS
- Joshua Chalifour, Digital Services & Engineering Librarian

A letter of support from Dr. Amir Asif, Dean of the Faculty of Engineering and Computer Science, and Dr. Graham Carr, Provost, is included on the next page.

Concordia University
FACULTY OF ENGINEERING
AND COMPUTER SCIENCE
Office of the Dean

October 24, 2017

School of Graduate Studies Graduate Curriculum Committee
School of Graduate Studies
GM 930.01

Dear Colleagues,

We write in support of the proposal for establishing graduate programs (Certificate, Diploma, MASc, and PhD) in Chemical Engineering in the recently created Department of Chemical and Materials Engineering.

The proposal is well aligned with the Faculty's strategic planning, touching on many of our strategic directions, especially our commitment to two important ENCS strategic imperatives, namely Enhancing Research Quality and Reputation, and Enhancing Through Innovation in Academic Programs. The proposal being brought forward also demonstrates our commitment to a third Faculty strategic imperative, Embracing Integration across Engineering, Arts, Science, and Business – Dr. De Visscher and his team have worked closely with colleagues in the Faculty of Arts and Science, in particular Dr. Christine De Wolf (Department of Chemistry and Biochemistry) and Dr. Paul Joyce (Associate Dean, Faculty of Arts and Science). Being interdisciplinary and involving faculty members working in physical sciences and engineering, the proposed programs are sufficiently different from existing graduate programs in chemical engineering offered elsewhere in Quebec. In addition, the proposed programs are modular in structure and offer flexibility to the students, allowing for several exit and entry points.

The institutional commitment to the programs is firm at both the Faculty and the University level. Since its establishment in May 01, 2017, three tenure-track/tenured faculty members have been hired in the Department of Chemical and Materials Engineering with one open position advertised in the 2017/18 hiring cycle. The University is committed to hiring two new faculty members in the Department in the 2018/19 hiring cycle and up to two faculty in 2019/20. Renovations for creating research and wet lab space have started in the Hall building. More space would be made available in the extension to the Science and Engineering Pavilion at the Loyola campus.

Interim Chair De Visscher and his team have shown true leadership and vision in proposing these innovative graduate programs, and we are pleased to offer our full support.

Sincerely,

Amir Asif, PhD, PEng
Dean, Engineering and Computer Science

Graham Carr, PhD
Provost and Vice-President, Academic Affairs

1455 De Maisonneuve Blvd. W., EV 2.139, Montreal, Quebec, Canada H3G 1M8
Tel. 514-848-2424 ext. 3109 Fax 514-848-4509 encs.concordia.ca

Appendix 7 Elective Courses Referred to by Subject Areas

List 2

E03 - SYSTEMS AND CONTROL

- ELEC 6041 Large-scale Control Systems
- ELEC 6061 Real-time Computer Control Systems
- ELEC 6091 Discrete Event Systems
- ENGR 6071 Switched and Hybrid Control Systems
- ENGR 6131 Linear Systems (*)
- ENGR 6141 Nonlinear Systems
- ENGR 7121 Analysis and Design of Linear Multivariable Systems
- ENGR 7131 Adaptive Control
- ENGR 7181 Digital Control of Dynamic Systems
- MECH 6681 Dynamics and Control of Nonholonomic Systems

E04 - FLUID MECHANICS

- ENGR 6201 Fluid Mechanics
- ENGR 6221 Microfluidic Systems
- ENGR 6241 Hydrodynamics
- ENGR 6251 The Finite Difference Method in Computational Fluid Dynamics
- ENGR 6261 The Finite Element Method in Computational Fluid Dynamics
- ENGR 6281 Modelling Turbulent Flows
- ENGR 6291 Rheology

E07 - ENERGY CONVERSION

- BLDG 6951 Solar Building Modelling and Design
- ENGR 6601 Principles of Solar Engineering
- ENGR 6611 Equipment Design for Solar Energy Conversion
- ENGR 6661 Solar Energy Materials Science
- ENGR 6811 Energy Resources: Conventional and Renewable

E37 - ENVIRONMENTAL ENGINEERING

- CIVI 6601 Modelling in Building and Environmental Engineering
- CIVI 6611 Environmental Engineering
- CIVI 6621 Engineering Aspects of Biological Treatment for Air and Water
- CIVI 6641 Unit Operations in Environmental Engineering
- CIVI 6651 Water Pollution and Control
- CIVI 6681 Environmental Nanotechnology
- CIVI 6691 Greenhouse Gases and Control
- CIVI 6901 Selected Topics in Civil Engineering I

E52 - THERMODYNAMICS AND HEAT TRANSFER

- MECH 6101 Kinetic Theory of Gases
- MECH 6131 Conduction and Radiation Heat Transfer
- MECH 6141 Heat Exchanger Design
- MECH 6181 Heating, Air Conditioning and Ventilation (*)
- MECH 6191 Combustion
- MECH 7101 Convection Heat Transfer

E57 - COMPOSITE MATERIALS

- MECH 6501 Advanced Materials
- MECH 6521 Manufacturing of Composites
- MECH 6581 Mechanical Behaviour of Polymer Composite Materials
- MECH 6601 Testing and Evaluation of Polymer Composite Materials and Structures
- MECH 6651 Structural Composites
- MECH 7501 Design Using Composite Materials

List 3

E08 - ACADEMIC COMMUNICATION SKILLS

- ENCS 5721 Composition and Argumentation for Engineers
- ENCS 6721 Technical Writing and Research Methods for Scientists and Engineers

E09 - PROFESSIONAL LEADERSHIP SKILLS

- ENCS 6041 Creativity, Innovation, and Critical Thinking
- ENCS 6042 Communication Techniques for the Innovation Process
- ENCS 6821 Development and Global Engineering

OFFICE OF THE VICE-PRESIDENT,
RESEARCH AND GRADUATE STUDIES

US-2018-1-D12

INTERNAL MEMORANDUM

To: Danielle Tessier, Assistant Secretary-General, University Secretariat

From: Christophe Guy, Vice-President, Research and Graduate Studies

Christophe

Date: December 15, 2017

Subject: Senate approval of Concordia University's **Equity, Diversity and Inclusion (EDI) Action Plan** for the Canada Research Chairs (CRC) Program

