UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Academic Calendar

2021-2022

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Message from the Dean

Welcome to the 2021–2022 academic year!

As a member of our diverse, talented and vibrant student community, you are at the very centre of everything we do at U of T Engineering. Your contributions are what make us Canada’s premier engineering school and one of the world’s best. Our most important job is to empower you to achieve success and join the next generation of global engineering leaders.

In this calendar, you will find everything you need to know about the curriculum for each of our nine undergraduate programs, as well as information on scholarships, financial aid and other important policies and procedures. I encourage you to take full advantage of the student support resources provided through our First Year Office, departmental offices (for upper-year students), Dean’s Office and Registrar’s Office. We will keep you informed of our Faculty’s activities and events through our student newsletters, our “Coffee with Chris” open discussions, information sessions, digital displays and communications from the Engineering Society, your own student body representatives. Your input and suggestions are always welcome.

I hope you will also explore your own interests by getting involved in the many curricular and extracurricular opportunities available to you here — our wide range of minors and certificates, our award-winning student clubs and teams, and our suite of programs dedicated to leadership, entrepreneurship and professional development.

I wish you an exciting and fulfilling academic year, and look forward to seeing all that you will accomplish during your time here and in the future.

Chris Yip
Dean, Faculty of Applied Science & Engineering

Important Notices

The Undergraduate Academic Calendar of the Faculty of Applied Science and Engineering is now published online. In the case of any discrepancy, the online version shall apply. Any post-publication corrections and/or updates to the Undergraduate Academic Calendar will be posted in the Calendar's Publication Updates section. Students are strongly advised to check back regularly to keep informed of changes.

The University reserves the right to change, without notice, any information contained in this calendar, including any rule or regulation pertaining to the standards for admission, requirements for the continuation of study in or the requirements for the granting of degrees or diplomas in any or all of its programs. The publication of information in this calendar does not bind the University to the provision of courses, programs, schedules of studies or facilities as listed herein.

The University will not be liable for any interruption in, or cancellation of, any academic activities as set forth in this calendar and related information where such interruption is caused by fire, strike, lock-out, inability to procure materials or trades, restrictive laws or governmental regulations, actions taken by faculty, staff or students of the University or by others, civil unrest or disobedience, or any other cause of any kind beyond the reasonable control of the University.

The University is required to report student-level enrolment-related data to the Ministry of Advanced Education and Skills Development as a condition of its receipt of operating grant funding. The Ministry collects this enrolment data, which includes limited personal information such as Ontario Education Numbers, student characteristics and educational outcomes, in order to administer government postsecondary funding, policies and programs, including planning, evaluation and monitoring activities.

January 2021 Update:

Ontario’s response to the COVID-19 pandemic continues to evolve. Changes will likely occur as the province and its municipalities adjust to new data about the virus. In these circumstances, please be advised that the manner of delivery of courses, co-curricular opportunities, programs and services is subject to change, in accordance with university policies. The University thanks its students, faculty, and staff for their flexibility during these challenging times as we work together to maintain the standards of excellence that are the hallmark of the University.

Changes in Program of Study and/or Courses

The programs of study that the Calendar lists and describes are available for the year(s) for which the calendar applies. They may not necessarily be available in later years. If the University of Toronto or Faculty of Applied Science and Engineering has to change the content of programs of study or withdraw them, all reasonable possible advance notice and alternative instruction will be given. The University will not, however, be liable for any loss, damages or other expenses that such changes might cause.

For each program of study offered by the University through the Faculty, the courses necessary to complete the minimum requirements of the program will be made available annually. We must, however, reserve the right otherwise to change the content of courses, instructors and instructional assignments, enrolment limitations, pre-requisites and co-requisites, grading policies, requirements for promotion and timetables without prior notice.

Regulations and Policies

As members of the University of Toronto community, students assume certain responsibilities and are guaranteed certain rights and freedoms.

The University has several policies that are approved by the Governing Council and which apply to all students. Each student must become familiar with the policies. The University will assume that he or she has done so. The rules and regulations of the Faculty are listed in this calendar. In applying to the Faculty, the student assumes certain responsibilities to the University and the Faculty and, if admitted and registered, shall be subject to all rules, regulations and policies cited in the calendar.

All University policies can be found at www.governingcouncil.utoronto.ca/policies.htm.

Those which are of particular importance to students are:

- Policy on Access to Student Academic Records
- Code of Behaviour on Academic Matters
- Code of Student Conduct
- University Assessment and Grading Practices Policy
- Policy on Official Correspondence with Students

More information about students' rights and responsibilities can be found online: www.viceprovoststudents.utoronto.ca/publicationsandpolicies/rights-and-responsibilities.htm.

Enrolment Limitations

The University makes every reasonable effort to plan and control enrolment to ensure that all of our students are qualified to complete the programs to which they are admitted and strike a practical balance between enrolment and available instructional resources. Sometimes such a balance cannot be struck and the number of qualified students exceeds the instructional resources that we can reasonably make available while at the same time maintaining the quality of instruction. In such cases, we must reserve the right to limit enrolment in the programs, courses or sections listed in the Calendar, and to withdraw courses or sections for which enrolment or resources are insufficient. The University will not be liable for any loss, damages or other expenses that such limitations or withdrawals might cause.

Copyright in Instructional Settings

If a student wishes to tape-record, photograph, video-record or otherwise reproduce lecture presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited. In the case of private use by students with disabilities, the instructor's consent will not be unreasonably withheld.

Person I.D. (Student Number)

Each student at the University is assigned a unique identification number. The number is confidential. The University, through the Policy on Access to Student Academic Records, strictly controls access to Person ID numbers. The University assumes and expects that students will protect the confidentiality of their Person IDs.

Fees and Other Charges

The University reserves the right to alter the fees and other charges described in the Calendar.

Notice of Collection of Personal Information

Freedom of Information and Privacy Act

The University of Toronto respects your privacy.

Personal information that you provide to the University is collected pursuant to section 2(14) of the University of Toronto Act, 1971.

It is collected for the purpose of administering admissions, registration, academic programs, university-related student activities, activities of student societies, safety, financial assistance and awards, graduation and university advancement, and reporting to government.

In addition, the Ministry of Training, Colleges, and Universities has asked that we notify you of the following: The University of Toronto is required to disclose personal information such as Ontario Education Numbers, student characteristics and educational outcomes to the Minister of Training, Colleges and Universities under s. 15 of the Ministry of Training, Colleges and Universities Act, R.S.O. 1990, Chapter M.19, as amended. The ministry collects this data for purposes such as planning, allocating and administering public funding to colleges, universities and other post-secondary educational and training institutions and to conduct research and analysis, including longitudinal studies, and statistical activities conducted by or on behalf of the ministry for purposes that relate to post-secondary education and training. Further information on how the Minister of Training, Colleges and Universities uses this personal information is available on the ministry's website.

At all times it will be protected in accordance with the Freedom of Information and Protection of Privacy Act. If you have questions, please refer to www.utoronto.ca/privacy or contact the University Freedom of Information and Protection of Privacy Coordinator at McMurrich Building, room 104, 12 Queen's Park Crescent West, Toronto, ON, M5S 1A8.

Sessional Dates

Academic Year 2021-2022 Sessional Dates

SUMMER SESSION 2021

April 6	First day students can enrol in engineering elective courses in ACORN (6 a.m. EDT).
April 13	First day U of T Engineering students can enrol in Arts & Science courses in ACORN (6 a.m. EDT).
April 21	Last day students can pay or defer fees.
May 3	F and Y session U of T Engineering classes begin.
May 5	Courses removed for non-registered students.
May 6	Last day students can waitlist F-term engineering minor courses.
May 9	Last day students can enrol in F/Y engineering elective courses on ACORN. Last day students can enrol in first-year T-Program courses.
May 21	Presidential Day: University closed.
May 24	Victoria Day: University closed.
June 1	Last day students can drop F-term courses without academic penalty*. Requests to drop T-Program courses must be submitted to the First Year Office by 4 p.m. (EDT)
June 18	F-session U of T Engineering classes end. Y-session engineering elective courses course break.
June 21 to June 22	F-session course study break for U of T Engineering courses.
June 23 to June 30	Final exams for first-year U of T Engineering courses.
July 1	Canada Day: University closed.
July 2	U of T President's Day closure: University closed.
July 5	S classes start / Y courses resume.
July 7	Last day students can waitlist S-term engineering elective courses.
July 11	Deadline to enrol in S-term courses in ACORN.
July 19	Last day students can drop Y-term courses without academic penalty*.
August 2	Civic Holiday: University closed. Last day students can drop S-term courses without academic penalty*.
August 18	S- and Y-term U of T Engineering classes end.
August 19	S- and Y- term course study break for U of T Engineering courses.
August 20 to August 25	Final exams for S and Y term U of T Engineering courses.

Refund Dates:

The last date to cancel a course or cancel your registration in a session with no academic penalty may not always coincide with the last date that you are eligible for a refund. Review the refund schedules for applicable dates and deadlines: studentaccount.utoronto.ca .

St. George Arts & Science Courses

For Arts & Science Academic Dates & Deadlines, please visit www.artsci.utoronto.ca/current/dates-deadlines/academic-dates .

FALL SESSION (F) 2021

July 14	First day U of T Engineering students can make changes to their personal timetables on ACORN (6:00 a.m. EDT). First day U of T Engineering students can enrol in Arts & Science courses with reserved seating on ACORN (6:00 a.m. EDT).
August 4	First day U of T Engineering students can enrol in all Arts & Science courses on ACORN (6:00 a.m. EDT).
July 29 August 3 August 5	No Arts & Science course enrolment.
August 19	Last day to pay or defer fees.
September 2	Courses removed for non-registered students.
September 6	Labour Day: University closed. Orientation programs for first-year students begin.
September 9	U of T Engineering lectures in F- and Y-term courses begin. Arts & Science lectures in F- and Y-term courses begin.
September 10	ESIP and PEY Co-op registration begins (www.engineeringcareers.utoronto.ca).
September 17	Last day waitlists are operational for F- and Y- term courses. Last day students can request transfers out of Engineering Science (first-year students).
September 21	Last day students can register for PEY Co-op or ESIP.
September 22	Last day U of T Engineering students can enrol in Arts & Science courses with reserved seating. Last day students can add or substitute F- or Y-term courses on ACORN.
September 23 to September 28	Late enrolment for Y-term courses only (Registrar's Office only).
September 29	Last day students can apply to re-enrol for the 2022 Winter Term.
October 11	Thanksgiving Day: University closed.
October 29	Examination timetable for F-term courses posted (tentative).
November 8	Last day students can apply to transfer to part-time studies.* Last day students can withdraw from the Fall Term without academic penalty.* Last day students can drop F-term engineering courses without academic penalty.* Last day students can drop F-term Arts & Science courses without academic penalty.*
November 8 to November 12	Engineering Fall Study Break. No Fall Engineering courses offered. Arts & Science Fall Reading Week. No Fall Term Arts & Science courses offered.
November	Fall Convocation ceremony for the conferring of the Bachelor of Applied Science & Engineering Science degrees. Visit www.convocation.utoronto.ca for more details.
December 8	Last day of lectures in the F-term; all term work should be submitted by this date. Last day of A & S classes.
December 9	Fall study day.
December 9	Makeup Monday. ***
December 10 to December 21	F-term U of T Engineering exams (the Faculty will hold exams on Saturdays, Sundays and evenings during this period). Exams for courses offered by other Faculties may be held during other periods.
December 10 to December 22	F-term A & S exams and Y-term A & S midterms.
December 22 to January 3	Winter break: University closed.
January 8	Emergency Winter Exam Date. The Faculty will use this date for any cancelled December Exams.

***Makeup Monday is on the day before the final exams start this year and will be scheduled the same as a regular Monday. Thus, instructors can use this day to make up for the missing Monday of Thanksgiving Day. Use of Makeup Monday in courses is optional. If it is not used, Dec 9 will be a study day. This overlap with Exam Study Day will be for the 2021 Fall Term only.

WINTER SESSION (S) 2022

January 10	Lectures begin in S-term courses and resume in Y-term courses for A & S. Lectures begin in U of T Engineering S-term courses and resume in Y courses.
January 5	ESIP and PEY Co-op registration begins.
January 13	Last day students can waitlist S-term courses.
January 17	Last day students can transfer out of Engineering Science (first-year students) to Track One or a Core 8 engineering program.
January 17	Lectures begin for T-program courses.
January 19	Last day students can register for PEY Co-op and ESIP.
January 23	Last day students can add or substitute S-term courses.
February 21	Last day students can drop Y-term courses without academic penalty.* Note: a student taking a Y-term course will not be allowed to drop this course in the Winter Term if a recalculation of their Fall Term load shows that dropping the course will reduce the F-term course load to fewer than 2.5 credits.
February 21	Family Day holiday: University closed.
February 21 to February 25	Reading Week: No lectures, tutorials or practicals.
March 1	Examination timetable for S- and Y-term courses posted (tentative).
March 14	Last day students can drop S-term courses without academic penalty, including S-term courses taken in Arts & Science. * Last day students can transfer to part-time studies. * Last day students can withdraw from S-term without academic penalty.* Last day students can apply to re-enrol for the 2022 Fall Term.*
April 8	End of classes for Arts & Science S- and Y-term courses.
April 11 to April 29	S- and Y-term exam period for A & S courses.
April 14	Last day of U of T Engineering lectures in S- and Y-term courses; all term work should be submitted by this date.
April 15	Good Friday holiday: University closed.
April 18	Winter study day. Exam Jam.
April 19 to April 30	S- and Y- term exams. Note: Exams for courses offered by other faculties may be held outside of this period.
May 1	Winter emergency exam day.
May 15	Application deadline for transfers between engineering programs.

Academic Year 2020-2021 Sessional Dates

SUMMER SESSION (F/S) 2020

Engineering Courses

April 7	First day students can enrol in engineering elective courses in ACORN (6 a.m.).
April 24	Last day students can pay or defer fees.
May 4	F-term engineering elective courses begin.
May 4	First-year T-Program courses begin.
May 6	Courses removed for non-registered students.
May 7	Last day students can waitlist F-term engineering minor courses.
May 10	Last day students can enrol in F/Y engineering elective courses on ACORN Last day students can enrol in first-year T-Program courses.
May 18	Victoria Day holiday: University closed.
June 1	Last day students can drop F-term courses (T-Program / F-term Engineering Minor) without academic penalty*. Requests to drop T-Program courses must be submitted to the First Year Office (GB170) by 4 p.m.
June 19	F-term engineering elective classes end. First-year T-Program classes end. Y-term engineering elective courses course break.
June 22 to June 26	Final examinations for F-term engineering elective and T-Program courses.
June 29	Presidential Day
June 30	Presidential Day
July 1	Canada Day: University closed.
July 6	S-term engineering elective courses begin. Y-term engineering elective courses resume.
July 8	Last day students can waitlist S-term engineering elective courses.
July 12	Deadline to enrol in S-term courses in ACORN.
July 20	Last day students can drop Y courses without academic penalty.*
August 3	Last day students can drop S-term courses without academic penalty*. Civic holiday: University closed.
August 19	S- and Y-term engineering elective classes end.
August 21 to August 27	Final examination period for S- and Y-term engineering elective courses.

Refund Dates:

The last date to cancel a course or cancel your registration in a session with no academic penalty may not always coincide with the last date that you are eligible for a refund. Review the refund schedules for applicable dates and deadlines: studentaccount.utoronto.ca/

St. George Arts & Science Courses

April 14	First day engineering students can enrol in Arts & Science summer courses (6 a.m.).
April 22	Last day students can pay or defer fees.
May 4	Classes begin in F- and Y-term courses.
May 6	Courses removed for non-registered students.
May 7	Last day F- and Y-term waitlists are available.
May 10	Deadline to enrol in F- and Y-term courses on ACORN.
May 11 to May 15	Late enrolment into Y courses (Registrar's Office only).
May 18	Victoria Day: University closed.
June 1	Last day to drop F-term courses without academic penalty*.

June 15	Classes end for F-term courses.
June 17 to June 25	Final examinations for F-term courses. Break for Y-term courses.
June 29	Presidential Day
June 30	Presidential Day
July 1	Canada Day: University closed.
July 6	Classes begin for S-term courses; Y courses resume.
July 8	Last day students can waitlist S-term courses.
July 12	Deadline to enrol in S-term courses in SWS.
July 20	Last day students can drop Y-term courses without academic penalty*.
August 3	Last day students can drop S-term courses without academic penalty*.
August 3	Civic Holiday: University closed.
August 17	Classes end for S- and Y-term courses.
August 19 to August 22	Final examinations for S- and Y- courses.

(*) REFUND DATES

The last date to cancel a course or cancel your registration in a session with no academic penalty may not always coincide with the last date that you are eligible for a refund. Review the refund schedules for applicable dates and deadlines: studentaccount.utoronto.ca/ .

FALL SESSION (F) 2020

July 15	First day U of T Engineering students can make changes to their personal timetables on ACORN (6:00 a.m.).
July 15	First day U of T Engineering students can add Arts & Science (A&S) courses with reserved seating on ACORN (6:00 a.m.).
August 5	First day U of T Engineering students can enrol in all Arts & Science (A&S) courses on ACORN (6:00 a.m.).
July 30 August 4 August 6	No Arts & Science course enrolment.
August 20	Last day to pay or defer fees.
September 3	Courses removed for non-registered students.
September 7	Labour Day: University closed.
September 7	Orientation programs for first-year students begin.
September 10*	Engineering lectures in F- and Y-term courses begin.
September 10	Arts & Science lectures in F- and Y-term courses begin.
September 11	ESIP and PEY Co-op registration begins (www.engineeringcareers.utoronto.ca).
September 18	Last day waitlists are operational for F- and Y-term courses.
September 18	Last day students can request transfers out of Engineering Science (first-year students).
September 22	Last day students can register for PEY Co-op or ESIP.
September 23	Last day U of T engineering students can enrol in A&S courses with reserved seating.
September 23	Last day students can add or substitute F- or Y-term courses on ACORN.
September 24 to September 30	Late enrolment for Y-term courses only (Registrar's Office only).
September 30	Last day students can apply to re-enrol for the 2021 Winter Term.
October 12	Thanksgiving Day: University closed.
October 30	Examination timetable for F-term courses posted (tentative).
November 9	Last day students can apply to transfer to part-time studies. Last day students can withdraw from the Fall Term without academic penalty*.

	Last day students can drop F-term Engineering courses without academic penalty. Last day students can drop F-term Arts & Science courses without academic penalty.
November 9 to November 13	Engineering Fall Study Break. No Fall Engineering courses offered. Arts & Science Fall Reading Week. No Fall Term Arts & Science courses offered.
November	Fall Convocation ceremony for the conferring of the Bachelor of Applied Science & Engineering Science degrees. Visit www.convocation.utoronto.ca for details.
December 9	Last day of lectures in the F-term; all term work should be submitted by this date. Last day of A & S classes.
December 10	Fall study day.
December 11 to December 22	F-term U of T Engineering exams (the Faculty will hold exams on Saturdays, Sundays and evenings during this period). Exams for courses offered by other Faculties may be held during other periods.
December 11 to December 22	F-term A & S exams and Y-term A & S midterms.
December 23 to January 3	Winter break: University closed.
January 9	Emergency Winter Exam Date. The Faculty will use this date for any cancelled December Exams
January 15†	Last day students can late withdraw (LWD) from courses without documentation. For more information on the extended LWD deadline for the Fall term, visit the Engineering Undergraduate 20201 Fall Term & 2021 Winter Term FAQs.

(*) **Refund Dates:**

The last date to cancel a course or cancel your registration in a session with no academic penalty may not always coincide with the last date that you are eligible for a refund. Review the refund schedules for applicable dates and deadlines at studentaccount.utoronto.ca/ .

WINTER SESSION (S) 2021

January 6	ESIP and PEY Co-op registration begins.
January 11	Lectures begin in S-term courses and resume in Y-term courses for A & S.
January 11	Lectures begin in U of T Engineering S-term courses and resume in Y courses.
January 18	Last day students can transfer out of Engineering Science (first-year students) to Track One (General First Year) or a Core 8 engineering program.
January 18	Lectures begin for T-Program courses.
January 20	Last day students can register for PEY Co-op and ESIP.
January 21	Last day students can waitlist S-term courses.
January 24	Last day students can add or substitute S-term courses.
February 15	Family Day holiday: University closed.
February 15 to February 19	Reading Week: No lectures, tutorials or practicals.
February 22	Last day students can drop Y (full-year) courses without academic penalty*. Note: A student taking a full-year core course will not be allowed to drop this course in the Winter Term if a recalculation of their Fall Term load shows that dropping the course will reduce the F-term course load to fewer than 2.5 credits.
March 8	Examination timetable for S- and Y-term courses posted (tentative).
March 15	Last day students can drop S-term courses without academic penalty, including S-term courses taken in A & S. Last day students can transfer to part-time studies. Last day students can withdraw from S-term without academic penalty*. Last day students can apply to re-enrol for the 2021 Fall term.
April 1	End of classes for A&S S- and Y-term courses. Last day students can apply for late withdrawal without documentation (LWD) from A & S electives.
April 2	Good Friday holiday: University closed.
April 5	Make-up day for FAS courses

April 13 to April 23	S- and Y-term exam period for A & S courses.
April 16	Last day of U of T Engineering lectures in S- and Y-term courses; all term work should be submitted by this date. Last day students can apply for late withdrawal without documentation (LWD) from electives for U of T Engineering courses.
April 17 to April 19	Winter study days. Exam Jam.
April 20 to April 30	S- and Y- term exams. Note: Exams for courses offered by other faculties may be held outside of this period.
May 14†	Last day students can late withdraw (LWD) from courses without documentation. For more information on the extended LWD deadline for the Winter term, visit the Engineering Undergraduate 20201 Fall Term & 2021 Winter Term FAQs.
May 15	Application deadline for transfers between engineering programs.

*** Refund Dates:**

The last date to cancel a course or cancel your registration in a term with no academic penalty may not always coincide with the last date that you are eligible for a refund. Review the refund schedule for applicable dates and deadlines: studentaccount.utoronto.ca/ .

† Some dates and deadlines have been moved. The Sessional Dates have been updated to reflect these changes. For more information please review the November 20, 2020, Dean's Message: www.engineering.utoronto.ca/extending-the-winter-break-for-students/ .

Overview of the Faculty

The Faculty of Applied Science & Engineering

Administrative Officers

Office of The Dean
Dean: Chris Yip, BASc, PhD, FEIC, FAAAS, PEng
Vice-Dean, Undergraduate: Thomas W. Coyle, BSc, BA, ScD
Vice-Dean, Graduate Studies: Julie Audet, BSc, MSc, PhD
Vice-Dean, Research: Ramin Farnood, BASc, MASc, PhD
Vice-Dean, First Year Engineering: TBA
Associate Dean, Cross-Disciplinary Programs: Bryan W. Karney, BASc, MEng, PhD, FAAAS, PEng
Director, Office of the Dean: Cathy Grilo
Assistant Dean, Administration: Lisa Simpson-Camilleri, BA

Office of the Registrar
Faculty Registrar: Don MacMillan, BA, MEd
Associate Registrar, Director of Admissions: Helen Bright, BA (Hon), MISt
Associate Registrar, Student Services & Records: Khuong Doan, BSc
Associate Registrar, Information Systems: Dan Pettigrew, BASc
Assistant Registrar, Academic Scheduling & Senior Business Analyst: Chris Brown, BA
Assistant Registrar, Scholarships & Financial Aid: Pierina Filippone

Engineering Computing Facilities
Director: Phil Poulos, BSc, MSc

Engineering Career Centre
Director: Roger Francis, BA, MA
Director, Student Development & Career Programming: Estelle Oliva-Fisher, MEd
Assistant Director: Chioma Ekpo, MA (On secondment)

Advancement Office
Director, Alumni Relations: Sonia De Buglio, BASc, MASc

An Overview

Founded in 1873, the Faculty of Applied Science and Engineering community includes 5,280 undergraduate students, 2,636 graduate students, 266 professors, 361 staff and more than 50,000 alumni worldwide.

Our graduates have pursued careers in all engineering fields throughout Canada and the world. They contribute towards resource industries, manufacturing, transportation, communications, as well as law, finance and health care systems. Skule™ alumni are employed by governments, private enterprise and throughout our educational system. Many have become leaders in major corporations, businesses and develop new companies as technological entrepreneurs.

Programs Of Study

The Faculty offers a wide range of undergraduate and post-graduate studies in engineering. Students will qualify for the Bachelor of Applied Science degree (BASc) in any one of the following programs:

- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical Engineering
- Industrial Engineering
- Materials Engineering
- Mechanical Engineering
- Lassonde Mineral Engineering

Students enrolled in Engineering Science will qualify for the Bachelor of Applied Science in Engineering Science (BASc in Engineering Science) in one of the following majors:

- Aerospace Engineering
- Biomedical Systems Engineering
- Electrical & Computer Engineering
- Energy Systems Engineering
- Infrastructure Engineering (no longer available to new students)
- Engineering Mathematics, Statistics & Finance
- Engineering Physics
- Machine Intelligence
- Robotics Engineering

Curricula for all programs of study are set out in detail in the Curriculum and Programs section of this calendar.

Faculty Structure

Most of Engineering's undergraduate students' teaching is provided by 266 professors across the Faculty's five departments and two institutes: the departments of Chemical Engineering & Applied Chemistry, Civil & Mineral Engineering, Electrical & Computer Engineering, Mechanical & Industrial Engineering, Materials Science & Engineering, University of Toronto Institute for Aerospace Studies and Institute of Biomedical Engineering.

The Faculty is fortunate to be part of a great University that provides access to a vast range of resources. The departments of Computer Science, English, Earth Sciences, Mathematics, Music, Philosophy and Physics — all in the Faculty of Arts & Science — make important contributions to the Engineering curriculum.

The Engineering Alumni Association, which all graduates belong to, supports the ongoing work of the Faculty, and, through representative membership on the Faculty Council, participates in governance. The buildings of the Faculty are located primarily at the south end of the University's St. George campus.

The Faculty's decanal offices are located in the Bahen Centre for Information Technology, University of Toronto, 44 St. George Street. Students seeking information about any aspect of study in the Faculty are encouraged to contact the Office of the Registrar.

Engineering Society

Every Engineering undergraduate is a member of the Engineering Society. Founded in 1885, the Society is the oldest formal Engineering organization in Canada. Together with its constituent "course clubs" (one for each program), the Society plans and operates many student activities and services. It is the focal point for the traditional Skule™ spirit that exists among Engineering students — the envy of other groups in the University. This sense of spirit and community continues throughout our graduates' professional careers. The Society operates the Engineering stores where students purchase most of their school supplies and instruments; additionally, it deals with matters of policy relating to student academic affairs and has representation on Faculty Council and its Standing Committees.

Engineering Computing Facility

The Engineering Computing Facility (ECF) provides a variety of computing services for teaching, learning and research within the Faculty, as well as offering support for departmental computers and computer communication throughout the Faculty. ECF has networks of distributed computing systems accessible from hundreds of terminals. Every undergraduate in the Faculty is entitled to an ECF account. The intention is to have the computing system used as often as the student requires it in their studies, just as one might use a library or other communal resource. Normally, students access their ECF accounts through terminals on campus.

There are two major components to ECF: general Linux and Windows environments. The general purpose Linux machines consist of 185 PCs that run Linux. All of these systems are interconnected with Ethernet and share files (using NFS). They are also connected to the campus backbone network, and thereby, to the Internet. This provides students with electronic mail and electronic file transfer capabilities, as well as access to remote sites such as supercomputer facilities.

The ECF Windows environment is composed of 183 PCs for CAD and general applications that run Windows 10. The ECF Windows servers also support labs in Civil, Lassonde Mineral, Mechanical & Industrial, Chemical, Materials Science, Engineering Science, Electrical & Computer Engineering and Aerospace. ECF also maintains Linux and Windows multiprocessor machines as well as a bank of remote access Windows workstations giving students the ability to work remotely.

Coordinated Bachelor/Master's Program

Students who intend to continue their studies to a Master’s degree after completion of the BASc program may pursue the Coordinated Bachelor/Master’s Program in the fourth year of the undergraduate curriculum. Departmental approval is required.

After completion of the BASc degree, and upon acceptance by the School of Graduate Studies, a student can extend the topic of their coordinated program thesis to a Master’s thesis, which is normally under the supervision of the same thesis advisor. This program permits a significant reduction in the time it would typically take a student to complete their Master’s degree requirements.

A student who wishes to enrol in a coordinated program thesis should consult the departmental graduate coordinators about the academic requirements for the MASc or MEng degrees and obtain approval from their thesis topic from the BASc Thesis Coordinator. The Thesis Coordinator will require assurance that the BASc thesis project provides a suitable preparation for the proposed MASc thesis or MEng project and that satisfactory arrangements have been made for supervision of both the coordinated program thesis and the proposed Master’s program.

Graduate Study And Research

Beyond the undergraduate level, the Faculty has a strong commitment to graduate studies and research. Our graduate students work in an environment where innovation thrives and they play a vital role in ground-breaking research.

The Faculty offers the following degrees at the graduate level:

- Master of Engineering (MEng): Professional degree in engineering with a number of emphasis options, including ELITE (Entrepreneurship, Leadership, Innovation & Technology in Engineering), Analytics, Advanced Soft Materials, Biomanufacturing, Robotics, Sustainable Energy, Advanced Manufacturing, Sustainable Aviation, Forensic Engineering, Identity, Privacy & Security, Aerial Robotics, Engineering & Globalization and Advanced Water Technologies.
- The Master of Engineering (MEng) in Biomedical Engineering focuses on the design and commercialization of biomedical devices.
- Master of Engineering in Cities Engineering & Management (MEng C.E.M)

- Master of Applied Science (MASc): Traditional, full-time, research-intensive master's degree.
- Master of Health Science in Clinical Engineering (MHSc): Combines the fields of engineering, life sciences, medicine and clinical application.
- Doctor of Philosophy (PhD): Highest degree in engineering

For further information, visit gradstudies.engineering.utoronto.ca.

Special Students

An individual who wishes to enrol as a special student or non-degree (not proceeding to a degree) should consult the Engineering Undergraduate Admissions Office at 416-978-0120 regarding admission requirements and the procedure for application.

The deadlines for submitting applications are as follows:

*Summer Session — April 1
*Fall Session — August 1
*Winter Session — December 1

Fees must be paid by the deadline listed in the Calendar. Failure to pay by this date will result in the cancellation of registration.

Undergraduate Enrolment as of November 1, 2019

Program	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Total**
Full-Time Enrolment					
Chemical Engineering	120	110	104	166	500
Civil Engineering	92	90	103	166	451
Computer Engineering	128	193	179	365	865
Electrical Engineering	295	203	182	312	992
Engineering Science	295	203	182	312	992
Industrial Engineering	68	121	119	183	491
Lassonde Mineral Engineering	33	8	11	18	70
Materials Engineering	61	38	41	59	199
Mechanical Engineering	127	186	167	312	792
Track One (General Engineering)	233	NA	NA	NA	233
Total: Full-time	**1225**	**1071**	**1038**	**1789**	**5123**
Part-Time Enrolment					
Chemical Engineering	5	7	0	1	13
Civil Engineering	3	2	6	7	18
Computer Engineering	8	6	3	14	31
Electrical Engineering	1	8	2	10	21
Engineering Science	1	2	2	15	20
Industrial Engineering	5	6	3	6	20
Lassonde Mineral Engineering	4	1	1	1	7
Materials Engineering	0	3	1	5	9
Mechanical Engineering	5	4	8	6	23

Track One (General Engineering)	6	NA	NA	NA	6
Total: Part-time	**38**	**39**	**26**	**65**	**168**
Program	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Total**
International Foundation Program					**42**
Professional Experience Year Co-op					**717**
Total Undergraduates	**1263**	**1110**	**1064**	**1854**	**5291**

Academic Staff of the Faculty

Aerospace Science & Engineering

Director
C. J. Damaren, BASc, MASc, PhD, FCASI, AFAIAA, PEng. J. Armand Bombardier Foundation Chair in Aerospace Flight

Professor & Associate Director
P. Lavoie, BSc (Queen's), MSc (Queen's), PhD (Newcastle), AFAIAA, PEng, Percy Edward Hart Professor in Aerospace Engineering

Associate Professor & Associate Director
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Associate Professor & Undergraduate Coordinator
P. R. Grant, BASc (Manitoba), MASc, PhD, PEng

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L. D. Reid, BASc, MASc, PhD, FCASI, FAIAA, PEng
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P. A. Sullivan, BE (NSW), ME (NSW), DIC, PhD (London), FCASI, PEng
R. C. Tennyson, BASc, MASc, PhD, FCASI, PEng

Titled Professors
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P. B. Nair, B. Tech. (IIT Bombay), MTech (IIT Bombay), PhD (Southhampton) Tier II Canada Research Chair in Computational Modeling & Design Optimization Under Uncertainty
D. W. Zingg, BASc, MASc, PhD, FCASI, AFAIAA, FCAE, PEng, U of T Distinguished Professor of Computational Aerodynamics & Sustainable Aviation

Titled Associate Professor
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Professors
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S. L. Waslander, BScE(Queen's), MS (Stanford), PhD (Stanford)

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J. W. Davis, BASc, MASc, PhD, PEng
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Associate Professor & Director, Space Flight Laboratory
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A. P. Schoellig, MSc (Georgia Tech), Dipl. in Eng. (Stuttgart), PhD (ETH Zürich)
M. Yano, BS (Georgia Tech), SM (MIT), PhD (MIT)

Assistant Professor, Status Only
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K. A. Carroll, BASc, MASc, PhD
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C. Ower, BASc, MASc, PhD (Carleton)
C. Sallaberger, BASc (Waterloo), MSc (Berkley), PhD

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C.A. Simmons, BSc (Guelph), SM (MIT), PhD (Toronto), PEng, MIE, Dentistry, Canada Research Chair in Mechanobiology

Chemical Engineering & Applied Chemistry

Professor & Chair of the Department of Chemical Engineering & Applied Chemistry
D. G. Allen, BASc, MASc (Toronto), PhD (Waterloo), PEng

Professor, Associate Chair & Graduate Coordinator
R. Mahadevan, BTech (Indian Institute of Technology), PhD (Delaware)

Associate Professor, Associate Chair & Undergraduate Coordinator
T. P. Bender, BSc, PhD (Ottawa), MCIC, MACS

Associate Professor & Associate Chair, Research
M. Radisic, BEng, PhD (MIT), Post-doc Harvard-MIT

Professors Emeriti
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D. Barham, BScEng, DIC, ARSM, PhD (London)
D. G. B. Boocock, BSc, ARCS, CIC, PhD (London), DIC
W. H. Burgess, BChE, MFS, PhD (Cornell), PEng
C. E. Chaffey, BSc, PhD (McGill), PEng, CChem
M. E. Charles, BSc (London), MSc, PhD (Alberta), FCIC, FCAE, PEng
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R. E. Jervis, BA, MA, PhD (Toronto), FRSC, FCIC, FCNS, FCSCA, FIAFS, PEng

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Professors
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J. Farmer, PhD (York University)
N. DeMartini, PhD
E. Bobicki, PhD (Alberta)
A. Chan, PhD (Queen’s), PEng

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W. C. W. Chan, BSc (Illinois), PhD (Indiana), BME
C-W. Chow, MD (Toronto), PhD (Toronto)
B. Cox, BA, PhD (Cambridge), Department of Materials Science & Engineering
J. E. Davies, BSc, PhD, DDS, BME (Professor)
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A. Yazdani, BSc, (Sharif University of Technology, Tehran), MSc (Tehran), PhD (Toronto)
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Robert Irish, BA (Waterloo), MA (Dalhousie), PhD (Toronto)
Ken Tallman, BA (NYU), MA (Toronto), PhD (Toronto)
Peter Eliot Weiss, BA (UBC), MFA (UBC), PhD (Toronto)

Engineering Science

Professor & Interim Chair
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Professors & Associate Chairs
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D. Kilkenny, BSc (Western), PhD (Western), Associate Professor, Teaching Stream, BME
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A. McLean, BSc, PhD (Glasgow), ARCST, FCIM, FIBF, FIREFE, CEng., PEng
T. H. North, BSc, MSc, PhD (Strathclyde), PEng
R. M. Pilliar, BASc, PhD (Leeds), PEng (Cross-appointed to Dentistry)
I. D. Sommerville, BSc, PhD (Strathclyde), ARCST
Z. Wang, BEng (Jiao-Tong), MSc, PhD (Polytechnic Institute of NYU)

Titled Professors
D. D. Perovic, BASc, MASc, PhD, FCAE, PEng, Celestica Chair in Materials for Microelectronics
H. E. Ruda, BSc (London), ARSM, PhD (MIT), FRSC, Stan L. Meek Chair in Advanced Nanotechnology

Professors
M. Barati, BSc, MSc (Isfahan), PhD (McMaster), PEng, Gerald R. Hefferan Chair in Materials Processing
U. Erb, DIPL Ing, Dr.rer.nat (Saarland)
G. Hibbard, BSc (Alberta), PhD, PEng
N. P. Kherani, BASc, MASc, PhD, PEng
K. K. Lian, BASc, MASc, PhD
Z. H. Lu, BSc (China), MSc, PhD, CRC Chair in Organic Optoelectronics
H. Naguib, BSc (Alexandria), MEng (Academy of Science & Technology, Egypt), PhD, FCMSE, FIMMM, CRC Chair in Smart & Functional Materials PEng
S. J. Thorpe, BASc, MASc, PhD

Associate Professors
G. Azimi, BASc, MASc (Sharif), PhD, PEng
K. Chattopadhyay, BEng (Jadavpur), MEng, PhD (McGill), PEng
T. W. Coyle, BSc, BA (ALFRED), ScD (MIT)
B.D. Hatton, BScE (Queen's), MScE (McMaster), PhD
J. Howe, BASc, (Changsha Institute of Technology), MASc (Alfred University), PhD (Alfred University)
N. Matsuura, BSc, MSc (Queen's), PhD, Medical Imaging
E. D. Sone, BSc, MS, PhD (Northwestern)
C. V. Singh, BSc (Dayalbagh), MTech (IIS), PhD (Texas A & M), Associate Chair, Research

Assistant Professors
E. Bobicki, BASc, (UBC / UNBC), PhD, (Alberta), PEng (Alberta)
Y. Zou, BEng (Beihang) (Beijing Univ. of Aero & Astro), M.Eng. (McGill University), Dr.Sc. (ETH Zurich), Postdoc (MIT)

Cross-Appointed Academic Staff
T. P. Bender, BSc, PhD (Carleton), MCIC, MACS,ChemE
W. C. Chan, BSc (Illinois-UC), PhD (Indiana), BME
C. Goh, BS (Philippines), PhD (California), Chemistry
M. D. Grynpas, MSc (Licence, Brussels), PhD (London), Laboratory Medicine & Pathology
R. A. Kandel, MD, Laboratory Medicine & Pathology
O. Kesler, BSE (Penn), SM (MIT), ScD (MIT), MIE
D. W. Kirk, BASc, MASc, PhD, PEng, ChemE
M. T. Kortschot, BASc., MASc, PhD (CANTAB), PEng, ChemE
C-G. Lee, BS (Seoul National University), MS (KAIST), PhD (Michigan), MIE
N. Matsuura, BSc, MSc (Queen's), PhD, Medical Imaging
J. Mostaghimi, BSc (Sharif), MSc, PhD (Minnesota), PEng, FASME, MIE
R. C. Newman, BA (Cambridge), PhD (Cambridge), DSc (Manchester), ChemE

W.T. Ng, BASc, MASc, PhD, PEng, ECE
G. A. Ozin, BSc, DPhil, FRSC, FCIC, University Professor, Chemistry
V. G. Papangelakis, Dipl Eng (Athens), MEng, PhD (McGill), PEng, ChemE
E. H. Sargent, BSc Eng (Queen's), PhD, PEng, ECE
J. K. Spelt, BASc, MASc, ME (Caltech), PhD, PEng, MIE

Adjunct/Special Lecturers
J. D. Young, BA Sc, MASc (U of T), PEng

Adjunct & Status-Only Professors
K. Coley, BSc, PhD PEng
S. Das Gupta, BSc (Calcutta), MSc, Phd, DIC (London), Adjunct Associate Professor
V. I. Lakshmanan, PhD, MIMM., FCIM, Adjunct Professor
S. Marcuson, BS, MS, Eng Sc D
G. Palumbo, BASc, MASc, PhD, Adjunct Professor
C. Ravindran, BSc, BEng, MSc, PhD, Adjunct Professor
R. Sridhar, PhD, DIC, Adjunct Professor

Associate Professor, Teaching Stream
S. Ramsay, MSc (Toronto), PhD (Toronto)

Mechanical & Industrial Engineering

Professor & Chair, Department Of Mechanical & Industrial Engineering
M. Bussmann, BASc (WAT), MASc (WAT), PhD (Toronto), PEng, FCSM

Professor & Associate Chair (Graduate Studies)
M. J. Thomson, BEng (McGill), MSc (Berkeley), PhD (Berkeley)

Associate Professor & Associate Chair (Undergraduate Studies)
Matthew Mackay, BASc (Queen's), PhD (Toronto)

Professor & Associate Chair, Research
B. Donmez, BS (Bogazici), MS (Iowa), PhD (Iowa)

Professors Emeriti
W. D. Baines, BSc (Alberta), MS, PhD (Iowa), PEng
W. L. Cleghorn, BASc (Toronto), MASc (Toronto), PhD (Toronto), FCSME, PEng
I. G. Currie, BSc (Strathclyde), MASc (UBC), PhD (Caltech), FCSME, PEng
R. G. Fenton, DIPL Ing (Bud.), PhD (NSW), PEng
A. A. Goldenberg, BSc, MSc (Technion), PhD (Toronto), CEng, FIEEE, FASME
F. C. Hooper, BASc, DIC, FEIC, PEng
D. F. James, BSc (QU), MS (Caltech), PhD (Caltech), MA (CANTAB), PEng
A. K. S. Jardine, BSc, MSc (Strathclyde), PhD (Birmingham), CEng, MI Mech E, MIEE, PEng
J. F. Keffer, BASc, MASc, PhD, PEng
D. McCammond, BSc(QU Belfast), PhD (QU Belfast), FCSME, PEng
A. W. Neumann, BA, DR RER NAT (Mainz) Northrup Frye Scholar
J. C. Paradi, BASc, MASc, PhD, PEng (SSHRC/NSERC Industrial Research Chair in the Management of Technological Change), ChemE
M. J. M. Posner, BASc, PhD, PEng
J. S. Rogers, BSc (Dalhousie), MS (Stanford), PhD (Stanford), PEng
J. W. Senders, AB (Harvard), PhD (Tilburg)
I. B. Turksen, BS (Pittsburg), MS (Pittsburg), PhD (Pittsburg), PEng
J. Van de Vegte, DIPL Ing (Delft), MASc, PhD, PEng
R. D. Venter, BSc (Rand.), MEng (MCM), PhD (MCM), PEng
C.A. Ward, BSc (Texas), PhD (Northwestern), PEng

Titled Professors
M. S. Fox, B.Sc., PhD (Carnegie-Mellon), FAAAI NSERC, Industrial Research Chair In Enterprise Integration

J. Mostaghimi, BSc (Sharif), MSc (Minnesota), PhD (Minnesota), PEng, FASME, Canada Research Chair in Advanced Coatings
H. E. Naguib, BSc (Alexandria), MEng (Academy of Science & Technology, Egypt), PhD (Toronto), PEng, Canada Research Chair of Smart & Functional Polymers
C. B. Park, BS (Seoul National University), MS (KAIST), PhD (MIT), PEng, FCSME, Canada Research Chair in Advanced Polymer Processing Technologies
C. A. Simmons, BSc Eng (Guelph), SM (MIT), PhD (Toronto), PEng, Canada Research Chair of Mechanobiology

Professors
C. Amon, Licenciatura (Simon Bolivor) MS (MIT), ScD (MIT), FAAAS, FASEE, FASME, FIEEE, PE(VA), NAE
N. Ashgriz, BS (Carnegie-Mellon), MS (Carnegie-Mellon), PhD (Carnegie-Mellon), PEng
A. Bazylak, BE(Saskatchewan), MASc (Victoria), PhD (Victoria), PEng
C. Beck, PhD (Toronto)
K. Behdinan, BEng (KN TOOSI), MASc (SHARIF), PhD (UVIC), PEng
B. Benhabib, BSc (Bogazici), MSc (Technion), PhD (Toronto), PEng
R. Ben Mrad, PhD (Michigan)
M. Bussmann, BASc (WAT), MASc (WAT), PhD (Toronto), PEng, FCSM
M. W. Carter, BMath (WAT), MMath (WAT), PhD (WAT)
T. Chan, BSc (UBC), PhD (MIT)
S. Chandra, BTech (Indian Institute of Technology, Kanpur), MS (Vanderbilt), PhD (Cornell)
M. H. Chignell, BS (Canter), MS (Ohio), PhD (Canter)
G.A. Jamieson, BS (Illinois), MASc (Toronto), PhD (Toronto), PEng
O. Kesler, BSE (Penn), SM (MIT), ScD (MIT), Canada Research Chair of Fuel Cell Materials & Manufacturing
C. Lee, PhD (Michigan)
V. Makis, MSc, PhD (Prague)
A. Mandelis, BS (Yale), MA (Princeton), MSc (Princeton), PhD (Princeton), FAPS
S. McCahan, BS (Cornell), MS (RPI), PhD (RPI), PEng
S. A. Meguid, BME (Cairo), MSc (Cairo), PhD (Manchester), PEng, CEng, FIMechE, MASME, MAIAA
P. Milgram, BASc, MSEE (Technion), PhD, PEng
J. K. Mills, BSc (MAN), MASc (Toronto), PhD (Toronto), PEng
J. Mostaghimi, BSc (Sharif), MSc (Minnesota), PhD (Minnesota)
G. Nejat, BASc (Toronto), PhD (Toronto), PEng
M. Sain, PhD, Dr.hc, FRSC (UK), FCAE, PEng
L. H. Shu, BS (Nevada), SM (MIT), PhD (MIT)
A. N. Sinclair, BASc (Toronto), MSE (Michigan), PhD (Michigan), PEng
D. A. Sinton, BASc (Toronto), MEng (McGill), PhD (Toronto), FCSME, FASME
J. K. Spelt, BASc (Toronto), MASc (Toronto), ME (Caltech), PhD, PEng
D. A. Steinman, BASc (Toronto), MASc (Toronto), PhD (Toronto), PEng
P. E. Sullivan, BSME (Clarkson), MSME (Clarkson), PhD (Queen's), PEng
Y. Sun, BS (Dalian), MS (Chinese Academy of Sciences), MS (Minnesota), PhD (Minnesota), PEng, FCSME, FEIC, FASME
M. J. Thomson, BEng (McGill), MSc (Berkeley), PhD (Berkeley), PEng
J. S. Wallace, BSME, BA (Lehigh), MSE, PhD (Michigan), FSAE, PEng

Associate Professors
D. M. Aleman, Baccalauriate, MSc, PhD (Florida), PEng
M. Consens, BEng (Uruguay), MSc (Toronto), PhD (Toronto)
B. Donmez, BS (Bogazici), MS (Iowa), PhD (Iowa)
T. Filleter, BSc Eng. (Queen's), PhD (McGill)
M. Gruninger, BSc (Alberta), MSc (Toronto), PhD (Toronto)
A. Guenther, MS (Hannover), PhD (ETH)
R. Kwon, PhD (Pennsylvania)
X. Liu, PhD, PEng (Toronto)
L. You, BSc (Peking), MSc (Peking), PhD (CUNY)
E. Young, BASc (Columbia), MASc (Columbia), PhD (Toronto)

Associate Professors, Teaching Stream
J. Bazylak, BSc (Saskatchewan), PEng
D. M. Frances, BASc (Toronto), MASc (Toronto), PhD (Toronto), PEng
M. Mackay, BASc (Queen's), PhD (Toronto)

Assistant Professors

F. Azhari, PhD (University of California), BSc (Isfahan University of Technology) and MASc (UBC) PEng
A. Bilton, BASc (Toront), MS (MIT), PhD (MIT)
M. Bodur, PhD (University of Wisconsin-Madison), BS & BA (Bogazici University)
E. Diller, BS (CWRU), MS (CWRU), PhD (CMU)
E. B. Khalil, BS (American University of Beirut), MS (Georgia Tech), PhD (Georgia Tech)
P. Lee, BSc (UBC), MASc (Toronto), PhD (Toronto)
A. Olechowski, BSc (MIT), PhD (MIT)
S. Sanner, BS (Carnegie Mellon), MS (Stanford), PhD (Toronto)
Vahid Sarhangian, PhD (Toronto)
Marianne Touchie, PEng, BASc (Toronto) and PhD (Toronto)

Cross-Appointed Academic Staff
M. Popovic, MSc, MASc, PhD, BME

Adjunct & Status-Only Professors
S. Armstrong, BSc (Westminister), MA (Toronto)
N. Atalla, BEng, MEng (UT COMPIEGNE), PhD (Florida Atlantic)
J. Bookbinder, BA (San Diego), MBA (Toronto), MS, PhD (California)
E. Croft, BASc (UBC), MASc (Waterloo), PhD (Toronto)
I. Dincer, BSc (Selcuk), MSc (Yildiz Technical University), PhD (Istanbul Technical University)
D. De Kee, PhD (Tulane University), FBIS, FCIC
S. Kim, PhD (Seoul National University)
Esmailzadeh, E. PhD (London) BSc (London)
K. Farkas, MSc (Miskolc), PhD (Waterloo)
S. Ketabi, PhD (Adelaide, Australia), MSc (University of Isfahan), BSc (Tehran)
D. Fels, BSc (Guelph), MHSc (Toronto), PhD (Toronto)
J. Hollands, BA (Waterloo), MA (Guelph), PhD (Toronto)
J. Li, PhD (Toronto), MASc (MacMaster), BSc (Taiwan)
F. Honarvar, BSc (Tehran), MASc (Waterloo), PhD (Toronto)
G. Liu, BASc (University of Science & Technology of China), MASc (Shenyang), PhD (Toronto)
F. Lu, PhD (Waterloo), MASc (Waterloo)
O. Romanko, PhD (McMaster), MASc (McMaster), MASc (Prague), BSc (Ukraine)
R. Maev, BSc and MSc (Moscow), PhD & DrSc (Russian Academy of Sciences)
M. Metcalfe, BASc (Toronto), MS (Stanford), PhD (Stanford)
K. Michaelian, PhD (Simon Fraser)
C. Moreau, BSc, MSc, PhD (Laval)
J. Moran, PhD (McMaster), MSc (Venezuela), BASc (Venezuela)
M. Nejad, PhD (Toronto)
M. Papini, BASc (Toronto), MASc (Toronto), PhD (Toronto)
S.E. Prasad, BSc, MSc, PhD (Andhra University)
F. Salustri, BASc, MASc, PhD (Toronto)
A. Smiley, BSc (Western Ontario), MASc (Waterloo), PhD (Waterloo)
D. Tandra, MBA (Georgia), MEng (Toronto), BEng (Indonesia)
V. Verter, PhD (Turkey), MSc (Turkey), BSc (Turkey)
P. Lea, PhD (Toronto), MSc (California), BSc (New York)
R. Pop-Iliev Remon, PhD (Toronto), MASc (Toronto), BEng (Skopje)
T. Purdie, PhD (London), BSc (McMaster)
D. Warnica, PhD (Waterloo), MSc(Minnesota), BASc (Waterloo)
Xie, H, PhD (London), MASc (Montreal), BA (Montreal), BA (China)

Faculty Teaching Awards

Faculty Teaching Award Recipient List

2019-2020	Professor Timothy Chan (Mechanical & Industrial)
2018-2019	Professor Jason Anderson (Electrical & Computer)
2017-2018	Professor Manfredi Maggiore (Electrical & Computer)
2016-2017	Professor Craig Simmons (Mechanical & Industrial, BME)
2014-2015	Professor Jason Foster (Engineering Science)
2013-2014	Professor Greg Evans (Chemical)
2012-2013	Professor Evan Bentz (Civil Engineering)

2011-2012	Professor Jonathan Rose (Electrical & Computer)
2010-2011	Professor James S. Wallace (Mechanical & Industrial)
2009-2010	Professor Ali Sheikholesmani (Electrical & Computer)
2008-2009	Professor John Carter (Electrical & Computer)
2007-2008	Professor Tarek S. Abdelrahman (Electrical & Computer)
2006-2007	Professor Raviraj Adve (Electrical & Computer)
2005-2006	Professor Frank Kschischang (Electrical & Computer)
2004-2005	Professor C.R. Ethier (Mechanical & Industrial)
2003-2004	Professor K.D. Pressnail (Civil)
2003-2004	Professor Z.G. Vranesic (Electrical & Computer)
2002-2003	Professor D.C.S. Kuhn (Chemical)
2001-2002	Professor B.W. Karney (Civil)
2000-2001	Professor A.N. Sinclair (Mechanical & Industrial)
1999-2000	Professor S. McCahan (Mechanical & Industrial)
1998-1999	Professor P.G. Gulak ((Electrical & Computer)
1997-1998	Professor G.T. Will (Civil)
1996-1997	Professor S.J. Thorpe (Metallurgy & Materials Science)
1995-1996	Professor T.C. Kenney (Civil)
1994-1995	Professor Y.L. Cheng (Chemical)
1993-1994	Professor A.W. Neumann (Mechanical)
1992-1993	Professor J.M. Lee (Metallurgy & Materials Science)
1991-1992	Professor M.V. Sefton (Chemical)
1990-1991	Professor W.L. Cleghorn (Mechanical)
1989-1990	Professor P.J. Foley (Industrial)
1988-1989	Professor A.S. Sedra (Electrical)
1988-1989	Professor M.P. Collins (Civil)
1987-1988	Professor I. McCausland (Electrical)
1986-1987	Professor D. Basmadjian (Chemical)
1985-1986	Professor W.H. Vanderburg (Industrial)
1984-1985	Professor W.H. Burgess (Chemical)
1984-1985	Professor D.G.B. Boocock (Chemical)
1983-1984	Professor D.F. James (Mechanical)

Early Career Teaching Award

2019-2020	Professor Elodie Passeport (Civil & Mineral, Chemical)
2018-2019	Professor Arthur Chan (Chemical)
2017-2018	Professor Vaughn Betz (ECE)
2016-2017	Professor Matthew Mackay (Mechanical & Industrial)
2014-2015	Professor Scott Ramsay (Materials)
2012-2013	Professor Timothy Chan (Mechanical & Industrial)
	Professor Jason Anderson (Electrical & Computer)
2011-2012	Professor Micah Stickel (Electrical & Computer)
2010-2011	Professor Sean V. Hum (Electrical & Computer)
2009-2010	Professor Glenn Hibbard (Material Science & Engineering)
2008-2009	Professor Craig A. Simmons (Mechanical & Industrial)
2007-2008	Professor Hani Naguib (Mechanical & Industrial)
2006-2007	Professor Wei Yu (Electrical & Computer)
2005-2006	Professor Ali Sheikholeslami (Electrical & Computer)
2004-2005	Professor Evan Charles Bentz (Civil)
2003-2004	Professor D.P. Gauvreau (Civil)
2002-2003	Professor P. Aarabi (Electrical & Computer)
2001-2002	Professor R. Ben Mrad (Mechanical & Industrial)
2001-2002	Professor B. Abdulahi (Civil)
2000-2001	Professor C.M. Yip (BME)
1999-2000	Professor J.R. Long (Electrical & Computer)
1998-1999	Professor B. McCabe (Civil)

Early Career Teaching Award not issued for the 2013-2014 academic year.

Sustained Excellence In Teaching Award

2019-2020	Professor Mark Kortschot (Chemical)
2018-2019	Professor Frank Kschischang (Electrical & Computer)
2017-2018	Professor Graeme Norval (Chemical Engineering)
2016-2017	Professor Will Cluett (Chemical Engineering)
2014-2015	Professor Jonathan Rose (Electrical & Computer)
2013-2014	Professor Glenn Gulak (Electrical & Computer)
2012-2013	Professor Tarek Abdelrahman (Electrical & Computer)

Centres & Institutes

BioZone

Director: Professor Elizabeth Edwards
Website: www.biozone.utoronto.ca

BioZone is a centre for collaborative and interdisciplinary bioengineering research that brings together researchers, students and industry partners to develop and deploy technically, socially and economically viable biotechnologies. We work to find solutions to optimize the use of natural resources, reuse waste material, remediate contaminated water and land, sustain robust and healthy ecosystems, curtail disease and offer renewable fuels and products that foster the long-term sustainability of our planet.

Our mission is to advance and capitalize on the dramatic progress in genomics and computational biology, while focusing on urgent societal needs in energy, environment and health. BioZone researchers have particular expertise in environmental and industrial microbiology, enzymology, metabolic engineering, synthetic biology, computational biology, food engineering, process design and techno-economic assessment.

BioZone's research facilities provide a collaborative space and cross-disciplinary approach that enables researchers to share knowledge, processes, and equipment as they tackle difficult technical problems. The facility occupies the west wing of the upper two floors of the Wallberg Building at the University of Toronto, providing over 1,800 square metres of collaborative laboratory and research workspace. The facility's research labs house a wide array of analytical instruments for molecular biology, protein purification and identification, enzyme kinetics, substrate and metabolite analysis, microscopy and cell growth. The facilities also include a state-of-the-art fee-for-service mass spectrometry facility, equipment for protein characterization and 5 and 80L bioreactors for biomanufacturing.

In 2019 BioZone launched the NSERC CREATE for BioZone, an open science centre for industrial biotechnology in the circular economy. The CREATE for BioZone is a training program that promotes open science principles and provides postdoctoral fellows, graduate students and undergraduate students with training in data fluency, programing, entrepreneurship, knowledge translation, science communication and leadership.

Centre for Advanced Coating Technologies (CACT)

Director: Professor Javad Mostaghimi
Website: www.cact.utoronto.ca

The Centre for Advanced Coating Technologies (CACT) was established in 1998 as a collaborative effort by researchers from the departments of Mechanical Engineering and Materials Science. The Centre now has over 35 researchers, including five professors from both departments, research staff members, post-doctoral fellows, visiting scientists and graduate students.

CACT conducts fundamental and applied research — both computational and experimental — in the areas of thermal spray coating, plasma processing and plasma chemistry, advanced manufacturing, design of novel direct current (DC) plasma torches and radio frequency inductively coupled plasma (RF-ICP) torches.

CACT works closely with industry, universities and research institutions. Research partners have included Pratt & Whitney Canada, Oerlikon-Metco, Sherwin-Williams, GE Global R&D, BMW, Mercedes-Benz Canada Inc., Perkin Elmer International, Fluidigm, Magna and leading universities in Canada, United States, Japan, France, Italy and Germany.

CACT is a member of the Green Surface Engineering for Advanced Manufacturing (Green-SEAM) Canadian strategic network which is funded by NSERC and involves Canadian universities and industry.

Center for Advanced Diffusion-Wave & Photoacoustic Technologies (CADIPT)

Director: Professor Andreas Mandelis
Website: cadipt.mie.utoronto.ca

Diffusion waves: they go where no light has gone before!

At the core of the Center for Advanced Diffusion-Wave & Photoacoustic Technologies (CADIPT) are the unique diagnostic capabilities of diffusion waves and photoacoustics, which include a wide range of physical fields and phenomena: thermal, electronic, photonic and environmental, to name a few. Photoacoustics is a field that encompasses conversion of optical (laser) energy to thermal, elastic and acoustic/ultrasonic processes with wide applications in instrumentation, non-destructive/non-invasive diagnostics and sensor science and technologies.

CADIPT activities offer opportunities in interdisciplinary research that encompass physics, mathematics, engineering, instrumental implementation and applications of novel laser-based analytical inspection and monitoring techniques, high-precision measurement methodologies, environmental sensor development, analytical, non-destructive and spectroscopic methodologies, signal processing and measurement science and imaging techniques for industrial, environmental, materials science and health sector applications.

For a full description of current CADIPT research, and research mission and objectives, please visit our website.

Centre for Advanced Nanotechnology

Director: Professor Harry E. Ruda
Website: sites.utoronto.ca/ecan/

Nanotechnology is the multidisciplinary field of design, fabrication and application of nanometer-scale materials, structures and devices. The field may involve the disciplines of materials science, electrical, computer and mechanical engineering, as well as chemistry, physics, mathematics and biotechnology. Specifically, in semiconductor applications, nanotechnology refers to the technology for the fabrication of electronic and photonic devices with sizes that range from a few nanometers to the sub-micron range; these fields are commonly termed “nanoelectronics” and “nanophotonics,” respectively. Additionally, the term nanotechnology is also currently used to refer to the rapidly developing area of nano-electro-mechanical systems (NEMS), which have only just begun to show their promise for the fields of sensing, biotechnology, integrated optoelectronic and fibre assemblies.

The Centre for Advanced Nanotechnology (CAN) is based on a multidisciplinary team of faculty and researchers from various departments including Applied Science & Engineering, Arts and Sciences, and Mathematics and Applied Mathematics. CAN is Canada’s first centre for nanotechnology research, and it is closely tied to industry and other key nanotechnology research institutions throughout the world.

The main objectives of the Centre, which was established in 1997, include advances in research in both theoretical and experimental methods for a new generation of nanoelectronic and nanophotonic materials, structures and devices; the education and training of a new generation of highly-qualified personnel for industry and academia; collaboration with other members of the academic and industrial community and the establishment of specialized resources and expertise in this expanding field for the scientific community and government.

Centre for Global Engineering (CGEN)

Director: Professor Amy Bilton
Website: cgen.utoronto.ca

As a leading global institution, the University of Toronto's Faculty of Applied Science & Engineering strives to provide its faculty and students with the tools, opportunities and partnerships to help address the world's most intractable problems, including food insecurity, energy poverty and lack of access to safe drinking water. The Centre for Global Engineering (CGEN) is a unique, multidisciplinary unit that works to bring engineering knowledge and talent at the University of Toronto together to solve some of these pressing challenges.

CGEN empowers our students through undergraduate and graduate teaching and research programs. Our courses provide students with an understanding of how they can apply their skills to improve the quality of life of the world's most vulnerable populations. Students can obtain real-world experiences addressing these issues through our collaborative capstone projects with NGOs and academic institutions worldwide. And our multi-disciplinary and innovative research initiatives work to bring together researchers and resources necessary to develop appropriate and sustainable solutions for reducing global poverty.

Centre for Maintenance Optimization & Reliability Engineering (C-MORE)

Director: Professor Chi-Guhn Lee
Website: cmore.mie.utoronto.ca

The Centre for Maintenance Optimization & Reliability Engineering's (C-MORE) research is driven by close interactions with industry — in particular, with MORE consortium members and researchers at universities worldwide.

Our focus is on real-world research in engineering asset management in the areas of condition-based maintenance, spares management, protective devices, maintenance and repair contracts, and failure-finding intervals. These strong industry connections not only benefit the companies we work with, but also our graduate students, who find work in maintenance divisions of industry leaders after graduation.

We apply our research with prototype software tools that obtain valuable information from data in corporate databases. Two of these tools are now commercially available through the Ontario-based C-MORE spin-off company OMDEC, and through industry leader and innovator in asset reliability solutions Ivara.

Centre for Management of Technology & Entrepreneurship (CMTE)

Director: Associate Professor Yuri Lawryshyn
Founder & Executive Director Emeritus: Professor Emeritus Joseph C. Paradi
Website: www.cmte.utoronto.ca

Established in 1991, the Centre has focused on bringing leading-edge problem solving and research innovation to the Canadian Financial Services Industry (FSI). The Centre is interdisciplinary and collaborative in nature. Today, more than ever, the pace of technological change is providing industry leaders unique opportunities to innovate and adopt new technologies. Through strategic partnerships with industry partners, the Centre is a focal point for the advancement of next-generation banking.

The Centre's goal is to provide the industry with quality, value added research-based practical work, related to three overlapping research areas, namely financial modelling, data mining/analytics and machine learning, while at the same time, providing a unique, practical but challenging industry-related experience for our students. The CMTE's focused research areas allow for the development of innovative solutions to many FSI related applications, including financial modelling, market risk, operational risk, portfolio optimization, customer analytics, FinTech, productivity enhancement, cyber security and bot applications.

The University of Toronto is at the forefront of technological innovation and is recognized as a world leader in artificial intelligence/machine learning. Through the Centre, industry partners gain access to the University's world-class researchers. Furthermore, the Centre's unique research management model ensures successful completion of projects both to the benefit of the students and the partners. Not only do students gain invaluable industry related experience, they develop important business skills. Accordingly, the Centre's partners often gain significant benefits associated both from the research outcomes, as well as interactions with the students.

Since the Centre's establishment, over 300 projects at all levels of complexity and intellectual challenge (BASc, MEng, MASc and PhD) have been completed. Graduates of the program are leading successful careers in finance, management, consulting, entrepreneurship and academia.

University of Toronto Robotics Institute

Director: Associate Professor Yu Sun
Website: robotics.utoronto.ca

The University of Toronto Robotics Institute is home to the largest and most diversified robotics research program in Canada. Centred around three key pillars — autonomous field robotics, healthcare robotics and advanced manufacturing — we unite, grow, and catalyze collaborations among the many exceptional robotics research clusters at the University and beyond.

The Robotics Institute serves as the headquarters for robotics collaboration, research and education at U of T. We collaborate with partner institutions and with industry to offer undergraduate and graduate students unparalleled opportunities to expand their robotics knowledge and gain hands-on experience through cross-disciplinary training and co-supervision opportunities. The Institute supports U of T Engineering's undergraduate minor in robotics and mechatronics, an Engineering Science major in robotics and a graduate emphasis in robotics.

Institute for Studies in Transdisciplinary Engineering Education & Practice (ISTEP)

Director: Professor Greg Evans
Website: istep.utoronto.ca

ISTEP is U of T Engineering's newest extra-departmental unit and the first institute of its kind in Canada. Bringing together the strengths of several U of T Engineering programs in leadership, technical communication and entrepreneurship, ISTEP is an innovator and leader in pedagogical innovation and transdisciplinary engineering education.

ISTEP provides an academic home for the Engineering Communication Program (ECP), Troost Institute for Leadership Education in Engineering (Troost ILead), Collaborative Specialization in Engineering Education (EngEd), Certificate in Entrepreneurship, Innovation and Small Business, Engineering Business Minor and some first-year instruction.

Institute for Sustainable Energy (ISE)

Director: Associate Professor Josh Taylor
Associate Director: Professor Tim Bender
Administrator: Mandeep Rayat
Website: energy.utoronto.ca

The University of Toronto Institute for Sustainable Energy (ISE) is a catalyst that facilitates interactions and collaborations to advance the development of cleaner and more efficient energy in Canada. The motivation behind the Institute was to advance the tremendous amount of research already underway throughout the University in a wide variety of energy-related fields and to tackle the most challenging problems facing sustainable energy through a multidisciplinary approach.

The ISE is open to students, faculty, industry and government members involved in increasing energy efficiency and reducing the environmental impact of energy use and conversion, whether through new technologies, policy work, computational sustainability, materials science or other routes.

The Institute is a focal point for energy research, collaboration, news and events. An increasingly important role for the unit is the coordination and administration of funding initiatives and connecting researchers to Canadian energy companies.

Institute of Biomedical Engineering

Director: Professor Warren C. W. Chan
Website: bme.utoronto.ca

Biomedical engineering aims to use engineering or physical science principles to solve biological and medical problems. The Institute is the largest biomedical engineering hub for education, research and community at the University of Toronto and Canada. It is the only division managed by three different faculties — Applied Science & Engineering, Medicine and Dentistry.

The diversity in education and research ecosystems equips our researchers with the ability to address pressing medical questions — ranging from fundamental mechanisms to clinical cases — and build new companies. The Institute has laboratories in the Rosebrugh Building, Lassonde Mining Building, Donnelly Centre for Cellular & Biomolecular Research and MaRS Building on the St. George campus and Holland Bloorview Kids Rehabilitation Hospital and Toronto Rehabilitation Institute (KiTE).

The Institute has over 100 core and cross-appointed faculty conducting research molecular, cell and tissue and clinical engineering. The faculty members lead state-of-art research in a series of emerging areas such as nanotechnology, systems biology, regenerative medicine, bioelectronics and rehabilitation engineering.

The Institute offers a PhD, MASc, and MHSc graduate program in biomedical and clinical engineering. Additionally, a one-year course-based professional master of engineering (MEng) program also joined our offerings in 2016. Since an undergraduate degree in engineering is not a prerequisite for admission into the Institute's graduate programs, we have welcomed students with backgrounds in engineering, biology, medicine, chemistry, physics and psychology.

While the Institute does not have a full undergraduate program, several undergraduate student bodies are associated with the Institute. Students enrolled in the Division of Engineering Science can select the Biomedical Systems Engineering major. These students take courses in tissue engineering, imaging, control and other relevant topics in biomedical engineering. The second student body is the biomedical engineering minor's program, where students from non-biomedical engineering departments can learn the basic principles of biomedical engineering.

The Institute’s graduates work in different industrial sectors (biotechnology, pharmaceutical, computer, marketing), government agencies and academia. A large number of our students are involved in building start-up companies. Overall, job opportunities for Biomedical Engineering students are broad.

Lassonde Institute of Mining

Director: Professor Lesley Warren
Website: www.lassondeinstitute.utoronto.ca

The Lassonde Institute of Mining is a world-leading interdisciplinary mining research institute at the University of Toronto.

It is a global leader in innovative research across the spectrum of mining activities, from exploration and extraction, to processing and metallurgy. It aims to attract and train future leaders in mining research and use its researchers’ expertise to benefit the mining industry.

Institute personnel develop leading-edge solutions for the mining industry with a focus on sustainability. Comprised of an exceptional community of students, researchers, and engineers, the institute addresses the most important scientific problems facing mining. The institute brings together mining, civil, materials, and chemical engineers, as well as geophysicists, geologists, geochemists, and environmental scientists, who conduct research that crosses traditional disciplinary boundaries.

By training and cultivating the people who will help find solutions to the greatest contemporary mining problems, and by contributing the ideas and pioneering the practical technologies that will make the difference, the Lassonde Institute of Mining fulfills its obligation as a world-leading centre.

The Institute was created with the financial assistance of the Canadian minerals industry, and in particular Dr. Pierre Lassonde, as well as with support from the Government of Canada and the Government of Ontario.

Pulp & Paper Centre

Director: Professor Honghi Tran
Website: www.pulpandpaper.utoronto.ca

A strategic material produced from a renewable resource, paper is critical to our civilization. Paper has been of paramount importance in the transmission and storage of information necessary to science and literature. It has also enabled the creation of modern business and industry. Even in the modern world, paper, in partnership with electronic information systems, is essential. Wood pulp is raw material not only for paper but for thousands of structural, absorbent and packaging products that are so completely embedded in our lives that we often overlook them. Canada is one of the largest suppliers of pulp and newsprint and has a long tradition of scientific and technological leadership. These factors make our country a major force in the pulp and paper world.

The Pulp & Paper Centre at the University of Toronto, which exists within the umbrella of the Department of Chemical Engineering & Applied Chemistry, was founded in 1987. Although the Centre has grown and changed with the challenges that face the industry, its mission since inception has been to stimulate research and support teaching in pulp and paper science and engineering and to encourage collaborative research with industry partners.

For the past 34 years, the Centre has hosted a continuous series of 12 university-industry research consortia that have traditionally focused on energy and chemical recovery, and have more recently broadened in focus to include biofuel combustion and biorefinery research projects which seek to convert forest biomass and mill waste into alternative sources of energy. This work has increased the competitiveness of the Canadian pulp and paper industry and its suppliers by improving energy and chemical recovery efficiency, improving operational safety, increasing equipment reliability and efficiency, increasing utilization of biofuels, reducing environmental impact, and lowering the carbon footprint. This long-lasting partnership has supported the research of many professors, researchers and students and, over the years, has engaged over 60 different companies. The present consortium on Effective Energy and Chemical Recovery in Pulp and Paper Mills, led by Professor Nikolai DeMartini, involves 15 professors and over 25 graduate students and postdoctoral fellows from four university departments, and 26 industry partners from seven countries.

The Centre continues to enrich students' educational experiences through interesting and relevant research projects, seminar programs, professional development programs, annual research meetings, and international exchanges. The Pulp and Paper Centre is also well integrated with the Technical Association of Pulp & Paper Industry's (TAPPI) student chapter, providing ample opportunity for networking within the industry worldwide.
Technical and engineering problems are illuminated and rigorous research methodologies are applied to investigate the underlying critical phenomena. This has made the University a significant source of expertise for the pulp and paper industry and their suppliers in Canada and the world and has created a unique learning environment for students.

Southern Ontario Centre for Atmospheric Aerosol Research (SOCAAR)

Director: Professor Greg Evans
Website: www.socaar.utoronto.ca

The Southern Ontario Centre for Atmospheric Aerosol Research (SOCAAR) is an interdisciplinary research centre — hosted in the Faculty of Applied Science & Engineering — dedicated to the study of air quality with a focus on the effects of aerosol on human health, the environment and climate. SOCAAR promotes collaborative research through access to state-of-the-art facilities and partnerships with government and industry. Additionally, the Centre offers the opportunity for student involvement at the graduate and undergraduate levels.

Recent research projects include exposure of urban populations to particulate matter, the toxicity of vehicle emissions, influence of particles on cloud formation and climate and the development of novel methods to analyze atmospheric pollutants.

SOCAAR represents the Canadian Aerosol Research Network (CARN), a collective that formally unites the expertise of leading Canadian aerosol researchers from the University of Toronto, Dalhousie University and University of British Columbia.

Toronto Intelligent Transportation Systems (ITS) Centre & Testbed

Director: Professor Baher Abdulhai
Website: uttri.utoronto.ca/research/research-facilities/its-centre-and-testbed/

The University of Toronto houses the Toronto Intelligent Transportation Systems Centre & Testbed (ITS). ITS is a global phenomenon that combines a broad range of diverse technologies that are applied to transportation to save lives, money and time.

ITS cuts across disciplines such as transportation engineering, telecommunications, computer science, economics, electronic and automobile manufacturing, to name a few. ITS is not restricted to civil engineers or a single department or agency. Instead, the field includes a number of departments, agencies and jurisdictions and a rapidly expanding worldwide market.

Access to this market is vital to transportation and related technology sectors. In addition to direct transport benefits, a healthy ITS industry also has a number of non-traffic-related societal benefits, which include the stimulation of new information technology-based industries and the creation of new markets and jobs. ITS is more than just intelligent solutions on the road. It is a strategic direction for national and international economies.

To train the next generation of ITS professionals, the University of Toronto offers a comprehensive ITS research and development program, which includes the ITS Testbed. The Testbed is composed of a University-based R&D centre equipped with capabilities for designing traffic analysis and decision-support tools and real-time traffic control methods.

The Testbed is designed to be a meeting ground for practitioners and researchers from the public, academic and private sectors to research new approaches to transportation systems management and to accelerate ITS deployment through advanced technology research.

Toronto Nanofabrication Centre (TNFC)

Director: Professor Wai Tung Ng
Website: tnfc.utoronto.ca

The Toronto Nanofabrication Centre (TNFC) is an open access interdisciplinary research prototyping and testing facility at the University of Toronto. The Centre offers global research leadership by providing access to state-of-the-art nanofabrication facilities, collaborative research networks, advanced educational opportunities and information exchange events for registered users and clients.

Technical staff at TNFC maintain the facilities, instruct, assist and provide nanofabrication services for domestic and international academic and industrial clients. Key research areas supported by TNFC include lab-on-a-chip fabrication, microfluidics, MEMS/NEMS, photonic materials and devices, micro/nano-electronic devices, integrated optics, nano-plasmonics, photovoltaic devices, CMOS Processing, power semiconductor devices, nanomaterial synthesis and spintronic devices.

TNFC is an important hub for prototype development and fabrication on campus. TNFC technical staff operate and maintain two specialized fabrication facilities, including the Pratt Microfabrication Facility and Wallberg Electron Beam Nanolithography Facility. The Pratt Facility houses comprehensive state-of-the-art fabrication, characterization and test equipment. The Wallberg facility’s e-beam lithography offers ultra-fine sub-10nm resolution.

The Centre provides a unique, valuable service to researchers and students involved in micro/nanofabrication fields. As an open-access facility, TNFC regularly provides dedicated technical expertise, including process development consultation and equipment training sessions, enabling students and other researchers to fulfil their research objectives and enhance their education. With a user base of over 50 principal investigators and over 100 users (mostly graduate research students) across 30 departments within the University of Toronto and external institutions/organizations, TNFC continues to be an essential resource for regional and national research communities.

Troost Institute for Leadership Education in Engineering (Troost ILead)

Director: Professor Emily Moore
Website: ilead.engineering.utoronto.ca

The Troost Institute for Leadership Education in Engineering (Troost ILead) provides transformative learning opportunities so that students and professionals can develop the leadership skills necessary for success in their future endeavours. We empower the whole engineer to maximize their potential and contribution.

Troost ILead undertakes student programming, academic and industry-focused research, as well as outreach to engineering leadership educators and engineering-intensive enterprises.

The world demands engineers who are successful problem solvers who are empowered to tackle complex, global issues. Leadership education allows individuals and groups to contribute more effectively to engineering and social innovation.

Our vision: Engineers leading change to build a better world.

University of Toronto Institute for Multi-Disciplinary Design & Innovation (UT-IMDI)

Director: Professor Kamran Behdinan
Website: imdi.mie.utoronto.ca

The University of Toronto Institute for Multi-Disciplinary Design & Innovation (UT-IMDI) was officially established in 2012 with Dr. Kamran Behdinan as its founding director. The aim of UT-IMDI is to create, in partnership with industry, a unique project-based-learning (PBL) environment in partnership with industry.

UT-IMDI provides undergraduate and graduate students with real-life training opportunities by involving them in practical, industry-based projects. It is a vehicle to promote awareness of design and development challenges facing the industry with emphasis on its multi-disciplinary nature and evolving technology.

Through the networking opportunities provided by the Institute, students develop links with industry, and, as a result, better position themselves for future careers. The design experience gained from the Institute is complementary to the experience gained through the capstone design courses.

University of Toronto Transportation Research Institute (UTTRI)

Director: Professor Eric Miller
Website: uttri.utoronto.ca

UTTRI brings the formidable depth and breadth of University of Toronto research to bear on real-world urban transportation problems from perspectives of engineering, physical and social sciences, architecture and humanities. As a solution-oriented think-tank, it fills a critical gap between traditional academic basic research, professional consulting and public sector transportation planning and operations.

Building upon our research expertise and working relationships with both the public and private sectors, UTTRI seeks solutions to pressing problems facing our cities, such as cost-effective suburban transit systems, politically acceptable road pricing systems for network performance, dynamic real-time control of road and transit systems for capacity maximization, improved urban logistics systems for goods movements, improved urban and street design for walking and cycling, and more.

How we design, build and operate our cities will directly determine our economic prosperity, environmental sustainability, health and social well-being. Major transportation challenges can be solved and major new opportunities can be exploited only through coordination and integration of multiple areas of research.
UTTRI's mandate is to provide the coordination and integration needed to support large-scale, high-impact research, provide the foundation for a comprehensive central hub for transportation-related research at the University of Toronto and to support research partnerships the University of Toronto establishes with other institutions around the world.

Admission Requirements

Admission to the Faculty of Applied Science & Engineering is competitive as each year we receive more applications than the number of available places. The Faculty selects students by taking into consideration a wide range of criteria including marks, subjects taken and supplementary information obtained through the mandatory Online Student Profile. Possession of the minimum entrance requirements does not guarantee admission. Applicants who have been out of studies for more than five years are generally not considered for admission. Detailed admission requirements can be found at Discover Engineering.

Ontario Secondary School Diploma (OSSD)

Applicants must be eligible to receive the Ontario Secondary School Diploma and present a minimum of six grade 12 U or M courses including:

- English (ENG4U)
- Advanced Functions (MHF4U)
- Calculus & Vectors (MCV4U)
- Chemistry (SCH4U)
- Physics (SPH4U)
- One additional U or M course

Canadian High School Students

Applicants from Quebec must present 12 academic CEGEP courses. Candidates from other provinces and territories of Canada must present grade 12 matriculation, including English, mathematics (with Calculus), physics, and chemistry. For more information, visit Discover Engineering.

Other Applicants

Information on admission requirements for applicants from outside of Canada is available online. All applicants must have completed senior level courses in mathematics (with Calculus), physics and chemistry.

Transfer Students

Candidates with acceptable standing at other post-secondary institutions will be considered for admission with transfer credit(s) on a case-by-case basis. Transfer credits are assessed at the time of admission. Candidates who already hold a recognized degree in engineering are not permitted to proceed to a second undergraduate degree in engineering.

Non-matriculants (Mature Students)

A student age 21 or over who has not previously completed a high school diploma must complete the pre-requisite courses in order to be eligible for admission. For information regarding admission as a non-matriculant (mature student), please contact the Engineering Undergraduate Admissions Office: engineering@utoronto.ca.

Non-degree Students

Non-degree students are students enrolled in Faculty courses who are not working towards an undergraduate degree within the Faculty of Applied Science & Engineering at the University of Toronto. Often, these are visiting students who have received Letters of Permission from their home universities and are working towards degrees at their home institutions.

Non-degree students must meet any prerequisites for the courses they wish to take and meet the University's minimum English language requirements. A non-refundable processing fee of $90 will be charged for applications.

Canadians and Permanent Residents interested in taking courses as non-degree students should contact the Engineering

Undergraduate Admissions Office at engineering@utoronto.ca or 416-978-0120.

International students interested in studying at U of T should contact the Centre for International Experience (CIE) at inbound.exchange@utoronto.ca or call 416-946-3739.

Curriculum

Accreditation & Licensure as a Professional Engineer

The practice of engineering is regulated, by statute, in all Canadian provinces and territories. To become a Professional Engineer you must satisfy the requirements of the licensing bodies. These requirements include a degree from an accredited program, successful completion of a professional practice examination in engineering law and ethics and suitable experience.

All programs listed in this Calendar are accredited and evaluated regularly by the Canadian Engineering Accreditation Board (CEAB) of Engineers Canada; therefore, graduation from the Faculty of Applied Science and Engineering may lead to licensure as a Professional Engineer by the provincial and territorial associations that regulate the practice of engineering, in accordance with their individual policies.

No student will be permitted to graduate who does not meet these requirements as this would jeopardize accreditation for the program.

Detailed information about Engineers Canada can be found at engineerscanada.ca.

General Program Guidelines

Each program in Engineering and in Engineering Science consists of a technical component and a complementary studies component. The curriculum provides considerable latitude to students in choosing their programs of study. On the following pages the curriculum of each program is set forth in detail. The curriculum for students in first year (in first and second years in Engineering Science) forms a basis in the fundamental subjects prior to subsequent specialization in various Engineering disciplines. Students are able to choose from a range of technical electives in their senior years. In the fourth year, all programs contain a thesis or a design project that provides students with the opportunity to carry out original work in their chosen fields of study.

The curricula, regulations and course information contained in this Calendar are valid for the current academic year only and so, over the course of a student's attendance in the Faculty, curricula, regulations and course information may change. All such changes will be posted on the Undergraduate Engineering website.

The Faculty reserves the right to withdraw any course for which there is insufficient enrolment or resources and to limit the enrolment in any course.

Weight Factor

Weight Factors are associated with every course and are intended to help students determine the relative weight of every course, in terms of time spent in class. Most courses in the Faculty of Applied Science & Engineering are weighted 0.5, but some (full-year courses) are weighted at 1.0 and others (quarter courses) are weighted at 0.25. Weight factors for courses outside of the Faculty may vary.

Weight factors are used to calculate what is referred to as the "weighted session average" used in promotions. A regular program normally consists of five courses per session with a total weight of 2.5 credits; with prior approval of the Chair of their Department, full-time students may elect to increase their loads to a maximum of 3.0 credits per session.

To be eligible for any scholarship or award granted solely on academic standing, a student must have completed not less than the normal full load (2.5 credits per term) within the two sessions upon which the award is based. A student whose program in these two sessions contains repeated courses will only be eligible if the aggregate of new courses is equal to or greater than 2.5 credits per term.

Course Definitions

Core Course
A core course is defined as any course in a program of study that is expressly required by a department or division in order to fulfil degree requirements.

Electives
Elective courses fall into three categories: technical, free and complementary studies. In general, students must not select elective courses that would involve excessive duplication of material covered elsewhere in their programs. As the promotion of engineering students is based on weighted session averages, honours/pass/fail or credit/no-credit courses may not be taken as electives.

Technical Electives
Each program has a selection of technical electives carefully designed to enhance students' technical knowledge in specific areas. Details regarding technical electives can be found under each program listing.

Free Electives
Some programs require students to take a free elective. A free elective has few restrictions: any degree credit course listed in the current calendars of the Faculty of Applied Science and Engineering, the Faculty of Arts and Science and the School of Graduate Studies is acceptable as a free elective provided it does not duplicate material covered in courses taken or to be taken.

Complementary Studies
All students are required to take Complementary Studies electives at some point during their program.

Complementary studies is broadly defined as studies in humanities, social sciences, arts, management, engineering economics and communication that complement the technical content in the curriculum. Language courses may be included within complementary studies provided they are not taken to fulfil an admission requirement.

Within this context of complementary studies, the Faculty is aware of the heavy responsibility that lies on the shoulders of engineers in our modern technological society, and it strives to educate engineering students with a strong sense of responsibility to others. The Faculty requires students build a firm foundation of engineering ethics, familiarity with their heritage and history and sensitivity to the social context in which they function. To this end, in addition to developing competence in appropriate aspects of mathematics, the physical sciences and design, aspiring engineers must acquire an understanding of the humane aspects of engineering.

Some areas of study under the heading of complementary studies are considered to be essential in the education of an engineer, namely these four elements (described in more detail below):

1. Introduction to the methodologies and thought process of the humanities and social sciences
2. Basic knowledge of engineering economics
3. Competence in oral and written communications
4. Awareness of the impact of technology on society

Some of these elements have been incorporated into the set curriculum for each program; others are introduced through the selection of Humanities and Social Science (HSS) and Complementary Studies (CS) electives. We urge students to plan their complementary studies electives in accordance with their career aspirations; however, to ensure eligibility for registration as a professional engineer, HSS/CS electives must fit set definitions as outlined below. Please note that HSS electives are a subset of CS electives, so while all HSS electives can count towards CS requirements, not all CS electives can be considered HSS electives. A listing of appropriate HSS and CS electives can be found on the Current Engineering Undergraduates website.

1. Humanities and Social Sciences (HSS)
Engineers' colleagues frequently have a background in the humanities and social sciences rather than in the physical or mathematical sciences, so students need to have some understanding of the modes of thought used in these disciplines. The Faculty of Arts and Science offers a very comprehensive selection of such courses. Individual programs have various requirements and opportunities to take Humanities and Social Sciences electives. Subject to conditions imposed by the Faculty of Arts and Science, students may choose any course that does not include languages, grammar, mathematics

(including symbolic logic and probability & inductive logic), economics, technique (e.g. art, music, video production), physical and life sciences (including, but not limited to astronomy, physics, chemistry, biology, zoology, computer science and psychology). A course must be pre-approved as HSS-eligible by the Faculty before a student may enrol.

The HSS courses that are available to students are listed on the undergraduate engineering website,

Students seeking a broader choice in their Humanities and Social Sciences electives can obtain more information about appropriate courses and enrolment procedures from the Faculty Registrar's Office or their departmental office. Enrolment may involve submission of a ballot or consultation with the offering department.

2. Engineering Economics
Each program includes at least one required course on engineering economics. These courses provide an opportunity for students to become familiar with the basic tools used to assess the economic viability of proposed engineering projects. The program-required courses are CHE249H1, CME368H1, MIE258H1, ECE472H1 and CHE374H1 .

3. Oral and Written Communications
Engineers must be able to communicate their ideas effectively to peers, other professionals and the public at large. Technically sound solutions will often be accepted only after the engineer has convinced the public and governmental agencies that they are also socially acceptable. Consequently, technical communication is essential to Engineering. Each program includes the equivalent of one course on technical communication and takes part in a Language Across the Curriculum program that develops communication skills in core engineering courses. The communication courses and the Language program aim to develop skills in report writing, public speaking and graphical presentation with the goal that students will gain solid experience as technical communicators before graduation.

4. Impact of Technology on Society
The courses APS111H1 and APS112H1 Engineering Strategies & Practice I and II are required for all programs except Engineering Science, for which ESC101H1 and ESC102H1 , Engineering Science Praxis I and II are required.

Letters of Permission

A Letter of Permission is required for engineering students seeking to take a course from another university. The Letter of Permission will outline the course(s) the student has permission to take, the transfer credit(s) that can be granted and how they will be applied to the degree (as extra credit, technical elective, HSS/CS, etc).