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I am pleased to submit for Senate approval Concordia University's Equity, Diversity and Inclusion (EDI) Action Plan for the Canada Research Chairs (CRC) Program, a shared undertaking of the Offices of the Vice-President, Research and Graduate Studies and the Provost and Vice-President, Academic Affairs. As indicated in our last Senate report, the EDI Plan is required by the CRC Secretariat for institutions with five or more chair allocations and is intended to guide institutional efforts in increasing and sustaining the participation of individuals from the four designated groups (FDGs)—women, persons with disabilities, Aboriginal Peoples and members of visible minorities. The Senate Research Committee met on December 08, 2017 to do a final review of the *Plan* (after receiving input from a joint Senate Research Committee/University Research Committee meeting on November 17, 2017, and presentation at Academic Cabinet on Nov 22, 2017). The Senate Research Committee unanimously recommends that Senate approve the proposed EDI Plan.

1455 De Maisonneuve Blvd. West, GM 900, Montreal, Québec, Canada H3G 1M8
Tel: 514-848-2424 ext. 4395 Fax: 514-848-4010 www.concordia.ca

Concordia University's Equity, Diversity and Inclusion (EDI) Action Plan for the Canada Research Chairs (CRC) Program

DRAFT being recommended to Senate meeting of January 19, 2018

December 15, 2017

Concordia University's Equity, Diversity and Inclusion (EDI) Action Plan for the Canada Research Chairs (CRC) Program DRAFT being recommended to Senate meeting of January 19, 2018

1. Executive Summary

Concordia University recognizes the essential role of diversity in fostering excellence by improving learning, advancing research, inspiring creativity, driving productivity and enhancing the experience and morale of the entire institution. We value and embrace the complexity of diversity, including but not limited to personal and social identities, perspectives, ideologies and traditions, and endeavour to cultivate the skills necessary to integrate and harness this complexity in order to effectively lead and innovate in society. We strive to cultivate an educational environment where all students, faculty and staff feel connected to the institution by seeing their experiences reflected in our curriculum, programming, partnerships and scholarship. We understand that diverse peoples and communities require different supports, acknowledgements, accommodations and considerations in order to fully participate in the livelihood of the Concordia community and address historical and contemporary inequalities in Canadian and global society. We commit to fostering all of these cornerstones of diversity as integral elements of the next-generation university.

The development of the Concordia Equity, Diversity and Inclusion (EDI) Action Plan for the Canada Research Chair Program has been a shared undertaking of the Offices of the Vice-President, Research and Graduate Studies (OVPRGS) and the Provost and Vice-President, Academic Affairs (OPVPAA). At Concordia, the OVPRGS has oversight for the processes related to Canada Research Chairs while the OPVPAA has oversight for the processes related to faculty hiring, both of which are implicated in the EDI Action Plan.

The EDI Action Plan is structured in an order that, as closely as possible, mirrors Concordia's processes related to Chair allocation, recruitment, and hire. The Action Plan then addresses the working conditions and institutional environment of the Chair once hired, along with available resources. Finally, existing and planned data collection mechanisms are considered before summarizing a list of 15 key actions, which appear in more detail throughout the document in bold text.

The key actions are comprised of both short- and long-term goals and were developed with the understanding that addressing the overarching themes of equity, diversity, and inclusion are not limited to the recruitment and retention of Canada Research Chairs but, rather, must be seen as an institutional imperative. While the main focus of this plan relates to the requirements of the CRC Program, the actions will be seen in a larger context of diversity that includes all members of the Concordia University community i.e. faculty, staff, and students.

2. Background and Context

As of December 3, 2017, Concordia University is meeting its targets for three of the four designated groups (FDGs), although data cannot be reported for two of the designated groups for confidentiality reasons. Details can be found in the table below (gaps equivalent to less than a Chair are not considered):

Figure 1 - Canada Research Chairs from the FDGs at Concordia as of November 3, 2017

23 Chairs currently occupied (6 Chairs are currently vacant)			
Designated Group	**CRC Program Target**	**Concordia Occupancy**	**Gap**
Women	32%	6 (26.1%)	1
Members of Visible Minorities	15%	6 (26.1%)	No gap
Persons with Disabilities	4%	*	*
Aboriginal Peoples	1%	*	*
** Please note that cells with fewer than 5 responses cannot be reported for confidentiality.*			

Please note that as of December 3, 2017, three (3) Canada Research Chair nominations and two (2) renewals have been submitted and are pending review. Results are expected in April 2018. One (1) Chair renewal is also expected to be submitted for review in April 2018.

In terms of context for the current exercise as this relates to CRCs only, Concordia has three vacant Chairs that have been allocated in the last few months for the following research areas: Critical Disability Studies and Communication Technology (SSHRC T2), Future Fibers and Experimental Textile Structures (SSHRC T2) and Molecular Biophysics in Human Health (CIHR T2). We expect to be able to submit nominations to the CRC Secretariat by October 2018. No other Chairs are currently vacant. Also, no current chairholder is ending a second term until October 2020, which falls outside of the period of the Action Plan. We will have one NSERC T2 ending a second term in October 2020, and then two NSERC T2 and two SSHRC T2 ending their second terms in the Spring/Summer 2021. We do, however, have four Chairs ending their first term during the Action Plan period (two NSERC T1, one CIHR T2 and one SSHRC T2), with two of these four Chairs currently occupied by women. As such, it is important to note that our leverage to modify the FDG representation in our current allocation is very limited before 2020-2021.

Regardless of the challenges imposed by our short-term circumstances, Concordia has resolved to make a concerted effort through this Plan and its measures to not only meet the targets as set by the CRC but to exceed them wherever possible. As such, one objective we have set in relation to the CRC Program is to be at least four (4) Chairs over the CRC program targets set for all FDG categories combined by July 2021, while also not being below the target in any one FDG category.