Students may request any course from a recognized Canadian university, or from an international university that the University of Toronto has an exchange agreement with. Students who wish to take a course from an institution not listed in one of these two categories should note that the course will be closely examined to ensure it is comparable to the academic standards of the University of Toronto. Courses should be academically rigorous and include a written examination, or a significant component of closely supervised work. Online courses will be subject to a special review, to ensure they meet the expectations of the University of Toronto.

Core courses are not usually approved on a Letter of Permission.

To receive credit for completing a course on Letter of Permission, the student must achieve at least one full letter grade above a pass at the host institution, or 60% using the University of Toronto grading scale.

The Letter of Permission request form can be found at the Office of the Registrar, located within the Galbraith building at 35 St. George Street (room 157). This form must be submitted with a copy of the official course description from the host institution's academic calendar. A non-refundable processing fee of $40 per letter of permission will be charged.

Please note that a Letter of Permission does not apply to courses taken while participating in an official International Exchange.

Practical Experience Requirement

Every student must complete a minimum of 600 hours of practical experience before graduation. The nature of the work should form an integral part of a student's education and career development. It, therefore, must contain a good measure of responsibility (e.g., management of programs, systems, equipment, personnel or finances), sound judgment and effective communication and be supportive of the professional career of the student after graduation. Work in many facets of industry, government or public service are acceptable for this requirement.

The 600-hour practical experience requirement (PER) may be obtained at any time during the program (often undertaken during the summer break). Work done before entering the Faculty may also meet the requirement. U of T Engineering students may elect to enrol and participate in the Engineering Summer Internship Program (ESIP) or Professional Experience Year Co-op Program (PEY Co-op) offered through the Engineering Career Centre (ECC).

Participation in a PEY Co-op or ESIP work term satisfies the practical experience requirement provided that students successfully complete the work term as well as submit the requisite report and evaluation elements. More details on these programs can be found in the ECC section below.

Experiences done outside of the ECC programs require the completion of the practical experience certificate form(s). This form may be obtained from the Registrar's website and shall be signed by the employer or supervisor. Students should return completed forms to their departmental counsellor's office. The satisfaction or non-satisfaction of this requirement for graduation will be indicated on the student's grade report in the fourth-year winter session as a grade of CR (Credit) or NCR (No Credit).

The Professional Engineers of Ontario (PEO) may allow pre-graduation experience to count towards 12 months of the four-year "engineering experience" required for eligibility for the PEng designation. For further information, visit the PEO website. Please note that the records required by the PEO are separate and distinct from the 600 hours practical experience required for completion of a degree program in the Faculty of Applied Science & Engineering.

Engineering Summer Internship Program (ESIP)

The Fields Institute
222 College Street, Suite 106
416-978-6649
pey.coop@utoronto.ca
www.engineeringcareers.utoronto.ca

The Engineering Summer Internship Program (ESIP) is a paid summer co-op program offered through the Engineering Career Centre. It is available to engineering students in year two or three of study during the 2020 – 2021 academic year. ESIP serves as an introductory career development program for participants. Through formalized and interactive workshops and individual counselling appointments, students are introduced to concepts and tools to prepare them for the workplace.

ESIP prepares students to be competitive for future opportunities, such as those offered in the Professional Experience Year Co-op Program (PEY Co-op) and beyond graduation.

Please note that as of 2021-2022, the ESIP program will be an optional 4-month summer work term within the Professional Experience Year Co-op Program.

Professional Experience Year Co-Op Program (PEY Co-op)

The Fields Institute
222 College Street, Suite 106
416-978-3881
416-978-6649

pey.coop@utoronto.ca
www.engineeringcareers.utoronto.ca

The Professional Experience Year Co-op Program (PEY Co-op) is a co-operative education program offered through the Engineering Career Centre (ECC). Engineering students as well as Arts & Science students (namely computer science, pharmacology, toxicology, pharmaceutical chemistry and commerce) participate in the PEY Co-op program.

This program connects students with industry where they can apply their in-class knowledge to a continuous 12-16 month co-op work-term. The length of the work term offers students sufficient time to become involved in large-scale projects, build relationships with employers and reach professional milestones. Students who elect to participate in this program make industry contacts, gain valuable career skills and significant professional experience prior to graduation.

In 2019-2020, approximately 1,100 students successfully secured PEY Co-op work-terms in 350 companies. Some of our past and current out-of-province and international work-terms include Alberta, British Columbia, Newfoundland & Labrador, United States, Peru, Barbados, Belgium, Botswana, Netherlands, France, Germany, Hungary, Spain, Switzerland, Finland, United Kingdom, Qatar, United Arab Emirates, India, Japan, Malaysia, Mauritius, South Korea, Taiwan, China, Hong Kong and Singapore.

Engineering Communication Program

Director: Professor Alan Chong

Our purpose is to help engineering undergraduates build professional-level, discipline specific communication skills. Our instructors are integrated into engineering courses across the curriculum in every program, from first to fourth year. Additionally, we facilitate one-to-one tutoring, offer elective courses (part of the Certificate in Communication) and workshops.

We create practices, programs and partnerships that enable engineering undergrads to become confident and effective communicators who will become leaders in their fields. For more information, visit us online.

The Jeffrey Skoll BASc/MBA Program (Skoll Program)

The Jeffrey Skoll BASc/MBA program provides University of Toronto engineering students with the opportunity to pursue a Master of Business Administration (MBA) degree at the Rotman School of Management immediately after completion of their BASc. This program is unique in Canada. Students admitted into the program will be considered for a Skoll scholarship to partially offset the Rotman MBA tuition.

Why combine engineering and business? Today's engineers are often team leaders, project managers, company directors and entrepreneurs, and make a significant impact in the business world. The Skoll BASc/MBA program offers select students the opportunity to earn both technical and management qualifications, to become the next generation of leaders in business and industry.

How does the Skoll Program work? Students interested in the Skoll program must complete a Professional Experience Year (PEY) internship of at least 12 months during their BASc program. Students apply to the Rotman MBA program during their fourth year of Engineering studies. If offered admission into Rotman, students will then be considered for a Skoll scholarship. Students then continue on to finish their BASc, and in September of the same year, enter the Rotman MBA program.

How to apply? Only fourth-year Engineering students who have completed a PEY internship can apply to the Skoll program. Students apply directly to Rotman. Please visit the Skoll Program website for admission requirements and instructions. The annual deadline for applying is February 1.

Part-Time Studies

All years of the BASc degree in Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical and Mineral Engineering may be taken on a part-time basis (maximum of three courses per session).

First-year Students
First-year students who are registered on a full-time basis may request to transfer to part-time studies by the deadline indicated under the “Fall Sessional Dates.” Permission to make this transfer must be obtained from either the Chair, First Year or the Faculty Registrar. Transfers from part-time to full-time studies will normally be permitted only after completion of an entire program year (usually 10 courses).

Upper-year Students
Students who have completed first, second or third year as full-time students may apply to transfer to part-time studies by submitting a transfer form by the deadline indicated under the “Winter Sessional Dates.”

Academic Program Load
A part-time student may enrol in a maximum of three one-session courses in each of the Fall Session, the Winter Session and the Summer Session with permission of the responsible Division or Department. Once enrolled in the part-time program, a student must complete all the courses for a program year over a minimum of two calendar years before requesting to continue studies on a full-time basis. For example, a part-time student who requires ten courses to complete first year may not proceed to second year after one year (i.e. the ten courses must be spread over a minimum of two years).

The selection of courses must satisfy the prerequisite and co-requisite structure specified in the course descriptions.

Students admitted with advanced standing who require the equivalent of at least 18 one-session courses to complete the requirements for a degree may register in a part-time program subject to the same conditions as other students. Students who require the equivalent of fewer than 18 one-session courses must attend on a full-time basis.

Promotion Regulations
Part-time students are governed by the promotion regulations described in Chapter 6.

Degree Requirements
To qualify for a degree, a student must complete a full undergraduate program within nine calendar years of first registration, exclusive of mandatory absences from their program.

International Student Exchanges

Student exchange is a Learning Abroad opportunity that enables students to study at partner institutions while gaining an understanding of different cultures, heritages, values and lifestyles found across borders.

Exchange programs operate under formal agreements between the University of Toronto and partner universities abroad and in Canada. University of Toronto students who participate in exchange programs will pay full-time tuition and compulsory incidental fees to the University of Toronto. Students can then study at one of the University of Toronto’s partner universities without paying tuition fees to the host university.

Please note that many of the universities in countries where English is not the host country’s official language still offer many, if not all, courses in English. Notable examples include universities in Hong Kong, the Netherlands and Sweden.

Learning Abroad also offers two- to four-month international summer research opportunities for qualified students.

Applications deadlines occur between December and April each year, depending on your program of choice and the term you intend to go abroad.

Funding is available on a needs basis for international opportunities. Select partner institutions offer guaranteed bursaries to students. Additional information is found on the Learning Abroad website: learningabroad.utoronto.ca.

The following exchange programs are available through the CIE:

Argentina • Torcuato di Tella University **Australia** • University of Sydney • Monash University • Australian National University • University of Adelaide • University of Melbourne • University of New South Wales • University of Queensland • University of Western Australia • University of Wollongong **Austria** • University of Graz **Barbados** • University of the West Indies **Belgium** • KU Leuven **Brazil** • Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP) • University of Sao Paulo **Canada** • McGill University • University of British Columbia (UBC) **Chile** • Pontifical Catholic University (PUC) Chile • University of Chile **China** • Beihang University • Southern University of Science & Technology (SUSTech)	**Estonia** • University of Tartu **Finland** • University of Helsinki **France** • Universite Grenoble Alpes • Lyon 3 (Jean Moulin University) • Arts et Metiers ParisTech (ENSAM) • Lyon 2 (Lumiere University) • Aix-Marseille University • Centrale Supelec • Ecole Polytechnique • ISAE-SUPAERO • Paris 1 (Pantheon-Sorbonne University) • Paris 3 (Sorbonne Nouvelle University) • Paris 9 (Paris-Dauphine University) • Sorbonne University **Germany** • University of Hamburg • Technical University Darmstadt • Technical University of Munich • Humboldt University of Berlin • University of Freiburg (Albert-Ludwigs-Universitaet-Freiburg) • University of Stuttgart • Goethe University • Frankfurt (Johann Wolfgang Goethe University) • Heidelberg University • LMU Munich • University of Bonn • University of Konstanz • University of Mannheim **Hong Kong** • Chinese University of Hong Kong • City University of Hong Kong	**Lebanon** • American University in Beirut **Mexico** • National Autonomous University of Mexico • Technical University of Monterrey **Netherlands** • Delft University of Technology • University of Amsterdam • Utrecht University **New Zealand** • University of Auckland • University of Otago **Norway** • University of Oslo **Portugal** • University of Porto **Scotland** • University of Edinburgh • University of Glasgow • University of St. Andrews • University of Strathclyde **Singapore** • Nanyang Technological University • National University of Singapore • Singapore Management University **South Africa** • University of Johannesburg

- Fudan University
- Peking University
- Shanghai Jiao Tong University
- Shanghai University
- Tsinghua University

The Czech Repbulic

- Masaryk University

Denmark

- University of Copenhagen
- Denmark Technical University

England

- University College London
- University of Nottingham
- University of Warwick
- University of Manchester
- Lancaster University
- King's College, London
- Queen Mary University of London
- Royal Holloway and Bedford New College, University of London
- University of Birmingham
- University of Leeds
- University of Liverpool

- Hong Kong University of Science & Technology
- University of Hong Kong

India

- Indian Institute of Technology, Bombay

Ireland

- Trinity College, Dublin

Israel

- Hebrew University of Jerusalem
- Technion-Israel Institute of Technology
- Tel Aviv University

Italy

- University of Siena
- Istituto Universitario di Studi Superiori di Pavia
- Universita Cattolica del Sacro Cuore

Jamaica

- University of the West Indies (Mona)

Japan

- RIKEN (SREP only)
- Keio University
- Kwansei Gakuin University
- Kyoto University
- Nihon University
- Osaka University
- Tohoko University
- Waseda University
- University of Tokyo

South Korea

- Korea University
- South Korea Advanced Institute of Science & Technology
- Seoul National University
- Yonsei University

Spain

- IE University
- University of Barcelona

Sweden

- Lund University
- Uppsala University

Switzerland

- Ecole polytechnique fédérale de Lausanne
- Swiss Federal Institute of Technology Zurich
- University of Geneva

Taiwan

- National Taiwan University

Thailand

- Chulalongkorn University
- King Mongkut's University of Technology Thonburi

Trinidad & Tobago

- University of the West Indies

Turkey

- Koç University

United States of America

- Killam Fellowships Program

Degree POSt (Program Of Study) Codes

The Faculty uses the following Degree POSt Codes to note which program a student is currently enrolled in. Options within a program are categorized by a unique degree POSt code. Full-time and part-time students will fall under one of these codes. It is possible for students to change their degree POSt code during their time in the faculty.

POST CODE	DEGREE	PROGRAM
AE NDEG		Non-Degree Special Student
AEENGBASC		Track One - General Engineering
AECHEBASC	BASc	Chemical Engineering
AECIVBASC	BASc	Civil Engineering
AECPEBASC	BASc	Computer Engineering
AEELEBASC	BASc	Electrical Engineering
AEESCBASE	BASc in Eng.Sci	Engineering Science
AEESCBASEA	BASc in Eng.Sci	Engineering Science (Aerospace Engineering Major)
AEESCBASEF	BASc in Eng.Sci	Engineering Science (Engineering Mathematics, Statistics and Finance Major)
AEESCBASEI	BASc in Eng.Sci	Engineering Science (Infrastructure Engineering Major)
AEESCBASEJ	BASc in Eng.Sci	Engineering Science (Energy Systems Engineering Major)
AEESCBASEL	BASc in Eng.Sci	Engineering Science (Machine Intelligence Engineering Major)
AEESCBASEP	BASc in Eng.Sci	Engineering Science (Engineering Physics Major)
AEESCBASER	BASc in Eng.Sci	Engineering Science (Electrical and Computer Engineering Major)
AEESCBASET	BASc in Eng.Sci	Engineering Science (Biomedical Systems Engineering Major)
AEESCBASEZ	BASc in Eng.Sci	Engineering Science (Robotics Engineering Major)
AEINDBASC	BASc	Industrial Engineering
AELMEBASC	BASc	Lassonde Mineral Engineering
AEMECBASC	BASc	Mechanical Engineering
AEMMSBASC	BASc	Materials Engineering
AEMINAIEN AEMINADVM AEMINBIO AEMINBME AEMINBUS AEMINENV AEMINENR AEMINMUSP AEMINNANO AEMINRAM		Engineering Minors Minor in Artifiial Intelligence Engineering Minor in Advanced Manufacturing Minor in Biogengineering Minor in Biomedical Engineering Minor in Engineering Business Minor in Environmental Engineering Minor in Sustainable Energy Minor in Engineering Music Performance Minor in Nanoengineering Minor in Robotics and Mechatronics
AECERAIEN AECERBUS AECERCOM AECERENTR AECERFORE AECERGLOB AECERLEAD AECERMINR AECERMUST AECERNUC AECERRRE		Certificate Programs Certificate in Artificial Intelligence Engineering Certificate in Engineering Business Certificate in Communication Certificate in Entrepreneurship Certificate in Forensic Engineering Certificate in Global Engineering Certificate in Engineering Leadership Certificate in Mineral Resources Certificate in Music Technology Certificate in Nuclear Engineering Certificate in Renewable Resources

Fees and Expenses

Tuition Fees

Method of Payment

Students will receive detailed instructions regarding fee payments prior to the Fall Term. Fees information is also available at Student Accounts.

Invoice Payment

A student's invoice, which details fees payable to the University of Toronto, will be posted in their account in ACORN. A student may pay their invoice in person at their bank either through a teller or automated teller machine (ATM).

Starting in the 2019-2020 academic session, a newly admitted international student must pay a non-refundable deposit of $2,000 in order to confirm their acceptance of an offer of admission. The deposit will go toward the student's tuition.

Electronic Payments

Students may also pay by telephone or online banking if their banks offer these services. Your account number is displayed on your invoice in ACORN; it consists of the first five characters of your surname (in capital letters) and ten numbers, which is your student number with leading zeroes. Ensure you distinguish between the letter "O" and the number "zero." The payee for the transaction is "University of Toronto."

Methods of Payment Outside Canada

Visit Student Accounts for details.

Official Registration

A minimum first installment of tuition fees posted in ACORN must be paid or deferred by the August deadline as listed in the "Session Dates" section of the Academic Calendar and the Current Engineering Undergraduates website.

Your registration is not complete until you have paid tuition and incidental fees, or have made appropriate arrangements to defer those fees.

Students who defer payment or whose payments are deferred pending receipt of OSAP or other awards acknowledge they continue to be responsible for payment of all charges, including any service charges that may be assessed.

Once you have successfully paid the minimum tuition fee or deferred your tuition, you will be registered in ACORN, thereby ensuring your courses are secure. If a student does not pay or defer their tuition fees by the posted deadline, their courses will be removed from their account. Requests for reinstatement into courses that have been removed are subject to late registration fees and course availability.

Students have the option to pay fees on a sessional basis — Fall and Winter terms together — or by term (separate Fall and Winter term payments). You must pay the "Minimum Payment to Register Amount" displayed on your current term ACORN invoice at least 3-5 business days (for an online payment at a major Canadian financial institution or by WU Union Global Pay service from outside of Canada) prior to the published registration deadline. Other types of payments can take up to 10 business days to be recorded in ACORN. If the minimum payment amount to register or fee deferral is successfully received, your registration status in ACORN will read "Registered."

Verify Your Registration Status

You may see if you have successfully registered for the term by logging into your ACORN account. Simply review the information in the "Registration" section. If your status is listed as "Registered" for the current term, your registration is complete. If your status reads "Invited to Register" you risk having your courses removed.

Ontario Student Assistance Program (OSAP) Deferrals

Students in financial need may apply for OSAP online. If you are an approved OSAP recipient, you may request to defer your fees provided that you have no outstanding fees from a previous session. Once your fees are successfully deferred, your status in ACORN will read "Registered."

Outstanding Balances

All fees are posted to your account in ACORN. Monthly payments towards an outstanding account balance are required and the balance of the account must be cleared by the end of the year (April 30 of each year).

The outstanding balance of the account is subject to a monthly service charge of 1.5 per cent (19.56 per cent per annum). For more information, please visit www.fees.utoronto.ca. Please note that when you make your tuition/fees payment at a bank, it takes at least five to seven business days from within Canada and 10 to 14 days from outside of Canada for it to be processed and received by the University. You are responsible for additional interest charges incurred for payments processed after deadlines have passed.

All payments are applied to outstanding charges from previous sessions first, then to the current session. Fees and other charges set forth in this Calendar are subject to change by the Governing Council.

Fees Schedule

The fees for the 2021-2022 academic year will be available for review on the Student Accounts website at studentaccount.utoronto.ca in July 2021.

For reference, fees for the 2020-2021 academic year are listed below.

Full-Time Students, 2020-2021

Domestic Students

Academic Fee	$14,180.00
Incidental Fees*	$1,1600.23
Total Fee (If paid in one installment)	$15,780.23

International Students

Academic Year	I	II	III	IV
Academic Fee	$60,440.00	$60,440.00	$59,310.00	$57,670.00
Incidental Fees*	$1,1600.23	$1,1600.23	$1,1600.23	$1,1600.23
University Health Insurance Plan (UHIP) Fees	$720.00	$720.00	$720.00	$720.00
Total Fee (If paid in one installment)	$62,760.23	$62,760.23	$61,630.23	$59,990.23

Part-Time & Special Students, 2020-2021

Domestic Students

For each Engineering 0.5 course load	$1,418.00
Incidental Fee (once annually)	$615.23

International Students

Academic Year	I	II	III	IV
For each Engineering 0.5 course load	$6,044.00	$6,044.00	$5,931.00	$5,767.00
University Health Insurance Plan (UHIP) Fees (once annually)	$720.00	$720.00	$720.00	$720.00
Incidental Fee (once annually)	$615.23	$615.23	$615.23	$637.98

*Non-academic incidental fees include campus fees; student society fees; Engineering Career Centre; Temporary study levy; system access fee.

Other Fees

Professional Experience Year (PEY) Internship Program Placement fee. Subject to annual approval. Visit engineeringcareers.utoronto.ca for details	
Engineering Summer Internship Program (ESIP) Placement fee. Subject to annual approval. Visit engineeringcareers.utoronto.ca for details	
Copy of documents in student information file (other than transcript).	$15
Copy of examination paper, per paper (non-refundable). Visit www.undergrad.engineering.utoronto.ca for applicable deadlines.	$15
Final examination re-grade, per course Visit www.undergrad.engineering.utoronto.ca for applicable deadlines. Note: Fee is refunded if an error is found.	$36
Letter of Permission.	$40
Final mark re-check, per course Visit www.undergrad.engineering.utoronto.ca for applicable deadlines. Note: Fee is refunded if an error is found.	$13
Re-enrolment application.	$25
Registration letter.	$8
Each additional copy.	$0.50
Special student application, per submission.	$90
Student Card replacement. TCard replacements can be obtained from the TCard Office. Bring photo ID.	$12
Transcript request, per copy. Processed by U of T Transcript Centre (UTTC). Students can order their transcripts in ACORN.	$12

*Please note that under University of Toronto policy, transcripts, letters of permission and registration letters cannot be issued by fax.

Summary of Student Expenses

The following statement of approximate expenses will provide students with a general idea of the cost of obtaining an education in the Faculty of Applied Science & Engineering at the University of Toronto, exclusive of personal expenses:

- Books and instruments per year: $1,500
- Fees (see fees schedule above)
- Room and board (meal plan included): approximately $7,840-$17,800 per year, or $980-$1,525 per month

Detailed information on student housing is available online.

Refund Schedule

Students who withdraw from the University (see section below regarding withdrawal penalty) may be eligible for a fees refund depending on the date of withdrawal from the institution. Further information about refund schedules can be found on the Student Accounts website.

Penalties

Withdrawal from the University

Students who withdraw entirely from the University, thereby cancelling their registration in a program (Degree POSt) on or after the published date for the first day of classes in the session, will be assessed a minimum charge of $263 in respect of academic fees.

Further information about the minimum charge is listed on the Student Accounts website.

Late Registration Reinstatement Fee

$61

Academic Sanctions

The following academic sanctions will be imposed on students who have outstanding University obligations:
1. Transcripts of academic record will not be issued.
2. Registration will be refused to a continuing or returning student.

An outstanding University obligation includes:

- Tuition fees
- Academic and other incidental fees
- Residence fees and other residence charges
- Library fines
- Bookstore accounts
- Loans made by colleges, faculties or the University
- Health Service accounts
- Unreturned or damaged instruments, materials and equipment
- Orders for the restitution of property or for the payment of damages and fines imposed under the Code of Student Conduct

Students Registered with Accessibility Services

Students with a documented permanent disability who are required to take a reduced course load as a learning accommodation will be billed per-course fees for a course load up to a maximum of 4.5 for the Fall/Winter session. The fee schedule is posted online at Student Accounts. Information on Accessibility Services is available online.

Scholarships and Financial Aid

Guidelines & Descriptions

Undergraduate students of the Faculty of Applied Science & Engineering who achieve scholastic excellence are eligible for scholarships, prizes, bursaries, medals and honours that have been established through the University, its alumni associations, governments, commercial organizations and other benefactors to encourage and honour outstanding achievement.

The awards are listed alphabetically in four sections: OSOTF Admission Scholarships/Awards and non-OSOTF Admission Scholarships for students entering their first year in the Faculty and OSOTF In-Course Scholarships/Awards and non-OSOTF In-Course Scholarships and Grants.

The National Scholarship Program

University of Toronto National Scholarships are awarded to Canadian secondary school students who demonstrate superior academic performance, original and creative thought and exceptional achievement in a broad context.

National Scholars are students who not only excel in academic pursuits but also have an enthusiasm for intellectual exploration and an involvement in the life of their school and community. The National Scholarship is available to Canadian citizens, Permanent Residents and protected persons currently in their final year of Canadian secondary school who meet the criteria above.

Each Canadian secondary school is invited to nominate one student on the basis of this criteria to receive a University of Toronto National Book Award. These students, and others who identify themselves as meeting the National Scholarship criteria, are invited to enter the National Scholarship Competition. Information is sent to secondary schools in the early fall; the National Scholarship application is available online and the deadline is in early November of the student's graduating year.

25 students are normally selected as winners, with approximately 15 being selected as National Scholars (winners) and the remaining finalists being designated as Arbor Scholars. National scholars receive a scholarship that covers tuition, incidental, and residence fees for up to four years of undergraduate study. Arbor Scholars receive an award valued at $7,500 in the first year and $1,500 per year for three additional years of undergraduate study. Additional information is available online.

University of Toronto Scholars Program

The University of Toronto Scholars Program recognizes outstanding students at admission and on an ongoing basis. There are over 800 admission awards, valued at $7,500 each, which may be held in conjunction with admission awards students may receive from their college/faculty. Outstanding students are automatically considered for these awards.

Awards under the University of Toronto Scholars Program are not renewable. Outstanding students, however, may be eligible for consideration for University of Toronto (in-course) Scholarships at the end of the first, second and third year of their programs. There are approximately 100 scholarships at each level. These in-course awards are worth $1,500 each and are tenable with other in-course scholarships.

President's Scholars of Excellence Program

Approximately 120 of the most highly-qualified students who apply to first-year of direct entry undergraduate studies will be distinguished as President’s Scholars of Excellence. This distinction includes a $10,000 entrance scholarship in first year, guaranteed access to meaningful part-time on-campus employment during second year and guaranteed access to an international learning opportunity during a student’s university studies.

Additional features may be offered by the admitting faculty, which will be communicated in the student's admission letter.

Outstanding domestic and international secondary school students are automatically considered for these scholarships. The scholarship is tenable only in the faculty that makes the offer.

Payment of the award is conditional on full-time registration at the University in the fall of the year the award is granted; retention of the higher-year opportunities attached to the award requires a student's continuing full-time registration in good standing.

Lester B. Pearson International Scholarship Program

Introduced in September 2016, the Lester B. Pearson International Scholarship recognizes international students who demonstrate exceptional academic achievement and creativity and who are recognized as leaders within their school. A special emphasis is placed on the impact the student has had on the life of their school and community, and their future potential to contribute positively to the global community.

This is U of T's most prestigious and competitive scholarship for international students. Each year, approximately 37 students are named Lester B. Pearson Scholars. The value of the scholarship covers tuition, incidental fees, books and living expenses for four years of undergraduate study. Recipients also have access to enriched programs and services. Eligible international students must be nominated by their home school; nominees must subsequently submit their application for the scholarship by the yearly deadline.

The University's Commitment

The University's Policy on Student Financial Support states that students should have access to the resources required to meet their financial needs as calculated by the Ontario Student Assistance Program (OSAP). The commitment is based on the assumption that Canadian citizens/Permanent Residents/protected persons (recognized convention refugees) will first access the government aid for which they are eligible.

University of Toronto Advance Planning for Students (UTAPS) funding is assessed based on the Ontario Student Assistance Program (OSAP), as OSAP provides a uniform, verified method of assessing student need. The University will ensure unmet needs are met for full-time students (in both terms of an academic year) who are assessed by OSAP as requiring maximum assistance and whose assessed needs are not fully covered by government aid. Full-time students receiving funding from other provinces, territories or a First Nations band are also eligible for consideration.

University of Toronto Advance Planning For Students (UTAPS)

Students who are concerned about the financial cost of attending university can obtain early information about the amount of funding they can expect to receive from government programs and other forms of financial assistance by completing a UTAPS application. Returning students with calculated unmet need above the government funding maximum will be considered for UTAPS grant assistance in the fall.

The University's Financial Aid website has additional information and the UTAPS Application. First-year applicants should submit their UTAPS applications by late February so they can be considered for need-based admission awards.

Government Financial Aid

The Ontario Student Assistance Program (OSAP) provides need-based financial assistance to Ontario residents who are Canadian citizens, Permanent Residents or protected persons (recognized convention refugees).

Students in course loads of 60 per cent or greater are considered for both federal and provincial interest-free student loans and non-repayable grants to assist with educational and living expenses.

OSAP applications are available in April through OSAP's website. Students from other Canadian provinces and territories should apply through their home provinces.

University of Toronto Work-Study Program

This program is funded by the University and the Ministry of Training, Colleges and Universities and provides on-campus part-time employment to eligible students. Information and applications are available from the Career Centre.

Financial Aid for Students with Disabilities

Non-repayable grants are available through the Ontario Bursary for Students with Disabilities (BSWD) and the Canada Student Grant for Services and Equipment for Persons with Disabilities to help with the disability-related supports and services for students with permanent or temporary disabilities. Information and an online applications are available from Enrolment Services and Accessibility Services.

Part-Time Studies

The Federal Government has established a loan and grant program for part-time students enrolled in course loads of less than 60 per cent or less than 40 per cent for students with a documented disability. Unlike OSAP loans, the interest on part-time Canada Student Loans becomes repayable thirty days after the loan is received. Federal grants for educational expenses are also available for high-need part-time students.

The Noah Meltz Grant program helps undergraduate students in certificate, degree, diploma programs, including Academic Bridging Program, pursue their University of Toronto studies on a part-time basis. Eligible students receive a non-repayable grant for tuition cost up to two credits during the fall/winter session and up to one credit during the summer session. The grant amount also includes a set amount for books, transportation to and from classes and, if applicable, child care. Further information and an online application may be obtained from Enrolment Services.

International Students

International students entering Canada or currently in Canada on student authorization are not eligible for government assistance and must ensure they have sufficient funds to cover all probable expenses. Such students cannot depend on gaining part-time employment in Canada to help pay for their studies.

Admission Scholarships

Please see the "OSOTF" and "Non-OSOTF" Admission Scholarships sections later in this Chapter for details.

In-Course Scholarships & Bursaries

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed in this chapter. Where it is necessary to apply for an award, details of how to apply are included. In all other cases, the award is made on the recommendation of the Faculty Council and no application is necessary.

Dean's Honours List

In 1983, Faculty Council instituted the Dean’s Honours List to give special recognition to every student who demonstrated academic excellence in an individual session. The requirements for qualifying for the Dean’s Honours List are outlined in the Academic Regulations section of the Academic Calendar.

The list is posted prominently for a limited time in a place designated by the Faculty for this purpose. The lists for successive sessions are compiled in a permanent record maintained in the Office of the Registrar.

General Terms & Conditions of Awards

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the Winter Term, and candidates are ranked on the basis of their achievements in the Winter and Fall Sessions previously completed.

To be eligible for any scholarship or award granted solely on academic standing, a student must normally have completed not less than the normal full load (approximately 5.0 credits units) within the two sessions upon which the award is based. A student whose program in these two sessions contains repeated courses will only be eligible if the aggregate of new courses is equal to or greater than 5.0 credits.

Scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted unless otherwise specified in the terms of the award. If the award is based on a single course or on part of the work of the session, the candidate must obtain unconditional pass standing in the work of the session, but not necessarily honours standing, unless the terms of the award so specify.

A candidate will not normally be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the Calendar specifies otherwise.

Tuition and residence fees are the first charge against awards. After the deduction of the applicable charges, any balance remaining will be paid to the recipient in November. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the program in which the award is established or granted.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by mail.

Awards granted to members of graduating classes, other than awards for graduate study and research, will be paid in one installment as soon as possible after the granting of the awards.

The Governing Council may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance in the Faculty for one year. Further postponement may be permitted on application.

Note: The value of an endowed scholarship or prize is dependent on the actual income of the fund; it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the Calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

Ontario Student Opportunity Trust Fund (OSOTF) Awards

In the case of all OSOTF awards, eligible candidates must be Ontario residents and they must demonstrate financial need. For the purpose of OSOTF awards, an Ontario resident is either a Canadian citizen or a Permanent Resident of Canada who has lived in Ontario for twelve consecutive months prior to starting a post-secondary program. Financial need is most easily demonstrated with receipt of OSAP for the current year; other examples of financial need will be considered. For admission OSOTF Awards, it is crucial that applicants for admission complete a UTAPS application in order to demonstrate financial need.

OSOTF Admission Scholarships

Fernando V. Agostinelli Memorial Scholarship
This scholarship was established in 2007 through a generous donation from Tow/Carruthers and Wallace Ltd., Antoinette Agostinelli and the family and friends of Fernando Agostinelli. The scholarship was created to honour Fernando's many contributions in the field of structural engineering. The award is issued on the basis of financial need and academic merit to a full-time student entering their first year of Civil Engineering studies. In addition, qualities of character and leadership as demonstrated through extra-curricular activities/community involvement are also considered.

Hira & Kamal Ahuja Award in Engineering
Established in 2004 through a generous donation by Professor Hira Ahuja, this award is given to a student entering their first year of studies in any program in the Faculty and is based on financial need. Academic merit is also considered. Additional preference is given to a student who has extra-curricular involvement/service in the East Indian community.

Kenneth Au-Yeung Memorial Scholarship
This scholarship was established in 1999 by Ben and Catherine Au-Yeung in memory of their son. The scholarship is awarded to a Computer Engineering student and is based on financial need, academic achievement in the prerequisite courses as well as a demonstrated commitment to community service.

Jack & Lily Bell Entrance Scholarship
Created through a generous donation by friends and family of Jack and Lily Bell, this award is given to a student entering first-year Industrial Engineering and is based on financial need and academic merit.

The Robert L. Bullen Admission Scholarship
This scholarship, derived from the income of a capital fund, was established in 1982 in memory of the late Robert L. Bullen, BASc, Metallurgical Engineering, 1929, by his wife, Mrs. Robert L. Bullen. The scholarship is awarded annually on the basis of financial need to one or more students entering their first year of studies in the Faculty of Applied Science & Engineering. Academic standing in prerequisite courses is also considered.

CIBC BASc Scholarships at the University of Toronto
Funded by a donation from CIBC, this fund is used in support of summer fellowships for students who have decided to fully commit (full-time) to the Hatchery Entrepreneurship program for the summer, running from May - August each year. Students must demonstrate financial need.

Class of 5T1 Bursary
This bursary, established in 2001, is provided by the generosity of the Class of 5T1. The bursary is awarded on the basis of financial need and academic merit to a student entering into the Faculty of Applied Science & Engineering.

Colcleugh Family Award
Established in 2004 through the generosity of the Colcleugh family, this award is given on the basis of financial need to a student entering their first year of Chemical Engineering. Preference is given to students who have achieved a high academic performance. In addition, students should exhibit leadership potential and have a broad range of interests and involvement and volunteerism. The award is renewable in second, third and fourth years providing recipient continues to demonstrate financial need and achieves a minimum average of 75 per cent in each year. If in any given year, the renewal portion is not granted, it shall be awarded, by reversion, to the next qualifying candidate in that year.

The Sydney C. Cooper Scholarships
Through the generosity of the family educational and charitable foundation of Sydney C. Cooper (CivE 4T5) two awards are established in the Department of Civil Engineering. One award is granted to a student entering first year and one to a student entering fourth year. The first year award is made on the basis of financial need. Academic achievement, involvement in athletics and participation in extra-curricular activities will also be considered.

I.E.E. Toronto Centre Scholarship
In 1997, the Toronto Centre of the Institution of Electrical Engineers established this scholarship in memory of the late Al Fabian. The award is granted to a student entering either first-year Electrical or Computer Engineering (alternated annually between the two programs) who demonstrates financial need. Academic merit is also considered.

The Lau Family Scholarships
These scholarships were established in 1997 through the generosity of Mr. Lee-Ka Lau and family. Two scholarships are granted: one to a student entering the first year in Computer Engineering and one to a student entering first year in Electrical Engineering. The awards are based on financial need. Academic achievement will also be considered. Scholarships may be renewed for second year in the designated programs on the basis of continued financial need and the achievement of honours standing.

J. Edgar McAllister Foundation Student Awards Program
Provided by the bequest of the late J. Edgar McAllister, BASc, numerous awards, varying in amounts, are available to students entering or continuing in Mechanical, Electrical, Mining or Chemical Engineering and who demonstrate financial need.

Motorola Foundation Scholarships
Established in 1996 through the generosity of the Motorola Foundation, two awards are available for students entering first year of either Electrical or Computer Engineering and are based on financial need. Academic standing is also considered.

Vera Catherine Noakes Scholarship
Established in 2001, this scholarship is to be awarded to a student entering first year of any undergraduate program in Engineering on the basis of financial need. Preference is given, when possible, to a student from the Windsor, Ontario, area.

ProScience Inc. Engineering Entrance Scholarship
Established in 2004 through the generosity of ProScience Incorporated, this award is granted to a student entering any undergraduate program in the Faculty who demonstrates financial need and excels academically. Preference is given to students with disabilities.

Robert John Richardson Memorial Scholarship
Established in 2002 from the estate of the late Robert John Richardson (5T0), this scholarship is awarded to a student entering the first year of any undergraduate engineering program and is based on financial need and academic achievement. Preference is given to students from North Bay. If the candidate is from North Bay, the scholarship is renewable for three years on the basis of continued financial need and provided satisfactory achievement (min. 60 per cent) is obtained at the end of each year. After the scholar has completed their four-year program, a new recipient will receive the scholarship. If the candidate is not from North Bay, the scholarship will be for the first year of study only.

Donald Ross Leadership Award
Through a generous gift of Mr. Donald Ross in 1997 this award was established in the Department of Chemical Engineering & Applied Chemistry. The award is granted to a student entering the first year of the program and is based on financial need, academic achievement and demonstrated leadership skills in high school through participation in team sports and/or student affairs. Community involvement will also be considered. The award may be renewed for second year provided at least 75 per cent standing is maintained and that the awardee remains deserving.

Leon Rubin Scholarships
Established in 1997 through the generosity of William F. McLean, a number of scholarships are available for students entering first-year Chemical Engineering and is based on financial need. Academic standing is also considered. Awards may be renewed for second year on the basis of continued financial need and academic achievement at the end of year one.

Robert Sangster Memorial Admission Award
A gift of the family and friends of the late Robert Sangster (ElecE 4T9), this scholarship, of the approximate value of $800, is awarded annually to a student entering the first year of any program in the Faculty of Applied Science & Engineering and is based on financial need and satisfactory academic standing in secondary school.

Fred Schaeffer Scholarship in Civil Engineering
Established in 2004 through a generous donation by Mr. Fred Schaeffer, this award is granted to a student entering first-year Civil Engineering. Financial need and academic merit are considered.

Edward & Helen Swanston Scholarships
The scholarship was established in 1997, made possible by a generous donation from Edward Y. Swanston. The scholarship is awarded to one or more students entering first-year Chemical Engineering & Applied Chemistry. Financial need, academic achievement, extra-curricular involvement in high school through participation in team sports (with an emphasis on sportsmanship) and/or community service is considered.

Christopher Skrok Memorial Scholarships
(See listing later in this Chapter)

The Jean Wallace Memorial Scholarship
This award was established in 1999 by William L. Wallace (MMS 5T6) in memory of his mother, the late Jean Wallace. The award is granted to one or two students entering first-year Materials Engineering and is based on financial need. Academic achievement and demonstrated leadership qualities through both school and community involvement are also considered. If no suitable candidate is found at the admissions level, the award, based on the same criteria, may be granted to a student completing first-year Materials Engineering. Departmental recommendation.

University of Toronto Engineering International Scholar Award
Several scholarships, of varying amounts, are awarded to international students entering First Year of any undergraduate program in the Faculty. Candidates must be enrolled in a secondary school outside of Canada. Decision is made on the basis of exceptional academic record and demonstrated leadership through involvement in the school or the broader community. The award may be renewable for the duration of the degree (up to 4 years) provided a minimum 75% average is maintained.

Non-OSOTF Admission Scholarships

Betz Entrance Scholarship in Electrical & Computer Engineering
Established in 2010 through a generous donation by Vaughn Betz, this scholarship is given on the basis of academic achievement to student(s) entering the Edward S. Rogers Sr. Department of Electrical & Computer Engineering. Extra-curricular activities, including a focus on design, may also be considered.

Jim Balsillie Engineering Scholarship
Established in 2020 through a generous donation by Julie Di Lorenzo, this award is given to a student entering First Year of any undergraduate program in the Faculty on the basis of academic merit; must be Canadian citizen or permanent resident.

The Bi-cultural Admission Scholarship
The Professional Engineers Wives' Association established an admission scholarship of the value of the income from the fund that is awarded to a student entering the first year of any program in the Faculty of Applied Science & Engineering. In addition to achieving outstanding results in the subjects prescribed for admission to the Faculty, candidates must have excelled in at least one course in either of Canada's official languages in the final year of high school in Ontario. The first award was made in June 1983.

William Buttimer Entrance Scholarship
Established in 2018 from the Estate of William Buttimer, this scholarship is given annually to an academically strong student entering any undergraduate program in the Faculty with a goal to enhance diversity (female, indigenous student).

Calgary Skule™ Admission Scholarship
Granted to one or more students entering the first year (full-time) of any program in the Faculty. Recipient(s) are selected on the basis of promising leadership ability as evidenced by extra-curricular/community involvement. Academic ability is also considered. Recipients must be Canadian citizens or permanent residents of Calgary.

Chemical Engineering & Applied Chemistry Alumni Entrance Scholarships
Established in 1995, these scholarships, provided through the generosity of alumni and friends of the Department of Chemical Engineering & Applied Chemistry, are open to students entering the first year of the program and is based on academic standing in the subjects required for admission.

Civil Engineering Admission Scholarships
Established in 1995, these scholarships, provided through the generosity of alumni and friends of the Department of Civil Engineering, are awarded to students entering the first year of the Civil Engineering program and is based on academic excellence. Some awards may be renewable provided the student achieves honours standing at the end of first year and proceeds to second year of the program.

Sydney & Florence Cooper Admission Scholarship
Established in 2007 through a generous donation by Sydney and Florence Cooper, this award is given to a student (or students) entering first-year Civil Engineering and is based on academic merit. Preference is given to students who demonstrate leadership in the community and through extra-curricular activities.

Dean's Merit Award
Established in 2015, the Dean's Merit Award is given to students entering first year of any undergraduate program in the Faculty on the basis of academic merit.

Edward L. Donegan Scholarship in Engineering
Established in 2007 through a generous donation by Mr. Edward L. Donegan, this scholarship is awarded to student(s) entering the first year of any program in the Faculty. The scholarship is granted on the basis of demonstrated academic excellence (min. 85 per cent average on pre-requisite courses). Recipient(s) shall have demonstrated leadership in extra-

curricular and community activities. Preference is given to students who demonstrate a credible interest in pursuing a Juris Doctor or Bachelor of Law degree or its equivalent following undergraduate engineering studies. Financial need may also be considered. The scholarship is renewable at the end of first, second and third year provided recipient(s) maintain an overall minimum average of 80 per cent. This award will be made on admission every four years, or in any year in which recipient(s) do not qualify for renewal.

Engineering Alumni Association Admission Scholarships
Five scholarships are annually provided annually by the University of Toronto Engineering Alumni Association for students entering the first year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of high standing in Ontario Secondary school.

There are two types of scholarships:

- The William Ian MacKenzie Turner 2T5 Scholarship, named after a “Schoolman of Distinction,” with a full value of $1,500
- Four Centennial Scholarships with a value of $1,000 each when entering first year

Engineering Science Alumni Admission Scholarships
These scholarships, established by the generosity of various donors, are awarded to two students entering the first year of the Engineering Science program. Academic merit is considered and extra-curricular activities may be considered.

Faculty of Applied Science & Engineering Admission Scholarship(s)
These awards, derived from the annual income of a capital donation, are granted to students entering the first year of any Engineering program and are based on outstanding academic achievement in the prerequisite courses.

J. Colin Finlayson Admission Scholarship
Established in 2007 through a generous donation by J. Colin Finlayson, this award is given to a student (or students) entering first-year Mechanical or Industrial Engineering and is based on academic merit. Preference is given to students who demonstrate leadership in the community and through extra-curricular activities.

Robert M. Friedland Scholarships
These scholarships were established in 1996 through a generous donation from Robert M. Friedland, Chairman of Indochina Goldfields Ltd. and Bakyrchik Gold PLC. The awards are granted on the basis of academic standing and preference is given to international students entering the first year of the Lassonde Mineral Engineering Program. If there are no suitable candidates in the Program, the award can be granted to international students entering the first year of any undergraduate program in the Faculty. If there are no suitable candidates in the Faculty, the award can be granted to students entering the first year in any Faculty at the University of Toronto. The admission awards are renewable in second year provided honours standing is maintained at the end of first year and that the candidate proceeds to the second year of the Lassonde Mineral Engineering Program.