An important new tool that will assist this is the recent announcement by the CRC Secretariat of additional flex moves. Concordia University had long ago exhausted its allowed flex moves, removing this a way to help manage our Chair allocations or meet FDG targets. **As a result of the additional flex**

moves recently provided by the CRC Program, a new process will be established (to be described in the Procedures and Guidelines for Research Chairs) before January 2019 that will support our EDI Action Plan and the goal of meeting, or exceeding, our equity targets.

3. Management of Canada Research Chair Allocations

Concordia University's allocation of Canada Research Chairs is managed by the Vice-President, Research and Graduate Studies. The internal process is governed by the university Senate-approved Policy on Research Chairs and its related Procedures and Guidelines for Research Chairs. At the root of this process is the general rule that Concordia uses its CRC allocations to recruit new faculty members and not for internal promotion. **We will, however, form a Working Group composed of members of the University Research and Senate Research Committees to assess the merits of internal promotion on an exceptional basis of members of the FDGs – either in the context of retention, or to meet CRC targets.** The Working Group will have a deadline of June 30, 2018 to make its recommendations to the Vice-President, Research and Graduate Studies and the Provost and Vice-President, Academic Affairs.

The internal allocation process also involves the Office of the Provost and Vice-President, Academic Affairs (OPVPAA), the University Research Committee (URC), the Faculty Research Committees (FRC) of Concordia's four Faculties and their Deans and Associate Deans, Research, and the heads of all academic and research units within the university.

The allocation process normally begins with the university having (or anticipating having) one or more vacant Canada Research Chair positions within the next 12 to 24 months. A call for letters of intent (LOIs) is then issued by the VPRGS to all Deans for distribution to the heads of academic units while the OVPRGS issues the call to university-recognized research units. The call (see example in appendix A) describes the CRC program, lists which chair allocations are vacant, and details the process, required documents and deadlines to submit letters of intent to the URC. The call for LOIs refers to the appropriate university Policies and Procedures and collective agreements.

Further to the call, Interested academic and research units then submit LOIs to their FRC, who will then review and select which of these letters should be forwarded to the URC. The URC will then review the LOIs received and decide on the allocation(s) within the university. The existing criteria used are: fit with Faculty and University Strategic Research Plans, the expected impact the allocation would have on the research area/unit, the potential to secure external funding and attract HQP, and the potential to increase Concordia's leadership, visibility and reputation locally, nationally and internationally**.** In addition, in more recent calls there has been emphasis placed on areas that are more likely to attract applicants from the FDGs. **For implementation with our next call, it will be required that the LOI's proposed area of research be further narrowed and it will also be required that the nature of the FDG applicant pool be addressed in the submission.** This will form part of the review criteria at both the FRC and URC for allocation purposes.

Of note is that in recent calls, there has been an increased emphasis on the importance of active recruitment of FDGs with the most recent call including a mandatory meeting of hiring committees with OVPRGS and OPVPAA staff to fully understand the relevant CRC guidelines. **These efforts will continue to expand with the implementation of mandatory training of hiring committee members along with the goal of implementing EDI training across the board as an institutional cultural imperative rather**

than reserving these efforts for CRC hiring committees only. **Notably, we aim to have mandatory EDI training for hiring committee members for all full-time faculty hiring processes by December 2019.**

4. Hiring Process: Committee Training and Conditions of Employment Safeguards

Faculty hiring at Concordia University is governed by the Concordia University Faculty Association Collective Agreement. Following a successful LOI for a CRC allocation, a faculty position is first advertised with emphasis always placed on attracting a wide range of candidates. All positions are advertised externally in appropriate discipline-specific journals, through networks, and in newspapers. For CRC recruitment, where a high-calibre researcher in a specific field is being sought, compliance with collective agreement issues, open and transparent processes, as well as a comprehensive search must all be balanced.

All CRC position advertisements (which can be found at https://www.concordia.ca/research/for-researchers/policies-guidelines.html, under the CRC EDI tab) clearly state that Concordia is strongly committed to employment equity within its community and to recruiting a diverse faculty complement. Advertisements specifically encourage applications from all qualified candidates, including women, members of visible minorities, Aboriginal persons, members of sexual minorities, persons with disabilities, and others who may contribute to diversification. We have also added text to our CRC ads that encourages individuals with legitimate career interruptions to consult the CRC guidelines and apply. To complement this regular advertising process, Concordia adheres to a transparent, committee-driven hiring process, which includes department hiring committees, department personnel committees, an equity committee, and where appropriate, department tenure committees and the Board of Governors. In the interests of attracting qualified candidates at multiple career stages, or with differing personal circumstances, the collective agreement also has provisions for spousal appointments (CUFA Article 12.09).

A key element to a successful recruitment is the applicant pool. Therefore, in addition to the advertising measures mandated by the CUFA collective agreement and current practice, **proactive measures to generate and not just tap a robust candidate pool will be developed**. Examples of such measures include, but are not limited to: diversifying where hiring ads are posted to help ensure that candidates from the FDGs are reached; instituting a practice of active recruitment whereby hiring committees and department members actively solicit candidates from the FDGs; and creating a hiring committee budget that gives the opportunity to bring in potential FDG candidates (notably indigenous) so that they can experience and evaluate the Concordia environment. In addition, Concordia is currently **piloting the use of search firms in higher-profile recruitments to improve interest from FDG candidates: the value-added of this pilot will be assessed throughout the 2018 hiring cycle with implementation in CRC searches to be established, as appropriate**.