James A. Gow Admission Scholarship
This scholarship was established in 1982 through donations provided by friends and colleagues to honour James A. Gow (4T6) on his retirement and recognize his many contributions to the Faculty. Jim Gow served the Faculty for 35 years, the last 20 as Secretary and Assistant Dean. During those years he was friend and counsellor to staff and to countless students who remember him as one dedicated to their well-being. The scholarship is awarded annually to a student who achieves high standing in an Ontario secondary school. The award is tenable for any program.

The Grabill Admission Scholarship
The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill (2T4). The scholarship is awarded to a candidate with high standing in an Ontario Secondary school.

George A. Guess Admission Scholarships
(see listing later in this Chapter)

Frank Howard Guest Admission Bursary
(see listing later in this Chapter)

Walter Scott Guest Memorial Scholarships
Established in 1995 by the estate of Frank Howard Guest as a memorial to his father, the late Walter Scott Guest, these

Scholarships are awarded entering the first year of any undergraduate program in the Faculty on the basis of academic standing.

Reginald & Galer Hagarty Scholarship
This award was established by Lieutenant-Colonel E.W. Hagarty and Charlotte Ellen Hagarty in memory of their sons, Reginald and Galer, and is to be granted to a student entering first year of any undergraduate program on the basis of academic achievement. Recipient must be a graduate of Harbord Collegiate.

Horace Hally Admission Scholarship
This scholarship was established in 1997 from the estate of the late Horace Angus Hally, a friend of the University of Toronto. The award will be granted to a student entering the first year of the Mechanical Engineering program on the basis of satisfactory academic standing in the secondary school courses required for admission.

Jane Elizabeth Ham Memorial Scholarship
This award was established in 1993 by Professor and Mrs. James Ham in memory of their daughter. The scholarship will be awarded to a student on entrance to the Faculty, in any program, on the basis of outstanding academic achievement consistently obtained in each of the subjects required and offered for admission. Range of personal interests and financial need is relevant. Half of the total amount of the award is made on entrance and the other half upon registration in the second year, on the condition that the student obtains honours in First Year. In addition, there is an OSOTF portion.

William Harland Leadership Award
This award, established in 2000 by Dr. Carlton Smith in memory of the donor's late wife, Marguerite Smith, and in honour of the donor's father-in-law, William Harland, is awarded to a student entering first-year civil engineering. Awarded based on academic credentials and leadership potential as demonstrated by involvement in student council activity, participation in athletics and community involvement.

Hatch Engineering Aboriginal Scholarship
This award, established in 2013 by a generous donation from Hatch Ltd., is awarded to an incoming first-year aboriginal student and is based on outstanding academic achievement and promise. The scholarship may be renewed for second, third and fourth year provided the student is eligible to proceed to the next academic year with a clear record.

Frank Leslie Haviland Scholarship
Established in 2018 from the estate of Margaret A. Kennedy, this award is given to an international student entering first year of any program in the Faculty on the basis of academic merit and is renewable for second, third and fourth year. Recipients must be international students from underrepresented regions, with a preference for Latin America. This scholarship will be made on admission every four years, or in any year in which the recipient does not qualify for the renewal.

Kenneth F. Heddon Memorial Admission Scholarship
Established in 2007 from the estate of Kenneth F. Heddon, this award is granted on the basis of outstanding academic merit to a student entering the first year of any undergraduate program.

The Murray Calder Hendry Scholarship
This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a 1905 graduate of this Faculty. It has a value of the income from a capital sum of $10,000 and the recipient must have attained an average of at least 75 per cent on the Ontario Secondary School subjects required for admission and be entering the first year of any course in the Faculty of Applied Science & Engineering. The first award issued during the 1962-1963 academic year.

Roy Jarvis Henry Admission Scholarships
The estate of the late Roy Jarvis Henry awards up to four scholarships to students who have achieved high standing on the Ontario Secondary school qualifications required for admission — one open to students entering Lassonde Mineral Engineering and the others to students entering any program in the Faculty. If there is no suitable candidate in Lassonde Mineral Engineering, all awards are tenable in any program in the Faculty.

The Hidi Award at the University of Toronto
Established in 2017 through generous donations by friends of Andrew Hidi, this award is given to a student entering first year of any undergraduate program in the Faculty on the basis of financial need and strong academic achievement, with preference given to students who were born outside of Canada.

John Hirschorn Memorial Scholarship
This award was established in 2002 by Ron and Linda Hirschorn to honour the memory of the late John Hirschorn (MechE 4T1). This scholarship is granted on the basis of academic merit to a student entering first-year Mechanical Engineering. The scholarship is renewable for three years provided the recipient maintains a minimum of 65 per cent average at the end of each year.

Arthur B. Johns Award
This award was established in 2007 through generous donations by friends and family of Arthur B. Johns. The award is given to a student (or students) entering first year, full-time studies in Civil Engineering and is based on outstanding academic merit. Preference is given to students who demonstrate leadership in the community and extra-curricular activities.

Albert & Rose Jong Entrance Scholarship
Established in 2006 through a generous donation by Dr. Roberta Jong, Dr. Raynard Jong and Dr. Winston Jong, this scholarship is awarded to a student entering the first year of either Electrical Engineering or Engineering Science. The scholarship is awarded on the basis of academic merit and financial need. Preference is given to students who demonstrate leadership in the Chinese-Canadian community. Recipients must be Canadian citizens or Permanent Residents.

Kenneth Raffles Kilburn Scholarship(s)
Established in 2006 by the estate of the late Kenneth R. Kilburn, these scholarships are awarded on the basis of outstanding academic ability to students entering or continuing in any program in the Faculty.

The Harvey W. Kriss Admission Scholarship in Industrial Engineering
This scholarship was established in 1989 by family, friends and colleagues in memory of Harvey W. Kriss (EngBus 5T9), S.M. (MIT, 1961). The award, derived from the annual income, is granted to a student entering first-year Industrial Engineering. In addition to academic excellence, qualities of character and leadership as demonstrated in school and community activities are considered.

Helmut Krueger Undergraduate Admission Scholarship in Engineering
Established in 2013 through a generous donation by Helmut Krueger, this scholarship is awarded to one or more students entering the first year of any undergraduate program in the Faculty. Academic merit is considered.

Kwong Family Scholarship
Established in 2019 through a generous donation by Professor Raymond Kwong, this award is given to a full-time student proceeding to fourth year in the Edward S. Rogers Sr. Department of Electrical & Computer Engineering who has demonstrated consistent improvement from years one through three, with preference given to students who demonstrate financial need. Selection is made on the recommendation of the Department Chair or designate.

Hok Chee Poon and Yim Hung Kwong Bursary
This bursary was established in 2019 through a generous donation by Pak Kin Poon and is given to a domestic full-time or part-time student in the Division of Engineering Science who demonstrates financial need. Students apply through the online grant application in ACORN.

Lassonde Scholarships
(see listing later is in this Chapter)

John C. H. Lee Memorial Scholarship
The Industrial Engineering Class of 8T7 initiated the John C .H. Lee Memorial Scholarship in memory of their friend and classmate. The scholarship was funded by friends, classmates, the Korean community and family members seeking to recognize full-time students entering the first year in any undergraduate program in the Faculty. The award is made on the basis of high academic achievement in the prerequisite courses, demonstrated athletic proficiency, and extra-curricular involvement both within the community and the high school. Applicants must be Canadian Citizens or Permanent Residents and must live in residence in order to enjoy this award.

Donald C. Leigh Memorial Scholarship
This scholarship was established in 2007 through a generous donation by Mrs. Anne Leigh in memory of her husband. The award is given to a student, based on academic excellence, entering first-year Engineering Science on a full-time basis. Recipients must be Canadian Citizens or Permanent Residents.

James Turner MacBain Scholarship
(see listing later in this Chapter)

Salim Majdalany Scholarship
(see listing later in this Chapter)

The Hal Major Memorial Admission Award
This award is provided by the generosity of Mr. George Bird (CivE 4T9) in memory of his uncle, Mr. Hal Major, who died in 1986 at the age of 94. The award is granted to a student entering first-year Civil Engineering. Financial need and demonstrated qualities of character and leadership are considered.

J. Edgar McAllister Foundation Admission Awards
Provided by the bequest of the late J. Edgar McAllister, numerous awards of varying amounts are available to students entering their first year of studies in Mechanical, Electrical, Mineral, or Chemical Engineering on the basis of financial need and high academic achievement in the prerequisite courses for admission.

Barbara McCann Tribute Scholarship
This award was established in 2015 by friends and family of Barbara McCann, along with a match from the Faculty of Applied Science & Engineering, to commemorate Barbara's retirement as Faculty Registrar. The award is given to a student (preferably female) entering first year of any undergraduate program in the Faculty on the basis of academic merit and demonstrated leadership**.**

The John Wolfe McColl Memorial Awards
The income of this fund is divided equally among the Faculty of Applied Science & Engineering, the Faculty of Arts & Science and the Faculty of Medicine. The funds available to the Faculty of Applied Science & Engineering provide admission scholarships for outstanding students entering first year in any program.

Lachlan Dales McKellar Admission Scholarships
Provided by a bequest of the late Leona D. McKellar, one or more scholarships are given to students who achieved high standing in the prerequisite courses for admission to the Faculty.

Mechanical & Industrial Engineering Admission Scholarship(s)
These scholarships are awarded to students entering first-year Mechanical or Industrial Engineering. Academic merit in the prerequisite courses, as well as involvement in extra-curricular activities, is considered. Some awards may be renewable at the end of first year. The department may also choose to offer an admission scholarship payable at the end of first year provided a minimum average is obtained. The minimum average is at the department's discretion.

Metallurgy & Materials Science Alumni Admission Scholarships
Established in 1995 by friends and alumni of the Department of Materials Science & Engineering, this scholarship is awarded to students entering first-year Materials Engineering. Outstanding academic performance in the subjects required for admission and involvement in school and community activities are considered.

George R. Mickle Admission Bursaries
Provided by a bequest of the late George R. Mickle, several bursaries are available to students entering the first year in the Faculty of Applied Science & Engineering. The awards are made on the basis of the applicants' academic standing in the prerequisite courses and financial need.

Allan Wai Chiu Mok & Isa Po Po Gok Admission Scholarship
Established in 2018 through a generous donation by Alvin Mok, this award is given annually to a full-time student entering the first year of any undergraduate program in the Faculty on the basis of academic merit.

Michael M. Mortson Industrial Engineering Admission Scholarship
Established in 2009 through a generous donation by Mr. Michael M. Mortson, this scholarship is given to a student entering first-year Industrial Engineering program and is based on academic merit. Preference is given to students who demonstrate excellence in extra-curricular activities.

Maasland Norman Family Scholarship in Memory of Paul Maasland
Established in 2020 through a generous donation by Michael Norman and Lisa Maasland, this scholarship is given to a student, Canadian Citizen or Permanent Resident, entering first year of any undergraduate program in the Faculty on the basis of academic merit.

Ontario Professional Engineers Foundation for Education Entrance Scholarships
The Ontario Professional Engineers Foundation for Education provides two admission scholarships of $1,500 each and are designated, where possible, to both a male and female student. They are awarded to the candidates who are well-rounded students and exhibit leadership characteristics.

Norman Ramm Scholarship
This scholarship, provided by a bequest of the late Norman Ramm, is awarded upon admission to a student from a Canadian province or territory (excluding Ontario) and is based on academic standing.

Edward S. Rogers Sr. Admission Scholarships
These awards are made possible through a landmark donation from Ted Rogers Jr. and the Rogers family. Edward S. Rogers Sr. was enrolled in the Department of Electrical Engineering at the University of Toronto from 1919-1921. He left the program before graduating to pursue his radio experimentation. In 1925, he invented the world's first alternating current (AC) radio tube, which enabled radios to be powered by ordinary household current. He also started the world's first all-electric radio station (CFRB – Canada's First Rogers Batteryless), which began broadcasting on February 10, 1927. In 1931, Rogers was granted the first television license in Canada. Edward S. Rogers Sr. was inducted into the Canadian Broadcast Hall of Fame in 1982. During his short but productive life, Edward S. Rogers Sr. displayed the qualities we wish to instill in all students of the Faculty.

The scholarships are awarded to students entering full-time studies in the Edward S. Rogers Sr. Department of Electrical and Computer Engineering and are based on academic achievement and extra-curricular activities. Some awards may be renewable.

Edward A. Rolph Scholarships
Established in 1994 by the estate of Edward A. Rolph and Kathryn S. Rolph, these scholarships are granted to one or more first-year Engineering students and are based on academic excellence. Application is not required.

Leslie & Lois Shaw Admission Scholarship
This award was created in 2002 by the friends and family of Leslie and Lois Shaw and is awarded to a student entering their first year of studies in either Chemical Engineering & Applied Chemistry or Mechanical & Industrial engineering. In addition to academic standing, preference is given to candidates who possess leadership capabilities as demonstrated through involvement in student council, athletics or community service.

The Shaw Admission Scholarship
Established in 2002 through a generous donation by William and Barbra Shaw, the Shaw Admission Scholarship is awarded to a student entering the first year of Engineering Science who demonstrates high academic achievement. Preference is given to students who possesses leadership skills and design capability as demonstrated in extra-curricular design projects and activities. The selection is made on the recommendation of the chair of the Division of Engineering Science. The scholarship is renewable for three years provided the recipient maintains a minimum 75 per cent overall average and continues in Engineering Science.

James C. Shen Scholarship in Mechanical & Industrial Engineering
Established in 2012 through a generation donation by James C. Shen, this scholarship is awarded to Canadian citizens or permanent residents, from outside of Ontario, entering first year in the Department of Mechanical & Industrial Engineering, on the basis of academic achievement.

Julius D. Solomon Scholarship
Established in 2014 from the estate of the late Julius Dennison Solomon, this award is given to one or more students entering first or second year Civil Engineering and is based on academic merit.

C. J. Dick & Ruth A. Sprenger Scholarship for Mature Students in Engineering
Established in 2018 through a generous donation by Ruth Sprenger, this award is given to a Canadian Citizen or Permanent Resident entering first year of Electrical or Computer Engineering as a full-time mature student. Preference wil be given to an individual who has been out of full-time studies or has been in the workforce for a number of years. The award is renewable for the second, third and fourth year of study based on academic merit and will revert back to admission once the recipient has convocated or is no longer eligible for the renewal. Candidates will be asked to submit a short essay outlining why they are applying as a mature student and what impact the award would have on their lives.

Joey & Toby Tanenbaum Admission Scholarships
Established in 2007 through a generous donation by Joseph Tanenbaum, these awards, of varying amounts, are granted on the basis of academic merit to students entering the first year of Civil Engineering.

Chand Tarneja Scholarship in Engineering
Established in 2020 through a generous donation by Vimla Tarneja, this award is given to a student who is Canadian Citizen or Permanent Resident, entering their first year of studies of any undergraduate program in the Faculty of Applied Science & Engineering on the basis of financial need and academic merit.

Stanley Timoshek Scholarship in Engineering
In 2015, at the age of 92, Stanley Timoshek fulfilled a dream to give back to his University, generously giving support to the “Stanley Timoshek Scholarship in Engineering” for Polish descendants studying engineering at the University of Toronto. Proud to have been an Aeronautical Engineering student at the University of Toronto, graduating in 1951, Stanley always shared how his education changed his life. After a short stint with Wardair as an Aeronautical Engineer, Stanley enjoyed a 30-year career with Dow Chemical Corporation where he, early on, advocated the use of magnesium manufacturing.

This award is given to an international student from Poland entering their first year of studies in any undergraduate program in the Faculty. Award is based on merit. Should there be no eligible international students from Poland, the award will be given to a domestic student (with preference to Polish-Canadian candidates) entering their first year of studies. Awarded on the basis of outstanding achievement.

If the recipient is an international student from Poland, the award is renewable for their second, third, and fourth year provided academic standing is maintained; the next admission candidate will be selected when the incumbent convocates or is no longer eligible for the renewal, whichever comes first. If the recipient is not an international student from Poland, the award is not renewable.

The Chung Tsang Memorial Admission Scholarship
This award, valued at $750, was established by Mrs. Pauline Tsang in cooperation with the Federation of Chinese Canadian Professionals Education Foundation in memory of John Hin Chung Tsang (ElecE 7T1) from. The award is granted to a student entering first-year Electrical Engineering who achieved the highest average on the prerequisite subjects required for admission to the Faculty.

Toronto & Area Road Builders Association Scholarship
This award, valued at $2,000, was established in 1987 through the generosity of the Toronto & Area Road Builders Association. The award is granted to a student entering first-year Civil Engineering and is based on good academic standing and qualities of character and leadership.

Wallberg Admission Scholarship
A number of admission scholarships, each valued at $1,000, are annually awarded from the income from the Wallberg bequest on the recommendation of the Council of the Faculty to the six candidates with the highest average percentage in subjects prescribed for admission to the Faculty.

To qualify for the scholarship a candidate must achieve an average of at least 75 per cent in the subjects prescribed for admission and must register in the Faculty of Applied Science & Engineering. The scholarship will not be awarded to a student who has spent more than five years in an Ontario Secondary school or its equivalent unless evidence can be provided satisfactory to Council that this extended attendance was for reasons beyond the student’s control.

Wilcox Family Scholarship in Chemical Engineering
Established in 2020 through a generous donation by Peter Wilcox, this award is given to a student entering their first year of studies in Chemical Engineering on the basis of demonstrated financial need and academic merit.

Elliott M. Wilson Scholarship
Established in 2015 from the estate of Elliott M. Wilson, this scholarship is awarded to student(s) entering their first year of any undergraduate program in the Faculty of Applied Science & Engineering on the basis of academic merit.

Robert Worrall Memorial Scholarship
Established in 2020 through the Worrall Family fund, this award is given to two students entering their first year of studies in Mechanical Engineering on the basis of high academic standing and demonstrated volunteerism and community spirit; recipients must be Canadian Citizens or Permanent Residents. This scholarship is renewable for second, third and fourth

years of study provided recipients continue in Mechanical Engineering, maintain a minimum “A” yearly average and have continued involvement within the community or involvement within the University. The award is made on admission every four years or in any year in which a recipient does not qualify for renewal.

W. J. T. Wright Admission Scholarship
The W.J.T. Wright Admission Scholarship was established in honour of Professor W. J. T. Wright, a highly regarded emeritus member of the Faculty. The capital donation was provided by the 67th University of Toronto Battery of the Canadian Army. The scholarship is annually awarded to a student entering first-year Civil Engineering who achieved outstanding marks in the Ontario high school subjects prescribed for admission. The first award was made in 1982.

OSOTF In-Course Scholarships

APSC Award
Established in 1997, this scholarship, derived from the annual income of a capital donation, is awarded to an engineering student in need of financial assistance. Academic standing is also considered.

T. Christie Arnold Scholarship
This award was established in 1997 through the generosity of T. Christie Arnold. The award is granted on the basis of financial need to a student proceeding to their fourth year of studies in Industrial Engineering. The recipient should also be recognized for engineering management, good academic achievement in the program and particular ability and creativity in their course work. The individual should be a well-rounded student involved in extra-curricular activities, i.e., athletic involvement with varsity sports.

Anthony A. Brait Memorial Scholarship
This scholarship was established in the Division of Engineering Science in 1997 by Margaret Brait in memory of her late husband, Anthony A. Brait. The award is granted to a student entering the second year of the Engineering Science Program and is based on financial need. Academic standing is also considered.

Paul Cadario Scholarship
This scholarship was established in 1996 in the Department of Civil Engineering through the generosity of Mr. Paul Cadario. The award is granted to a student entering the fourth year of the program and is based on financial need. Additionally, academic achievement in the program and particular ability and creativity in the field of transportation engineering, specifically third-year transportation engineering courses will also be considered. The recipient is expected to continue their studies in transportation engineering in their fourth year.

John Dixon Campbell Memorial Scholarship
Established in 2004 by friends, family and colleagues of the late John Dixon Campbell, this award is granted to a student in their fourth year of any program in the Faculty who has demonstrated financial need and has the highest academic merit in the area of Maintenance Optimization and Reliability Engineering. Should the recipient of the John Dixon Memorial Prize demonstrate financial need, he or she will be eligible to receive this scholarship as well.

Canadian Imperial Bank of Commerce BASC/MBA Scholarships
These scholarships, established in 2001, are awarded to students entering the Jeffrey Skoll BASc/MBA Program. Preference will be given to students who have displayed high academic merit in their first three years of Engineering studies and have a high level of leadership potential. Additional preference is given to students who demonstrate financial need.

Chachra Family Scholarship in Engineering Science
This scholarship was established in 2004 by Mrs. Saroj and Mr. Fakir Chachra in honour of their daughter, Debbie, who received her PhD in Biomedical Engineering from U of T in 2001. The scholarship is awarded to a student proceeding to second year of Engineering Science and is based on financial need and academic achievement. Preference is given to female students who meet the criteria.

Chemical Engineering Alumni In-Course Awards
These awards were established in 2004 by staff and alumni of the Department of Chemical Engineering & Applied Chemistry. Two awards are granted to students completing their second or third year of Chemical Engineering and based on financial need. Academic ability and leadership ability as demonstrated by participation in community and/or University involvement will also be considered.

Class of 3T7 Scholarships
These scholarships, established in 1997 through the generosity of the Class of 3T7, are granted to students in any program in the Faculty and based on financial need.

Class of 5T0 Engineering Leadership Award
This award was established through the generosity of the Class of 5T0 and is granted to a student entering second year of any program who has demonstrated financial need and attained high academic performance. The recipient should also have the ability to inspire and motivate others to become involved and to achieve. Preference is given to students who exhibit leadership potential and have a broad range of interests and involvement including student council activity, participation in athletics, community involvement and volunteerism.

Class of 8T3 Vince Volpe Memorial Award
This award was established through the generosity of friends and classmates of Vince Volpe (CivE 8T3). Volpe was an outstanding leader and friend to all his classmates. He was active in intramural sports, the Civil Engineering Club and was vice-president of the Engineering Society. The award is given to a student entering fourth-year Civil Engineering. Selection is made on the basis of financial need, academic achievement and extra-curricular activities/community involvement.

Class of 9T7 Award
This award, established through the generosity of the Class of 9T7 in their graduating year, is given to a full-time student who has completed second year and is proceeding to third year (full-time) of any program and is based on financial need. Academic standing and extra-curricular/community involvement are also considered.

Colantonio Family Leadership Award
This award was established in 2004 through the generosity of John Colantonio in memory of his father, the late Mr. Frank Colantonio. This award is granted on the basis of financial need and high academic achievement to a student proceeding to fourth year of Electrical Engineering. Preference is given to students who exhibit leadership potential and have a broad range of interests and involvement as demonstrated through student council activity, participation in athletics, community involvement and volunteerism.

The Sidney C. Cooper Scholarships
Through the generosity of Sidney C. Cooper (CivE 4T5) two awards have been established in the Department of Civil Engineering. One award is granted to a student entering first year and another to a student entering fourth year. The fourth-year award is made on the recommendation of the Chair on the basis of financial need. Academic achievement in the third-year work and a demonstrated interest (through summer employment) in construction engineering will also be considered.

George and Norma Craig Scholarship
This award, provided through the generosity of Professor Steve J. Thorpe, was established in 1997 for George B. Craig, BASc, MASc, PhD, FASM, PEng, professor emeritus and former speaker of Faculty Council. The award, derived from the annual income, is granted to two students in the Department of Materials Science & Engineering who have demonstrated financial need. Academic achievement will also be considered.

C. William Daniel Leadership Awards
Established in 1998 through the generosity of Mr. C. William Daniel, this award is granted to three students entering either third or fourth year of studies in any undergraduate Engineering program. Decisions will be made on the basis of academic standing and leadership qualities as demonstrated by student council activity, participation in athletics and community involvement. Additionally, two of the recipients must demonstrate financial need.

Duncan R. Derry Scholarships
The scholarship fund was established in 1997 through the generosity of Mrs. Duncan Derry, Mr. Donald M. Ross and friends and family of Mr. Duncan R. Derry. The scholarship is awarded to a student entering second year of the Lassonde Mineral Engineering Program and is based on financial need. Academic standing, qualities of character and leadership and extra-curricular activities will also be considered. The scholarship is renewable for both third and fourth years provided academic standing is maintained and continued financial need is demonstrated.

Dharma Master Chuk Mor Memorial Scholarship
T. Y. Lung established this endowed scholarship in memory of Buddhist monk Chuk Mor (1913-2002) who was an educator and artist well known in the fields of Chinese poetry, Chinese painting and Chinese calligraphy. This scholarship

is awarded to a full-time student entering third year of any engineering program on the basis of financial need and academic achievement.

R.A. Downing Scholarship in Civil Engineering
This award was established in 2003 through a generous donation by Lois Downing in memory of the late Robert Downing. The award is awarded to an undergraduate student in Civil Engineering and is based on financial need and academic merit.

ECE Alumni Scholarship
This scholarship was established in 1997 through the generous donations of alumni of the Department of Electrical & Computer Engineering. The award will be made to a student, based on financial need, in either Electrical or Computer Engineering. Academic achievement will also be considered.

Engineering Society Award
Established in 1997 and provided by the generosity of the undergraduate students in the Faculty of Applied Science & Engineering, these awards, based on the annual income, are distributed based on financial need. Academic ability and extra-curricular involvement within the undergraduate engineering community is also considered. Awards are made in consultation with the Engineering Society Executive.

Ford Electronics Scholarship
This scholarship, derived from the annual income of a capital donation made in 1997, was established through the generosity of Ford Electronics Manufacturing Corporation. It is granted to a student in financial need who is enrolled in the Electrical Engineering Program. Academic standing is also considered.

Andrew Frow Memorial Award
This award was established in 2004 through a generous donation made by the Engineering Society and augmented by friends and family in memory of Andrew Frow. Andrew, a Mechanical Engineering student, was killed in a two-vehicle collision while driving the Blue Sky Solar Racing team's solar car on Highway 7/8 near Kitchener-Waterloo. Andrew was a member of the team that was participating in the Canadian Solar Tour to highlight alternative energy technology. The award is granted to an engineering student entering their second, third or fourth year of undergraduate studies and is based on financial need, academic merit and strong extra-curricular involvement within the University of Toronto.

General Motors Environmental Engineering Awards
This award was established in 1997 through a generous donation from the General Motors of Canada Limited. Annual income derived from the capital provides up to seven awards to students entering second, third, and fourth year in Environmental Engineering on the basis financial need. Academic achievement is also considered.

General Motors Women in Electrical & Mechanical Engineering Awards
This award was established in 1997 through a generous donation from the General Motors of Canada Limited. Annual income derived from the capital provides up to fifteen awards to female students in first, second, and third year of Electrical & Mechanical Engineering studies on the basis of financial need. Academic achievement is also considered.

Jack Gorrie Memorial Undergraduate Scholarship
Established by donations from Mary Louise Gorrie and friends of the late Jack D. Gorrie, this scholarship is given to a student completing second-year Engineering Science and proceeding into the third year of the same program. The award is made on the basis of financial need, academic achievement and involvement in extra-curricular activities within the University.

Herbert Gladish Memorial Scholarship
This scholarship was established in 1997 by Sailrail Automated Systems Inc. in memory of the late Herbert Gladish. The award is granted to a student entering their third year in Engineering Science and is based on financial need. Academic achievement in the program is also considered. Preference is given to a student who has demonstrated innovation and excellence in the second-year design course.

J. Frank Guenther Scholarship
The J. Frank Guenther scholarship was established in 1997 in the Division of Engineering Science through the generosity of BVA Systems Limited. The scholarship is awarded to either a student entering second year who has shown progress and increased effort from the first to second semester or a student entering third year who has demonstrated progress and increased effort from the first to second year. The candidate must demonstrate financial need to receive the award. Selection will be made on the recommendation of the chair of Engineering Science.

Anthony A. Haasz Scholarship
This scholarship was established in 1997 by Anthony A. Haasz, BASc, MASc, PhD, PEng, Professor and Director of the Institute for Aerospace Studies. The scholarship, derived from the annual income, is granted to a student entering the third year in the Aerospace Option in the Engineering Science Program on the basis of financial need. Academic achievement will also be considered.

Lisa Anne Hamann Memorial Award
This award was established by family and friends in memory of Lisa Ann Hamann (nee Anzil) PEng, a graduate of the Class of 8T6 Mechanical Engineering, who passed away in 1995 in her 31st year. Lisa was a successful Nuclear Engineer with Ontario Hydro, whose career path evolved from nuclear design, through project management and lastly as an Account Executive in International Sales. A consummate professional, committed to excellence in all her ventures, Lisa was gifted with intelligence, talent and strength.

Her personality and qualities never failed to inspire and encourage individuals with whom she came into contact with. She excelled in a business environment that is often difficult and challenging for female professionals and earned the respect of those she worked with around the world from Korea, China and Japan, to Kenya, Ukraine, Bulgaria and the Czech Republic. She chaired the Toronto Chapter of the Canadian Nuclear Society for two years, committed to the promotion of nuclear energy and its benefits to society and the electrical industry.

Lisa promoted an athletic lifestyle while at Ontario Hydro, organizing the annual fun runs and multi-team participation at the YMCA Corporate Challenge. Outside of work, she was an active member of the Ontario Association of Triathletes. She competed for many years and twice successfully completed the Ironman Canada Triathlon, a grueling endurance race consisting of a 2k swim, 180k bike ride and full marathon run.

This endowment fund, created through generous contributions from family, friends and colleagues, has a capital value of approximately $30,000. The annual income will generate an award to be presented to a female student in third or fourth year of Mechanical Engineering. The recipient is chosen on the basis of good academic standing, demonstrated leadership ability, commitment to a healthy and athletic lifestyle, involvement in community activities and financial need. It is hoped that through this Award, Lisa's values, courage and accomplishments can become a beacon and opportunity for other women to pursue a career in the field of engineering.

Chester B. Hamilton Scholarship
Members of the family of the late Chester B. Hamilton, a 1906 graduate of the Faculty, established an annual scholarship in his memory. The first award was made in the 1958-1959 academic year. In 1997, Diana L. MacFeeters, Elizabeth D. Hamilton and David C. Hamilton augmented the fund through a generous gift. The award is granted to a third-year student in Mechanical Engineering on the basis of financial need and who has shown academic ability at the annual examinations of the third year.

John Karl Hergovich Memorial Scholarship
Established in 2011 through a generous donation by Eva Gerhardine Hergovich, this award is given to a student entering second-, third- or fourth-year Chemical Engineering and is based on financial need, academic ability and challenges faced with the same dignity and perseverance John Hergovich was known for during his time at U of T.

Dr. John G. Hogeboom Scholarship
Established in 2011 through a generous donation by the Hogeboom family, this award is given to a student who has completed first year of Track One and proceeding to second year of any engineering program. The award is made on the basis of financial need and outstanding academic achievement; exceptional character and demonstrated leadership involvement is also considered. Former Track One students proceeding to third or fourth year of any engineering program will also be considered.

Johannes Michael Holmboe Undergraduate Summer Research Fellowship
This fellowship was established in 2004 through a bequest from the estate of Ruth Anna Holmboe in memory of her late husband, Johannes Michael Holmboe (ChemE 5T0). One or more fellowship(s) are available to student(s) completing years one, two or three and is based on financial need. Additionally, academic ability and the responsibility of the applicant in the research project will also be considered. The fellowship(s) will be awarded to student(s) to work on research project(s) under the supervision of staff and/or graduate students during the summer.

Philip H. Jones Scholarship
Established in 1997, this scholarship is granted to a student entering the fourth year of the Environmental Engineering Option in Civil Engineering and is based on financial need. Academic achievement in the program and particular ability

and creativity in the field of Environmental Engineering is also considered. The recipient is expected to continue their studies in Environmental Engineering in the fourth year of the program.

Andrew Alexander Kinghorn Scholarships
Four scholarships are available annually based on financial need. One is awarded to the student on the basis of financial need and academic standing in the first year of Engineering Science; one to the student on the basis of financial need and academic standing in the first year of all programs except Engineering Science and one each to the students on the basis of financial need and academic standing in the second and third years respectively among the candidates of all programs. Should a candidate hold an award of equal or greater value, the award may be made to the next ranking candidate.

Dietmar Koslowski Memorial Bursary in Electrical Engineering
This award was established in 1987 in memory of the late Dietmar Koslowski, P.Eng, (6T7) by his parents and family. The bursary, derived from the annual interest of the capital fund, is granted on the recommendation of the chair to a student completing their third year of Electrical and Computer Engineering. In addition to financial need, good academic standing is also considered. The first award was made in the 1987-1988 academic year.

Frankie Kwok Memorial Scholarship
This scholarship, established in 1997, is provided through the generosity of McKinsey & Company, family, friends and colleagues of the late Dr. Frankie Kwok. The award is granted to a student entering their third year of Mechanical Engineering and based on financial need. Academic achievement and demonstrated leadership skills through participation in team sports and/or student affairs and community involvement will be considered.

Ronald Paul Manning Scholarships
Provided through the generosity of Ronald P. Manning (BASc,5T9, MEng) in 1997, one or more awards are granted to students entering their fourth year of Electrical Engineering studies and based on financial need. Academic achievement in the program and demonstrated particular ability and creativity in the field of communications or computers will be considered. Recipients must be Canadian citizens working towards a degree in Electrical Engineering and are expected to continue their studies in the fourth year of the program. Special consideration is given to students who have a history of good grades but experienced adversity during the third year due to illness or bereavement.

Eric Miglin Scholarship
This scholarship was established by Eric J. Miglin in 1997 on the occasion on his 25th reunion. Miglin is an Industrial Engineering graduate and was president of the Engineering Society in 1972. This award is granted to a student who has completed third year in any program in the Faculty and is based on financial need. Academic standing and active involvement in student and/or University government will be considered.

Samer Mutlak Memorial Award
Samer Mutlak graduated from Industrial Engineering in 1988. On February 3, 1990, at the age of 23, he passed away after courageously fighting a two-year battle with cancer. Samer was a warm, jovial and caring person, always able to bring a smile to those whose lives he touched. He took part in many social events within the University. He was a leader and an organizer taking part in F!rosh orientation, Lady Godiva Week, hockey and the student industrial engineering conferences. Samer took pride in being an industrial engineer. He is remembered fondly for his sense of humour. He was a good friend.

The award, derived from the annual income, is made on the recommendation of the department chair to a student completing third-year Industrial Engineering and is based on financial need, academic ability and contribution to, and involvement in the activities of the Department and the University.

Barry James O’Sullivan Grant
This grant was established in 2003 through a bequest from the estate of Victoria Doris O’Sullivan in memory of her son Barry James O’Sullivan, whose untimely death in 1969 occurred while he was studying engineering at U of T. This award is made to a student entering or proceeding in any undergraduate program in the Faculty on the basis of financial need. Applications should be through the Undergraduate Grant Application Form.

James A. Peers Scholarship in Industrial Engineering
The James A. Peers Scholarship was established in 1997 by Jim Peers, who graduated from the Department of Industrial Engineering in 1973. This award, derived from the annual income, is granted on the recommendation of the chair to a student proceeding to the second year in Industrial Engineering and based on financial need. Academic standing, qualities of character, leadership and commitment to the profession will be considered. Not tenable with other awards.

Ryn Pudden Memorial Award
Through the generosity of her family, the Ryn Pudden Memorial Award was established in 1999 in Ryn's honour. The award is granted to a female student in Engineering Science who demonstrates financial need. Preference is given to students entering their third year of the Aerospace Option and involved in extra-curricular activities (e.g. music, student council, athletics).

The Peter Sands Award in Engineering Science
This award was established by family and friends in memory of the late Peter Sands, BASc (1962), MASc (1966). The award is made on the recommendation of the Chair to a student completing their second year of Engineering Science studies and based on financial need. Good academic standing (not necessarily honours), qualities of character, leadership and commitment to the profession will also be considered. Students must be registered in the Computer Option in third year in order to receive the award.

Kenneth A. Selby Scholarship in Construction Engineering in the Department of Civil Engineering
This scholarship was established in 1997 by Kenneth A. Selby, BASc, MBA, PhD (ILL), PEng. The award is granted to a student entering fourth-year Civil Engineering and based on financial need. Academic achievement in the program and particular ability and creativity in the field of construction engineering, specifically second and third-year construction engineering-related courses will also be considered.

Douglas Scott Shaw Memorial Scholarship
This award was established by Andrea Boucher-Shaw in loving memory of her husband, the late Douglas Scott Shaw. The award is granted to a student who has completed their first, second or third year of Industrial Engineering and is based on financial need and a shown marked improvement in grades from the previous year.

Shell Canada Limited Engineering Scholarships Program
Established in 1997 through the generosity of Shell Canada Limited, these scholarships are granted to two students entering third year and two entering fourth year in each of the following three departments: Mineral Engineering, Chemical Engineering & Applied Chemistry and Mechanical & Industrial Engineering. The awards are granted on the basis on financial need. Academic performance will also be considered. The first awards were granted in the 1998-1999 academic year.

William Bernard Silverston Scholarship
William Bernard Silverston, having received a degree in Mechanical Engineering in Poland, went on to lead a distinguished international career in engineering, management and business. To recognize his tremendous innovation in design and management, his son, Robert Silverston, established this scholarship in the Faculty in 1997. The award, derived from the annual income, is granted to a student entering third-year Mechanical Engineering and is based on financial need. The recipient should also demonstrate the ability to produce innovative and original designs which are based on sound engineering and applied science principles. Candidates should convey a spirit and love for the discipline.

Jeffrey Skoll Scholarships at the University of Toronto
As a result of an amendment to the original scholarship set up by a generous donation from the Skoll Foundation, funds are now being directed to support business education for undergraduate engineering students. Several awards are now available to FASE students who can demonstrate financial need, and are pursuing a Business Minor, with special consideration given to students who have demonstrated goals to address pressing global challenges. Other conditions may apply.

Christopher Skrok Memorial Scholarships
These scholarships were established in 2003 through the generosity of Stanislawa Skrok, in honour of her husband Christopher Skrok (CIV 6T0). The awards will be granted to three students entering first-year and three students entering fourth-year Civil Engineering on the basis of financial need and academic standing.

Gordon R. Slemon Scholarship
Established in 1997 through the generosity of Gordon R. Slemon, OC, BASc, MASc, DIC (Imperial College), PhD,(London), DSc (London), DEng (Memorial), Hon. FIEE, FEIC, FCAE, CEng, PEng, former chair of the Department of Electrical Engineering and former dean of the Faculty. The award is granted to a student entering third year of Electrical Engineering on the basis of financial need. Academic achievement in the second year of the program and an aptitude in design will also be considered. The award is made on the recommendation of the chair.

Kenneth Carless Smith Award in Engineering Science
Established in 2004 through a generous donation by Professor Kenneth Carless Smith and Ms. Laura Fujino, this award is

made on the recommendation of the chair of the Division of Engineering Science to one or more students completing second- or third-year Engineering Science. The award is made on the basis of financial need and a demonstrated interest and aptitude in the area of electronics. Interest may be shown by strong performance in appropriate courses and/or research and design projects.

Kenneth Ward Smith Scholarships
Provided through the generosity of Carlton G. Smith, two awards are granted on the recommendation of the chair of the Division to students completing second year of Engineering Science and who are proceeding to third year in the Aerospace Option. Recipients are selected on the basis of financial need, academic standing and qualities of character and leadership.

Robert M. Smith Scholarships
These scholarships, made possible by a generous donation, were established in 1996. The awards are granted to a student entering the third year of Lassonde Mineral Engineering and are based on financial need. Academic standing is also considered. The scholarship is renewable in fourth-year on the basis of continued financial need and academic standing. Should the candidate not qualify for the renewal, the award can be granted by reversion to the next qualifying candidate in the fourth year of the program.

SNC-Lavalin Scholarship
This scholarship was established in 1997 through the generosity of SNC-Lavalin Group Inc. and is awarded to a student entering second year of the Lassonde Mineral or Materials Engineering Program on the basis of financial need. Academic standing will also be considered.

Dr. Irving H. Spinner Scholarship in Chemical Engineering & Applied Chemistry
This scholarship, established in 2011 by family and friends of Dr. Irving H. Spinner, is awarded to a student in any year of Chemical Engineering on the basis of demonstrated financial need as well as significant involvement in extra-curricular activities within the University and local community. Candidates must have strong academic background and achieve a minimum overall 75 per cent in the previous year.

The St. George's Society of Toronto Endowment Fund
This award, valued at $5,000, was established through a generous donation by the St. George's Society of Toronto. Several awards are available to students within the University, one of which is specifically for the Faculty of Applied Science & Engineering. In Engineering, the fund is awarded based on financial need and a minimum B average to an undergraduate or graduate student. Preference is given to in-course students.

Peter K. Strangway Scholarship
This award was established in 1997 through the generosity of Dr. Peter K. Strangway. The scholarship is granted to a student entering the third or fourth year in Materials Engineering on the basis of financial need. Academic credentials will also be considered.

The Maurice Stren Memorial Scholarship
This scholarship was established in 1995 by Mrs. Sadie Stren in memory of her husband, Maurice, who graduated from Mechanical Engineering in 1943. Throughout his long career, Mr. Stren possessed an unbounded enthusiasm for all facets of Engineering. The award, which is derived from the annual income of a bequest of a capital sum of $10,000, is granted on the recommendation of the chair to a student completing the second year of Mechanical Engineering. In addition to academic excellence, qualities of character and financial need will also be considered. The first award was granted in the 1995-1996 academic year.

Sullivan Memorial Scholarship
The Sullivan Memorial Scholarship commemorates May and Philip Sullivan, of Sydney, Australia. Being denied the benefits of an advanced education, they fostered their three children's ambitions. All became university faculty — one in Australia, one in New Zealand and one in Canada. The award is derived from the annual income and is awarded to a student entering second-year Engineering Science and is based on financial need. Academic standing is also be considered. The selection is made by the chair of the Division. The first award was granted in the 1998-1999 academic year.

James M. Toguri Memorial Scholarship
This scholarship was established in 2004 by friends and family in memory of Professor James M. Toguri. The award is to be granted to a full-time student proceeding third- or fourth- year Materials Engineering and based on financial need and academic achievement. Additionally, candidates should have a genuine interest in a career in chemical process

metallurgy, as demonstrated by either course selection, summer research experience, PEY Co-op placement and/or fourth-year thesis topic. Preference is given to students with demonstrated qualities of leadership. This scholarship is awarded on the recommendation of the Chair or their designate.

The Trenwith & Galipeau Aerospace Science Award
This award was established in 1997 through a donation from Mr. John Galipeau. The income derived from the capital provides a scholarship to a student in the third or fourth year of the Aerospace Option in Engineering Science based on financial need. Academic merit is also considered. If given at the third-year level, the award may be renewed for the fourth year provided the criteria is still met.

William Ian MacKenzie Turner Scholarship in Industrial Engineering
This award was established in recognition of the professional achievements of William Ian MacKenzie Turner (ElecE 2T5), and of his dedication to the interests of the undergraduates and graduates of the Faculty of Applied Science and Engineering.

The scholarship, derived from the annual income, is awarded to a student based on financial need who, having obtained Honours standing, ranks in first place on the results of Industrial Engineering's third-year examinations. Should the candidate hold an award of greater value, the award may be made to the next ranking candidate. The first award was made in the 1998-1999 academic year.

University of Toronto Women's Association Scholarship
In 1995 the University of Toronto Women's Association donated a capital sum to the University, a portion of which provides an award in the Faculty of Applied Science & Engineering. This scholarship is awarded to a male or female student in any year of any program in the Faculty and is based on financial need and academic standing. The value of the award is derived from the annual income.

Lloyd George Webber Memorial Scholarship
This scholarship was established in 1997 in memory of Lloyd George Webber (ChemE 3T6). The award will be granted to a student completing third-year Chemical Engineering and Applied Chemistry and is based on financial need. Academic standing is also considered.

Julie Wilkinson Memorial Scholarship
This scholarship was established by family and friends of the late Julie Wilkinson. Julie was the office manager of the Engineering Society for 11 years. In addition to her job in the Faculty, she worked part-time for the Automobile Journalists Association of Canada (AJAC) where she eventually became treasurer. On top of all this responsibility, Julie went back to school part-time to work towards a degree in Industrial Engineering. Julie was a warm and caring person who always had a smile for everyone.