Related to inclusive and transparent hiring practices, we have implemented a wide-ranging and comprehensive education campaign that emphasizes diversity and inclusion in faculty hiring. Areas of particular focus include conflict of interest (real or perceived), employment equity, and unconscious bias. In particular, hiring committees are being instructed to document processes, to detail how conflicts of interest have been addressed, to check for unconscious bias, and to ensure confidentiality. The composition of the hiring committee is expected to be diverse and representative of the candidate pool and representation from related departments or research units may be added in order to either supplement or provide required expertise. Hiring committee members must also: discuss and review their full range of criteria, which must include diversity priorities; establish a short-list based on qualifications that they must be able to document and justify; and not unreasonably exclude candidates with qualifications and experience acquired in non-traditional ways. The committees are being instructed on consistent practices to ensure that each candidate is considered by the same members, asked the same questions, measured against the same criteria, and have included the same external input (e.g., colleagues, references, etc.). In addition, committee members are being encouraged to use behavioural interview questions to measure a candidate's ability and experience against the criteria and to embed equity and diversity into the interview questions.

Further, in the recent Canada 150 competition (http://www.canada150.chairs-chaires.gc.ca/home-accueil-eng.aspx), as part of its shortlist criteria, one of the hiring committees successfully implemented a very specific evaluation rating system whereby 20% of the overall ranked score was devoted to diversity. This rating was further refined by assessing the candidate on various sub-criteria of the four main criteria (in addition to Diversity, these were: Research/Academic Merit (30%); Prospects for the Quality of the Institutional Support (20%); and Potential (30%)). **This best practice related to diversity as an element of evaluation will be incorporated into EDI training going forward.** Moreover, as part of the training initiative, hiring committees will be encouraged to consider and establish a broader and more diverse element in their evaluation of criteria of excellence in addition to the traditional and limited quantifiable metrics. This will enhance the likelihood of the selection of a qualified candidate who may also belong to one of the FDGs. While being implemented for regular hires, as mentioned earlier, this training will be mandatory for CRC hiring committees. **Paired with this will be the mandatory involvement of the Senior Lead, Equity and Diversity, immediately after the URC makes CRC allocation decisions so that he/she is involved at the earliest possible stage in the hiring process.** This will allow issues related to the advertisement and ideal candidate qualifications, as these relate to EDI principles, to be addressed and reconciled as early as possible in the process. **A longer-term goal will be to compose a team of equity officers (Equity Training Team) from among the faculty and staff complement in order to extend this level of involvement to non-CRC hiring committees so that it becomes a routine exercise for all hires.**

In September 2017, the aforementioned Senior Lead, Equity and Diversity joined Concordia. The position's dual mandate includes (1) working with academic hiring committees on equitable search practices, and (2) working across units on strategic diversity planning. The Senior Lead has taken an active role in the CRC program through hiring workshops and consultations.

For the three current CRC searches underway, the first instance of the required training on Diversity and Equity in CRC recruitment workshop going forward was offered. The topics addressed included:

- Overview of essential role of diversity in modern business and educational contexts, including research and highlighting institutional and student benefits of diversity.
- Overview of CRCP EDI Action Plan and equity obligations.
- Overview of best practices in equitable faculty search processes including
    - Committee composition
    - Developing a diverse pool of candidates
    - Broadly defined disciplinary areas
    - Mitigating effects of unconscious bias
    - Conducting reviews with broad, inclusive conceptualizations of excellence, including EDI practices with respect to work interruptions
    - Providing a welcoming environment during the interview
    - Considering only job relevant criteria in evaluating candidates

- Notification of the required completion of the TIPS unconscious bias training module by November 2017, with subsequent reminder sent following the workshop.
- Discussion of conflict of interest based on Concordia's Code of Ethics, collective bargaining agreements, and potential COIs.
- Offer of ongoing consultation with the Senior Lead, Equity and Diversity throughout the search process.

Particular attention was – and will continue to be – paid to the differences in career path that members of the FDGs might have. Specifically, the following best practices were highlighted:

- Work interruptions and non-traditional career paths including an overview of the 'Work interruptions and personal Circumstances' EDI Practices featured on the CRC website, and the research on the differential impacts of work interruptions on women and underrepresented minorities.
- Within the job posting, acknowledgement of the potential impact that legitimate career interruptions can have on a record of research achievement.
- Encouraging potential candidates to explain within their application the impact that career interruptions have had on their record.
- Allowing potential candidates to submit a full career or extended CV in cases where they have had career interruptions.
- Sensitizing and instructing hiring committees to carefully consider the impact of career interruptions on a potential candidate's record.
- Limiting the potential negative impact of unconscious bias and common cognitive shortcuts and errors within recruitment, nomination and decision-making processes for a chairholder position.

In addition to the inclusion of the Senior Lead in the search process, we have also identified the following action items for implementation in the short- and long-terms:

- Refine/develop tools evaluating each candidate along multiple criteria, including ability to add diverse perspectives, research and teaching agendas focusing on diverse populations, and ability to mentor diverse undergraduate and graduate students and junior faculty.
- Improve composition ratios of search committees with respect to diverse representation
- Actively engage in strategies to create a broad pool of applicants.
- Ensure that each candidate is able to meet with diverse members of the community, including broad representation at each candidate's job talk.
- Ensure that at least one member of a FDG is included in the shortlist for all searches, perhaps a specific group, e.g. a woman, depending on the current target gaps.
- If the final recommended candidate is not a member of a FDG/specific gap-incurring target group, have search committees justify why that chosen candidate was demonstrably superior to the candidate who was recommended.

Upon identification of the preferred candidate, the collective agreement between CUFA and the university contains a salary grid (CUFA Appendix 4) that determines the salary offer for appointment. Though not unique in Canada, the lack of this type of mechanism is often responsible for discrepancies in compensation. The salary grid has three components:

- The Step upon which candidates are placed based on education and experience (non-negotiable)
- The Market Supplement based on specific disciplines (CUFA Appendix 3, non-negotiable)
- Individual supplements (negotiable), subject to review by the Salary Review Committee (CUFA Article 11.19).

All chairholders receive a minimum of one three-credit course remission per year. The amount of research support coming from the CRC program funding is also the same for all CRC T2 ($45K per year) and CRC T1 ($90K per year).

Additional support (cash or in-kind) for research, salary stipends, additional protected time, and equipment is dealt with on a case by case basis through the hiring process, and involves the Faculty administration (Dean and Associate Deans), the heads of academic and (if applicable) research units where the appointment will be held, and the Provost and his/her Office, and the Vice-President, Research and Graduate Studies and his/her Office.