In honour of her memory, the scholarship is awarded to a student registered in any year of Industrial Engineering and is based on financial need, extra-curricular activities, demonstrated involvement in the Engineering Society and academic standing. Recommendations will be made by the departmental chair in consultation with the president of the Engineering Society.

WSP Scholarships in Building Engineering
Provided in 1997 through the generosity of Halsall Associates Ltd. (now owned by WSP Canada), these awards are tenable in the Department of Civil Engineering or in the Infrastructure Option of Engineering Science. One award, based on financial need, is made to a student completing second year and one to a student completing third year. The recipients should also exhibit a high level of interest and academic achievement in civil engineering applied to buildings, as well as a significant contribution to the community and/or student activities. The relevant course content would include structures, materials and building science.

WSP Scholarship in Civil Engineering
This award was established in 1997 through a generous donation from Marshall Macklin Monaghan Limited (now owned by WSP Canada). The award, derived from the annual income, is granted to a student in Civil Engineering and is based on financial need and academic ability.

Yolles-Bergmann Scholarship
This Civil Engineering scholarship was established in 1997 through the generosity of Yolles Partnership Inc. in recognition of the significant accomplishments of the Yolles Group, and, in particular, the contribution made to structural engineering by Mr. Morden Yolles and Mr. Roland Bergmann. The scholarship is awarded to a student proceeding to the fourth year of

the program who achieved a high academic standing and who successfully completed a structural design project in their third year that demonstrated a creative interest and talent in linking structure and architecture. Department nomination.

Non-OSOTF In-Course Scholarships & Grants

Henry G. Acres Medal
The Henry G. Acres Medal is awarded annually to the fourth-year student in Civil, Mechanical, Electrical or Computer Engineering who obtains the highest aggregate percentage at the annual examinations of third and fourth year, provided the student obtains honours standing in the examinations of the fourth year. In addition to the medal the student will receive an honorarium in the amount of $500. Receipt of the award does not preclude a student from being granted such other awards as may, in the opinion of the Council, be appropriate.

The Henry G. Acres Medal was established in 1950 by Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, ME, DSc (0T3). From 1981 onward, the continuation of the award has been possible through the generosity of Acres International Limited who also provide an honorarium of $500 to the recipient of the medal.

Throughout his professional life, Dr. Acres was associated with major power developments in Canada and abroad. As Chief Hydraulic Engineer for the Hydro-Electric Power Commission of Ontario from 1911-1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. In 1924, he formed H.G. Acres and Company Ltd., now known as Acres International Limited, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and was responsible for the design and construction of the Shand Dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which were vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

Harvey Aggett Memorial Scholarship
This scholarship was donated by the late Mr. J.T. Aggett of Toronto as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in the military in March 1915, during his second year in the Faculty; he was killed in action at Passchendaele on November 6, 1917.

This annual scholarship is awarded to a second-year engineering honour student who ranked one of the first three in the annual examinations and adjudged the highest of the three in general student activities and service in the University during first year. The annual value of the scholarship is the income from the fund. When regulations do not permit the winner to hold this scholarship, the students considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

American Concrete Institute, Ontario Chapter Scholarship
Established in 1992 through the generosity of The Ontario Chapter of the American Concrete Institute, this scholarship is awarded, on the recommendation of the Chair, to a student graduating from Civil Engineering with the most meritorious final-year thesis related to the use of concrete.

Donald L. Angus Scholarship in Mechanical Engineering
Established in 2014 through a generous donation by HH Angus, this award is given to a full-time student entering their third or fourth year of Mechanical Engineering with demonstrated leadership on a design intensive extra-curricular team or activity.

Rob & Sky Bicevskis Research Opportunities Award in Engineering Science
This award was established in 2020 through a generous donation by Robert Bicevskis and is given to a first- or second-year student in the Division of Engineering Science's Research Opportunities Program. Selection is made on the basis of academic merit and appropriateness of the proposed research project, and as determined at the discretion of the Chair of the Division of Engineering Science.

Rob & Sky Bicevskis Scholarship
This award was established in 2014 through a generous donation by Rob and Sky Bicevskis. The award is given to a full-time student entering their second, third or fourth year of studies in Engineering Science. There is an increasing demand for people who can work across boundaries and in many different fields. With the term polymath in mind, students will be selected based on academic merit and having demonstrated interests in a variety of fields through involvement in extra-curricular activities or volunteer experience, which could include sports, arts and cultural and/or international exchanges. On the recommendation of the Chair of the division (or alternate).

Bixler Family Scholarship in Chemical Engineering & Applied Chemistry
Established in 2019 through a generous donation by Harris J. Bixler, this scholarship is given out annually to one or more undergraduate student(s) in the Department of Chemical Engineering & Applied Chemistry on the basis of academic merit and at the discretion of the Dean of the Faculty or their alternate.

OPWA Ontario Chapter Bruce Brunton Award
Established in 2000 by the Ontario Chapter of the American Public Works, the award is issued to a Civil Engineering student and is based on financial need and academic achievement sufficient enough to allow the student to proceed to the next year of the program. The value of the award is $2,500.

Ardagh Scholarship
The Ardagh Scholarship has been provided by Professor E.G.R. Ardagh, BASc, FRSC, formerly professor of Applied Chemistry, in memory of his parents. It is awarded to a student completing second year of Chemical Engineering who demonstrated academic achievement and exemplary leadership within the University or the broader community. The first award was issued in 1946.

Wellington Thomas Ashbridge Memorial Bursaries
Established by members of the family of Wellington Thomas Ashbridge, C.E., a graduate of the School of Practical Science in 1888, this fund provides bursary assistance to students in good standing in any year of the Civil Engineering program who are in need of financial assistance. In any session, any residue of income remaining after the awards to Civil Engineering students may be used to provide bursaries for students in other Programs in the Faculty. Application is made through the Undergraduate Grant Application Form.

The Babb Bursary Fund
Bursaries from this fund are available to students in any year of the Aerospace Option in Engineering Science. Application is made through the Undergraduate Grant Application Form.

Ballan Family Scholarship in Civil Engineering
This scholarship, established through a generous donation by Steven Ballan, is awarded to a student completing second year Civil Engineering and is based on their aggregate performance on assignments in both Introduction to Civil Engineering and Construction Management, as recommended by the chair of the Department.

Bangia Kick-Start Award
This award was established in 2014 through a generous donation by Naresh Bangia. The award is given to a student entering third-year Engineering Science–Computer Engineering Option, on the basis of academic merit, entrepreneurial spirit, and extra-curricular and community involvement. In the inaugural year, 2014, and in celebration of the 20th anniversary of AJB Software Design Inc., there was a one-time only award for a student entering first-year Engineering Science.

Baptie Scholarship
The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie of Ottawa. The Governing Council has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of their first year. The Board of Governors also authorizes a remission of fees, up to $75, in the case of the holder of the scholarship.

The conditions of the award are that the scholarship is awarded to the student who, in the annual examinations of first year, enrolled in any of the programs of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, Computer Engineering or Materials Engineering, obtained the highest aggregate percentage of marks in those subjects which are common to the first year curricula. The first award was issued during the 1925-1926 academic year.

Ben Bernholtz Memorial Prize in Operational Research
This prize is awarded to the student completing Third year of Industrial Engineering who achieved the highest aggregate mark in Operational Research I and II.

The prize was established in 1980 by colleagues and friends of the late Dr. Ben Bernholtz, twice chair of the Department of Industrial Engineering and a founder of the Canadian Operational Research Society. Should the candidate be qualified for another award of higher value, the award may be reverted to the student with the next highest aggregate mark in the specified courses.

The BFMI Sesquicentennial Trust Scholarship
This scholarship was established in 2019 through a generous donation by the BFMI Sesquicentennial Trust (2017). The scholarship, valued at $5,000, is awarded to a full-time student proceeding to second, third, or fourth year in the Faculty of Applied Science & Engineering on the basis of academic merit.

The Edith Grace Buchan Summer Research Fellowship
A summer research fellowship is provided by a bequest of the late Edith Grace Buchan. The fellowship is open to students who have completed the first, second or third year in any program in the Faculty. Interested students should apply by application to the chair of their department early in the Winter Session. The selection will be made based on the applicant's academic background and interests.

Bill Bowers Bursary
This bursary was established in 2020 through a generous donation by Ian McGregor. The grant is given to an Indigenous undergraduate student on the basis of financial need; preference will be given to Indigenous students who demonstrate an interest in sustainability.

Ann & Myrtle Bumgardner Scholarship in Chemical Engineering
This scholarship was established in 2019 through a generous donation by Carl Bumgardner. The scholarship is awarded annually to a student proceeding to third or fourth year of Chemical Engineering based on academic achievement and a spirit of humanity and civic-mindedness as demonstrated through relevant extra-curricular activities, student clubs, and/or volunteerism. Preference will be given to students from the Maritimes.

The Burge-Connell Bursary
Provided through the generosity of the Women's Association of the Mining Industry of Canada, this bursary is open to students in second-year Geology or Lassonde Mineral Engineering.

Consideration is given to academic standing and financial need. The recipient must be a Canadian Citizen or Permanent Resident and show an interest in pursuing the study and application of geological science both on earth and on other planets. Application information can be obtained from the Office of the Registrar in the Faculty of Applied Science & Engineering.

Carman Burton Bursary
This bursary was established in 1986 in memory of the late Carman Burton (ElecE 2T0) by his wife, Mrs. C.E. Burton. The annual income from a capital donation will provide bursaries to students registered in the Faculty in any undergraduate program on the basis of good academic standing and financial need. Application should be made on the Undergraduate Grant Application Form.

Norman E. Byrne Award
This $1,000 award is made annually by the University Masonic Lodge in honour of one of their members. A past grand master of the Grand Lodge of Canada in Ontario, Mr. Norman E. Byrne was also a graduate of U of T Mechanical Engineering. The award is made on the recommendation of the chair to a first-, second-, or third-year Mechanical Engineering student and is based on financial need, academic excellence and qualities of character as demonstrated by University and community activities.

John Dixon Campbell Memorial Prize
Established in 2004 by friends, family, and colleagues of the late John Dixon Campbell, this award, in the form of a certificate, is granted to a student in fourth year of any program in the Faculty who achieved the highest academic merit in the area of maintenance optimization and reliability engineering. Should the recipient of this prize demonstrate financial need, he or she will be eligible to receive the John Dixon Memorial Scholarship as well.

#2 Canadian Army University Course Award
Established in 2002, this award is granted to a student entering the third year of any undergraduate program and is based on high academic achievement and participation in other activities (i.e. sports, drama, school activities). The student must demonstrate financial need.

Canadian Institute of Mining, Metallurgy and Petroleum — GTA West Scholarship
Established in 2018 through a generous donation by the Canadian Institute of Mining, Metallurgy and Petroleum — GTA West, this award is given to a student proceeding, full-time, to their third or fourth year of studies in any undergraduate program in the Faculty who demonstrates interest and passion in the mining sector through course selection, extra-

curricular activities, and/or PEY Co-Op placements. Preference is given to Canadian citizens or permanent residents that currently reside or have completed high school in Mississauga, Oakville, or Burlington.

Canadian Society of Industrial Engineering Scholarship
The Toronto Chapter, Canadian Society for Industrial Engineering, offers a scholarship of $300 to a student entering the fourth-year Industrial Engineering. The student must have consistently maintained high, though not necessarily honours standing, during the previous three years, and must be an active member of the University of Toronto Student Chapter of CSIE. The selection is made on the recommendation of the chair of Mechanical & Industrial Engineering.

Canadian Society for Chemical Engineering Medal
The Canadian Society for Chemical Engineering provides a medal and a cash award of $100 to the student registered in Chemical Engineering who, having achieved Honours, receives the highest standing in third-year written and laboratory work. The first award was made on the results of the final examinations of 1947. From 1985 onwards, the cash portion of the prize has been provided by the Local Toronto Chapter of the Canadian Society for Chemical Engineering.

Ruth E. & Harry E. Carter Memorial Scholarship for Engineering
This award was established in 2018 through a generous donation by Glenn H. Carter. The award is granted on the basis of academic merit to a second, third, or fourth year Computer Engineering student who has completed Track One. If a suitable candidate cannot be identified in any given year, it is to be awarded to a student in another Engineering program who has completed Track One, with a preference for the Mineral Engineering program.

Centennial Senior Project Awards
The Centennial Thesis Awards were established in 1972-1973 in honour of the Faculty's centennial. To recognize excellence in a fourth-year thesis or capstone design project, one award is made annually to a student or team of students in each of the Faculty's nine degree programs. The decision is based on departmental recommendations. The award is in the form of a $500 prize and an accompanying certificate. Original funding was provided through the Office of the Dean and is continued through the generosity of the University of Toronto Engineering Alumni Association.

The Wallace G. Chalmers Engineering Design Scholarships
In 1986, Mrs. Clarice Chalmers established the Wallace Chalmers Engineering Design Awards to encourage and provide recognition for students in Mechanical Engineering creative design courses. In 1997, Mrs. Chalmers converted the Wallace Chalmers Engineering Design Awards to the Wallace G. Chalmers Engineering Design Scholarships in order that the scholarship may continue in perpetuity.

Throughout his career, Wallace Chalmers (Mech 5T0) demonstrated a keen interest in design and perceived the need to place greater emphasis on the design aspect of engineering education.

The three awards (one issued in second year, one in third year, and one in fourth year) are given to students (or a team of students) in Mechanical or Industrial Engineering who demonstrate strong academic performance and design capabilities in design-intensive courses. Department recommendation and financial need is also considered.

CHE 8T2 Emerging Leaders Award in Chemical Engineering
This award was established in 2014 through donations by the ChemE Class of 8T2. The award is given to a student in second-year Chemical Engineering who has shown the potential of becoming an exceptional leader through his/her ability to inspire others to action as demonstrated through involvement and leadership in engineering leadership development programs, student councils or clubs, community organizations and/or athletics.

7T6 Chemical Engineering Scholarship
This award was established in 2019 through a generous donation by Sidney Siu. The award is given to a full-time student proceeding to fourth year in the Department of Chemical Engineering & Applied Chemistry on the basis of academic success, with a preference for student(s) who excelled in Engineering Thermodynamics.

Chemical Engineering Undergraduate Scholarship
This award was established in 2014 through a generous donation from an anonymous donor. The award is given to a student completing first, second or third year of Chemical Engineering on the basis of strong merit and a strong record of extra-curricular activities and/or community involvement. Department recommendation.

Chemical Engineering Undergraduate Summer Fellowship
This award was established in 2014 through a generous donation from an anonymous donor. The award is given to a student completing first, second or third year of Chemical Engineering on the basis of strong academic performance and a

keen interest in research. The recipient would work on research projects under the supervision of Faculty members and/or graduate students over the course of the summer (May-August). Department recommendation.

Chemical Institute of Canada Book Prize (Toronto Section)
This award consists of a $100 book prize plus a certificate and a one-year membership in the relevant constituent society of the CIC. The award is presented to the student in third year of Chemical Engineering who has shown the most improvement in a chemistry and/or chemistry-related program. The award does not necessarily go to the student who achieved the second-highest standing in a particular program.

Chodas Family Scholarship for Space Exploration
This award, valued at $2,500, was established through generous donations by Dr. Janis Chodas and Dr. Paul Chodas. The award is granted to a student proceeding to third or fourth year who demonstrates leadership and passion for space exploration. The scholarship will be awarded based on declared Major (Aerospace), performance in relevant courses, and/or activities outside of the classroom.

5T6 Civils Scholarship
This award was established by the 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto. The scholarship is granted to a student who completes second year of Civil Engineering on the basis of high academic merit and leadership as demonstrated through involvement in extra-curricular activities. The award is not tenable with any other scholarship of greater value with the exception of OSOTF/OTSS awards. The first award was made in 1964.

Ross L. Clark Memorial Scholarship
The friends of Ross L. Clark, 3T7 Civil graduate, have set up a scholarship to honour his substantial contributions to municipal and environmental engineering, practiced so well by him as Commissioner of Works for Metropolitan Toronto for many years. The value of the scholarship is the annual income. It will be awarded to a student entering the fourth year of Civil Engineering, who has demonstrated a significant interest in Environmental Engineering and has a high academic standing. Recommendation for the scholarship is made by the chair of Civil Engineering. The scholarship is not tenable with other awards of $1,000 or higher value. Application is not required.

Richard M. Clarke Awards for Leadership in Engineering Design for the Improvement of the Environment
Established through a generous donation by Richard M. Clarke, this award was created to encourage the leadership development of engineering students working towards improving the environment. Winning teams will be selected through a process developed and executed by the Director of ILead with approval from the Dean of the Faculty. The process will include expert judges, public presentations made by finalists, and an online, video/digital archive. Prizes may be given in multiple categories and at multiple levels (first place, second place. etc.).

Class of 2004 Grant
This grant, established through the generosity of the Class of 2004 in their graduating year, is given to one or more undergraduate student(s) in the Faculty on the basis of financial need. Applications should be made on the Undergraduate Grant Application Form.

Class of 4T3 Engineering James Ham Award
This award was established in 2004 through the generosity of the members of the class of 4T3 in memory of James Ham. Professor Ham, a 4T3 Electrical Engineering graduate, served as the Head of the Department of Electrical Engineering in 1964 and then as Dean of the Faculty for seven years starting in 1966. From 1974 to 1976, he chaired the Royal Commission on Health and Safety of Workers in Mines. His Commission's Report was the impetus for the government's 1978 Occupational Health and Safety Act governing worker Safety in the Province of Ontario. The Report's challenge to the mining industry to develop and maintain an Internal Responsibility System (IRS) for the protection of workers has been heeded by many other industries as well. The IRS model is now the recognized standard for safe and healthy workplaces around the world.

James Ham became Dean of the School of Graduate Studies in 1976 and, two years later, University President for five years. While still President, in 1980, Professor Ham was bestowed with our country's highest honour, the Order of Canada. After his term as President, Professor Ham returned to teaching for the Department of Industrial Engineering.

This award is granted to a student entering either third or fourth year of any undergraduate program. The recipient must have achieved an average of 70 per cent or higher. In addition, the award will be made on the basis of demonstrated leadership qualities as exhibited through participation in athletics, community involvement and/or student council activity. The recipient must be a Canadian citizen or Permanent Resident.

Class of 4T7 Bursaries
The bursaries, established in 1997, are provided by the generosity of the Class of 4T7. Derived from the annual income, the bursaries are awarded to an engineering student in financial need. Applications should be made through the Undergraduate Grant Application Form.

Class of 5T5 Civil Engineering Scholarship
Established in 2004 through the generosity of the Class of 5T5 Civil Engineering, this award is granted to a student entering fourth-year Civil Engineering and is based on financial need. Preference is given to students who excel academically. Additional preference is given to students who demonstrate leadership qualities as exhibited through student council activity, participation on Faculty/University teams and clubs, community involvement and athletics.

Class of 5T9 Chemical Engineering Leaders of Tomorrow Award
This award was established in 2006 through a generous donation by the Chemical Engineering Class of 5T9. The objective of this award is to recognize students in their third year of Chemical Engineering who have shown the potential to become outstanding leaders and to inspire others to action and to excellence. This may be demonstrated in a number of ways, including participation in student council or clubs, community organizations, cultural groups or athletics. Candidates should enumerate their service to others through volunteering or community work.

Class of 7T0 Industrial Engineering Scholarship
Established in 2020 by the Industrial Engineering Class of 7T0, this award is given to a full-time student (Canadian Citizen or Permanent Resident) proceeding to second, third or fourth year of Industrial Engineering. The student must have a minimum ‘B’ average and demonstrate a well-rounded student experience through a broad range of extracurricular and volunteer activities within the University or broader community.

Professor Morris A. Cohen Scholarship in Engineering Science
This award was established in 2016 through a generous donation by Professor Morris A. Cohen. The award is given based on academic merit to a full-time student proceeding to third or fourth year of Engineering Science and enrolled in the Engineering Business Minor.

Constant Temperature Control Ltd. Scholarship
This scholarship was established through a generous donation by Constant Temperature Control Ltd. It is awarded to a student who achieved a high academic standing in their third year of studies and is proceeding into their fourth year of studies in engineering.

Crocker Foundation Bursaries
The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science & Engineering who are in need and are worthy of financial assistance. Applications should be made through the Undergraduate Grant Application Form.

Daisy Intelligence Scholarships in Engineering Science
Established in 2017 through generous annual donations by Daisy Intelligence, these awards are given out each year to students who have completed third year in Engineering Science. Three scholarships will be awarded to the top student based on academic merit in each of the following three majors: (1) Math, Statistics and Finance, (2) Robotics, and (3) Electrical and Computer Engineering or (4) Machine Intelligence. Preference for students who have demonstrated interest in artificial intelligence applications or machine learning; demonstrated interest would be determined by the Scholarship Committee and could be based on courses, extra-curricular involvement in student clubs or programs such as the Hatchery, or student-identified interest.

Gavin Dass Memorial Scholarship
Established in the Faculty of Arts & Science, on the recommendation of the Department of Physiology, this award is granted to a student completing fourth year of the Specialist or Major Program in Biology and Physics, the Specialist Program in Theoretical Physiology or the Biomedical Engineering option in Engineering Science. The student should demonstrate a strong interest in theoretical physiology, either through classroom projects or summer research, and, additionally, should show an interest in the world around them. The student should have some significant involvement in student or community organizations. A letter outlining the applicant’s extra-curricular activities and motivation for studying theoretical biology should be submitted to the Department of Physiology by April 1.

Davis + Henderson Hatchery Award
This award was established in 2013 through a generous donation by Davis + Henderson Corporation. Recipients are

selected based on the merit of their entrepreneurial ideas by recommendation of the Chair of the Hatchery Advisory Board.

Roger E. Deane Memorial Scholarship
This scholarship was established in memory of Professor Roger E. Deane by his colleagues within the University and the geology profession; it is in commemoration of his distinguished contributions to geology. The scholarship is awarded annually to the students, full or part-time, who show the best performance at the department geological field camp.

Joseph A. Devine Bursary
Established in 2010 from the estate of the late Joseph A. Devine, one or more bursaries awarded to students on the basis of financial need.

Eric Dittmar Scholarship
Established in 2020 through a generous donation by Tim Dittmar, this scholarship is given to a student proceeding to second, third, or fourth year in Mechanical & Industrial Engineering who has faced challenges with dignity and perseverance. Selection made on the recommendation of Department Chair or alternate.

Satinder Kaur Dhillon Memorial Scholarship
Established in 2011 from the Estate of the late Satinder Kaur Dhillon, this award is given to a student completing first or second year of Engineering Science on the basis of outstanding academic achievement.

G.W. Ross Dowkes Memorial Prize
Donated by W.J. Dowkes, a graduate of the class of 1962, in memory of his father, the late G.W. Ross Dowkes, this prize is awarded to the student in the Chemical Engineering Program who, in the opinion of the Chair, has demonstrated the most marked improvement in academic standing. Preference is given to a final-year student.

William J. Dowkes Undergraduate Summer Research Grant
Established in 2013 through a generous donation by Mr. William J. Dowkes, this research grant is awarded on the basis of financial need to students completing first, second or third year of any undergraduate program in the Faculty. Academic standing will also be considered. The research grant is given to students to work on research projects on campus during the summer under the supervision of faculty, staff, and/or graduate students within, or associated with, the Department of Chemical Engineering & Applied Chemistry.

Canadian Society for Mechanical Engineering Earl H. Dudgeon Bursary
This bursary was established in 1997 through the generosity of T. Christie Arnold. The bursary is awarded to a student in any year of the Mechanical Engineering Program on the basis of financial need. Application should be made through the Undergraduate Grant Application Form.

Duhamel Helsing Environmental Engineering Scholarship
This award was established in 2013 through a generous donation by Dr. Melanie Duhamel. The scholarship is awarded annually to a full-time student entering third or fourth year who is pursuing their studies with concentrated and focused attention on environmental and sustainability-oriented challenges. Candidates are selected on the basis of strong academic performance and demonstrated financial need.

Douglas Dunbar Memorial Scholarship
Established through a generous donation by Professor Craig Dunbar, this award is given to a student in any year of Civil Engineering on the basis of academic excellence and extra-curricular involvement.

William Dunbar Memorial Scholarship
Established in 2014 from the estate of the late William Dunbar, this scholarship is awarded to students in any year of the Mechanical Engineering program on the basis of outstanding academic achievement. Recommendation of the chair of the department.

Oluwatobi "Tobi" Edun Scholarship
Established in 2020 through a generous donation by Oluwatobi "Tobi" Edun, this award is given to a student proceeding to second, third or fourth year of any undergraduate program in the Faculty of Applied Science & Engineering on the basis of high academic merit and leadership as demonstrated through involvement in extra-curricular activities.

Edward S. Rogers Sr. Department of Electrical & Computer Engineering Top Student Award
Awarded to the top 3 students with the highest GPA in both fall and winter terms in each program, Electrical & Computer

Engineering in years one, two and three — 18 awards in total annually. Students must have been in full-time studies (minimum five courses) to be eligible.

Stuart Ellam Grant
The income from a capital fund established from the estate of the late Ida Maud Lillian Ellam in memory of her late son Stuart Ellam. The grant is given to an undergraduate student in the Faculty on the basis of financial need. Application should be made through the Undergraduate Grant Application Form.

The John M. Empey Scholarships
This fund was established by a bequest of $10,000 in the will of the late John Morgan Empey, BASc, 1903. Three scholarships of equal value are provided from the income from the fund. A scholarship is awarded to a student in the first, second and third years on the annual examinations who, obtaining Honours, achieved the highest average percentage of marks in the year's written and laboratory subjects. The scholarships are open to engineering students. If the winner does not attend the Faculty during the session following the award, the right to the scholarship is forfeited and it will be issued to another eligible student. The scholarships were awarded for the first time in 1944.

Enbridge Scholarship in Engineering
Established in 2006 through a generous donation by Enbridge Gas Distribution Inc., this scholarship is awarded to a student entering their third year of any undergraduate program in the Faculty. The recipient must have achieved a minimum' B' average in second year. Preference is given to students who demonstrate significant community involvement and volunteer work. Additional preference is given to students who exhibit leadership qualities as demonstrated through involvement in extra-curricular activities, athletics and student council.

Engineering Alumni Centennial Bursaries
Through the generosity of the Engineering Alumni Association, several bursaries have been established in the Faculty of Applied Science & Engineering. The bursaries are awarded on the basis of academic achievement and financial need. Preference is given to third- and fourth-year students. Applications should be made through Undergraduate Grant Application Form.

5T3 (1953) Engineering Award
The Class of 5T3 established the 5T3 (1953) Engineering Award in 2003. This award is given to a third-year, full-time or part-time student in any undergraduate program on the basis of high academic achievement, financial need and qualities of character and leadership as demonstrated through involvement in extra-curricular activities both within the University and the community at large. Recipients must be Canadian Citizens or Permanent Residents.

Engineering 8T4 Leadership Award
Established in 2009 by the Engineering Class of 8T4, this award is given to a full-time student entering second, third or fourth year in any program in the Faculty and is based on academic achievement. Recipients must demonstrate leadership skills through involvement in extra-curricular and/or community involvement. Financial need may also be considered.

Engineering Class of 5T6 Award of Merit
The award, of the value of the annual income, is granted to a student who completes first year in any Engineering undergraduate program. The recipient must demonstrate qualities of leadership and character through involvement in extracurricular activities either within the University of Toronto or the community at large in addition to academic achievement. Nominations are made by the Engineering Society, in consultation with members of the Class of 5T6 wherever possible. The recipient will also receive a certificate.

Engineering Science Chairs' Scholarship
This award was established in 2011 through generous donations by former chairs of the Division of Engineering Science. The award is given to a student completing the foundation years and proceeding to year three of Engineering Science. The scholarship is issued on the chair's recommendation on the basis of outstanding academic achievement and extra-curricular involvement.

Engineering Science Foundation Scholarship
This award was established in 2011 through a generous donation by Dr. Rong Kai Hong. The award is given to three full-time students entering third-year Engineering Science and is based on strong academic achievement and on a recommendation from the Chair (or alternate) of the Division of Engineering Science.

ERCO Worldwide Leaders of Tomorrow Award
This award was established in 2011 through a generous donation by ERCO Worldwide Division of Superior Plus LP. The award is given to a student in third- or fourth-year Chemical Engineering who has shown the potential to become an outstanding leader and to inspire others to action and to excellence. This may be demonstrated in a number of ways, including participation in student councils or clubs, community organizations, cultural groups, or athletics. Applicants should enumerate their service to others through volunteering or community work.

Etkin Medal for Excellence
This Etkin medal was established by University Professor Bernard Etkin, formerly Chair of Engineering Science (1967-1972) and dean of the Faculty (1973-1979). The prize was first awarded in 2003. It is an award for academic excellence that commemorates a career-long interest in the theory and application of solid and fluid mechanics, subjects he taught for many years to students in Engineering Science, and which were the basis of most of his research and professional work. The award is presented to a third-year Engineering Science student. Each year, the chair of Engineering Science chooses one or more courses from among the relevant offerings in solid and fluid mechanics in the second and third-year curriculum and nominates the recipient of the medal for outstanding performance in those courses.

Faculty of Applied Science and Engineering Leadership Award(s)
Established in 2006, these awards are available to students entering second, third, or fourth year of any program in the Faculty. Though academic ability is considered, candidates must have shown the potential to become outstanding leaders and to inspire others to action and excellence. This may be done through participation in student council or clubs, community organizations, cultural groups or athletics. Candidates should enumerate their service to others through volunteering or community work.

Manual A. Fine Scholarship
Established in 2009 through a generous donation by Heavy Construction Association of Toronto, this award is given to a full-time student entering third- or fourth-year Civil Engineering on the basis of strong academic achievement and a demonstrated interest in construction as evidenced by their focus of study, extra-curricular activities and/or summer employment.

J. A. Findlay Scholarships
These scholarships were established through a legacy bequeathed by the late Janet Findlay to the Department of Mechanical & Industrial Engineering. Two scholarships are available, each the value of half the fund’s income. One is for a third-year student in Mechanical Engineering; the other is intended for a fourth-year student, but only if the student continues in Mechanical Engineering.

The selection is made on the recommendation of the Chair of the Department from the four students with the highest average percentage of marks at the annual examinations in second and third year respectively. The student’s general character, fitness for the profession and financial circumstances are given consideration. If a student wins one of the scholarships and changes program, or does not attend this University during the next following session, the award shall be made to another eligible student.

The Denis Flynn Memorial Scholarship
Established through the generosity of the Metropolitan Toronto Road Builders Association, this award has a value of $1,000 and is granted to a student completing first-year Civil Engineering and is based on good academic standing and qualities of character and leadership. In order to receive the award, the recipient must register in the second year of the program.

The James Franceschini Foundation Scholarship
Scholarships of the annual value of the income of this foundation are awarded to students in first-, second- and third-year Civil Engineering. Students must have achieved high standing, with Honours, at the annual examinations.

Laura Chizuko Fujino Scholarship in Engineering Science
This scholarship was established in 2012 through a generous donation by Kenneth Carless Smith and Laura Chizuko Fujino. The award is given to a female student entering the third- or fourth-year of the Electrical and Computer Engineering Option in the Division of Engineering Science and is based on academic achievement. Extra-curricular activities may also be considered.

Fujino/Smith Emergence Scholarship
This scholarship was established in 2015 through a generous donation by Kenneth Carless Smith and Laura Chizuko Fujino. The award is given to a full-time student in First Year Engineering Science who receives the highest average

grade after term 1F, is proceeding to the winter term in Engineering Science and who did not receive an entrance scholarship. Preference will be given to students who graduated from an Ontario high school.

Hugh Gall Award
The Hugh Gall Award was established in 1946 by the graduating class of 1910 to "commemorate a deceased classmate who was a splendid type of student, a loyal friend and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951, the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest.

The award is made to a student who, having completed first year with a general average of at least 66 per cent without conditions, has entered second-year and requires financial assistance to continue. It is desirable, but not necessary, that the recipient not have already been given any other scholastic award or scholarship applicable to the second year and shows indications of a firm intention and ability to follow successfully the profession of engineering. Applications should be made using the In-course Bursary Form.

Vern Gomes Memorial Award
Established by classmates and friends of the late J. Vernon Gomes, this award is issued to a student entering fourth-year Electrical Engineering or Computer Engineering who, having obtained an average not lower than 60 per cent in third year, is considered by the Electrical and Computer Engineering Student Staff Committee to have made the most valuable contribution to the class. Preference is given to Electrical Engineering students.

The Blake H. Goodings Memorial Award in Mechanical Engineering
The Blake H. Goodings Memorial Award was established in 1987 by his wife, Mrs. Gloria Goodings, in memory of her husband, a 1949 graduate of this Faculty. The award, which is the value of the annual income of a capital donation, is set up in perpetuity. It is made on the recommendation of the chair of the Department of Mechanical & Industrial Engineering and awarded to a student completing second-year Mechanical Engineering who has attained good academic standing, is of sound character and has limited financial resources to support the costs of their education. This award is tenable with other awards.

H.J. Greeniaus ESROP Fellowship
This award was established in 2002 by the H.J. Greeniaus family and is awarded to a student who has been accepted to the ESROP Program, which was created to provide undergraduate students in Engineering Science with the opportunity to undertake research over the summer with a faculty member.

The George A. Guess Scholarships
The estate of Edna F. Guess, wife of George A. Guess, formerly Head of the Department of Metallurgical Engineering & Materials Science, has bequeathed funds to the University to establish the George A. Guess Memorial Fund for the assistance of needy students in the Materials Engineering program.

The annual income of the fund is used to provide graduate fellowships; summer studentships and an undergraduate fund in the Department and two kinds of undergraduate scholarships: the Guess Admission Scholarship and the Guess In-Course Scholarships, in recognition of academic achievement in the Faculty.

The Guess Admission Scholarship is awarded to student(s) with high standings in the subjects needed for admission to the first year of the Materials Engineering program. The Guess In-Course Scholarships are awarded to students completing their first, second or third year of Materials Engineering and are made on the basis of achievement a minimum average of 75 per cent. Extra-curricular/leadership qualities may also be considered.

Frank Howard Guest Admission Bursary
Established in 1995, this bursary, based on academic achievement and financial need, is awarded to students entering the first year of any undergraduate program in the Faculty of Applied Science & Engineering.

Selvarani Gulasekaram Award
This award was established in 2020 through a generous donation by Sahana Kesavarajah and Jeyashankar Gulasekaram. This annual award is given to one or two full-time undergraduate engineering students who are Canadian Citizens or Permanent Residents and who demonstrate financial need and self-identify as Black, Indigenous, or are members of the Bangladeshi Students' Association, Hindu Students' Council, Lesbians, Gays, Bisexuals & Trans People of the University of Toronto (LGBTOUT), Tamil Students' Association, Pakistan Students' Association and/or the University of Toronto Punjabi Association. Academic standing may be considered.

Frank Howard Guest In-Course Bursary
Established in 1995, this bursary is awarded to students enrolled in any year of any undergraduate program in the Faculty of Applied Science & Engineering and is based on academic standing and financial need. Applicants must complete the Undergraduate Grant Application form. Special attention is given to applicants who are participating in exchange programs in other universities and countries.

Norm and Nellie Hann Scholarship
Established in 2015 through a generous donation by Normal and Cornelia Hann, this award is given annually to a student who, after term 1F finds themselves on academic probation (1F average less than 60%, or less than 55% if Engineering Science), and who has improved the most after fall term of 2nd year (term 2F average), an indication that they never gave up.

B. Conrad Hansen Memorial Award Fund
The fund was established in 1979 in memory of the late B. Conrad Hansen (ElecE 6T2). The income from the fund is used to provide one or more bursaries for students in need of financial assistance, preference being given to students in second- or third-year Electrical or Computer Engineering.

Sydney George Harris Bursary
Established in 1994, the bursary is granted, on the recommendation of the Chair, to a student entering third or fourth year in any program. In addition to mental capacity, the student must show leadership ability and give promise, through activities, of becoming a worthwhile influence in the affairs of the profession and community. While attention is given to scholastic ability, as evidenced by academic standing, it is not the governing factor. The recipient must, however, stand in the top quarter of the class. Special consideration is given to students in financial need. The annual value is approximately $1,000.

Glenn and Richard Hauck Memorial Scholarship
Established in 2010, through a generous donation by Stephen and Linda Hauck, this scholarship is awarded to a student entering third-year Engineering Science who is facing challenges with dignity and perseverance and who participates in extra-curricular activities. Recommendation by the chair of the Division.

S. Haberer Energy Systems Scholarship in Engineering Science
Established in 2015 through an annual donation by Sean Haberer, this award is given to a full-time student proceeding to third or fourth year of Engineering Science whose academic focus relates to Energy Systems. Recipients will be selected on the basis of academic standing. Participation in extra-curricular activities, including summer employment and PEY, related to energy systems will also be considered.

Dr. Arthur Herrmann Memorial Award
The family of Dr. Arthur Alexander Herrmann has established a memorial fund in memory of the 100th anniversary of his birth (July 4, 1891). The award is derived from the income of the fund and will be granted to a fourth-year student in Mechanical Engineering whose major interest and thesis topic reflect concern for the protection of the environment.

Dr. Herrmann won international recognition as an expert on plywood and its applications; he invented a machine for the manufacture of plywood pipes or tubes, and was a well-known researcher, lecturer and author.

Mackay Hewer Memorial Prize
This prize, of the value of the annual income, was established in memory of the late Professor Mackay Hewer, a member of the teaching staff in the former Department of Mining Engineering and later in the Department of Chemical Engineering & Applied Chemistry. The prize is awarded to the student completing their fourth year of Chemical Engineering who achieved the highest standing in fourth-year courses related to environmental studies. The first award was made during the 1980-1981 academic year.

Hill & Schumacher Entrepreneur Award
This award was established in 2013 through a generous donation by the Hill & Schumacher Professional Corp. and is given to an undergraduate student in the Faculty who is associated with the Entrepreneurship Hatchery. The award is granted to a student or group of students who demonstrate strong design and entrepreneurial skills. This award is issued on the basis of an outstanding business plan for an innovative product or service that seeks to solve “real-life problems” or improve the lives in a concrete and meaningful way.

General D. M. Hogarth Bursary
Established in 1992, this bursary is awarded to students registered in any year in either Lassonde Mineral Engineering or

Materials Engineering and is based on financial need. Applicants must complete the Undergraduate Grant Application form.

Otto Holden Scholarship
Otto Holden, BASc, CE, DEng, was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death, Mr. Holden left a sum of money that was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science & Engineering. This scholarship, which has a value of approximately $900, is awarded to the student who, completing their fourth year of either Civil Engineering or Mechanical Engineering studies with Honours, achieves the highest aggregate marks in hydraulic engineering subjects in the program. The first award was made during the 1967-1968 academic year.

William V. Hull Scholarship
Established in 1981 from a bequest of the late William V. Hull, this award of the annual value drawn from the income of the fund is made to a student ranked first place in any program in third-year exams.

Interface Biologics Inc. Undergraduate Biomedical Engineering Scholarship
This award was established in 2019 through a generous donation by Interface Biologics Inc. and is awarded to a student proceeding to second, third or fourth year of any undergraduate program on the basis of the following: (1) must demonstrate a strong interest in biomedical engineering, i.e. pursuing a major in Biomedical Engineering Systems or a minor in Bioengineering; (2) involvement in any area of community service and/or extra-curricular activities not just those related to biomedical engineering; (3) must have a minimum overall program average of at least 80% in the year prior to qualifying for the scholarship (i.e. proceeding to second year, first year average must be min. 80%). Scholarships are annual awards and are available for competitive renewal, i.e. incumbent students are eligible in subsequent years provided they meet the award criteria.

Darius & Bapsy Irani Family Scholarship
This scholarship was established in 2020 through a generous donation by Darius Irani and is awarded to three full-time undergraduate students enrolled in the Edward S. Rogers Sr. Department of Electrical & Computer Engineering on the basis of academic merit, with preference given to female full-time students.

Sue Joel CIV6T5 Scholarship
This scholarship was established in 2011 by the Department of Civil Engineering in honour of the first five women to graduate from Civil Engineering, of which Sue Joel was one. The award, valued at $500, is given to a student entering their second year of Civil Engineering, having completed first year of any program in the Faculty, who achieves the fourth highest mark in the first year Statics course (CIV100/102). The award is not tenable with other merit-based scholarships of greater value. Should this be the case, the award would revert to the next qualifying student.

Margaret Kende CIV6T0 Scholarship
This scholarship was established in 2011 by the Department of Civil Engineering in honour of the first five women to graduate from Civil Engineering, of which Margaret Kende was one. The award, valued at $500, is awarded to a student entering second-year Civil Engineering, having completed first year of any program in the Faculty and displays the most improvement between first and second session of first year as measured by the full-time term averages. The award is not tenable with other merit-based scholarships of greater value.

Konrad Group Scholarship
This award was established in 2012 through a generous donation by Geordie Konrad, Konrad Group, and is given to a full-time student proceeding into their third or fourth year of studies in the Faculty and is based on strong academic achievement. Preference will be given to students who demonstrate an interest in software development based on course selection, extra-curricular activities and/or work terms.

Kordellas-Tripp Foundation Engineering Award
This award was established in 2015 through a generous donation by Nicolas Kordellas and Shirley Tripp. Nicolas Kordellas was a student from Greece who graduated from U of T Engineering in 1959. It was his grandfather, Andreas Kordellas, a very successful engineer in Lavrion, Greece, who inspired him to study Mechanical Engineering in Canada. This award is given to student(s) entering third or fourth year and is based on financial need and social awareness. To apply, a student must submit an application, which includes a personal statement that outlines thier views on how society should function so humanist values are honoured.

Catherine Lacavera Hatchery Award
This award was established in 2014 through a generous donation by Catherine Lacavera and is to provide summer fellowships for student entrepreneurs enrolled in the Hatchery Entrepreneurship Program at the Faculty. Recipients will be selected based on the merit of their entrepreneurial ideas by recommendation of the chair of the Hatchery Advisory Board.

Lacavera Prize for Entrepreneurship
This prize was established in 2013 through a generous donation by Anthony Lacavera. Recipients are selected based on the merit of their entrepreneurial ideas by recommendation of the Chair of the Hatchery Board.

Lassonde Scholarships
The Lassonde Scholarships were established through the generosity of Mr. Pierre Lassonde. These scholarships, derived from the annual interest of the capital fund. Several scholarships are granted on admission to the Lassonde Mineral Engineering Program or Lassonde Institute of Mining based on academic standing and qualities of character and leadership. The remaining scholarships are divided among students in the second, third and fourth years of the Lassonde Mineral Engineering Program on the basis of academic standing and qualities of character and leadership. The recipients of these awards will be known as the Lassonde Scholars.

Lassonde Bursaries
In addition to the above scholarships, Lassonde Bursaries have also been established. The bursaries are granted to students in any year of the Lassonde Mineral Engineering program and based on financial need. Applicants must complete the Undergraduate Grant Application form.

Stavros Leventis Award
Provided by Mrs. Elsha Leventis, classmates 6T8 and friends of the late Stavros Leventis, this award is given to a student in second- or third-year Electrical Engineering who, while maintaining a B average or better, contributed to the University and community at large through volunteer participation. The student must possess qualities of leadership and integrity and demonstrate a keen interest in computers.

W. & J. Loui Scholarship
Established in 2020 through a generous donation by Winston Loui, this award is given to a student proceeding to third or fourth year of any undergraduate program in the Faculty. The award is given out on the basis of good academic standing and a demonstrated passion for developing innovative solutions to address health or environmental issues to support one or more of the global sustainable development goals of the United Nations or of a similar international organization. Preference is given to Canadian citizens/permanent residents.

Loumankis Family Engineering Scholarship
Established in 2020 through a generous donation by Anthony Loumankis, this scholarship is given to a student graduating from the Faculty of Applied Science & Engineering with a minimum 'B' average, demonstrated financial need, and leadership during their tenure at the University, as well as involvement in the GTA community.

Charles A. Lowry Prize
Gift of the late Mrs. B. Lowry, this prize is awarded to a student in Mechanical, Electrical or Computer Engineering who, having successfully completed the first year in the Faculty of Applied Science & Engineering, achieved the highest mark in Structures, Materials and Design (CIV101F).

John Richard Luke Scholarship for Women
This scholarship was established in 2020 through a generous donation by Carolyn Ray and is given to an undergraduate female student in Engineering with a demonstrated interest in healthcare engineering. This interest can be demonstrated in many ways, such as but not limited to, pursuing a major in Biomedical Engineering Systems, a minor in Bioengineering or other demonstrated involvement related to healthcare. First preference will be given to Black or Indigenous students. Secondary preference will be given to students from Oshawa. Academic merit will also be considered.