Concordia has substantially increased its efforts in the area of diversity, equity, and inclusion that are beneficial for all faculty and add to the culture of inclusivity and general conditions of productive employment. These efforts and strategies include the following:

- A new Senior Director for the Office of Community Engagement was hired, representing a significant period of investment and period of growth. The Office supports, connects and promotes new and existing community-university partnerships.
- The Indigenous Directions Leadership Group was launched and explores, identifies and recommends priority areas in which Concordia can improve its responsiveness to the Truth and Reconciliation's (TRC) Principles for Reconciliation and Calls to Action. This came with an appointment of a Special Advisor to the Provost on Indigenous Directions and a chair of the Indigenous Directions Leadership Group.
- A joint committee between the faculty association and the university has been struck to do a gender-pay equity analysis for faculty. Specifically, the committee is being asked to perform a gender-based analysis of compensation to determine whether current policies and procedures contribute to gender-based inequities in the compensation of tenured and tenure-track faculty members. They will be looking at possible inequities in base salary, remuneration, start-up funds, and other incentives that may impact remuneration and recognition.
- Every hiring dossier reviewed by the Joint Employment Equity Committee (JEEC, CUFA Article 11.15), whose purpose is to ensure that fair hiring practices are observed with respect to members of designated groups. However, few dossiers are returned for revision based on equity concerns. Possible reasons for this include the JEEC review being at the end of the hiring process and lack of desire to challenge a process near its completion. **We will actively explore opportunities to work with JEEC to increase their role and influence on the hiring process.**

Further, and in keeping with the larger goal of fully integrating EDI measures into the Concordia culture, **we will also move towards targets in internal chair allocations and research unit director positions**. More specifically, targets beyond the gender balance already sought in the Concordia University Research Chairs program will be implemented. These chairs, which are also governed by the Policy on Research Chairs and its related Procedures and Guidelines for Research Chairs, are subject to annual calls and selection. Past practice has had equity efforts focused on gender balance, however, this will be expanded to better address the FDGs and further enhance an inclusive culture at the university. We will also promote the EDI measures to university-recognized research units, which are governed by the Policy on Research Units and Infrastructure Platforms and its related Procedures for Research Units and Infrastructure Platforms.

5. Chair Evaluation, Renewal and Re-allocation

The Policy on Research Chairs and its related Procedures and Guidelines for Research Chairs describe the process for review of Canada Research Chairs, which includes annual reports, a mid-term review and a renewal evaluation. Examples of the criteria used for the renewal evaluation of Tier 1 and Tier 2 Chairs in the Faculty of Arts and Science are included in Appendix B. The relevant Faculty Research Committee (or a subset of the committee) conducts the review and the process involves the chairholder submitting a report of activities along with a presentation to the Committee (including a Q&A). The FRC then meets in camera to assess the chairholder's dossier and to make a recommendation (to renew or not to renew) to the URC. The URC will then review the recommendation and dossier, incorporating in its review the elements relevant to the overall university context and our Equity, Diversity and Inclusion Action Plan to make its decision on whether to allow the application for renewal of the chair to the CRC Program. Should the URC not authorize the renewal of a Chair, the position would revert to the pool and be subject to a new allocation process as described earlier.

Concordia only lost Chairs twice through re-allocation exercises, once in 2010 and once in 2012, and both were SSHRC Tier 2 Chairs. However, at the time and in both instances, there was a vacant/unused SSHRC Tier 2 Chair that could be targeted without having to phase-out an existing chairholder, so these re-allocation decisions were easily made. Should such a re-allocation process take place in the future and Concordia lose one or more Chair allocation, a new process will be established that will incorporate the measures included in the Equity, Diversity and Inclusion Action Plan and of meeting our equity targets. **In cases of non-renewal or re-allocation, we will ensure that the subsequent call and allocation addresses any gaps in meeting our targets.**

6. Collection of Equity and Diversity Data

Concordia has been engaged in an ongoing process of identifying optimal strategies for equity data collection. This process involves discussions with administrative leadership, faculty members and legal counsel, outreach and consultation with colleagues at other Canadian universities, and collecting various data recording templates.

Simultaneously, there are a range of concerns that have arisen during this process. For example, we will need to go through a complicated administrative process to identify where the data will be stored, who will have access to it, and how it will be shared with committees and departments, all while protecting the privacy of each candidate. Also, in consulting colleagues at other institutions, it is apparent that the rate of response to equity surveys by job applicants is consistently low, possibly due to concerns regarding privacy and having the data used to disqualify them from certain positions.

An expert legal opinion on the university's plans to collect demographic and other data pertaining to equity and diversity has been commissioned and we are awaiting the results. The recent announcement by Universities Canada on the necessity of collecting institutional data and the accompanying Inclusive Excellence Principles (https://www.univcan.ca/media-room/mediareleases/universities-canada-principles-equity-diversity-inclusion/) and the EDI Action Plan provide additional rationale for the urgency of these efforts.

In terms of what is current practice at the university, an 'Employment Equity Questionnaire' (see Appendix C) is available on the university's employee portal and all new employees are invited to complete it prior to their first day. It is not well-known at the moment and, therefore, we are, in process of assessing with our Department of Human Resources the feasibility of engaging in a campus-wide campaign to invite employees to revisit and complete the survey if they have not already done so. Part of this campaign will include:

- Widespread communication strategy.
- Emphasis that participation is optional and confidential.
- Clarification that the data will be kept by one person.
- Articulate the reasons why we are collecting data, including: Concordia's commitment to equity and an inclusive campus environment, the opportunity to obtain accurate information on our community, and the recent commitment made by Canadian universities to collect and make public demographic data on faculty, staff and students as part of a plan to increase the diversity and inclusion of their campus communities.
- An expert legal opinion on the entire process is being sought.
- Plans on how to analyze and report data while respecting all privacy laws and concerns will be developed.