The Earl Charles Lyons Memorial Award
The Earl Charles Lyons Memorial Award was established in 1983 by his wife, Mrs. Earl C. Lyons, in memory of her husband, Earl Charles Lyons (3T3). The award, which is set up in perpetuity, is of the value of the annual income of a capital donation. It awarded on the recommendation of the chair of the department of Mechanical & Industrial Engineering to a student completing the third-year Mechanical Engineering. In addition to honours standing, consideration is given to character and leadership capabilities through involvement in student and professional activities. This award is not tenable with other awards. The first award was issued during the 1983-1984 academic year.

James Turner MacBain Scholarship and Bursaries
Established in 1990, this bequest from the estate of James Turner MacBain provides awards annually from the income of the fund. The James Turner MacBain scholarship, derived from half of the income, is awarded to a student entering the first year in any program in the Faculty on the basis of academic excellence. One half of the annual income will provide one or more bursaries to students registered in any year in the Faculty on the basis of financial need. Application for the James Turner MacBain bursaries should be made on the Undergraduate Grant Application form. The first awards were made during the 1991-1992 academic year.

J.R. MacCoon Footsteps Grant
Established in 2014 through a generous donation by Jacquelyn Rebecca MacCoon, this grant is given to a student who has enrolled in the T-Program and is proceeding to the summer session to complete first year. The grant is given to a student who has demonstrated financial need and experienced hardship during first year.

The Elsie Gregory MacGill Memorial Scholarship
Established in 1995, this award is granted to an outstanding female student in the fourth year of any program in the Faculty and is based on academic standing and demonstrated a commitment to women's issues within the Faculty and the community at large. In addition to academic standing, qualities of character and leadership abilities are also considered. The award alternates with the Faculty of Arts & Science.

The Alexander MacLean Scholarship
The scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean (0T8) who retired in 1954. The scholarship is awarded to an outstanding student in GLG 318H and/or GLG319H in the Department of Geology, Faculty of Arts and Science or completing third-year Lassonde Mineral Engineering, Faculty of Applied Science & Engineering. The first award was made in 1955.

MacLennan-MacLeod Memorial Prize
The graduating class of 1910 donated an annual prize in memory of their first class president, George MacLennan, who was killed in action in France in 1917, and Doug MacLeod, their first secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of approximately $25, is awarded to the first-year student in the Faculty of Applied Science & Engineering who ranked highest in Calculus among those who obtain standing without condition at the annual examinations; or, in the event of more than one student obtained equally high rank in Calculus, to the one of these who also has the highest standing in some other subject common to the competitors, such as Algebra, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available the next year.

Salim Majdalany Scholarship
The scholarship was established by the family and friends of the late Salim Majdalany (BASc, 1980, Civil Engineering). The award is granted on academic standing to a student from Lebanon, Syria, Jordon, Iraq or any other member state of the Arab League, who is entering or is enrolled in the Faculty of Applied Science & Engineering or the Faculty of Law. The award is open to students in both Faculties; however, priority is given to candidates from the Faculty of Applied Science & Engineering.

Steven Mann Award in Wearable Computing
Established in 2013 through a generous donation by Martine Rothblatt, this award is given to a third or fourth-year student who achieves the highest mark in a course on Wearable Computing (ECE516) taught by Steven Mann.

Charles Gordon Manning Prize
The Charles Gordon Manning Prize was established by a bequest under the will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the prize.
The recipient must be enrolled in the second year of a course offered by the Faculty of Applied Science & Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations for the award of that scholarship. Specifically, these are: achieving Honours in the final examinations and being ranked one of the first three at those examinations relative to the pass requirements in the department; being adjudged highest of the three in general student activities, and service in the University during first year. The first award was made on the results of the annual examinations in 1954.

Oscar J. Marshall Scholarship
This award was established through a donation from the estate of Oscar J. Marshall. The scholarship is to be awarded to a full-time student in third year Civil Engineering who has obtained the highest academic standing in the Survey Camp course.

Christina and Logan Martin Scholarship in Engineering
Established in 2018 through a generous donation by George W. Martin, this award is given to a full-time student proceeding to fourth year of any undergraduate program in the Faculty on the basis of academic merit. Preference will be given to students with demonstrated financial need.

Nicole & Michael Martin Scholarship Engineering Scholarship
Established in 2020 through a generous donation by Nicole and Michael Martin, this award is given to one or more upper-year female undergraduate engineering students on the basis of academic merit and demonstrated financial need.

J. Edgar McAllister Foundation Undergraduate Summer Research Award
Provided by the bequest of the late J. Edgar McAllister, BASc, this award is given to students in Mechanical, Electrical, Mining, or Chemical Engineering who are completing first, second or third year (with preference to students completing third year). The awards are given to students to work on research projects on campus over the course of the summer. Financial need is also considered.

John B. McGeachie Grant
Established in 2002 through a generous donation by John B. McGeachie, this grant is given to a third-year student in any program on the basis of financial need. Applications should be made using the Undergraduate Grant Application Form.

The Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science
Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to create a scholarship for a first-year Engineering Science student. The value of the scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours in first-year examinations in Engineering Science. If for any reason the student is ineligible to hold the scholarship, it will be awarded by reversion to the second-ranked student. To receive payment the winner must register in second-year Engineering Science. The scholarship was awarded for the first time in 1947.

The Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarships
Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, received financial assistance from certain organizations and individuals to help him in the prosecution of his research work in geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science & Engineering. Additional amounts received from the estate of Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. have been added to this fund. The scholarships are awarded by Governing Council to a student on the recommendation of the Council of the Faculty of Applied Science & Engineering. The first awards were made on the results of the annual examinations in 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship
This scholarship is awarded to the student in second-year Engineering Science who has the highest aggregate standing at the examinations of the first and second years in the program provided the student obtains honours standing in second-year exams.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship
This scholarship is awarded to the student who ranks second in second-year Engineering Science and achieves the highest aggregate standing in the first and second years of that course provided the student obtains honours standing in second-year exams.

If, in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the second year of Engineering Science who achieves the second highest aggregate standing at the examinations of the first and second years of that course, provided the student obtains honours standing in second-year examinations.

METSCO Award for Energy Innovation
Established in 2018 through a generous donation by METSCO Energy Solutions, this award is given to a full-time student proceeding to fourth year of Engineering Science, Electrical, Computer, Mechanical or Industrial Engineering and whose

academic focus relates to the Energy Sector. In addition to academic merit, participation in extra-curricular activities related to the energy sector (including employment or student clubs) may be considered.

Marlene Metzger CIV6T0 Scholarship
This scholarship was established in 2011 by the Department of Civil Engineering in honour of the first five women to graduate from Civil Engineering, of which Marlene Metzger is one. The award, valued at $500, is given to a student entering second-year Civil Engineering, having completed first year of any program in the Faculty, who achieves the second-highest mark in the first-year statics course CIV100/102. The award is not tenable with other merit-based scholarships of greater value. Should this be the case, the award would revert to the next qualifying student.

Hugh Middleton Bursary
This bursary, established in 2001, is awarded to a student in the Faculty of Applied Science & Engineering and is based on financial need. Applications should be made through the Undergraduate Grant Application form.

Mike & Hana CIV 8T8 Scholarship
This scholarship was established in 2020 through a generous donation by Michael Volpatti. The scholarship is given to a full-time student proceeding to third year of Civil Engineering on the basis of academic merit and an interest in entrepreneurship. This interest may be demonstrated in various ways including, but not limited to, a stated interest, involvement with an entrepreneurship program, involvement with a start-up, plans to pursue entrepreneurship / business education, or any other indication the awarding body feels displays an authentic interest in entrepreneurship.

R.W. Missen Memorial Prize in Thermodynamics
This award was created in 2008 through a generous donation by family and friends of the late Professor Ronald W. Missen, a faculty member of the Department of Chemical Engineering and Applied Chemistry for 35 years, in memory of his professional and scholarly achievements. The award is given to the student who receives the highest mark in CHE323H1: Engineering Thermodynamics, which was taught by Professor Missen for many years.

Alec Monro Award in Chemical Engineering
Established in 2020 through a generous donation by H. Alexander B. Monro, this award is given to full-time student proceeding to their third year of Chemical Engineering studies on the basis of financial need and academic standing. Recipients must be Canadian Citizens or Permanent Residents.

Kiyoharu & Kiyoaki Momose Memorial Scholarship
This scholarship in the amount of approximately $300 was bequeathed by Yoshiko Momose. The award is made to a student entering their penultimate or final year in Medicine, Engineering or Sociology. It was the hope of the donor that the recipient would exhibit qualities of leadership and all-around participation in extracurricular activities. The award will alternate among the Faculties of Medicine, Engineering and Arts & Science.

James L. Morris Memorial Prize
The James L. Morris Memorial Prize is the gift of Mrs. J.H. Craig and Mr. J.R. Morris, K.C., in memory of their father, James L. Morris, CE, OLS, DEng, the first graduate of the School of Practical Science, who died in 1946 after a distinguished career.

As the sole member of his 1881 graduating class in Civil Engineering, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For forty-three years he conducted a successful civil engineering practice in Pembroke, Ontario.

The prize, the value of the annual income from $3,000, is awarded annually to the student in second-year Civil Engineering who achieved the highest aggregate percentage at the annual examinations of the first and second years of the program, provided the student achieved Honours standing second-year exams.

Joseph G. Monkhouse Memorial Bursary in Engineering
This award, established in 2000 by the Estate of Margaret E. Monkhouse, is awarded to a student who has high academic qualifications and shows financial need. Application should be made through the Undergraduate Grant Application form.

Peter L. Munro Memorial Scholarship
This fund was established in 1987 by family, friends and business associates of Peter L. Munro (Min 5T9). One award is granted on the recommendation of the chair of the Division of Mineral Engineering to a student completing their second or third year of studies and who demonstrate a commitment to the Canadian mining industry. In addition to good academic

standing, financial need and qualities of character and leadership will be considered. The first award issued during the 1987-1988 academic year.

Henry and Mary Nahrgang Bursaries
The income of the capital sum donated by the late Armond R. Nahrgang, class of 1923, is used to provide bursaries for qualified students in need of financial assistance. Applications should be made through the Undergraduate Grant Application Form.

Nortel Institute Undergraduate Scholarship(s)
This scholarship is made possible through a donation from Nortel Networks Limited. The scholarship is awarded to students in their second or third year of studies in the Faculty of Applied Science & Engineering or Arts & Science and is based on financial need, academic merit and an essay. Candidates must submit an essay on the future of communications (maximum 500 words) along with two references. The application deadline is November 1. Applications are available at www.adm.utoronto.ca.

Ontario Power Generation Award
Provided through the generosity of Ontario Power Generation, this scholarship is awarded to students entering the second year of either electrical, mechanical, chemical, computer, or environmental engineering, with a preference for electrical, mechanical or chemical engineering. Students must be a member of an employment equity target group (women, aboriginal, disabled, visible minority).

In addition to academic standing (minimum B average), the following will also be considered: demonstrated leadership skills, strong oral and written communication skills, and involved in extra-curricular activities. Candidates must be legally eligible to work in Canada upon graduation. Will not be receiving more than one award of equal or greater value in second year.

Otegbade Scholarship for Students and Africa
This award was established in 2014 through a generous donation by Adediran Otegbade. The award is given to a student from Africa with a preference for students that have shown a marked and consistent improvement from one academic year to the next, and for students involved in Skule activities including international student clubs and associations.

Gary L. Palmer Memorial Scholarship
This award was established in 2009 through the generosity of Anne Palmer in memory of her late husband, Gary Palmer, and by her two daughters, Jennifer and Kristianne, in honour of their father who died in an airplane accident in 2006.

Gary, a former student of the Engineering Physics program at the University of Toronto, went on to enjoy a successful career in computer engineering and telecommunications. A lifelong passion for cycling led Gary to race competitively in Canada, the United States and France. He also shared his enthusiasm for aviation through his involvement with the EAA, ultimately holding the position of president of his local chapter for 13 years. Gary was a man blessed with great intellect, a rich sense of humour, compassion and a desire to contribute. A natural leader, he was always eager to share his knowledge and help others.

The award is presented to a student who is entering third-year Engineering Science and who demonstrates financial need and promise in their field as evidenced by a year-to-year academic improvement.

Fu Siang Pang and Ying Au Yeung Bursary
Established in 2019 through a generous donation by Pak Kin Poon, this bursary is granted to a domestic student (full-time or part-time) in the Division of Engineering Science who demonstrates financial need.

The Dr. John Hamilton Parkin Scholarship
Established by family friends and colleagues in 1983, this award honours the late Dr. John Hamilton Parkin, a graduate and former faculty member of this Faculty.

His class of 1908-1911 was the last in the S. P. S. Diploma course with degree option. From the mechanical field, he moved to a pioneering role in aeronautics on staff in the University of Toronto’s new Mechanical Department from 1912 until 1929 (Associate Professor), with a three-year wartime leave, to the chemical industry. He set up Canada’s first university wind tunnel (1919), initiated Canada’s first undergraduate Aeronautical Program (1928) and began a lifelong career in applied research.

Moving to Ottawa, he gave strong leadership at the National Research Council, becoming Director, Division of Mechanical Engineering (1937), and founding Director, National Aeronautical Establishment (1951). His authorship was prolific and his career accomplishments have been widely acknowledged through distinguished honours and awards, including CBE and FRSC.

The award, the value of which is the annual income of a donation, is given to a student completing the third year of the Aerospace Option in the Engineering Science Program on the basis of financial need, academic standing and a demonstrated sincere interest in the aerospace field. This award is tenable with other awards.

Joseph C. Paradi Scholarship in Entrepreneurship
This scholarship was established in 2018 through a generous donation by Linda Zhixing Li and Jixin Huang. The award is given to a full-time undergraduate student in the Faculty of Applied Science & Engineering who has demonstrated interest in entrepreneurship through participation in the Engineering Entrepreneurship Hatchery. Students will be selected by the Director, Engineering Entrepreneurship Hatchery or his/her designate upon recommendations from the Hatchery Mentors.

Professor William Paul Memorial Scholarship
Established in 2020 through a generous donation by Sarah and Cary Lavine, this award is given to a student proceeding to third or fourth year of Engineering and who is pursuing either a major in Biomedical Systems Engineering or a minor in Biomedical Engineering; recipients must demonstrate financial need; academic standing will also be considered.

Paulin Memorial Scholarship
The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a 1907 graduate of this Faculty, was established in memory of his brother, John Cameron Paulin, a student of this Faculty who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, is awarded to a student who obtained high-standing in the work of the first year in the Faculty of Applied Science & Engineering.

Peri Family Industrial Engineering Design Award
Established in 2017 through a generous donation by John Peri, this award is given to the team that demonstrates exceptional design capabilities in the Fourth Year Industrial Engineering capstone design course. A design panel, appointed by the Chair of the Department of Mechanical and Industrial Engineering, will select the winner.

A. B. Platt Award, Toronto Section of the Society of Tribologists and Lubrication Engineers
Funded in perpetuity by a capital donation from the Toronto Section of the Society of Tribologists and Lubrication Engineers (STLE), this prize is awarded annually to the student in the fourth year of either Mechanical, Chemical or Materials Engineering program whose work in tribology (friction, wear, lubrication, wear resistant coatings) is considered to be of suitable quality and the most satisfactory. The award has a value of $100, of which $75 is presented to the student and the remaining $25 is given to the department for the purchase of publications on tribology.

Florence Evelyn and William Leonard Prideaux Award
This award, established by the estates of Florence Evelyn and William Leonard Prideaux is to be awarded to a Canadian Inuit or Aboriginal Boy Scout from the North West Territories or Moosonee area who is entering or registered in the Faculty of Applied Science & Engineering, Architecture Programs in the Faculty of Arts and Science or Wycliffe College. It is to be awarded on the basis of scouting service and experience.

Ontario Professional Engineers Foundation for Education Undergraduate Scholarships
The Ontario Professional Engineers Foundation for Education offers a total of eight scholarships (each valued at $1,500) to students in their first, second and third years of study in the Faculty of Applied Science and Engineering in any program. The awards are granted on the basis of strong academic performance and leadership or role model qualities as demonstrated through involvement in professional affairs and extra-curricular activities.

Ontario Professional Engineers Foundation for Education Gold Medal for Academic Achievement
The Ontario Professional Engineers Foundation for Education has established in the Faculty of Applied Science & Engineering an award in the form of a medal. The award will be made to the student in the final undergraduate year in any program who, obtaining Honours, achieves the highest weighted average percentage in the practical work and written examination of the year.

Ransom Scholarship in Chemical Engineering
The Ransom Scholarship in the Chemical Engineering & Applied Chemistry was established by A.C. Ransom, Esq. of Toronto to encourage and give financial assistance to students in the Department. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount derived from the income of the donation. The first award was made on results of the annual examinations in 1938. The scholarship is awarded annually to the student registered in

Chemical Engineering who achieved the highest aggregate percentage of marks in the examinations of the first year. The scholarship will be paid to the winner only if the recipient proceeds to the second year of the program at the University of Toronto.

Reginald J. Redrupp Award
This award was established in 1987 by the friends and colleagues of the late Reginald J. Redrupp, a distinguished mining banker with the Canadian Imperial Bank of Commerce who was active in the Prospectors and Developers Association and the Canadian Institute of Mining and Metallurgy. Two awards derived from the income will be given annually to students proceeding to the second year of Lassonde Mineral Engineering. Academic standing, financial need and commitment to the Canadian mining industry may be considered.

J.E. Reid Memorial Prize
This prize, established in 1967 in memory of the late Professor J.E. Reid, is awarded to the student in the fourth-year Electrical or Computer Engineering who, graduating with Honours, achieved the highest aggregate marks in electronic communication.

Russell Reynolds Memorial Scholarship
This award, established in 2001, is awarded to a student entering third-year Engineering Science. This student must have displayed high academic achievement. Preference is given to students who demonstrate financial need. This scholarship is not tenable with other awards.

Dagmar Rinne Scholarship
This scholarship was established in 2012 through generous donations by Inga Rinne and friends. The award is given to a student entering their third year of full-time studies in Industrial Engineering who has demonstrated the most improved academic standing from first to second year.

The Bertrand G. W. Robinson Award
The annual income from a bequest made in 1991 from the Estate of the late Bertrand G.W. Robinson provides one or more bursaries to students in the third year in any program, on the basis of financial need. Mr. Robinson graduated in Mining Engineering in 1930 and was employed in managerial positions in the gold mining industry of Northern Ontario. He was the Canadian representative of Hardinge Mining Equipment of York, Pennsylvania, and acted as a consultant to mining projects in Canada, England, and East Indies. After retiring, he returned to the University of Toronto and in November 1979 graduated with his Master of Engineering. Applications should be submitted through the Undergraduate Grant Application Form.

Hugh Rose Scholarship
The annual income from a bequest made in 2018 from the Estate of Mary Margaret Rose will be used to provide a scholarship to one or more students in the Department of Civil Engineering on the basis of academic performance in the Survey Camp course.

Ian and Shirley Rowe Innovative & Entrepreneurial Spirit Award
This award was established in 2018 through a generous donation by Ian H. and Shirley Rowe. The award is given to a student (Canadian Citizen or Permanent Resident) enrolled in Engineering Science and accepted into the Entrepreneurship Hatchery program. Candidates must demonstrate passion, desire and determination to being an innovative-driven entrepreneur as shown by their commitment to the journey of developing novel technology for building a successful business enterprise in Canada. Recipients will be selected on the basis of their involvement in Entrepreneurship Hatchery as recommended by the Executive Director or the Chair of the Division of Engineering Science, and a written statement (500-1,000 words) demonstrating their creative connection to an entrepreneurial story.

The Richard Rowland Memorial Scholarship
This scholarship was established by family, friends and colleagues in memory of Richard Rowland, an active member of Phi Delta Theta and a 1989 Mechanical Engineering graduate. Richard passed away in 1996 as a result of an automobile accident. While Richard was successful in his work as an engineer, he found time to explore the outdoors when canoeing and skiing. He was also active in amateur theatricals. His circle of friends reflected these varied activities. The scholarship is awarded on the recommendation of the Chair to a student completing third year of Mechanical Engineering and who has a good overall academic record, intends to continue to fourth year and has demonstrated an interest in heating, ventilating and air conditioning. By request of the donor, this award is restricted to students who are Canadian Citizens or Permanent Canadian residents and is not tenable with other awards of equal or greater value.

Melvyn Paul Rubinoff Scholarship in Aerospace Engineering
Established in 2017 by Sheila Rubinoff, this scholarship, valued at $10,000, is given to a student based on financial need who is enrolled full-time entering third or fourth year in the Division of Engineering Science, Aerospace Engineering option. Preference will be given to students who demonstrate a passion for this field through extra-curricular involvement and/or community involvement. Leadership and academic merit may also be considered.

Margaret Agnes Runciman and James Dempsey Runciman Bursary
This bursary was established in 2014 through the Estate of Margaret Agnes Runciman. The bursary is given to one or more undergraduate students in the Faculty on the basis of financial need. Preference is given to students in their second or third years of study. Application through the Undergraduate Grant Application.

Don Salt Memorial Scholarships
In memory of Donald John Salt, a graduate of the Faculty of Applied Science & Engineering and a practicing geophysicist, the Canadian Exploration Geophysical Society provides two scholarships valued at $500 each. The scholarships are open to students in the third and fourth years of certain courses in the Faculty of Arts & Science and Lassonde Mineral Engineering in the Faculty of Applied Science & Engineering. The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics. Application should be made either to the chair of the Department of Physics or the chair of the Department of Geology and Applied Earth Science by March 1 in the calendar year in which the award is to be made.

John Gordon Saunders Memorial Scholarship
This award was established in 2019 through the Estate of John Gordon Saunders and is awarded to an undergraduate student in the Department of Civil & Mineral Engineering on the basis of academic merit and financial need.

Frederick W. Schumacher Scholarship
The Frederick W. Schumacher Scholarship was established in the Faculty of Applied Science & Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must be enrolled in the second, third or fourth year in Lassonde Mineral Engineering in the Faculty of Applied Science & Engineering, or in Physics and Geology of Geological Sciences in the Faculty of Arts & Science and must have high academic standing.

Marcia Lamont Scott CIV4T7 Scholarship
This scholarship was established in 2011 by the Department of Civil Engineering in honour of the first five women to graduate from Civil Engineering, of which Marcia Lamont Scott is one. The award, valued at $500, is given to a student entering second year of Civil Engineering, having completed first year of any program in the Faculty, who achieves the highest mark in the first year Statics course (CIV100/102). The award is not tenable with other merit-based scholarships of greater value. Should this be the case, the award would revert to the next qualifying student.

Scrymgeour Scholarship in Engineering Entrepreneurship
This scholarship was established in 2020 through a generous donation by David Scrymgeour. This scholarship is given to a full-time domestic student in third year of any undergraduate program in the Faculty on the basis of enrolment in the Engineering Business Minor in addition to entrepreneurial spirit and leadership demonstrated through involvement in sports, cultural and extracurricular activities and community engagement. The scholarship is renewable for fourth year provided the candidate continues in the Business Minor with a minimum annual GPA of 3.0.

Class of 3T5 Second Mile Award
This award was established by the Engineering Class of 3T5 and has been awarded every year since 1945. The name is based on the biblical text “Whosoever shall compel thee to go one mile, go with him twain." The second mile is the voluntary mile. Convinced that a successful engineer must be not only professionally competent but also constantly aware of their broader responsibilities, the donors encourage undergraduates to participate fully in extra-curricular activities of all kinds. The award is comprised of a monetary prize and illuminated scroll that is presented to a student in their final year. Consideration is given to academic standing, voluntary service and breadth of extra-curricular activities. The ultimate objective is to encourage each engineer to engage in "second mile" activities throughout thier career, resulting in benefits for the individual, the profession and for society.

Adel S. Sedra Bursary Fund
This bursary fund was established in 1997 by Adel S. Sedra, BSc, MASc, PhD, a graduate of the Faculty, former chair of the Department of Electrical & Computer Engineering and vice-president and provost of the University of Toronto. The awards, derived from the annual income from a capital donation, are granted to students in any year in Electrical and Computer Engineering on the basis of financial need. Applications should be made on the Undergraduate Grant Application Form.

Adel S. Sedra Gold Medal
This award was established in 2002 through the donation of J. Robert S. Prichard, former president of the University of Toronto, to recognize Professor Sedra's exceptional contributions to both the discipline of engineering and the leadership of the University of Toronto through his service as professor, chair and vice president and provost. The medal is awarded annually to two students in the graduating class who have earned the highest cumulative grade point average in each of Electrical & Computer Engineering.

Rudolph and Frieda Seidl Memorial Award in Mechanical Engineering
This award was originally established by Mrs. Rudolph Seidl in memory of her husband, Mr. Rudolph Seidl, an employee in Mechanical Engineering until his retirement in 1975. Upon Mrs. Seidl's passing in 2018, their daughter, Caroline Seidl Farrell, provided an additional donation. The award is given to a student who has achieved honours standing in the second year of Mechanical Engineering and has demonstrated a strong character and has financial need. Issued by departmental recommendation.

The Joseph Seidner Bursary Fund
The Joseph Seidner Bursary Fund was established in 1987 by Mr. Joseph Seidner, a principal in the firm of Brady & Seidner Associates Ltd., a large mechanical contractor in Ontario. For many years, Mr. Seidner contributed to the well-being of the construction industry. The annual income of the capital in the bursary fund, which was established in the Faculty of Applied Science & Engineering at the University of Toronto, is awarded to one or more deserving second or third year students in mechanical engineering in Ontario and on the basis of financial need arising during the course of an academic year. This award is open to Canadian Citizens or Permanent Residents. Applications should be submitted via the Undergraduate Grant Application Form.

Som Seif Scholarship
This award was established in 2013 through a generous donation by Som Seif. The award is given to full-time students in Industrial Engineering with preference to students who demonstrate an interest in business and/or entrepreneurship based on course selection and/or extra-curricular activities such as, but not limited to, the Hatchery or participation in external start-ups.

John W. Senders Award for Imaginative Design
This award was established in 2013 through a generous donation by John W. Senders and Ann Crichton-Harris. The award is given to a student or students who, in their graduating year, demonstrate an imaginative and successful application of engineering to the design of a medical device capable in the generality of its application to restore normal human functions. The award is issued on the recommendation of the Multi-Disciplinary Capstone Lead Committee.

The Shaw Design Scholarship(s)
Established in 2002 through a generous donation by William and Barbra Shaw, these scholarships are awarded to students beginning their third year of Engineering Science. Preference is given to students who have achieved a high academic standing in the first two years of their studies. Additional preference will be given to students who demonstrate strong achievement in the second-year Engineering Design course and involved in extracurricular design projects. The selection is made by departmental nomination and announced on a suitable occasion, such as the annual Engineering Science dinner.

Michael Schenker Scholarship
Established in 2020 from the Estate of Alda Schenker, this award is given to a student proceeding to second, third or fourth year of any undergraduate program in the Faculty on the basis of academic merit.

Francis Shen Hatchery Award
Established in 2019 by the Shen Family Charitable Foundation, this award is given to student entrepreneurs enrolled in the Hatchery Entrepreneurship Program at the Faculty of Applied Science & Engineering, chosen on the merit of their entrepreneurial ideas by recommendation of the Chair of the Hatchery Advisory Board

Skule Nite Award
Established in 2020 through a generous donation by Mathew Szeto, this award is given an undergraduate Engineering student with demonstrated financial need who is part of the Skule Nite team. Preference will be given to a first- and/or second-year student with significant involvement in Skule Nite. Academic standing may be considered.

Gordon R. Slemon Capstone Design Award in Electrical and Computer Engineering
This award was established in 2013 through generous donations by the friends and family of Gordon R. Slemon. The award is given to student(s) in Electrical and Computer Engineering on the basis of completion of an exceptional fourth-year capstone design project.

KC Smith and Laura Fujino Scholarship in Electronics
This scholarship was established in 2018 through a generous donation by KC Smith and Laura Fujino. The scholarship is to be awarded to a full-time student in either the Electronics Circuit or the Analog Electronics course. Preference will be given to students that have a demonstrated passion in electronics, on the recommendation from the Electronics Group Chair for the Department of Electrical & Computer Engineering. Students in both the Department of Electrical & Computer Engineering and the Division of Engineering Science, ECE Option, are eligible.

Kenneth Carless Smith Engineering Science Research Fellowship
Established in 2011, this fellowship will be awarded to students in the Division of Engineering Science on the basis of academic merit and suitability for the fellowship.

Professor James W. Smith Chemical Engineering Leaders of Tomorrow Award
This award was established in 2006 through generous donations by Dr. Stephen G. Dunn, Dr. Joseph C. Paradi, Dr. Larry E. Seeley and Dr. Bert O. Wasmund who are former students of Professor J.W. Smith; an additional donation was made by Hatch Limited. The objective of this award is to recognize students in their second year of Chemical Engineering who have shown the potential to become outstanding leaders and to inspire others to action and to excellence. This may be demonstrated in a number of ways, including participation in student council or clubs, community organizations, cultural groups or athletics. Candidates should enumerate their service to others through volunteering or community work.

Society of Chemical Industry Merit Award
The Society of Chemical Industry Merit Award presents a commemorative plaque each year to the student in fourth-year Chemical Engineering and Applied Chemistry who achieved the highest weighted average over four years.

Murray F. Southcote Scholarship
This scholarship was established in 1965 through the generosity of friends and associates of the late Murray F. Southcote (through W.R. Laidlaw). This scholarship is granted to a student who obtains high academic standing at the end of their third year in any program in the Faculty.

C. H. E. Stewart Bursaries
Under the provisions of the will of the late Mary Jones Stewart, a sum of $10,000 was bequeathed to the University, the income of which is to be used to provide a number of bursaries to students in third and fourth years of courses in the Faculty of Applied Science & Engineering. The awards are made on the basis of financial need, scholastic ability and general character with preference given to students who are descendants of veterans of the First and Second World Wars. The application should be made on the Undergraduate Grant Application Form.

Victor and Nadia Szenhereta Scholarship
Established in 2020 from the Estate of Nadia Szenhereta, this award is given to a student in the Department of Electrical &Computer Engineering, based on academic merit. Preference is given to a student from Ukraine or a student involved in the Ukrainian community. If no eligible student can be found under these parameters in any given year, consideration will be given to any other student enrolled in the Department of Electrical & Computer Engineering.

Gordon F. Tracy Scholarship
Donated by the family of the late Gordon F. Tracy, professor of Electrical Engineering in this Faculty, this scholarship has the value of the annual income on the capital fund of $10,000. It is awarded to the student who, achieving honours standing in the third year of Electrical Engineering, obtained the highest aggregate marks in third-year examinations in the subjects that pertain to electromechanical energy conversion.

Charles Edwin Trim Scholarship
This scholarship fund was established in 1991 by Mrs. Hazel Trim in memory of her husband Charles Edwin Trim. The income derived from the capital will provide one or more scholarships on the basis of academic excellence. Preference will be given to students entering the third or fourth year.

Troost Family Leaders of Tomorrow Award
This award was established in 2010 through a generous donation by Mr. William (Bill) and Mrs. Kathleen Troost. The objective of this award is to recognize students in their fourth year of Chemical Engineering who have shown the potential to become outstanding leaders and to inspire others to action and to excellence. This may be demonstrated in a number of ways, including participation in student council or clubs, community organizations, cultural groups or athletics. Candidates should enumerate their service to others through volunteer or community work.

Marjorie Hilda Merrick Turner Award
The President of the Engineering Society receives the Marjorie Hilda Merrick Turner Award, which is derived from the income of a capital fund, established in 1985 by the sons of Mrs. Marjorie H.M. Turner. As a granddaughter, daughter, wife, mother and grandmother of engineers, and as wife, mother, and grandmother of members of Engineering Societies, Mrs. Turner has observed first-hand the evolution and growth of the engineering profession in Canada, from the construction of the country's infrastructure, through the expansion of its resource and secondary manufacturing industries, to the development of its high technology capabilities. This award reflects her recognition and support of the well-rounded individual, as typified by the President of the Engineering Society. It was her wish to provide some modest financial assistance to the incumbent with the hope that it will further encourage the recipient to strive for excellence in all areas of life.

Dr. Chris Twigge-Molecey Scholarship in Mechanical Engineering
This award was established in 2012 through a donation by Mr. and Mrs. Chris Twigge-Molecey and is awarded to a student in any year of Mechanical Engineering on the basis of financial need, high academic merit and a demonstrated interest in sustainable energy.

James W. and H. Grattan Tyrrell Memorial Scholarship in Civil Engineering
Established in 1976 by H. Grattan Knox Tyrrell of the United States in memory of James W. Tyrrell and H. Grattan Tyrrell, graduates of the School of Practical Science in 1883 and 1886 respectively, this scholarship recognizes academic excellence in the work of the third year of the Civil Engineering Program. The award is restricted (by request of the donor) to students holding Canadian citizenship.

UMA Scholarship in Civil Engineering
Established in 1984 through the generosity of the UMA Group, this scholarship is awarded on the recommendation of the Chair to a student completing the second year of the Civil Engineering Program. In addition to high academic achievement, diversity of interests and suitability for leadership in the engineering profession will be considered. The first award was made on the results of the 1984-1985 session.

U.S. Steel Canada Undergraduate Scholarships
These scholarships, derived from the annual income of a capital donation were established in 1997 through the generosity of U.S. Steel Canada (formerly Stelco Inc.). Several scholarships are available to students in the Department of Materials Science and Engineering on the basis of academic standing. In addition, leadership qualities as demonstrated through extra-curricular activities may also be considered.

The Lorne Wagner Memorial Bursary
Annually, two or more awards derived from the annual income will be made to students registered in any year in the Engineering Science Program. The selection will be made by the Chair on the basis of financial need to students who show promise and have a commitment to the Engineering Science Division. The award was established in memory of the late Lorne Steven Wagner, who was killed in an automobile accident in 1980 after completing his first year in Engineering Science. Application should be made on the Undergraduate Grant Application Form.

Wallberg Undergraduate Scholarships
These scholarships, eight in number and valued at $1,500 each, are derived from the Wallberg bequest. They are awarded annually on the basis of academic standing. Four scholarships are awarded in first year and two in each of the third and fourth years. The first awards were made on the results of the annual examinations in 1947.

Irene Gordon Warnock Memorial Scholarship
Established in 2009 by the estate of the late Irene Gordon Warnock, this scholarship is awarded to a student entering their second year of Materials Engineering studies and is based on academic achievement. Recipients must be Canadian citizens or permanent residents and must have achieved honours.

John H. Weber Scholarship in Mechanical Engineering
Established in 2017 through a generous donation by H. Partners Management, this award is given to a student, or team of students, in Mechanical Engineering with a demonstrated interest in automotive and/or aviation design. The scholarship will be awarded to the student/team with the highest rating, as determined by the MIE Capstone showcase judges.

Paul Wilde ChemE 7T8 Award
This award was established in 2014 through a generous donation by William G. Timbers of Timbers Consulting Inc., on behalf of the Chemical Engineering Class of 7T8. The award is given to a student entering their second, third, or fourth year of studies in Chemical Engineering and is based on financial need, academic ability and demonstrated qualities of

selflessness akin to those of Paul Wilde as evident by extra-curricular involvement in support of others in the community. Recommendation of the Department Chair or alternate.

The Stewart Wilson Award
This award, first made in 1965-1966, is available through the generosity of the Engineering Alumni Association. Its value fluctuates to cover the residence fee of New College. It is open to students who, proceeding into second- or third-year studies in the Faculty of Applied Science and Engineering, were resident or non-resident members of New College during their first or second year. The award is based on academic ability, leadership qualities, contribution to New College activities and financial need. The winner shall reside in the New College residence during the academic year of the award.

W.S. Wilson Medals
These medals have been provided by the Engineering Alumni Association in recognition of the service to the Faculty of Applied Science and Engineering of former Assistant Dean and Secretary William Stewart Wilson. A medal is awarded to the student in each graduating course, who, attaining Honours, achieved the highest standing in the final year of the course. The first awards were issued during the 1962-1963 academic year.

David Woods Family Scholarship(s)
Established in 2020 by the Estate of David Harold Woods, this scholarship is given to undergraduate students enrolled in Electrical Engineering on the basis of academic merit and financial need.

Women in Technology Award
Established in 2017 through a generous donation by Natasha Lala, a total of three awards, each valued at $3,000, will be awarded annually to female students in electrical or computer engineering. Awards will be determined on the basis of demonstrated academic merit and participation in extra-curricular activities that focus on technology. Preference will be given to students proceeding to their third or fourth years of study. Additional consideration will be given to students who demonstrate financial need.

William R. Worthington Memorial Scholarship
The William R. Worthington Memorial Scholarship, the gift of Ida R. Worthington in memory of her brother, William R. Worthington, DIPL (1904), BASc (1905), of the value of the income from the fund, is awarded annually to a student in the second year of the civil engineering program who ranks highest at the annual examinations of that year. The first award was made in the 1954-1955 academic year.

Joseph W. Wright Memorial Scholarship
This scholarship, valued at $5,000, was established in 2019 through a generous donation by the Marjorie and Joseph Wright Memorial Foundation. The award is given to a student proceeding to third or fourth year of Mechanical Engineering with demonstrated financial need, minimum 'B' average and qualities of leadership as demonstrated through academic achievements, extra-curricular activities, and/or involvement in the broader community.

Victor Xin Scholarship in eSports
Established in 2017 through a generous donation by Victor Xin, this scholarship is awarded annually to a full-time undergraduate student in the Faculty who has achieved academic excellence, preferably a minimum 3.5 GPA, but can be flexible if there is an outstanding candidate who does not meet the minimum GPA. Students will also demonstrate a passion for eSports or gaming through engagement in a leadership role or participation in extra-curricular clubs or activities.

Jack Young Memorial Award for Survey Camp
This award was established in 2019 through a generous donation by The Association of Ontario Land Surveyors Educational Foundation. This award is given to a student who obtains the highest academic standing in CME358 - Civil & Mineral Practicals (Survey Camp) with one recipient chosen for each of the two Survey Camp cohorts (each recipient receives $750). If there is a tie, the recipient will be chosen based on their topographic mapping grade.

Barbara Zdasiuk Memorial Scholarship
An award fund has been established by the family and friends of Barbara Zdasiuk, a graduate of Engineering Science, who died in a traffic accident in 1980. The award is given on the basis of academic merit to a full-time student proceeding to second year of Engineering Science.

Loan Funds

Small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must be restricted both in amount and number. Inquiries for loans should be made by contacting the Office of the Registrar.

Student Services and Resources

Student Support, Services & Resources

A variety of advising opportunities and registrarial services are available to undergraduates in the Faculty of Applied Science and Engineering. Depending on the service, the services can be accessed through a department office, the Office of the Registrar or the University.

Commonly requested services are listed below.

Office of the Registrar

The Office of the Registrar works closely with departments and the First Year Office concerning all matters related to engineering students. U of T Engineering's Undergraduate Admissions Office (GB 157) manages the admissions process, transfer credits, financial aid and OSAP distribution.

Some of the services offered include:

- Academic and personal advising
- Academic scheduling
- Course listings: building and classroom locations
- Final exam scheduling
- Post-exam services (e.g. final exam viewing, final exam copies, final mark re-checks, final exam re-grades)
- Graduation
- Letters of registration/confirmation of registration
- Petitions and appeals
- Program transfers
- Registration and enrolment
- Student records
- Scholarships and financial aid
- Transfer credits

For more information, contact the Office of the Registrar. If you have questions regarding any aspect of your undergraduate experience, you can email the Office of the Registrar at registrar@engineering.utoronto.ca or visit the office (GB 157).

Office of the Faculty Registrar

Don MacMillan, Faculty Registrar
Helen Bright, Associate Registrar & Director, Admissions
Khuong Doan, Associate Registrar, Student Services & Records
Dan Pettigrew, Associate Registrar, Information Systems
Rosemary Guido, Assistant Registrar, Admissions
Pierina Filippone, Assistant Registrar, Scholarships & Financial Aid
Chris Brown, Assistant Registrar, Academic Scheduling & Senior Business Analyst

35 St. George Street, Room 157
416-978-5896
Fax: 416-978-1866
registrar@engineering.utoronto.ca
undergrad.engineering.utoronto.ca/academics-registration/registrars-office-2/about-the-registrars-office/

First Year Office

TBA, Vice-Dean, First Year Engineering
Chirag Variawa, Director, First Year Curriculum
Leslie Grife, Assistant Director, First-year Academic Services & Advisor
Emzhei Chen, Assistant Director, First-year Student Success & Transition & TrackOne Advisor
JesusMiracle Chiadika, First Year Advisor, Intercultural Learning & Experience
Jennifer Fabro, First Year Advisor
Stephen Johns, EngSci Student Counsellor (Years 1 & 2)
Mikhail Burke, Inclusion & Transition Advisor
Hannah de Haan, First Year Coordinator

35 St. George Street, Room 170
416-978-4625
firstyr@ecf.utoronto.ca
undergrad.engineering.utoronto.ca/first-year-office

Undergraduate Program Offices

Upper-year students should contact their academic advisors for assistance related to their programs. Academic advisors can provide detailed guidance regarding course selections and options for your specific program, as well as assistance in interpreting Faculty policies and procedures.

Chemical Engineering
Vanessa Andres
Wallberg Building, Room 216A
416-978-5336
ugrad.chemeng@utoronto.ca

Civil & Mineral Engineering
Shayni Curtis-Clarke
Galbraith Building, Room 116
416-978-5905
shayni@civ.utoronto.ca

Electrical & Computer Engineering
Leanne Dawkins
Sandford Fleming Building, Room B600
416-978-8570
leanne.dawkins@utoronto.ca

Cross-Disciplinary Program Office (Engineering Minors & Certificates)
Sharon Brown
44 St. George Street
416-978-3532
Fax: 416-946-0371
engineering.minors@utoronto.ca

Engineering Science
Stephen Johns
Bahen Centre, Room 2110
416-946-7351
engsci12@utoronto.ca

Brendan Heath (third- and fourth-year students)

Bahen Centre, Room 2110
416-946-7352
engsci34@utoronto.ca

Mechanical & Industrial Engineering
Gayle Lesmond
Mechanical Building, Room 109
416-978-6420
undergrad@mie.utoronto.ca

Materials Engineering
Agnes Hsin
416-978-7308
agnes.hsin@utoronto.ca

Student Web Service: ACORN

www.acorn.utoronto.ca

ACORN stands for "Accessible Campus Online Resource Network." For those unfamiliar with the system, it is where students enrol in courses, check fees and finances, transcripts, academic standing, and do other records and registration tasks such as making updates to their contact information. The purpose of ACORN is to provide a more convenient, personalized and guided experience for students using U of T's online services.

Responsible Use of ACORN
You are expected to be responsible when using ACORN. You should not attempt to flood the system with requests or to automate the process of course enrolment. Such activity may clog the system so that other students may be denied access or experience degraded performance. Any student(s) attempting such activity may be denied access to ACORN until after the relevant registration period.

Quercus

q.utoronto.ca

Quercus is the hub of academic life for U of T students. As of Sept. 1, 2018, the Quercus online teaching and learning system will officially be in use across the University's three campuses. It replaces the old Blackboard (Portal) system, which has been officially phased out.

T-Card/Library Card

tcard.utoronto.ca

The student photo identification card is a wallet-sized card bearing the student's photograph and signature; the card serves as evidence of registration in the Faculty. It is used for identification purposes within the University, such as Faculty examinations, University libraries, student activities and Athletic Association privileges. There is a fee to replace a lost card.

Letters of Registration

uoft.me/EngStudentPortal

If a current U of T Engineering student needs a letter that confirms their registration, they can make such a request through the Engineering Student Portal. Letters of Registration are $8.00 with tax included. Payment must accompany the request (debit or credit); processing takes up to five business days. The Office of the Registrar cannot be responsible for letters lost or delayed in the mail.

Third-party requests for confirmation of degree should be submitted through U of T's degree confirmation website.

Transcripts

www.transcripts.utoronto.ca

The transcript of a student's record reports the standing in all courses attempted, information about the student's academic status including a record of suspension and refusal of further registration and completion of degree requirements. Course results are added to each student's record at the end of the session. Individual courses from which a student withdraws within the normal time limit are not shown.

Transcript requests should be submitted through ACORN. Requests may also be made in person or by writing the University of Toronto Transcript Centre, 172 St. George Street, Toronto, Ontario, M5S 3G3. A fee is charged for each transcript. Transcripts are not issued for students who have outstanding financial obligations to the University. The University is not responsible for transcripts lost in the mail.