Therefore, we will actively research and consult on best practices across the country in order to modify our collection mechanism and implement the updated version by July 2018. Further, **the development and use of a more comprehensive self-identification form is an EDI Action Plan priority** and we will be guided by the best practices in place at other institutions.

7. Retention, Inclusivity and Resources

Concordia has several resources available to all members of the campus community in order to improve the working climate and support underrepresented members. These include:

- Indigenous Direction Leadership Group, the Critical Feminist Activism and Research (CFAR) Project, Center for Gender Advocacy, HR Employee Assistance Program (accessibility issues).
- Individual supplements (as referenced above), which can be used for retention.
- Several types of leave are available to accommodate flexible work schedules / variable life circumstances, including compassionate leave (CUFA Article 33), maternity leave, paternity leave, and parental leave (CUFA Article 35), unpaid salary leave (CUFA Article 32), and reduced time appointments (Article 25). This range of leave options gives the institution flexibility as this relates to life circumstances and the need for flexible work schedules. The collective agreement protects against penalization for taking leave.
- Spousal appointments are directly addressed in the collective agreement (Article 12.09)

Concordia has not had many chairholders leave and, given this infrequency, has not developed a formal exit interview process. In the few instances we have had, the faculty member has typically left for what they have determined to be career advancement. The annual reports required from all chairholders provides important updates on their research program and typically also includes issues related to impediments or difficulties experienced. **We will expand on this existing reporting mechanism to develop a simpler, regularized survey related to chairholder conditions and implement it for the 2017-2018 chairholder reporting cycle that will be requested in spring 2018.**

There is more than one avenue available to chairholders/faculty who may wish to lodge an equity-related complaint. There is either the university's Office of Rights and Responsibilities, which administers the Code of Rights and Responsibilities, or the Ombuds Office, which has the mandate of assisting in the informal resolution of concerns and complaints related to the application of all university policies, rules and procedures. The Code of Rights and Responsibilities is the university's policy on behaviour and provides a mechanism for members (faculty, staff and students) to file complaints related to discrimination and/or harassment based on the grounds specified in the Quebec Charter of Human Rights and Freedoms (race, religion, gender identity, etc.). It also specifies the procedures for resolving these complaints (e.g. Section IX). The Ombuds Office conducts independent and objective inquiries into complaints that have already exhausted the usual avenues for grievance and appeals. Following the inquiry, the Ombudsperson will recommend solutions to help resolve concerns and complaints as well as recommend improvements to university policies, rules and procedures that are unclear or unfair.

Beyond what is mentioned above, please note that while there are currently no specific processes in place to manage complaints regarding equity, diversity and inclusion concerns for the Canada Research Chairs allocation, selection and nomination processes, all equity, diversity and inclusion concerns can be reported to Concordia's Senior Lead, Equity and Diversity:

Dr. Mark Andrew Galang Villacorta
Senior Lead, Equity and Diversity
Office of the Provost and Vice-President, Academic Affairs

Tel: 514-848-2424, ext. 4875
Fax: 514-848-8766
Email: equity.vpfr@concordia.ca

1550 de Maisonneuve Blvd West, Suite GM 806.27
Montreal, QC H3G 1N2

Given that the Senior Lead, Equity and Diversity is a new position, he will require sufficient time to assess whether a process specific to chairholders, or all faculty members, beyond what currently exists is required.

8. Summary of Actions

- To be four (4) Chairs over the CRC program targets set for all FDG categories combined by July 2021, while also not being below the target in any one FDG category.
- A new process will be established to use additional flex moves in order to meet, or exceed, our equity targets.
- A Working Group will be established to consider internal promotion, on an exceptional basis, of members of the FDGs either in the context of retention, or to meet CRC targets.

- Design future calls for CRC letters of intent to further narrow the requested area of research and request that the nature of the FDG applicant pool be addressed in the submission.
- Implement mandatory training of hiring committee members by December 2019.
- Develop proactive measures to generate and not just tap an existing pool of FDG candidates.
- Assess value-added of the pilot use of search firms for potential implementation in future CRC searches.
- Incorporate best practice related to diversity as an element of candidate evaluation.
- Mandatory involvement of the Senior Lead, Equity and Diversity at the earliest possible stage in the hiring process.
- Create an Equity Training Team composed of faculty and staff.
- Actively explore opportunities to work with the Joint Employment Equity Committee to increase their role and influence on the hiring process.
- Move towards FDG targets in internal chair allocation and research unit director positions.
- In cases of non-renewal or re-allocation, ensure that the subsequent call and chair allocation addresses any gaps in meeting targets.
- Actively research and consult on best practices across the country in order to fully develop an equity and diversity data collection mechanism.
- Expand existing annual reporting mechanism to develop a simpler, regularized survey related to chairholder conditions.

9. Conclusion

As an institution, Concordia has historically been quite successful in meeting its CRC-prescribed targets. Nevertheless, we believe that, as a forward-thinking, next-generation university, it is our responsibility to not simply meet these targets but rather to exceed them wherever possible. Critical to the success of such an initiative is to move forward not only on the goals and actions outlined in our EDI Action Plan but also to make diversity and inclusion part of the overall Concordia narrative. We have made great strides in this direction with a variety of undertakings already addressed above. Continued success will depend on a concerted effort at all levels of the university from faculty to staff to senior administration. Further, these interventions cannot be limited but, rather, must be seen as an institutional imperative in all aspects of the academic life cycle from hiring of new faculty and staff, attracting and training of highly qualified personnel to knowledge mobilization, knowledge transfer and community partnerships and outreach wherever and whenever applicable.