Additional Student Services & Resources in the Faculty

Accessibility Advisor at U of T Engineering

undergrad.engineering.utoronto.ca/advising-and-wellness/accessibility-services

The Accessibility Advisor at U of T Engineering is an extension of Accessibility Services and is located within the Engineering Complex. The Advisor is familiar the Faculty, and, along with other members of Accessibility Services, they facilitate the inclusion of students with disabilities into all aspects of university life. Their focus is on skills development, especially in the areas of self-advocacy and academic skills.

Services are provided to students with a documented disability. The disability can be physical, sensory, a learning disability, or a mental health disorder. Students with temporary disabilities (e.g. broken arm) are also eligible for the service.

Students first go through an intake interview to discuss their eligibility and needs. Where appropriate, students are referred to one of the Service's professionals (e.g. Adaptive Technologist Consultant, Learning Disability Specialist) to discuss strategies and determine accommodations. All discussions are kept confidential with AS and information is disclosed outside the Service only with permission of the student.

Engineering Campus Experience Officers (engCEOs)

undergrad.engineering.utoronto.ca/skule-life/eng-ceo

U of T Engineering Campus Experience Officers (engCEOs): building community through peer-to-peer mentorship, conversation and support. Have a question about the Faculty or just want to meet someone new? Connect with a U of T

Engineering engCEO.

Engineering Career Centre (ECC)

www.engineeringcareers.utoronto.ca
The Fields Institute
222 College Street, Suite 106
416-978-3881
416-978-6649
ask.ecc@utoronto.ca

The Engineering Career Centre (ECC) offers co-operative education to introduce keen and innovative students to industries, ranging from local start-ups to large international companies across multiple sectors.

ECC's work-integrated learning opportunities offer students opportunities to refine their professional interests and chart their career paths and valuable professional experience. For employers, it means having eager and highly-capable individuals working in their organizations as co-op students/interns and prospective full-time employees post-graduation.

Engineering Communication Program

ecp.engineering.utoronto.ca
Two offices:
-Sanford Fleming Building
10 King's College Road, room SFB670
-Myhal Centre for Engineering Innovation & Entrepreneurship
55 St. George Street, room 723
ecp@engineering.utoronto.ca

Our purpose is to help engineering undergraduates build professional-level, discipline specific communication skills. Our instructors are integrated into engineering courses across the curriculum in every program, from first to fourth year. Additionally, we facilitate one-to-one tutoring, offer elective courses (part of the Certificate in Communication) and workshops.

We create practices, programs and partnerships that enable engineering undergrads to become confident and effective communicators who will become leaders in their fields.

Engineering Computing Facility (ECF)

undergrad.engineering.utoronto.ca/undergrad-resources/engineering-computing-facility-ecf
Engineering Annex, 11 King's College Road, room 212K
ECF Labs: Various locations across the Engineering Complex & remote access
ecfhelp@ecf.utoronto.ca

Engineering Computer Facilities (ECF) provides a variety of computing services for teaching and research within the Faculty, as well as offering support for departmental computers and computer communication.

ECF has numerous networks accessible to the Faculty from hundreds of PC workstations. Every undergraduate and graduate student in the Faculty is entitled to an ECF account. Relatively few constraints are placed on the usage of the system. The intention is to have the systems used as often as a student requires for their studies, just as one might use a library or other communal resource.

ECF operates five Windows labs and three Linux labs totaling 428 workstations. In addition, there are over 630 Windows workstations accessible from departmental labs in various buildings. Remote access is provided for both Windows and Linux so that students can access ECF software and their files from off campus.

U of T Engineering's Equity, Diversity & Inclusion Initiatives

www.engineering.utoronto.ca/about/equity-diversity-and-inclusion

We are committed to fostering an environment in which each member of our community can excel, contribute and benefit from different perspectives. Attracting students, staff, and faculty from a wide range of backgrounds, we leverage all forms of diversity to promote inclusivity and create opportunities to experience working collaboratively across cultures. We aim to build a community that reflects the society we serve.

U of T Engineering First-Year International Student Advisors

undergrad.engineering.utoronto.ca/first-year-office-2/first-year-office-team

Engineering's First Year International Student Advisors (of the First Year Office and the Division of Engineering Science) support students as they transition to the learning environment at U of T Engineering.

U of T Engineering's Inclusion & Transition Advisor

undergrad.engineering.utoronto.ca/advising-and-wellness/academic-advising/inclusion-and-transition-advisor

U of T Engineering's Inclusion & Transition Advisor is available to assist students who may be experiencing barriers to their transition into and inclusion within the Faculty.

Engineering Learning Strategist

undergrad.engineering.utoronto.ca/advising-and-wellness/learning-skills-strategist

The Faculty's Learning Strategist develops academic programming and workshops to assess and enhance U of T Engineering students' academic skills related to task-management, critical thinking, problem-solving, test/exam preparation, and coping with stress and anxiety. U of T Engineering undergrads can make appointments with the Learning Strategist through the Advising Portal (located in the Engineering Portal), the Advising Portal, or through their Academic Advisor.

Engineering's Mental Health Programs Officer

www.uofteng.ca/mentalhealth

The Faculty's Mental Health Programs Officer builds capacity at U of T Engineering to support student mental health and well-being by offering mental health programs and training, conducting research and offering best practice insights.

First Year Team & Advisors

undergrad.engineering.utoronto.ca/first-year-office-2/first-year-office-team

The First Year Team is here to help you make a successful transition to a new and exciting learning environment at the Faculty of Applied Science & Engineering.

Health & Wellness Counsellor at Engineering

undergrad.engineering.utoronto.ca/advising-and-wellness/health-wellness

U of T Engineering students are able to access individual, time-limited life coaching, personal counseling and solution/goal-focused psychotherapy within a holistic approach to personal wellness through the Faculty's wellness counsellors. This service is an extension of Health & Wellness. Health & Wellness offers U of T students the same services as a family doctor's office and more.

They provide confidential, student-centred health care, including comprehensive medical care, travel education, immunization, counseling, and referrals. The multidisciplinary health team includes family physicians, registered nurses, dietitians, social workers, psychologists, psychiatrists, health promoters, support staff, lab technicians and much more.

Registrar's Office

undergrad.engineering.utoronto.ca/academics-registration/registrars-office-2

U of T Engineering's Office of the Registrar works closely with program departments to support undergraduate student matters.

Scholarships & Financial Aid Office and Advisor

undergrad.engineering.utoronto.ca/fees-financial-aid/u-of-t-engineering-scholarships-financial-aid-office

Engineering students are welcome to call or visit the Scholarships & Financial Aid Office, located inside the Office of the Registrar, and make an appointment with the Financial Advisor for support surrounding financial challenges.

Upper-Year Academic Advisors

undergrad.engineering.utoronto.ca/advising-and-wellness/academic-advising-2/upper-year-advising

Upper-Year Academic Advisors are available to provide support for personal, academic, and career related matters.

University of Toronto Student Services & Resources

Academic Integrity

www.academicintegrity.utoronto.ca

The University of Toronto is deeply committed to the free and open exchange of ideas and to the values of independent inquiry. As such, academic integrity is also fundamental to the University's intellectual life. What does it mean to act with academic integrity? U of T supports the International Center for Academic Integrity's definition of academic integrity as acting in all academic matters with honesty, trust, fairness, respect, responsibility, and courage.

The University offers many resources to help you if you're feeling stuck or confused by an assignment or in a course. The first place to start is always your instructor, who can also tell you about further resources available within your faculty and department.

Additional resources:

- Student rights and responsibilities
- Code of Behaviour on Academic Matter

Academic Success

www.studentlife.utoronto.ca/asc
Student Success Front Desk
Koffler Student Services Building
214 College Street, room 150
416-978-7970
Online chat: www.studentlife.utoronto.ca/asc/chat

We help you reach your highest learning potential. Your life is more complex than your academic responsibilities, so we look at the whole picture and tailor our support to you.

Accessibility Services

studentlife.utoronto.ca/department/accessibility-services
455 Spadina Avenue, Suite 400
416-978-8060
TTY: 416-978-1902
Fax: 416-978-8246
accessibility.services@utoronto.ca

The Accessibility team assists in navigating disability-related barriers to your academic success at U of T for your on-going or temporary disability. We provide services and supports for learning, problem solving and inclusion.

Antiracism & Cultural Diversity Office

antiracism.utoronto.ca
Health Sciences Building, 155 College Street
3rd Floor (Faculty offices, room 356)
416-978-1259
antiracism@utoronto.ca

The Anti-Racism & Cultural Diversity Office (ARCDO) collaborates with equity offices and community partners to promote a University campus that is free of discrimination and harassment based on race, ancestry, place of origin, colour, ethnic origin, citizenship and/or creed (faith) and as they intersect with other social identities.

U of T Campus Community Police

campuspolice.utoronto.ca
21 Sussex Ave, Main Floor
24/7 Dispatch: 416-978-2323
24/7 Urgent: 416-978-2222

Working in partnership with our community, we are dedicated to creating a safe and secure environment for all students, staff, faculty and visitors. We provide programs on personal safety, protection of property, conflict resolution, maintenance of public order, community service and referral, emergency response assistance, crime prevention and detection, enforcement of the criminal code, selected provincial and municipal statutes and University policies. Information on reporting an incident is available online.

Career Exploration & Education

studentlife.utoronto.ca/department/career-exploration-education
Koffler Student Services Centre
214 College Street
416-978-8000
careercentre@mail.careers.utoronto.ca

We support students and recent graduates as they build their future in our changing world. We help students explore what they can do with their degree, discover job opportunities and further education.

Centre for Community Partnerships

studentlife.utoronto.ca/department/centre-for-community-partnerships
569 Spadina Avenue, Suite 315
416-978-6558

info.ccp@utoronto.ca

We work with students to explore and enact their vision of a better world. Through community-engaged learning and research experiences, students have the chance to learn outside of the classroom, build community on- and off-campus, and contribute to a more just society.

Centre for International Experience (CIE)

studentlife.utoronto.ca/department/centre-for-international-experience
33 St. George Street
416-978-2564
cie.information@utoronto.ca

We help you engage with the world. We provide an array of services unique to international students and enable global learning for the U of T community.

Centre For Women & Trans People

womenscentre.sa.utoronto.ca/student-resources
North Borden Building
563 Spadina Avenue, Room 100
416-978-8201

The Centre exists as a drop-in space for University of Toronto students and community members to hang out, meet, learn, and share experiences in a safe, anti-oppressive and communal environment. A list of student resources is available online.

Clubs & Leadership Development

www.studentlife.utoronto.ca/department/clubs-leadership-development
21 Sussex Avenue

We support students in formal leadership positions (clubs, groups, representative leaders), students wanting to join clubs and students who want to develop leadership skills.

Community Safety Office

communitysafety.utoronto.ca
21 Sussex Avenue, 2nd Floor
416-978-1485

The Community Safety Office responds to students, staff, and faculty members of the University of Toronto community who have personal safety concerns.

The Office responds to all personal safety concerns by addressing the complaint, assessing the personal and community safety risks, providing a continuum of intervention options that the complainant can explore in order to address their personal safety concern(s), presenting information about the particular issue experienced, co-creating a safety plan, referring and working in partnership with various offices in order to address the individual's personal safety concerns. Additionally, the Office provides consultations to those dealing with difficult behavior, facilitates women's self-defense sessions, and organizes Men Against of Violence initiatives.

Equity, Diversity & Inclusion

hrandequity.utoronto.ca/inclusion

Through our equity programs, services and offices, U of T is working to remove a range of barriers and support our community members in fulfilling their academic, research and employment goals. Equity offices provide resources and conduct education and awareness initiatives on how to best realize the University's commitment to equity, diversity and human rights and provide guidance on specific issues as they arise.

Family Care Office

familycare.utoronto.ca
Koffler Student Services Centre
214 College Street, Room 103
416-978-0951
family.care@utoronto.ca

The Family Care Office provides confidential guidance, resources, referrals, educational programming and advocacy for the University of Toronto community and their families. They raise awareness of family care issues central to the achievement of education and employment equity at the University of Toronto.

The Office supports current University of Toronto students, staff, faculty, post-doctoral fellows and their families with any family care related issue. The FCO has always emphasized an inclusive definition of family.

First Nations House Indigenous Student Services

studentlife.utoronto.ca/department/first-nations-house
North Borden Building
563 Spadina Avenue, Third Floor
416-978-8227
fnh.info@utoronto.ca

We provide culturally relevant services to Indigenous students to support academic success, personal growth and leadership development. We offer learning opportunities for all students to engage with Indigenous communities at U of T and beyond.

Freedom of Information & Protection of Privacy Office

governingcouncil.utoronto.ca/fipp

The University of Toronto respects your privacy. The University is committed to the requirements of FIPPA. Established University of Toronto values and long-standing practices for privacy and access are consistent with FIPPA principles. These principles were reflected in University practice and policy long before FIPPA applied to the University. The University continues to support access and privacy through its commitment to the requirements of FIPPA.

Health & Wellness

studentlife.utoronto.ca/department/health-wellness
Koffler Student Services Centre
214 College Street
416-978-8070

We provide a range of health services for your physical and mental health, wellness programs and information to help support you in achieving your personal and academic goals.

Housing

studentlife.utoronto.ca/department/housing
Koffler Student Services Centre
214 College Street, Room 150
416-978-8045
Residence inquiries: residence@utoronto.ca
All other inquiries: housing.services@utoronto.ca

The staff at Housing can help you find a great home. Use the StarRez portal to apply for residence, or log in to the Off-Campus Housing Finder to search for rentals and find roommates. Attend our events or meet with us in person to get help with your housing search and learn about your tenant rights.

Hart House

harthouse.ca
7 Hart House Circle
416-978-2452

Hart House is the co-curricular centre of the University of Toronto: a place that welcomes both campus and community to explore cultural, intellectual and recreational activities. Aside from a wide array of events, lectures, live music and performances, Hart House offers classes for every interest from filmmaking and acting to archery and dance.

Open 365 days a year, our facilities include a range of impressive rooms for study, dining, recreation and socializing, a modern athletics and aquatics facility, a satellite farm location, the acclaimed Justina M. Barnicke Art Gallery, a dynamic theatre, complete wedding, meeting and event services as well as the top-rated Gallery Grill restaurant all housed within a stunning, neo-Gothic building.

Information Commons

onesearch.library.utoronto.ca/ic-home

U of T's Information Commons provides telephone and walk-in support for UTORid, email and internet access, wireless connectivity and more; software at negotiated discounts for U of T students, faculty and staff; access to their 3D printing service; video and production services; access to computers and printers in the Computer Access Facility on the first floor of Robarts Library.

International Student Exchanges/Learning Abroad

learningabroad.utoronto.ca
33 St. George Street
416-978-1800
learning.abroad@utoronto.ca

No matter where or for how long you go, learning abroad will shape you and how you see and relate to the world. Gain exposure to different cultures, backgrounds, and forms of teaching.

Mentorship & Peer Programs

studentlife.utoronto.ca/department/mentorship-peer-programs
21 Sussex Avenue

Our team provides training, programming, events and resources to mentors and support for students looking for mentors.

Multi-Faith Centre for Spiritual Study & Practice

studentlife.utoronto.ca/department/multi-faith-centre-for-spiritual-study-practice
569 Spadina Avenue
416-946-3120

Our team supports the spiritual well-being of everyone on campus and provides opportunities for people to learn from each other through interfaith dialogue, arts and social justice. While U of T is a secular institution, we respect everyone's right to worship.

U of T My Student Support Program (My SSP)

uoft.me/myssp
1-844-451-9700 (outside of North America: 001-416-380-6578)
Download the My SSP app: Apple App Store | Google Play

U of T My SSP provides students with real-time and/or appointment-based confidential, 24-hour support for any school, health, or general life concern at no cost to you. You can call or chat with a counsellor directly from your phone whenever, wherever you are.

Ongoing support is available over the phone in 146 languages. Immediate support is available over the phone in 35 languages and over chat in simplified Chinese, English, French and Spanish.

Navi

Access tool: prod.virtualagent.utoronto.ca
viceprovoststudents.utoronto.ca/navi

U of T students have a streamlined way to discover mental health resources and supports. Navi, short for navigator, is a chat-based virtual assistant that can understand the questions you ask, and provide accurate and relevant responses – any time, anywhere. Check out the Navi tool today and visit the OVPS site for more information and FAQs.

Office of the University Ombudsperson

governingcouncil.utoronto.ca/ombudsperson
McMurrich Building, Room 102, 12 Queen's Park Cres. West
Telephone: 416-978-4874
ombuds.person@utoronto.ca

As part of the University's commitment to ensuring the rights of its individual members are protected, the University Ombudsperson investigates complaints from any member of the University not handled through regular University channels. The Ombudsperson is independent of all administrative structures of the University and is accountable only to Governing Council.

In handling a complaint, the Ombudsperson has access to all relevant files and information and to all appropriate University officials. All matters are in strict confidence unless the individual involved approves otherwise. The Ombudsperson offers advice and assistance and can recommend changes in academic or administrative procedures where this seems justified. For additional information, please visit our website. The services of the Office are available by appointment at all three U of T campuses.

Orientation, Transition & Engagement

studentlife.utoronto.ca/department/orientation-transition-engagement
21 Sussex Avenue

Starting with university orientation and continuing to graduation and beyond, we support active participation in campus life and a broad range of co-curricular involvement opportunities.

Reporting Homophobic or Transphobic Harassment On Campus

sgdo.utoronto.ca/getting-help/reporting-a-complaint

The University of Toronto has a large and diverse population of students, staff and faculty. As a University, we celebrate this diversity and are committed to equity; equal access to opportunities for all members of the community; freedom of expression and academic freedom; and providing a safe, welcoming and harassment-free working and learning environment for all.

We also recognize that lesbian, gay, bisexual, transgender and queer (LGBTQ) people are still frequently the targets of hostile, intimidating and harassing behaviours on our campus, and we attach high priority to dealing with any such incidents.

If you have experienced harassment or discrimination, we encourage you to find support and discuss your experiences. This can be done with a trusted friend, partner or family member, a staff person at the University, or a health professional. You are always welcome to meet with staff at the SGDO to discuss their experiences and find support, even if you do not want to file a report.

Sexual & Gender Diversity Office

sgdo.utoronto.ca
21 Sussex Avenue, Suites 416 & 417
416-946-5624
sgdo@utoronto.ca

The Sexual & Gender Diversity Office (SGDO) develops partnerships to build supportive learning and working communities at the University of Toronto by working towards equity and challenging discrimination. The Office provides innovative education, programming, resources and advocacy on sexual and gender diversity for students, staff and faculty across the University's three campuses. Join the SGDO Listserv to receive weekly communications about upcoming events and programs.

Sexual Violence Prevention & Support Centre

svpscentre.utoronto.ca
St. George campus — Gerstein Science Information Centre (Gerstein Library), Suite B139
UTM — Davis Building, Room 3094G
UTSC — Environmental Science & Chemistry Building, EV141
416-978-2266 (all locations)
thesvpcentre@utoronto.ca

The Sexual Violence Prevention and Support Centre works to create a campus environment where all members of the University community can study, work and live free from sexual violence.

Established as part of the University of Toronto's Action Plan on Preventing and Responding to Sexual Violence, the Centre has locations on each campus to help students, staff and faculty who have been affected by sexual violence or sexual harassment access support, services and accommodations.

The Centre offers:

- Confidential, non-judgmental, client-centred services.
- Coordination and navigation of University supports, services and accommodations.
- Support in making a disclosure.
- Assistance with reporting.
- Referrals to on- and off-campus services.
- Self-care resources.

Student Life

www.studentlife.utoronto.ca

The Division of Student Life brings coherence to the complexity and creates opportunities to build skills, foster community and integrate learning. They connect life to learning.

Summer Abroad Programs

summerabroad.utoronto.ca
Professional & International Programs
Woodsworth College, 119 St. George Street, 3rd Floor
416-978-8713
summer.abroad@utoronto.ca

Administered by Woodsworth College and the Faculty of Arts & Science, the University of Toronto's Summer Abroad program is designed to enrich students' academic lives by providing an exciting and educational international experience. Students complete a University of Toronto undergraduate credit course that is relevant to the location in which the course is taught. The program takes place over 4-6 weeks in the summer. The courses offered through the Summer Abroad program are typically all Arts & Science courses, but U of T Engineering students are welcome to apply and use the credit as a possible elective.

Travel Safer

TravelSafer St. George campus: campuspolice.utoronto.ca/travelsafer-2/
TravelSafer UTM: www.utm.utoronto.ca/campus-police/safety-programs/work-alone-walksafe-programs
TravelSafer UTSC: www.utsc.utoronto.ca/police/travel-safer
416-978-7233 (SAFE)

A safer alternative when travelling on campus, TravelSafer is a reliable and safe alternative to walking alone at night. Available 24/7, 365 days per year. Includes all U of T buildings and abutting TTC stations. To request a TravelSafer escort, call 416-978-7233 (SAFE). A security guard or special constable will meet you at your location.

ULIFE

www.ulife.utoronto.ca

Ulife is a one-stop website listing a large and diverse directory of student clubs, organizations, activities and opportunities on all three campuses. The thousands of entries include film appreciation clubs, debating societies, sports teams, social activism, drop-in classes, and research opportunities and awards.

Student Organizations

Engineering Society (EngSoc)

skule.ca
Sandford Fleming, B740
10 King's College Rd.

Every undergraduate in the Faculty is a member of the Engineering Society. Founded in 1885, it is the oldest formal Engineering organization in Canada. Together with its constituent "course clubs" (one for each program), the Society plans and operates many student activities and services. It is the focal point for that traditional unity of spirit among Engineering students, which is the envy of other groups in the University and which continues throughout its members' professional careers. The Society operates the Engineering Stores in the basement of the Sandford Fleming building, which supplies students with most of their school supplies and instruments. In addition, the Society deals with matters of policy relating to student academic affairs and has representation on the Faculty's governing body, the Council and its working committees.

EngSoc Club Directory

skule.ca/affiliated_clubs

Association of Part-Time Undergraduate Students (APUS)

apus.ca

All part-time undergraduate students on all three campuses of the University of Toronto are members of the Association of Part-time Undergraduate Students (APUS). The mission of APUS is to ensure that part-time undergraduate students have access to the full range of programs, services and resources at the University of Toronto in order to improve the quality of the part-time undergraduate educational experience. APUS works to ensure that a variety of post-secondary educational opportunities are available for students who, for any reason, choose to study part-time. APUS believes that education can be combined with work, family and other activities and that part-time study represents a viable option for students who cannot study full-time. To this end, APUS promotes the concepts of life-long learning, evening, weekend and summer study and flexible academic programming across the University. The objectives of APUS services are to improve the quality of the total educational experience, in its broadest sense.

University of Toronto Student Union (UTSU)

www.utsu.ca

The UTSU works for you in many ways, but primarily through advocacy, events, and programs and services. We advocate for you by regularly lobbying the government and university, organizing public education campaigns, and supporting student-led initiatives. We organize major events for students, including Orientation, Winter Week of Welcome, Unity Ball, Pasta Night, and more. And most importantly, we offer services such as a Food Bank (offered every Friday at the U of T Multi-Faith Centre), Student Aid, an annual Tax Clinic, Clubs Funding, a Resource Bank for Clubs, and of course, the UTSU Health & Dental Plan.

Academic Regulations

I. Responsibilities of Students

Students are responsible for making themselves familiar with the information in the Calendar. Remember: a minimum first installment or deferral of fees must be paid before a student is considered registered. Please refer to the Fees & Expenses section of this Calendar.

- Students are responsible for ensuring that their course enrolment is accurate and complete and that the courses in which they enrol meet the requirements for graduation. Course prerequisites and any restrictions on enrolment should be noted carefully prior to registration. Whenever the requirements are not understood, a student should consult their department's undergraduate advisor or the Associate Chair of Undergraduate Studies.
- Students are required to attend the courses of instruction and the examinations in all subjects prescribed.
- Students must conform to all lecture, tutorial and laboratory regulations.
- Students shall comply with all due dates and manner of submission for all work submitted for credit in a course. Consequences for failure to comply shall be specified and announced by the instructor. All session work must be submitted no later than the last day of lectures in the session as published in this Calendar.
- If a student is unable to complete any portion of their course work due to medical, psychological or compassionate circumstances, they should inform the instructor by submitting a "Petition for Consideration in Course Work", with supporting documents (e.g., U of T Medical Certificate). Please refer to "Section I - Petitions," in this chapter.
- A student has the right to withdraw from a course or program without academic penalty before the published deadline (see "Sessional Dates" listing at the beginning of the Calendar) with approval from their department's undergraduate advisor. A student who does not complete the course or write the final examination will receive final marks in the course consisting of the sum of their earned session marks with zero for the uncompleted work and examination. These marks will be included in the calculation of session averages. A student who in any session withdraws from the Faculty after the deadline to withdraw without academic penalty (as specified in the calendar) is deemed to have failed the session.
- It is generally desirable for students to engage in extracurricular activities to a reasonable extent so that they do not become too narrowly academic in interest and outlook but no academic credit can be given for such activities. Extracurricular activities require considerable time for the proper performance of the duties connected with them. A student on probation, or with marginal academic records, should not undertake such activities. Students will not be given any special consideration for conflicts resulting from such activities and are responsible for meeting the requirements of all aspects of their academic work.

Responsibilities of Students with Regard to the Use of Computer Facilities

- All computer equipment in the Faculty is to be used for academic purposes only.
- The use of any computer equipment to display or distribute material that could reasonably be expected to degrade, offend or promote hatred or violence against any person or group is inconsistent with the purpose of the equipment, and is not permitted. Examples of unacceptable material include pornography, racial slurs and pictures of men or women who are not fully dressed.

These regulations are designed to promote an atmosphere in which all students can pursue their academic programs, as well as discourage waste of computer resources. Violators are subject to having all their U of T computer accounts closed down, and/or other disciplinary action under the provisions of the University of Toronto Code of Student Conduct. Maintaining the integrity of the Faculty's computer facilities is everyone's responsibility. If you see an individual using computer equipment anywhere in this Faculty in a manner that you believe to be inconsistent with the regulations, please record the time, date, room number, workstation number (if in a facility with more than one terminal or computer) and the exact nature of the offence (description of what is being displayed). Send the information to the Director, Engineering Computing Facility, Engineering Annex Room 206 or send an email to office@ecf.utoronto.ca. The Director will then determine the identity of the user and the type of activity in which the user was engaged at the time it was recorded.

II. Definitions of Terms

1. Sessions

The academic program consists of a consecutive sequence of sessions. There are three sessions per academic year:

- Fall Session (September – December)
- Winter Session (January – April)
- Summer Session (May – August)

With permission of the responsible division or department, courses may be taken in summer sessions. The evaluation period for the purpose of promotion is the Fall Session or the Winter Session.

The notations 1F, 1W, 2F, 2W, etc., are used to represent the Fall Session and the Winter Session for the respective year of study.

2. Sessional Averages

a. Fall Session Average
   The Fall Session Average is calculated on the basis of all Fall Session courses in which the student is enrolled. The weighting factor for each course is the number of weight units assigned to it. Full-year courses are not included in the calculation of the Fall Session Average. These courses are identified as "IPR" on the student's record in the Fall Session.
b. Winter Session Average
   The Winter Session Average is calculated on the basis of all Winter and full-year courses in which the student is enrolled. The weighting factor for each course is the number of weight units assigned to it. The results of full-year courses are included in the Winter Session Average with a weight equal to the sum of the Fall and Winter Session weights.

3. Course Marks & Grades

The following course marks and grades relate to the performance of a student in the work of a particular course. A course grade or mark should not be interpreted as an assessment of status within a program of studies since this is determined by the Promotional Regulations set out in Section III, IV and V. In particular, please refer to Section III, Part 8 regarding credit for courses.

The equivalents of the Numerical Scale of Marks in the refined Letter Grade Scale and the Grade Point Value are as follows:

* The grade point values below apply to marks earned in individual courses; grade point averages are weighted sums of the grade points earned (see below), and thus do not necessarily correspond exactly to the scale below. For example, a B+ average would include grade point averages from 3.20 to 3.40, while the lowest B- average would be 2.50.

Numerical Scale of Mark	Letter Grade	Refined Grade Point Value
90-100	A+	4.0
85-89	A	4.0
80-84	A-	3.7
77-79	B+	3.3
73-76	B	3.0
70-72	B-	2.7
67-69	C+	2.3
63-66	C	2.0
60-62	C-	1.7
57-59	D+	1.3
53-56	D	1.0

50-52	D-	0.7
0-49	F	0.0

4. Grade Point Average

Note: the Faculty of Applied Science & Engineering does not promote students on the basis of the GPA but on the basis of the weighted sessional average.

The Grade Point Average is the weighted sum of the grade points earned, divided by the number of courses in which grade points were earned.

Courses noted “AEG” are not included in the average, nor are transfer credits, courses taken elsewhere on a Letter of Permission, nor courses designated as “extra.”

Three types of grade point averages are shown on the Official Student transcript:

- The Sessional GPA (SGPA) is based on courses taken in a single session (Fall, Winter or Summer).
- The Annual GPA (AGPA) is based on courses taken in the Fall-Winter Sessions.
- The Cumulative GPA (CGPA) takes into account all courses taken for degree credit in the Faculty.

5. Non-grade Symbols

The following non-grade symbols may appear on grade reports and transcripts instead of course marks and /or equivalent letter grades. They have no grade point or term sessional average values:

- AEG: Aegrotat standing granted on the basis of session work and medical or similar evidence where the student was not able to write the final examination in the course. AEG is assigned by a division upon approval of a student's petition. It carries credit for the course but is not considered for averaging purposes.
- CR/NCR: Credit/No Credit. Used to report results for academic requirements such as practical experience, English proficiency, field camps, etc. The grades CR and NCR have no numerical equivalence and are not included in the calculation of Sessional Averages.
- DNW: Did not write/did not attend/did little work (when used as final course result, DNW is assigned by the instructor and must be changed to another grade/symbol during the divisional grade review).
- GWR: Grade withheld pending review under the Code of Behaviour on Academic Matters.
- IPR: (Course) in progress.
- LWD: Permitted to withdraw from a course without academic penalty without supporting documentation. Applies only to elective courses such as technical electives, humanities and social science electives, complementary studies, and free electives. More information about late withdrawal without supporting documentation can be found in the Promotion Regulations section.
- NGA: No grade available.
- SDF: Standing deferred on the basis of incomplete course work because of medical or similar reasons (to be replaced by a regular mark before the expiry of a specified extension period).
- WDR: Granted privilege of late withdrawal without academic penalty from a course caused by circumstances beyond the student’s control.

The following non-grade statements may appear on grade reports and transcripts in conjunction with the course mark and letter grade:

- Assessed: Indicates that an assessed mark has been granted through petition to the Committee on Examinations on the basis of session work and medical or similar evidence.
- EXT: Extra course. Not for degree credit; course has no effect on status or grade point average. Refer to section VII., 9. Promotion Regulations.
- INC (incomplete): Notwithstanding the mark obtained by a student in a course, the instructor may report the designation "incomplete" in addition to the student’s final course mark, if:

a. a student has not made a reasonable attempt to complete major session assignments, projects laboratories, tutorials or the thesis, and
b. the instructor has made a reasonable effort to inform the student as early as possible in the session that an important part of the session work is incomplete. If the instructor's report is confirmed by the Committee on Examinations, the student will be required to clear the incomplete status to receive credit for the course, although the original course mark will not be altered.

An incomplete status may be cleared by obtaining an evaluation of 50% or greater on the required course work which must be completed within a time period specific by the professor but not later than the end of the next corresponding session. A student who does not clear an incomplete course designation in the manner prescribed above will not receive credit for the course and the result will be treated as an F grade, i.e., Regulation IV-8 pertaining to the repeating or replacing of courses with F grades will apply.

III. University of Toronto Policies & Guidelines

As members of the University of Toronto community, students assume certain responsibilities and are guaranteed certain rights and freedoms. The University has several policies that are approved by the Governing Council and which apply to all students. Each student must become familiar with the policies. The University will assume that they have done so.

The rules and regulations of the University are listed in this Calendar. In applying to the University, the student assumes certain responsibilities to the University and, if admitted and registered, shall be subject to all rules, regulations and policies cited in the Calendar, as amended from time to time.

Governing Council's website hosts all of the University's policies. Policies of particular interest to students are as follows:

- Guidelines Concerning Access to Official Student Academic Records
- Code of Behaviour on Academic Matters
- Code of Student Conduct
- University Assessment and Grading Practices Policy
- Policy on Official Correspondence with Students

Additional Provostial guidelines, reports, practices and frameworks are posted on the Division of the Vice-President and Provost's website.

IV. Officers of the University

A list of officials of the University of Toronto can be found on the Governing Council website at governingcouncil.utoronto.ca.

V. Academic Program Load

Please note, program load may vary by year of study and program.

The normal full academic load is 2.50 credits per session. Students in second or higher years may, in exceptional cases, increase their academic load to a maximum of 3.00 credits. Full-time students may take a CS or HSS elective course in any term starting in the summer after their initial registration, and subject to the rule above.

Part-time students may take a CS or HSS elective course in any term. Students taking a full-year core course will not be allowed to drop this course in the Winter Session. A full-time student may reduce their academic load below the full academic load by 0.50 credits by dropping a CS, HSS or technical/free elective course if it is possible to take the same or a replacement course in a summer or subsequent session. It is recommended that a student consult their undergraduate advisor for advice on how this may impact their ability to complete their degree requirements within the expected period of time.

Reducing the academic load to less than a full load as defined by a student's year and program of study will make the student ineligible for certain scholarships and Dean's Honours list. Full-time students with reduced course loads are still required to pay the full-time program fee, and will not be entitled to any tuition fee refunds.

VI. Degree Requirements

To qualify for a degree, a student must complete a full undergraduate program as outlined in the Faculty Calendar within nine calendar years of first registration, exclusive of mandatory absences from their program. Further, no student will be allowed to graduate if they do not meet the criteria that may lead to registration as a Professional Engineer as set by the Canadian Engineering Accreditation Board (CEAB).

A full undergraduate program consists of eight Fall and Winter Sessions taken in order. To gain credit for a session a student must:

a. Satisfy the academic regulations to proceed to the succeeding session as described herein, and
b. Not be subsequently required to repeat the session for which credit is to be gained, and
c. Not have any outstanding designations of "standing deferred," "incomplete," "No Grade Available," or "GWR" (Grade Withheld pending Review under Code of Conduct on Academic Matters) for any course in any session (see Regulations I-5 and I-7).

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

An academic standing of *Proceeding on Probation,* or *On Repeat Probation* will be removed and changed to *Pass* (or *Honours* if applicable) at the conclusion of the final session during which all requirements for graduation are satisfied.

3. English Proficiency Requirement
The Faculty requires each student to show an ability to write English coherently and correctly in all written work submitted for evaluation. Consequently, the Faculty reserves the right to ask each student to write a post-admission English Proficiency Assessment at the beginning of their first year of studies. Every student will also take at least one course that includes a written communication component within their curriculum. Satisfactory completion of the course or courses is required for graduation.

4. Practical Experience Requirement
It is a regulation of the Faculty of Applied Science and Engineering that all students complete a minimum of 600 hours of practical work before graduation. Full details of the practical experience requirement are outlined in "Curriculum and Programs."

VII. Academic Standing

1. There are three categories of Academic Standing used for promotion:

Clear: A student with a Clear standing may proceed to subsequent sessions.

Proceeding On Probation: A student is placed on Probation the first time the Session Average is between 55% to 60%. Probation is a warning that academic performance is not satisfactory.

On Repeat Probation: A student placed on Repeat Probation must withdraw from the Faculty for a prescribed period of time in accordance to the promotion regulations. A second instance of Repeat Probation will result in refusal of further registration in the Faculty.

2. Honours Standing (Full-time or Part-time):

Honours academic standing for a non-repeat Fall or Winter term is granted to students who earn a weighted term average of 79.5% or higher, excluding courses designated as “Extra” (EXT).

3. Dean's Honours List

a. **Dean's Honours List for Full-time Students**: Students with full-time (FT) attendance class will be recognized on the Dean’s Honours List for any non-repeat Fall or Winter term in which they complete a minimum of 2.0 credits (usually 4 half courses) with a weighted term average of 79.5% or higher, counting only non-repeat and non-extra courses. Note: valid full-year courses that are still in progress (“IPR”) in which a student remains enrolled also count towards minimum Fall Term load requirements.

b. **Dean's Honours List for Part-time Students:** Students with part-time (PT) attendance class in sequential Fall and Winter terms will be recognized on the Dean’s Honours List once for the combined terms if they complete at least 2.0 credits (usually 4 half courses) with a combined term weighted average of 79.5% or higher, counting only non-repeat and non-extra courses.

4. Honours Upon Graduation

a. To obtain High Honours upon graduation, a student must achieve a cumulative weighted average of 87.5% or higher across courses taken in terms in which their year of study was 2, 3 or 4, as well as a cumulative weighted average of 82.5% or higher across courses taken in terms in which their year of study was 4, excluding any repeat courses or courses marked as "Extra."

b. Students not eligible for High Honours obtain Honours upon graduation if they have achieved a cumulative weighted average of 79.5% or higher across courses taken in terms in which their year of study was 2, 3 or 4, as well as a cumulative weighted average of 74.5% or higher across courses taken in terms in which their year of study was 4, excluding any repeat courses and courses marked as "Extra."

   Note: Summer Session registrations also have an associated year of study; as such, valid summer courses are also included.

VIII. Promotion Regulations

The Promotion Regulations are the academic standards that dictate whether a student will proceed to the next session or not. These regulations apply to all students who are registered in the Faculty. The first session (Fall Session) commences in September and ends in December. The second session (Winter Session) begins in January and ends in April/May.

1. Removing Probation:

Full-time students

A full-time student who has completed a non-repeated fall or winter term with a weighted Session (term) Average of 60% or greater while maintaining a minimum 1.50 cumulative GPA will have their probation status improved by one academic standing category. For example, a student who has a probation status of “Repeat Probation” after one session with a weighted Session Average of 60% or better and a CGPA of 1.50 or higher will have a new status of “Proceed on Probation.” Note: For the purposes of probation lifting, a full-time session means four or more non-repeated HCEs (half-course equivalents.)

Part-time students

Students who are in part-time studies will have their probation status improved by one academic standing category after having completed the minimum number of sequential part-time fall or winter terms required to have numeric grades registered in four or more non-repeated HCEs with a composite average of 60% or greater across all non-repeated courses in those terms and a CGPA of 1.50 or higher.

Upon Graduation

An academic standing of "Proceeding on Probation," or "On Repeat Probation" will be removed and changed to "Pass" (or "Honours" if applicable) at the conclusion of the final session during which all requirements for graduation are satisfied.

2. Required Withdrawal:
A student who has failed a session is required to withdraw and must discontinue their studies as soon as grades are made official. This applies whether or not the student is enrolled in courses that continue in the following session. In all cases where a full year course is dropped, the student will not receive credit for any work already done in the course. A student who is required to withdraw after a Fall Session will be withdrawn by the Registrar’s Office and will receive a refund for the Winter Session. A student who wishes to withdraw voluntarily must complete a withdrawal form at the Registrar’s Office. A student who is required to withdraw after a Winter Session need not complete a withdrawal form.

Under some conditions, students in years 2–4 may request to be enrolled in a maximum of three half-course equivalents during the withdrawal period. These courses must consist of previously failed technical courses (not from the term leading to second probation status), and, in special cases, complementary studies courses. Students who receive second probation status following term 1S may request to be enrolled in a maximum of two half-course equivalents during the following fall term session. Students will make such requests through an academic advisor; decisions will be made on a departmental basis. Petitions to the Committee on Examinations are required for requests outside this scope.

3. Repetition of a Session:
A student is not permitted to repeat the same session more than once. Thus, any student who would otherwise be required to repeat a session more than once is given the status "Failed — will not be considered for re-admission." In permitting a student to proceed to the next session, it is assumed by the Faculty that the student has both the ability and necessary background to obtain a weighted Session Average of 60% or greater.

a. In a repeated session, no credit is retained for courses previously taken in which a mark of less than 70% was achieved. Courses in which a mark of 70% or greater has been achieved need not be repeated. A student who is repeating a session may choose elective courses different from those he or she chose on the previous attempt.
b. A first-year student may not improve their academic standing by voluntarily repeating a session. For example, if a student is on academic probation and the promotional standing of the student will not be improved by the results of the voluntarily repeated session if their weighted Session Average for the session is 60% or greater.

4. Re-enrolment after Withdrawal:
A student who has withdrawn from the Faculty must apply for re-enrolment by the stated deadline dates for the Fall Session and Winter Session as stated in the Calendar for a decision on their eligibility to resume studies in the Faculty. Specific deadline dates are listed in the “Sessional Dates” section of the Calendar. Please contact the Office of the Registrar for application information. Re-enrolment is not automatic. First-year students making such applications should consult a first-year advisor.

5. Credit for Courses in the Fall & Winter Session:

a. A student whose mark is less than 50% in any course taken as part of the academic load in a session will not be given credit for the course. If credit is not obtained for a course, the students must register for and repeat the course at the first opportunity. If a mark of 50% or greater is obtained in the repeated course, credit will be given for the course.
b. If credit is not obtained for the original course on the second attempt, be it through repeating or substituting of a course, the student will be permitted one additional opportunity to clear the requirement. In such case, the student must register for and repeat the course or a substituted course at the first opportunity. If credit is not obtained for the original course or for the substituted course on the third attempt, the student will be given the status "Failed — Refused Further Registration."
c. A student who is not in a regular full-time or part-time program and is taking courses either to obtain credit for a missing requirement or to repeat a previous failed course must achieve a mark of 50% or greater in order to retain credit in such courses.
d. PEY Co-op students who are given permission to take courses during their internship programs will be given credit for those courses in which they obtain a mark of 50% or greater.
e. In the event that the requirement to repeat or substitute a course causes timetable conflicts that cannot be sanctioned by the department or division, study of higher level conflict courses must be deferred.
f. Promotion rules shall apply in the usual manner to students who are repeating or substituting courses or repeating examinations. Grades for repeated or substituted courses or repeated examinations shall be included in the weighted Session Average.

6. Credit for Courses in the Summer Session:
A student taking any University of Toronto summer course(s) including repeated courses, must obtain a grade of at least

50% in order to retain credit. Therefore, there will be no audit/promotional assessment for the Summer Session and credit for courses will be assessed on a per course basis except for students participating in the T-Program.

7. Late Withdrawal Without Supporting Documentation
This policy applies to students wishing to withdraw from courses after the withdrawal deadline, but prior to the start of the Faculty's examinations period.

Case (1): Students in Years 2–4
Students are allowed to drop, without penalty, a maximum of two half-credit (0.5 wt) elective courses. This would be a three-year total and does not include courses dropped under this policy in Year 1. This applies to technical electives, CS/HSS electives and free electives taken at the University of Toronto.

Case (2): Students in Year 1 Engineering Science
Students are allowed to drop a maximum of three half-credit courses in:

a. Term 1F as part of a transition to term 1S in a core-8 program, or
b. Term 1S as part of a transition to term 2F in a core-8 program.

Case (3): Students in Year 1 Core 8/Track One
Students are allowed to drop a maximum of two half-credit courses over the combined 1F and 1S terms.

Students will make such requests through their academic advisors; petitions to the Committee on Examinations are not required. "LWD" will appear on a student's transcript for all courses dropped under this policy. This course status will have no effect on the GPA, sessional averages or other elements of the academic record.

9. Designating Credit Courses as Extra
With the approval of their department's undergraduate academic advisor or Chair's designate for undergraduate studies, a student may elect to take an extra course. These courses cannot be used for degree program credit. Their marks are shown on the transcript but not included in the calculation of sessional averages. Any course taken by a student in a degree program that is not listed in the curriculum requirements for that program in the "Curriculum and Programs" section of the academic calendar will be designated as "EXT." This includes courses taken for interest or additional elective courses beyond what is prescribed in a program's curriculum.

The deadline for requesting any credit course be changed to an extra course is the same as that for dropping a course. The deadline for requesting an extra course be changed to a credit course (if applicable) is the same as that for adding a course.

Promotion Regulations: Text

There are two important parameters to the Promotion Regulations: a student's previous record and the weighted Session Average (SA) achieved by the student in the current session. The regulations are presented below in text format. They are presented in nine sections, according to the student's previous record.