APPENDIX A

INTERNAL MEMORANDUM

TO: Amir Asif, Dean, Faculty of Engineering and Computer Science
Stéphane Brutus, Interim Dean, John Molson School of Business
Rebecca Duclos, Dean, Faculty of Fine Arts
André Roy, Dean, Faculty of Arts and Science

cc: Mourad Debbabi, Associate Dean, Research and Graduate Studies, Faculty of Engineering and Computer Science
Kim Sawchuk, Associate Dean, Research and Graduate Studies, Faculty of Arts and Science
Thomas Walker, Associate Dean, Research, John Molson School of Business
Graham Carr, Provost and Vice-President, Academic Affairs
CUFA

FROM: Justin Powlowski, Interim Vice-President, Research and Graduate Studies

DATE: January 12, 2017

SUBJECT: **Call for Letters of Intent for Canada Research Chair (CRC) nominations**

I am pleased to announce that Concordia has three Canada Research Chair allocations available for nomination:

- One CIHR – Tier II chair; and
- Two SSHRC – Tier II chairs.

As per the *Policy on Research Chairs (VPRGS-7)*, academic and research units are invited to submit Letters of Intent (LOIs) identifying a strategic area of research and demonstrating the impact of allocating a CRC to that area that will assert or solidify Concordia's leadership in the field. For LOIs submitted by University-recognized research units or by institutes, such as PERFORM and MILIEUX, the LOI must be reviewed and ranked by the Faculty Research Committee (FRC) corresponding to the field of hire and must include a letter of support from the relevant academic unit head. For detailed instructions on the content and format of the LOI, please refer to the *Policy* and accompanying *Procedures and Guidelines for Research Chairs*.

A few key points to keep in mind at the LOI stage are:

- Concordia uses its CRC allocations to recruit top researchers to the University. Individuals who currently hold a tenured or tenure-track faculty position at Concordia are not eligible candidates for a CRC.

- The nomination for a CRC appointment will involve the recruitment of the candidate to the University in parallel with the nomination. Since the recruitment process for new faculty members must be conducted in accordance with the CUFA collective agreement (posting, search, selection), a specific candidate is not expected to be identified at the LOI stage.

…/2

- The CRC Program Secretariat requires all recruitment practices for chairholder positions to be open, transparent and equitable.

- From the outset of the search process, the University must demonstrate that it has actively encouraged to apply, and actively recruited, applicants from designated groups including women, persons with a disability, Aboriginal Peoples, and visible minorities. ***Therefore, when the allocations are made, it will be mandatory for the relevant academic unit heads and DHC chair, to participate in an orientation session to ensure complete compliance with the guidelines.***

- The successful candidate may be recruited for membership in a university-recognized research unit but will be hired into a department or cross-appointed between departments.

The FRC must submit all ranked LOIs, together with justifications for the rankings, to the Office of the Vice-President, Research and Graduate Studies by **Monday, May 1st, 2017**. The University Research Committee (URC) will then meet to review the ranked LOIs and make decisions on which submissions will be retained for the available CRC positions. The URC will take into consideration the rankings proposed by the FRC and justifications for recommended areas of research. The decision by the URC will be communicated as soon as possible and will include a specific timeline for the search process and submission of the CRC nominations, as well as additional details about the recruitment process for chair candidates.

Each Faculty will then be responsible for conducting the search for a candidate who meets the criteria as stated by the CRC program for Tier II Chairs: *tenable for five years and renewable once, are for exceptional emerging researchers, acknowledged by their peers as having the potential to lead in their field.*

Once a candidate is selected, the Office of Research will assist with the development of the complete dossier to be submitted to the CRC Program Secretariat for peer review. In the cases of Canadian nominees, the CRC Secretariat accepts dossiers twice per year – in April and October. International nominees may be submitted to the Secretariat at any time.

Please distribute this Call for LOIs to the academic and research units in your Faculty and do not hesitate to contact my office should you have any questions.

APPENDIX B

EVALUATION CRITERIA FOR CRC RENEWALS

CRC TIER I		
Topic	**Criteria**	**Achieved**
Quality of the Chair	• Continue to distinguish themselves as an outstanding, world-class researcher	
Dissemination of Results	• Type of dissemination produced: peer-reviewed journals, monographs and books, conferences, patents, copyrights, products, services, technology transfer, creative/artistic works • The significant impact that each type of dissemination has made in the field	
Training of Highly Qualified Personnel (HQP)	• Training strategies created to attract students, trainees and future researchers • Encouragement provided to these individuals to develop expertise • Creation of an environment that attracts, develops and retains outstanding researchers in areas and technologies that are critical to Canada's cultural, social and economic growth, vital public policy issues, and quality of life	
Program of Research	• The goals achieved for the program of research • Improvement to Canada's ability to lead in research that has high social, cultural, scientific, or technological impact	
Integration with the University's Strategic Research Plan	• Relationship building with other research initiatives in Canada and abroad • Impacts produced that demonstrate the institution's strategic development of research • Improvement to the institution's ability to leverage additional research funding (if applicable)	
Benefits to Canada	• Benefits to society, health, the environment, quality of life, or public policy • Increased economic activity	

QUESTIONS

Quality of the Chair:

How will you continue to distinguish yourself as an outstanding, world-class researcher?

Dissemination of Results:

What types of dissemination have resulted from you holding the Chair?

Examples: peer-reviewed journals, monographs and books, conferences, patents, copyrights, products, services, technology transfer, creative/artistic works.

What types of non-academic dissemination have you produced?

Which audiences – both academic and non-academic - have benefited from the dissemination of your research results?

What is the significant impact that each type of dissemination has made in your field, and on each of the audiences described above?

Training of Highly Qualified Personnel (HQP):

As a Chair, what training strategies have you created in order to attract students, trainees and future researchers?

What types of encouragement have you provided to these individuals in order to develop their expertise?

What kind of environment have you created in order to attract, develop, and retain outstanding researchers in areas and technologies that are critical to Canada's cultural, social and economic growth, vital public policy issues, and quality of life?

Program of Research:

How has the Chair added to your research program - what can you do now that you could not do before receiving the Chair?

Have you achieved the goals set out for your program of research?

How have you improved Canada's ability to lead in research that has high social, cultural, scientific, or technological impact?

Integration with the University's Strategic Research Plan:

What kinds of relationship building have you conducted with other research initiatives in Canada and abroad, and what types of collaborations have resulted?

What outcomes have the collaborations produced?

What are the impacts produced that demonstrate the institution's strategic development of research?

What improvements to the institution's ability to leverage additional research funding have occurred through your Chair?

Benefits to Society:

What are the expected benefits of your research, how will they be realized, and what is the timeframe over which they are expected?

Who are the potential users of the technology developed, or of the research results?

What are your plans for the translation of knowledge, including potential contributions to policy and practice?

What are your plans for the transfer of technology and skills, and for the commercialization of products, services and processes?

CRC TIER II		
Topic	**Criteria**	**Achieved**
Quality of the Chair	• Developing into an outstanding, original and creative researcher of world-class caliber, and is poised to become a leader in their field	
Dissemination of Results	• Type of dissemination produced: peer-reviewed journals, monographs and books, conferences, patents, copyrights, products, services, technology transfer, creative/artistic works • The significant impact that each type of dissemination has made in the field	
Training of Highly Qualified Personnel (HQP)	• Training strategies created to attract students, trainees and future researchers • Encouragement provided to these individuals to develop expertise • Creation of an environment that attracts, develops and retains outstanding researchers in areas and technologies that are critical to Canada's cultural, social and economic growth, vital public policy issues, and quality of life	
Program of Research	• The goals achieved for the program of research • Improvement to Canada's ability to lead in research that has high social, cultural, scientific, or technological impact	
Integration with the University's Strategic Research Plan	• Relationship building with other research initiatives in Canada and abroad • Impacts produced that demonstrate the institution's strategic development of research • Improvement to the institution's ability to leverage additional research funding (if applicable)	
Benefits to Canada	• Benefits to society, health, the environment, quality of life, or public policy • Increased economic activity	

QUESTIONS

Quality of the Chair:

How are you developing into an outstanding, original and creative researcher of world-class caliber who is poised to become a leader in your field?

Dissemination of Results:

What types of dissemination have resulted from you holding the Chair?

Examples: peer-reviewed journals, monographs and books, conferences, patents, copyrights, products, services, technology transfer, creative/artistic works.

What types of non-academic dissemination have you produced?

Which audiences – both academic and non-academic - have benefited from the dissemination of your research results?

What is the significant impact that each type of dissemination has made in your field, and on each of the audiences described above?

Training of Highly Qualified Personnel (HQP):

As a Chair, what training strategies have you created in order to attract students, trainees and future researchers?

What types of encouragement have you provided to these individuals in order to develop their expertise?

What kind of environment have you created in order to attract, develop, and retain outstanding researchers in areas and technologies that are critical to Canada's cultural, social and economic growth, vital public policy issues, and quality of life?

<u>Program of Research</u>:

How has the Chair added to your research program - what can you do now that you could not do before receiving the Chair?

Have you achieved the goals set out for your program of research?

How have you improved Canada's ability to lead in research that has high social, cultural, scientific, or technological impact?

<u>Integration with the University's Strategic Research Plan</u>:

What kinds of relationship building have you conducted with other research initiatives in Canada and abroad, and what types of collaborations have resulted?

What outcomes have the collaborations produced?

What are the impacts produced that demonstrate the institution's strategic development of research?

What improvements to the institution's ability to leverage additional research funding have occurred through your Chair?

<u>Benefits to Society</u>:

What are the expected benefits of your research, how will they be realized, and what is the timeframe over which they are expected?

Who are the potential users of the technology developed, or of the research results?

What are your plans for the translation of knowledge, including potential contributions to policy and practice?

What are your plans for the transfer of technology and skills, and for the commercialization of products, services and processes?

APPENDIX C

MY EMPATH

Employment Equity > Workforce Survey > Workforce Survey - Details

NAME AND CONCORDIA ID#

The information that you provide will be kept confidential and will be used for Employment Equity purposes only. Completion of this form is voluntary; we however ask you to check the box located at the bottom of the screen if you do not wish to complete it.

To start, click on Modify located top left of screen. Thank you for your collaboration.

Survey Code: Employment Equity

:

Date Returned:

Date Revised:

Gender:	Blank Declined to Answer Female Male
Persons with Disabilities:	Blank Declined to Answer No Yes
Aboriginal person:	Blank Declined to Answer No Yes
Members of visible minorities:	Blank Declined to Answer No Yes
Members of ethnic minorities:	Blank Declined to Answer No Yes

If you do not wish to complete this questionnaire, click in the box:

US-2018-1-D13

SENATE
OPEN SESSION
Meeting of January 19, 2018

AGENDA ITEM: Emeritus status for retiring librarians

ACTION REQUIRED: For approval

SUMMARY: Senate is being asked to approve the awarding of the Emeritus status for retiring librarians.

BACKGROUND: Current practice for awarding emeritus status for all retiring professors is described in Resolution US-2001-3-D8 adopted on March 9, 2001 "*That the designation to be given to all faculty members retiring in good standing be that of 'Professor Emeritus*".

At Concordia, librarians are members of the academic staff and are appointed with ranks that parallel those of professors: assistant librarian, associate librarian, and senior librarian. Upon retirement, however, the status of Emeritus is not awarded to Concordia librarians even though they may continue to work on projects and research related to the University and serve on committees in a professional capacity.

Other universities, including the University of Toronto, McGill, Ryerson, Saskatchewan, Alberta, Berkeley, and University of Washington, confer emeritus status to librarians upon retirement.

Since Concordia librarians are members of the academic staff they should, upon retiring in good standing, be given the designation "Librarian Emeritus/Emeritae."

As it is for the case of faculty holding the Emeritus title, the designation will be honorific only and will not have any other privileges associated with it.

DRAFT MOTION:

That Senate approves the awarding to all librarians retiring from Concordia University in good standing a title testifying to the holder's professional relationship with the University; and

That the designation be [rank at the time of their retirement] Emeritus/Emeritae (ex: Senior Librarian Emeritus, Associate Librarian Emeritus).

PREPARED BY:

Names: Guylaine Beaudry and Danielle Tessier
Date: December 13, 2017