1. First-year Students Enrolling with a Clear Record — Session 1F

a. Session Average 60% or greater: Passed. Proceed to the next session 1W with a clear record.
b. Session Average between 55% and 60%: Placed on Probation with three options:
   i) Proceed to 1W on probation if all course marks are 50% or greater.
   ii) Enrol in the T-Program on probation. Repeat all courses with marks less than 50%. Students may elect to repeat other courses which have marks between 50% and 59%. Must repeat specific courses as decided by the Chair, First Year and the T-Program Coordinator. Up to three courses may be repeated. Students who are part-time or who are required to repeat/take four or more 1F courses are not eligible to enrol in the T-Program.
   iii) Withdraw from the Faculty with the right to return to a subsequent Session 1F on probation. If more than three course marks are less than 50% or is required to take four or more 1F courses, a student must withdraw.
c. Session Average between 50% and 55%: Placed on Probation with two options:
   i) Enroll in the T-Program on Probation. Will repeat all courses with marks less than 60%. If more than three courses have marks less than 60%, normally, the three courses with the lowest grades will be repeated. Students who are part-time or who are required to repeat four or more courses are not eligible to enrol in the T-Program

and must withdraw.
ii) Withdraw from the Faculty with the right to return to a subsequent Session 1F on probation. If more than three course marks are less than 50%, a student must withdraw.

d. Session Average between 45% and 50%: Placed on probation. Must withdraw from the Faculty and is eligible to repeat sessions when next offered.
e. Session Average less than 45%: Failed. May apply for re-admission. Re-admission, if granted, will be on repeat probation.

2. First-year Students proceeding with a Clear Record — Session 1W*

a. Session Average 60% or greater: Passed. Proceed to the next session with a clear record.
b. Session Average between 55% and 60%: Placed on probation. Proceed to the next session on probation.
c. Session Average less than 55%: Placed on repeat probation. Repeat session immediately when next offered.

*Students cannot proceed to second year if more than two first-year courses are outstanding.

3. First-year Students in the T-Program — Session 1W

a. Session Average 60% or greater: Passed. Proceed to the Summer Session on probation in the T-Program.
b. Session Average less than 60% or a mark in a repeated course below 50% Failed. May apply for re-admission. Re-admission, if granted, will be on repeat probation.

4. First-year Students in the T-Program — Summer Session*

a. Session Average 60% or greater: Passed. Proceed to 2F on probation
b. Session average less than 60%: Placed on repeat probation. Repeat session 1W when next offered on repeat probation.

*Students cannot proceed to second year if more than two first-year courses are outstanding.

5. First-year Engineering Science Students — Session 1F

a. Session Average 60% or greater: Passed. Proceed to the next session (1W) with a clear record.
b. Session Average between 55% and 60%: Passed. Proceed to the next session (1W) with a clear record in Engineering Science or:
i) Conditionally transfer to another Engineering program of choice. Final acceptance into a program of choice is conditional upon a student achieving a Winter Session Average of 60% or greater.
ii) Transfer to another Engineering program with space with no conditions.
c. Session Average between 45% and 55%: Placed on Probation. Required to transfer to a program with space with two options:
i) Enrol in the T-Program on Probation. Required to take as repeated those courses equivalent to courses with marks less than 60% (APS111H1 in lieu of ESC101H1 if the mark in ESC101H1 is less than 50%). If more than three courses have marks less than 60%, the three courses with the lowest grades will be repeated.
ii) Withdraw from the Faculty with the right to return to a subsequent Session 1F on probation in a program with space. If more than three course marks are less than 50%, a student must withdraw. Not eligible to apply for re-admission to the Engineering Science program.
d. Session Average less than 45%: Failed. May apply for re-admission. Re-admission, if granted, will be on repeat probation. Not eligible to apply for re-admission to the Engineering Science program.

6. First-year Engineering Science Students — Session 1W*

a. Session Average equal to or greater than 65%: Passed. Proceed to next session with a clear record.
b. Session Average between 55% and 65%: Passed. Proceed to next session with a clear record in any other second-year Engineering program.
c. Session Average between 50% and 55%: Placed on Probation. Proceed to next session on probation in an Engineering program with space.

d. Session Average less than 50%: Placed on repeat probation. Repeat session immediately when next offered on repeat probation in a program with space (not Engineering Science or Track One).

*No first-year Engineering Science student transferring to a Core 8 program, shall proceed to second year (2F) with more than two outstanding Core 8 course equivalents.

7. Students proceeding with a Clear Record — Sessions 2F, 2W, 3F, 3W, 4F or 4W

a. Session Average 60% or greater: Passed. Proceed to the next session with a clear record.
b. Session Average between 55% and 60%: Placed on Probation. Proceed to the next session on probation.
c. Session Average less than 55%: Placed on repeat probation. Repeat session immediately when next offered.

8. Students proceeding on Probation — Sessions 1W, 2F, 2W, 3F, 3W, 4F or 4W

a. Session Average 60% or greater: Passed. May proceed to the next session with a clear record. See Section VIII.1. Removing Probation for details and conditions.
b. Session average less than 60%: Placed on repeat probation. Repeat session immediately when next offered.

9. Students proceeding on Repeat Probation — Sessions 1W, 2F, 2W, 3F, 3W, 4F or 4W

a. Session Average 60% or greater: Passed. May proceed to the next session on probation. See Section VIII.1. Removing Probation for details and conditions.
b. Session average less than 60%: Failed. Refused further registration. Will not be considered for re-admission.

10. Students repeating any session

a. Session Average 60% or greater: Passed. Proceed to the next session on probation.
b. Session average less than 60%: Failed. Refused further registration. Will not be considered for re-admission.

Promotion Regulations: Chart

The following chart summarizes the text version of the promotion regulations. In the event of conflict between the text version and the chart version, the text version shall govern.

First-year Fall Session — 1F Newly Admitted First-year Students

Status at Start of Session	Session Average				
	0	45%	50%	55%	60%
Clear	**Repeat Probation** Failed. May apply for re-admission.	**Probation** Withdraw for eight months and repeat 1F Session.	**Probation** Proceed to 1W in T-Program or withdraw for eight months and repeat 1F.*	**Probation** Proceed to 1W on Probation, or T-Program or withdraw for eight months and repeat 1F.	**Clear** May proceed. Pass or Honours.

*A student who is part-time or has more than three course marks below 50% will be required to withdraw and is eligible to return to repeat 1F in a subsequent session on probation.

First-year Winter Session —1W

Status at Start of Session	Session Average		
	0	55%	60%
Clear	**Repeat Probation** Failed. Must withdraw for eight months. Upon return, must repeat session.	**Probation** Proceed on probation.	**Clear** May Proceed. Pass or honours.
Probation	**Repeat Probation** Failed. Must withdraw for eight months. Upon return, must repeat session.		**Probation** Proceed on Probation.* *See Section VIII.1 Removing Probation for details and conditions.
Repeat Probation	**Refused Further Registration** Failed. Not eligible to continue in the Faculty of Applied Science & Engineering.		**Repeat Probation** Proceed on repeat probation.* *See Section VIII.1 Removing probation for details and conditions.

*Students cannot proceed to second year if more than two first-year courses are outstanding.

T-Program Winter Session — 1W

Status at Start of Session	Session Average	
	0	60%
On Probation in the T-Program	**Repeat Probation** Failed — May apply for re-admission.	**Probation in the T-Program** Pass — May proceed to Summer Session on Probation in the T-Program.*

*Condition: No repeated course may have a final mark less than 50%

T-Program Summer Session

Status at Start of Session	Session Average	
	0	60%
On Probation in the T-Program	**Repeat Probation** Failed — Must withdraw for six months. Upon return must repeat regular 1W.	**Probation** Pass — May proceed to second year on probation.

*Students cannot proceed to second year if more than two first-year courses are outstanding.

First-year Engineering Science Fall Session — 1F Newly admitted First-year Students

Status at Start of Session	Session Average			
	0	45%	55%	60%
Clear	**Repeat Probation** Failed — May apply for re-admission in a program with space.	**Probation** Enrol in the T-Program or withdraw and repeat 1F — in a program with space.	**Clear** Remain in Engineering Science or transfer to another Engineering program.*	**Clear** May Proceed — Pass or Honours — or Transfer to any program.

*55-60% Options:
a) Remain in Engineering Science and proceed to 1W subject to Engineering Science promotion rules.
b) Voluntarily transfer to another Engineering program with space and be unconditionally accepted.
c) Voluntarily transfer to another Engineering program. Acceptance in a program of choice in 1W is conditional upon receiving a Winter Session average of 60% or greater.
d) Students who transfer into Track One are subject to Track One 1W transfer regulations.

First-year Engineering Science Winter Session — 1W

Status at Start of Session	Session Average			
	0	50%	55%	65%
Clear	**Repeat Probation** Failed — Repeat session 1W immediately in a program with space (not Engineering Science or Track One).	**Probation** Transfer to a program with space on probation.	**Clear** Transfer to another Engineering Program.	**Clear** May Proceed — Pass or Honours. May remain in Engineering Science or Transfer to any program.

*No first-year Engineering Science student transferring to a Core 8 program shall proceed to second year (2F) with more than two outstanding Core 8 course equivalents.

Fall and Winter Sessions 2nd, 3rd and 4th year

Status at Start of Session	Session Average		
	0	55%	60%
Clear	**Repeat Probation** Repeat session immediately when next offered.	**Probation** Proceed on probation.	**Clear** May Proceed. Pass or honours.
Probation	**Repeat Probation** Failed. Repeat session immediately when next offered.		**Probation** Proceed on Probation.* *See Section VIII.1 Removing Probation for details and conditions.
Repeat Probation	**Refused Further Registration** Failed. Not eligible to continue in the Faculty of Applied Science & Engineering.		**Repeat Probation** Proceed on repeat probation.* *See Section VIII.1 Removing probation for details and conditions.

Any Repeated Session

Status at Start of Session	Session Average	
	0	60%
Clear	**Refused Further Registration** Failed. Not eligible to continue in the Faculty of Applied Science & Engineering.	**Clear** May proceed.
Probation	**Refused Further Registration** Failed. Not eligible to continue in the Faculty of Applied Science & Engineering.	**Probation** Proceed on probation.
Repeat Probation	**Refused Further Registration** Failed. Not eligible to continue in the Faculty of Applied Science & Engineering.	**Repeat Probation** Proceed on repeat probation.

IX. Transfers

1. Transfer within the Faculty

A student may apply to transfer from one program to another within the Faculty of Applied Science & Engineering. Students must submit an online "Request to Transfer" application available via the Registrar's Office website. Program transfers at the completion of first year will not normally involve any additional courses to remedy deficiencies.

a. Transfers between regular Engineering programs:
   i) Applications to transfer between Engineering programs may be submitted at any time during the Winter Session of first year but not later than the deadline as listed in the Sessional Dates section. All such applications are considered together on their merits after that date.
   ii) The approval of transfers is subject to the availability of places reserved for internal transfers. Often, programs are unable to accept all students seeking transfer.
   iii) Students who have submitted an online request to transfer application before the deadline and who have completed first year with a clear record and with a Winter Session Average of 65% or greater will receive preference for these internal places. Students who obtain Honours in both sessions of first year will be allowed to transfer to the second-year program of their choice.
b. Transfers from Track One:
   i) A Track One student who has achieved a Session Average of 60% or greater in both terms of first year (1F and 1W) may transfer to their program of choice.
   ii) A Track One student who has achieved less than a 60% session average in either term (1F or 1W) but who is eligible to proceed to second year may apply to enrol in a program of their choice. However, their choices may be limited to a program with space.
c. Transfers between Electrical & Computer Engineering programs:
   Students will select their courses in third and fourth year to fulfill program requirements in computer engineering or in electrical engineering.
d. Transfers between Mechanical & Industrial Engineering programs:
   i) Applications to transfer between Mechanical and Industrial Engineering programs must be submitted no later than the deadline after the current academic year.
   ii) Students who wish to transfer between the Mechanical and Industrial Engineering programs will be allowed to do so if admitted directly to the first-year Fall Session of the Mechanical or Industrial Engineering program.
   iii) Students not in category (ii) above will be allowed to transfer if places are available.
e. Transfers to the Engineering Science program:
   Transfers from Engineering programs to Engineering Science are permitted after sessions 1F and/or 1W only in cases where the student has a superior academic record.
f. Transfers from the Engineering Science Program:
   i) Newly admitted first-year Engineering Science students will be accepted to transfer to any Engineering program on or before the last day to add or substitute Fall Session courses.
   ii) First-year Engineering Science students who obtain a Fall Session Average of 60% or greater will be accepted to transfer to any Engineering program on or before the last day to add Winter Session courses. Students with Fall Sessional Averages between 55% and 60% will be conditionally accepted into a program of choice. Students with Fall Sessional Averages between 45% and 55% will be accepted to transfer to any program in which space is available, in the T-Program.
   iii) First-year Engineering Science students who obtain Winter Sessional Averages of 55% or greater will be accepted to transfer to any Engineering program provided their "Request to Transfer" online application is submitted prior to the deadline. Students who obtain Winter Sessional Averages between 50% and 55% must have submitted an application to transfer not later than the deadline and these applications will be considered on their merits along with the applications for transfer from students in Engineering programs.

2. Transfers to Other Faculties:

A student interested in admission to another Faculty in the University of Toronto should consult with the Registrar or Admissions Officer of the Faculty concerned about the feasibility of obtaining transfer credit upon admission. Information regarding the application process can be found at future.utoronto.ca. More information may also be obtained from the Undergraduate Engineering website: www.undergrad.engineering.utoronto.ca or the Office of the Registrar.

X. Faculty Final Examinations

Final examinations are held at the end of the Fall and Winter sessions. Students who make personal commitments during the examination period do so at their own risk. No special consideration will be given and no special arrangements made in the event of conflicts with personal or extra-curricular activities. Information regarding dates and times of examinations will not be given by telephone.

Rules for the Conduct of Examinations

(Additional resources: undergrad.engineering.utoronto.ca/exams/exam-rules-regulations)

1. Timetable & Seating Lists

The timetable of examinations and a list showing the rooms in which the candidates in each course have been assigned to write will be posted in prominent locations prior to the examinations.

2. Aids Permissible and Not Permissible

a. A candidate will be permitted to bring to the examination and use only pen and pencil, drafting instruments, and if permitted, electronic calculators. All equipment brought to the examination must be placed on the candidate's desk and kept in view during the examination.

b. With the exceptions noted under f), g) and h) below, a candidate must not bring to the examination desk any books, notes in any form, loose paper, calculator cases, instrument cases, or other containers.

c. Permissible calculators must be non-printing, non-communicating, silent and self-powered. The type of calculator permitted will be one of the following, as specified by the professor at the commencement of the course and on the final examination paper.
   i) All programmable and non-programmable electronic calculators and pocket computers.
   ii) All non-programmable electronic calculators.
   iii) Calculators from a list of approved calculators as issued by the Faculty Registrar.
   iv) No electronic or mechanical computing devices will be permitted.

d. Bilingual dictionaries may be used under the following conditions by students who have language difficulties:
   i) The dictionary shall be submitted by the student for inspection by the presiding examiner.
   ii) The dictionary must not contain any material other than that which was originally printed in it.
   iii) The dictionary must be bilingual, i.e. contain the English equivalents of foreign words and vice versa, but no other material.

e. All coats and jackets should be placed on the back of each candidate's chair. All notes and books, pencil cases, turned-off cell phones, laptops, purses, and other unauthorized aids should be stored inside a candidate's knapsack or large bag, which should then be closed securely and safely placed under the candidate's chair. Candidates are required to place their watches or timepieces on the desk throughout the examination. Material placed on the desk may be inspected by invigilators. Candidates are NOT allowed to have a pencil case on their desk and any pencil cases found on desks will be searched. Candidates are not allowed to touch their knapsack or bag or the contents therein until the exam is over. Candidates are not allowed to reach into the pockets or any part of their coat or jacket until the exam is over.

f. For those examinations marked C in the timetable, a single aid-sheet may be prepared and taken by the candidate to the examination for their personal use only. This aid-sheet is a standardized form that must be downloaded from the Faculty website. Students must print the form onto an 8.5" x 11" piece of paper and print and sign their names in the places provided. Both sides of the sheet may be used. A "closed book" examination. A student may take a single, double-sided aid sheet to a Type C exam. The aid sheet is for personal use only and must be printed using the Faculty's template. Students may enter information on both sides of the aid sheet, without restriction. Such entries will be handwritten and not mechanically reproduced. Nothing may be fixed or appended to the sheet. The template may not be modified in any way and must be printed on 8.5″ x 11″ paper. Such entries will be handwritten and not mechanically reproduced.

g. For those examinations marked D in the timetable, a candidate may bring to the examination and use such books, notes, or other printed or written material as may be specified by the examiner.

h. For those examinations marked X in the timetable, a candidate may bring to the examination and use any books, notes, or other printed or written material.

3. Beginning the Examination

a. Only those candidates who are there to write the examination will be allowed in the room during the examination.

b. Candidates will be admitted to the examination room two minutes before the hour appointed for the examination. They shall proceed quietly to their desks, where they will find all necessary material for the examination, except authorized aids which may be brought into the room. (See 2 above.)
If the examiner considers it necessary, candidates may find on their desks with the examination paper special data such as log books, tabular data, curves or plans. Such special data are not to be written upon or marked in any way, and are to be returned with the answer books.
c. At the beginning of the examination period, answer books must be endorsed as follows: name and student number of the candidate, Faculty, course, instructor, date and room number. If more than one answer book is required, each must be endorsed when received and the books marked, “Book 1,” “Book 2,” and so on. The extra books are to be placed inside Book 1 when the candidate is through writing.
d. A candidate will not be permitted to leave the room during the first sixty minutes, nor to enter the room after that period. A candidate who arrives more than sixty minutes late will have to petition the Committee on Examinations for special consideration.

4. Ending the Examination

a. At ten minutes and five minutes before closing time the presiding examiner will announce the number of minutes remaining for writing.
b. Candidates who have finished writing and wish to leave the examination room before the five minute announcement must first personally hand in all their answer books, whether used or not, at the presiding examiner’s desk, together with special data if provided.
c. After the five minute announcement all candidates still in their seats must remain quietly seated, even if finished writing, until all the answer books and special data have been collected, and the presiding examiner announces that they may leave the room.
d. When closing time is announced, all candidates are to stop writing immediately, assemble their answer books, whether used or not, and special data which may have been provided, and hand them to the Assistants who will collect all materials from the seated candidates.
e. The examination paper belongs to the candidate unless otherwise stated.
f. When all materials have been collected, the presiding examiner will announce that candidates may leave the room. All rules for the conduct of candidates during examinations remain in full force until this announcement is made.

5. Conduct during the examination

a. A candidate giving assistance to or receiving assistance from, or communicating in any manner with any person other than the examiner, the presiding examiner or assistants, or copying, or having at the examination unauthorized aids of any kind, is liable to the sanctions listed in the Code of Behaviour on Academic Matters.
b. Eating, drinking and smoking are not permitted in examination rooms.
c. If it is necessary for a candidate to leave the room he or she may do so and return if accompanied by the presiding examiner or an assistant.
d. A candidate must not write on any paper, other than that in the answer book, and must keep all papers on the desk.

6. Reproduction of Final Examination Papers
A student may obtain a photocopy of any final examination paper that they have written under the jurisdiction of the Faculty of Applied Science & Engineering by submitting an online request within the period ending February 15 or October 15 (whichever comes first), following the session in which the course was taken. A fee of $15, payable by credit card or cash, for each examination paper to be reproduced must accompany the request. The Office of the Registrar may offer a period of Final Exam Viewing appointments after the term. Contact the Office of the Registrar for details.

7. Final Mark Re-check & Final Examination Re-grade
If a student believes an error has been made in the calculation of marks or in the marking of a Faculty final examination, there are two procedures that can be followed to request a review of marks.

Final Mark Re-check

If a student believes there has been an arithmetical error in the calculation of a course mark, they may request a “re-check.” The student must indicate precisely where they believe the error has occurred. Final mark re-check requests submitted without a specific error identified will not be processed.

The instructor will review the student's examination paper (if a final examination was held in the course) to ensure that all questions were properly marked in accordance with the marking procedure used for the entire class, that the addition of marks was correct, that the term marks were correctly compiled, and that the clerical operations involved in the computation and reporting of the final mark were correct. Mark adjustments based upon lenient reconsideration of the students work will not be made. The examination will not be reread.

A final mark re-check may result in a raised mark, lowered mark or no change. The Instructor has the authority to re-grade other questions if they deem it necessary. If a grade is changed, the final mark recheck fee will be refunded to the student.

A student can request a final mark re-check through the Engineering Portal. The cost for a re-check is $13.

Final Examination Re-grade

If a student believes that a final examination has been incorrectly marked, or that a portion of an examination has not been marked, they may request a "re-read." The student must indicate precisely where they believe the error occurred. Final Examination Re-grade requests submitted without a specific error identified will not be processed.

The student must demonstrate that his/her answers are substantially correct by citing specific instances of disagreement, supported by such documentary evidence as course handouts, textbooks, lecture notes, etc. The student must do more than simply assert that "I disagree with the marking," or that "I believe I deserve more marks." The Instructor will reread the examination with the arguments presented in mind.

A final examination re-grade may result in a raised mark, lowered mark or no change. The Instructor has the authority to regrade other questions if they deem it necessary. Any re-grading of the student's exam must be done in a manner consistent with the rest of the class. If a grade is changed, the final examination re-grade fee will be refunded to the student.

A student can request a final examination re-grade through the Engineering Portal. The cost for a regrade is $36.

Deadlines to request a final mark re-check or re-grade:

- Fall Session (December exams): February 15
- Winter Session (April-May exams): June 15
- Summer Session (June exams): October 15

XI. Grading Policies

1. The instructor in each course shall announce, at a regularly scheduled class meeting held as early as possible in the session but before the final date to add or substitute courses, the details of the composition of the final mark which applies to the course, the exam type, the timing of each major session evaluation and the type of electronic calculators which will be permitted on session tests and final examinations. This information shall also be submitted to the Committee on Examinations via the Registrar of the Faculty, specifying the weighting of each component of the final course mark.

2. After the final date to add or substitute courses, the composition of the final mark in a course cannot be changed without the consent of a simple majority of students attending the class, provided the vote is announced no later than in the previous class. Any changes must be reported to the Committee on Examinations. The only exception to this is in the case of the declaration of a disruption.

3. Instructors shall submit course results as percentages.

4. a) All written session work must normally be returned to students after evaluation with what the instructor considers to be appropriate commentary. At least one piece of session work worth at least 10% of a student's performance, whether lab report, assignment, essay, etc., shall be returned to the student prior to the last day for withdrawal from the course without academic penalty.
b) After evaluating and returning items of session work, the instructor or the teaching assistant(s) shall be available as appropriate to meet with each student who wishes to discuss the work and/or the commentary offered.

c) Final examination papers are not returned to students. The instructor shall deliver the marked examination papers in alphabetical order to the Office of the Registrar for storage. The papers will be stored until February 15 or October 15 (whichever comes first) following the session in which the course was offered, after which they will be destroyed.

5. The following rules and guidelines apply to the evaluation of student performance in all courses offered within the Faculty. Where appropriate, however, an instructor may apply to the Committee on Examinations for permission to deviate from the rules.

a. The composition of final marks may be based upon:
   i) a final examination
   ii) independent term work performed under supervision, i.e., session tests or any other work which, in the judgment of the instructor, is a reliable measure of the performance of the student evaluated, and;
   iii) session work not closely supervised;
b. The dates of session tests should be announced in advance. Unannounced session tests, if used, should not count for more than a minor fraction of the total mark for independent session work, and the value of this fraction should be specified early in the session when the details of the composition of the final course mark are announced in class.
c. A final examination, conducted under the jurisdiction of the Faculty Council and counting for at least 35% of the final mark shall be held in each lecture course.
d. Closely supervised term work shall account for at least 15% of the final mark in each course.
e. No one essay, test, examination, etc., should have a value of more than 80% of the final grade.
f. A component of the final course marks must be derived from session work, and the final examination must not count for all of the final mark, unless the Committee on Examinations approves other arrangements on an annual basis.
g. The portion of marks for lecture courses which is derived from not closely supervised work shall not exceed a total of 50% of the final mark in a course unless the Committee on Examinations approves other arrangements; recommended practice is that not-closely supervised work be limited to 25% or less of the final mark in a course. Work included in this category shall normally be accompanied by a sign-off statement attesting to the fact that the work being submitted either by an individual student or a group of students is their own work. The proportion of marks which can be derived without a sign-off statement, where students are free and encouraged to work together, is to be limited to 5% of the final course mark.
h. Each instructor must specify on session test and final examination papers the type of calculator permitted (see X (2) (c) above).
i. The only aids which a candidate may bring to the final examination and use, other than those which may be provided by the examiner or specified on the examination paper, are pen and pencil, a bilingual dictionary (for students having difficulty with the English language) if presented to the presiding examiner for inspection and approval prior to each examination at which its use is proposed, and drafting instruments without their carrying cases.
j. The following five types of final examination papers are approved for use in examinations conducted under Council's jurisdiction. The relative value of each part of the examination must be indicated on all final examination papers. Further, unless otherwise specified, the only aids permitted are those outlined in Regulation X-2.

- **Type A:** Papers for which no data are permitted other than the information printed on the examination paper.
- **Type B:** Papers for which separate special aids or data, as specified at the top of the examination paper, are provided by the examiner for distribution to the candidates by the Registrar of the Faculty.
- **Type C:** Papers for which the candidate may prepare, bring to the examination and use, a single aid sheet, downloaded from the Faculty's website, printed on an 8.5"x11" piece of paper. Students may enter on both sides of the aid sheet any information they desire, without restriction, except that nothing may be affixed or appended to it. Such entries will be handwritten and not mechanically reproduced.
- **Type D:** Papers for which the candidate may bring to the examination and use such aids (in the form of printed or written material) as the examiner may specify. The nature of the permitted aids must be clearly specified at the top of the examination paper, and must be announced to the class by the examiner in advance of the examination.
- **Type X:** Papers for which the candidate may bring to the examination and use, any books, notes or other printed or written material, without restriction.

k. Any variation from the normal Faculty examination procedures (e.g. take-home examinations, pre-distribution of examination questions, zero-weight, low-weight, or no examinations in lecture courses, oral examinations, confidential examinations, multiple examinations in multi-section courses, examinations which are not of the standard 2.50-hour duration) requires on an annual basis the prior approval of the Committee on Examinations. Requests for approval of special examination arrangements should be made as early as possible in the session, and announcement to the class may not be made until the approval of the Committee on Examinations is obtained.

l. Normally multiple-choice questions are not used in final examinations conducted in the Faculty. In any event the Committee on Examinations must give its prior approval if the value of multiple choice questions exceed 25% of the total marks for any examination.

m. Group Evaluation:
(i) In situations where a student's performance is evaluated by a student peer group, the results of such evaluation shall not constitute more than 25% of the final course mark.
(ii) In courses in which group work or group assignments are performed, the proportion of a student's final mark derived from undiscriminated evaluation of such group work or submission shall not exceed 25%, unless the Committee on Examinations has granted approval for a higher weighting of the undiscriminated group component. When such approval has been granted it shall remain in force so long as there is no change in the circumstances on which the original application was based or until the instructor requests approval for the arrangements.

n. Under no circumstances will students be permitted to evaluate their own work for credit in a course.

6. Instructors are responsible for the grading of the final exam and are expected to exercise their best judgment in assessing answers to examination questions and in determining final course marks. Any assessment of the performance of students is not to be based on any system of quotas or predetermined arbitrary limits.

7. a) Instructors shall submit their final course marks to the Committee on Examinations via the Registrar of the Faculty in conformity with a prescribed deadline.
b) The Chair of each department or division of the Faculty may elect to appoint a departmental marks review committee, to review results in courses offered by the department. If such a marks review procedure is carried out, instructors, after having submitting their marks to the Registrar of the Faculty, shall also report their results to the departmental committee. The departmental marks review committees are not authorized to make recommendations directly to instructors but may make recommendations to the Faculty's Committee on Examinations.
c) A student's final course mark is unofficial until approved by the Committee on Examinations.

The full text of the University Assessment and Grading Practices Policy is available online.

XII. Petitions & Appeals

I. Petitions

Petition forms are available on the Undergraduate Engineering website: uoft.me/petitions.

There are three types of petitions:

i. Petition for Consideration in Course Work: A student who is unavoidably absent during the term and consequently misses any graded work should submit a term-work petition through the Engineering Portal within one week of the graded work. The petition must be accompanied by appropriate documentation.

ii. Petition for Consideration in Final Examinations: A student who believes that their academic performance has been adversely affected by illness, mishap or other circumstance during the examination period should submit a petition for consideration in final examinations. Such petitions must be submitted online through the Engineering Portal within one week of the date of the student's last examination.

iii. Petition for Special Consideration: A student may petition for exemption from a specific academic regulation of the Faculty; however, they must provide sufficient reason why the regulation should be waived or altered. It is highly recommended that students first consult with their undergraduate advisor before they submit a petition for special consideration.

Students may petition with respect to the applicability to them of any academic regulation of the Faculty. These petitions must show the grounds on which they believe that the regulation should be waived or altered. Students should consult their undergraduate advisor before submitting such petitions through the Engineering Portal website. Petitions requesting the alteration of marks or promotional regulations will not be considered.

II. Appeals

1. A student wishing to appeal a decision with respect to any petition should submit an appeal in written form to the Faculty Academic Appeal Board via the Registrar's Office. Appeals to the Faculty Academic Appeals Board must be made within thirty days of the date of notification of a petition decision from a standing Committee of Council. The Faculty Academic Appeal Board Chair will appoint a hearing panel which will consist of at least three members of the Board of whom at least one shall be a student member. Normally, the Chair of the Academic Appeals Board acts as the Chair of the hearing panel. Hearings will be called by the Chair as required, but not later than ninety business days after the submission of the appeal. Both parties to the appeal are entitled to present throughout the hearing, to make opening statements, call evidence and make closing submissions. After hearing the appeal, the hearing panel may dismiss the appeal, allow the appeal and render the decision that it believes should have been made, or remit the matter back to the decision-maker for consideration. The decision of the Faculty Academic Appeals Board is considered the final decision of the Faculty.
2. A student wishing to appeal against a final decision of the Faculty may appeal to the Governing Council of the University. In that event, the student should consult the Director, Appeals, Discipline and Faculty Grievances, Office of the Governing Council, about the preparation and submission of the appeal. Appeals to the Governing Council must be made within ninety days of the date of notification of the final decision of the Faculty. Resource Page: governingcouncil.utoronto.ca/adfg.

III. Office of the University Ombudsperson

As part of the University's commitment to ensuring that the rights of its individual members are protected, the University Ombudsperson investigates complaints from any member of the University not handled through regular University channels. The Ombudsperson offers advice and assistance and can recommend changes in academic or administrative procedures where this seems justified. In handling a complaint, the Ombudsperson has access to all relevant files and information and to all appropriate University Officials. The Ombudsperson handles all matters in strict confidence, unless the individual involved approves otherwise. The Ombudsperson is independent of all administrative structures of the University and is accountable only to Governing Council.

Office of the Ombudsperson
McMurrich Building
First Floor, Room 102
12 Queen's Park Cres. West
Toronto, Ontario M5S 1S8
Phone: 416-946-3485
Fax: 416-978-3439
ombuds.person@utoronto.ca

XIII. Undergraduate Voluntary Leave of Absence Policy for International Students

An approved leave of absence will be permitted for international undergraduate FASE students who have completed at least one academic term (e.g., Fall 2020 or Winter 2021) and whose current academic standing is in good standing or on academic probation.

Students may request a leave for the Fall Term, Winter Term, or the complete Fall-Winter Session, for up to a maximum of two consecutive Fall-Winter sessions. Note: formal leave is generally not required for the Summer Session.

Students should contact the Centre for International Experience (CIE) to request a leave of absence and to obtain an understanding of the impact a leave of absence will have on their legal status in Canada for the period of the leave.

Newly admitted students are not eligible for a leave of absence and should instead, if relevant, request a deferral of admission.

Students may request a leave for the following reasons:

- Serious health, personal or family issues.
- Issues related to childbirth or childcare.
- Military service.

Students may extend an approved leave of absence for up to a maximum of two consecutive Fall-Winter sessions. An extension beyond two consecutive Fall-Winter sessions will not be approved; students may choose to continue a leave, but it will not be considered an approved leave of absence.

While on approved leave, students do not pay any tuition, incidental, or ancillary fees; are not permitted to enrol in courses or register in the Faculty; are not considered for scholarships or awards; and cannot normally access University services, participate in student internships, or undertake undergraduate research.

A student who has been granted an approved leave of absence under this policy is not exempt from academic deadlines, financial responsibilities, current or future policies, curriculum changes, fees schedules, increases in annual fees, or the requirement to complete a full undergraduate program within nine calendar years of first registration (exclusive of mandatory absences from their program).

To initiate a return to studies, students should contact the Registrar's Office at least three months in advance of the term or session in which they plan to resume their studies.

Track One

Vice-Dean, First Year Engineering
Associate Professor, Teaching Stream, Micah Stickel, BASc, MASc, PhD

Director, First Year Curriculum
Assistant Professor, Teaching Stream, Chirag Variawa, BASc, PhD

Assistant Director, First Year Academic Services
Leslie Grife, Hons BA, MEd

Assistant Director, First Year Student Success & Transition
Emzhei Chen, Hons BSc BEd, MEd

First Year Advisor
Jennifer Fabro, Hons BA, MEd

First Year Advisor, Intercultural Learning & Experience
TBD

First Year Coordinator
JesusMiracle Chiadika, Hons BSc

Room 170, Galbraith Building
416-978-4625
firstyear@engineering.utoronto.ca
www.firstyear.engineering.utoronto.ca

The first-year engineering curriculum is designed for students continuing in one of the following programs in second year: Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical or Mineral Engineering. Students are admitted to one of these programs or TrackOne on entering first year. This guarantees a place in a program in subsequent years, subject to maintenance of satisfactory standing. Students who complete first year with a clear record in one of the above programs may request to transfer to another program (see Academic Regulations for details). Students in TrackOne or who wish to transfer at the end of first year must submit their requests to the First Year Office no later than the deadline as listed in the Sessional Dates section of the Calendar.

The academic year consists of two terms, Fall (September through December) and Winter (January through April). Students typically take five courses per term. Timetables, detailing which courses students will take in each term, will be provided to students in August. The first-year curriculum is shown in each program section, with the TrackOne General Engineering first-year curriculum shown below:

FIRST YEAR UNDECLARED ENGINEERING (AEENGBASC)

TrackOne is the general First Year curriculum of the Faculty. Students admitted to this program transfer to one of eight Engineering Programs, including Chemical, Civil, Computer, Electrical, Industrial, Mechanical, Mineral, or Materials Science Engineering, after the successful completion of the First Year curriculum, as listed below.

FIRST YEAR - TrackOne

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50

Winter Session - Year 1		Lect.	Lab.	Tut.	Wgt.
APS105H1: Computer Fundamentals	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
APS191H1: Introduction to Engineering	S	1	-	-	0.15
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MIE100H1: Dynamics	S	3	-	2	0.50

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.

TRANSITION PROGRAM IN FIRST YEAR

The Transition Program (T-Program) enables students in First Year who have been placed on probation after the Fall Term to immediately repeat a maximum of three courses and defer up to three Winter Term courses to the Summer Term (May and June). Full-time students must carry five courses during the Winter Term.

The courses offered in the Summer Term are:
APS110H1: Engineering Chemistry and Materials Science or APS164H1 Introductory Chemistry from a Materials Perspective
APS111H1: Engineering Strategies & Practice I
CIV100H1: Mechanics
MAT186H1: Calculus I
MAT188H1: Linear Algebra

The courses offered in the Summer Term are:
APS106H1: Fundamentals of Computer Programming and APS105H1: Computer Fundamentals
ECE110H1: Electrical Fundamentals
APS112H1: Engineering Strategies & Practice II
MAT187H1: Calculus II
MIE100H1: Dynamics

Courses to be dropped from the Winter Term and courses to be taken in the Summer Term will depend on the student's program of study and will be decided by the First Year Office.
For details regarding the T-Program Promotional Regulations, please see the Academic Regulations portion of the calendar.

Track One Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS105H1 - Computer Fundamentals

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and problem solving using computers. Topics include: the representation of information, programming techniques, programming style, basic loop structures, functions, arrays, strings, pointer-based data structures and searching and sorting algorithms. The laboratories reinforce the lecture topics and develops essential programming skills.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

APS191H1 - Introduction to Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will preview the core fields in Engineering. Each seminar will highlight one of the major areas of Engineering. The format will vary and may include application examples, challenges, case studies, career opportunities, etc. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Faculty to enable them to make educated choices for second year. This course will be offered on a credit/no credit basis.

Total AUs: 12.80

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

Electrical and Computer Engineering

ECE110H1 - Electrical Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An overview of the physics of electricity and magnetism: Coulomb's law, Gauss' law, Ampere's law, Faraday's law. Physics of capacitors, resistors and inductors. An introduction to circuit analysis: resistive circuits, nodal and mesh analysis, 1st order RC and RL transient response and sinusoidal steady-state analysis.

Total AUs: 57.60

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

Mechanical and Industrial Engineering

MIE100H1 - Dynamics

Credit Value: 0.50
Hours: 38.4L/25.6T

This course on Newtonian mechanics considers the interactions which influence 2-D, curvilinear motion. These interactions are described in terms of the concepts of force, work, momentum and energy. Initially the focus is on the kinematics and kinetics of particles. Then, the kinematics and kinetics of systems of particles and solid bodies are examined. Finally, simple harmonic motion is discussed. The occurrence of dynamic motion in natural systems, such as planetary motion, is emphasized. Applications to engineered systems are also introduced.

Exclusion: APS161H1
Total AUs: 51.20

Aerospace Science and Engineering

Undergraduate Program in Aerospace Science & Engineering

The University of Toronto offers a comprehensive program of study in Aerospace Science and Engineering at both the undergraduate and graduate levels. The undergraduate program is offered through the Division of Engineering Science, while the graduate program is offered at the University of Toronto Institute for Aerospace Studies (UTIAS). All Engineering Science students follow a common curriculum during the first two years, with emphasis on mathematics, science, and engineering fundamentals. The final two years in the Aerospace Option focus on aeronautics and space engineering, with courses delivered primarily by faculty from UTIAS.

The undergraduate aerospace curriculum reflects the diverse and dynamic activities associated with the aerospace industry in Canada and abroad. Students are exposed to courses associated with aeronautical and space sciences and engineering, and also gain practical experience in laboratory and design courses. Capstone design courses in fourth year include Space Systems Design, where student teams design hardware associated with a space mission, such as a Hubble telescope repair mission, or a Europa landing probe. Engineers from MDA Space Missions play a major role in the delivery of this course. In the Aircraft Design course, student teams design and build model aircraft with various configurations, which are then flown in a fly-off competition at the end of the term.

The aerospace field has progressed extensively since the record-setting flights by F. W. Baldwin and J. A. D. McCurdy — both University of Toronto engineering graduates — during the early 1900s. It has evolved into a multi-disciplinary activity that finds itself at the cutting edge of high technology research and development. Consequently, the field is rich with technological and engineering challenges in diverse areas such as hypersonic aerodynamics, multi-disciplinary optimization and space exploration. Students at the fourth year level will have opportunities to select courses and work on thesis projects related to the many specialized areas of active research at UTIAS.

While the undergraduate program prepares students for immediate entry into a professional engineering career, many students continue to the graduate level in order to enhance their qualifications and employment opportunities.

For further information regarding undergraduate aerospace studies please refer to the Engineering Science program in this Calendar, the Engineering Science website www.engsci.utoronto.ca or the Engineering Science Office at (416-978-2903).

Graduate Program in Aerospace Science & Engineering

UTIAS offers graduate programs leading to research intensive MASc and PhD degrees and a professionally-oriented MEng degree. Graduate research areas include aircraft flight systems and control, flight simulation, computational fluid dynamics, combustion and propulsion, aerodynamic shape optimization, experimental fluid dynamics, flow control, structural mechanics, advanced composite materials, multidisciplinary optimization of aircraft, multifunctional systems, spacecraft dynamics and control, autonomous space robotics, microsatellites, space mechatronics, plasma-materials interactions and materials for fusion reactors. Details regarding entrance regulations and courses of study are available in the School of Graduate Studies's calendar and at www.utias.utoronto.ca.

Students who graduated in another branch of engineering, mathematics, physics of chemistry may be admitted to the graduate program. In those cases, the courses leading to the MASc or MEng degree will be arranged on an individual basis to make up for deficiencies in undergraduate training.

Biomaterials and Biomedical Engineering

Institute of Biomaterials and Biomedical Engineering (IBBME)

Director: Professor Warren Chan
Website: ibbme.utoronto.ca
Contact: undergrad.ibbme@utoronto.ca

Biomedical engineering aims to use engineering or physical science principles to solve biological and medical problems. The Institute is the largest biomedical engineering hub for education, research and community at the University of Toronto and in Canada. It is the only division that is managed by three different faculties — Applied Science & Engineering, Medicine and Dentistry. The diversity in education and research ecosystems equips our researchers with the ability to address pressing medical question — ranging from fundamental mechanisms to clinical cases — and to build new companies. The Institute's core laboratories are principally located in the Rosebrugh Building, Lassonde Mining Building, Donnelly Centre for Cellular & Biomolecular Research and MaRS Building on the St. George campus. Additionally, the Institute has labs at Holland Bloorview Kids Rehabilitation Hospital and Toronto Rehabilitation Institute (KiTE).

There are over 100 faculty (core and cross-appointed) who conduct research in molecular, cell and tissue and clinical engineering. Faculty members lead state-of-art research in a series of emerging areas such as nanotechnology, systems biology, regenerative medicine, bioelectronics and rehabilitation engineering. The Institute offers three graduate programs at the doctoral- and masters-level (PhD, MASc and MHSc) in biomedical and clinical engineering. Additionally, a one-year course-based professional masters of engineering (MEng) program also joined our offerings in 2016. Since an undergraduate degree in engineering is not a prerequisite for admission into the graduate programs, we have welcomed students with backgrounds in engineering, biology, medicine, chemistry, physics and psychology.

While the Institute does not have a full undergraduate program, several undergraduate student bodies are associated to the Institute. Students enrolled in the Division of Engineering Science can select the Biomedical Systems Engineering major. These students take courses in tissue engineering, imaging, control, and other relevant topics in Biomedical Engineering. The second student body is the biomedical engineering minor's program, where students from non-biomedical engineering departments can learn the basic principles of Biomedical Engineering.

Students who graduate from IBBME work in different industrial sectors (biotechnology, pharmaceutical, computer, marketing), government agencies and academia. A large number of our students are involved in building start-up companies. Overall, there are a broad range of job opportunities for IBBME students.

Chemical Engineering and Applied Chemistry

Undergraduate Program and Chemical Engineering (AECHEBASC)

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Chemical engineering is the primary engineering discipline that is based on the fundamental sciences of chemistry, physics, biochemistry and mathematics, in which processes are conceived, designed and operated to effect compositional changes in materials of all kinds. Chemical engineers play an important role in the development of a healthier environment and safer and healthier industrial workplaces. They develop new industrial processes that are more energy-efficient and environmentally friendly and create products that improve quality of life. Chemical engineers are responsible for improvements in technologies and in evaluating and controlling hazards. In addition to the basic sciences, chemical engineers use a well-defined body of knowledge in the application of the conservation laws that determine mass flow and energy relations; thermodynamics and kinetics which determine whether or not reactions are feasible and the rate at which they occur; and the chemical engineering rate laws that determine limits to the transfer of heat, mass and momentum.

Students who graduate from the chemical engineering program are skilled problem solvers. A strong background in applied chemistry furnishes the chemical engineer with the knowledge to participate in the broadest range of engineering activities and pursue other professional careers in management, medicine, law, teaching and government. Instruction in important aspects of economic analysis is also included. In the Fall Term of fourth year, students participate in small teams in the design of a chemical plant. Fourth-year students may undertake individual full-year research projects. These projects, the culmination of which is a thesis, serve, in many cases, as an introduction to research, and provides opportunities to apply the principles developed during the first three years of the program to problems of engineering interest. A thesis project may, for example, concern an experimental laboratory investigation, the design of a process, or a computer study of a complex chemical system.

The technical elective subjects available in years three and four cover a wide range of fundamental and application areas of chemical engineering and applied chemistry. By choosing electives from a restricted list, it is possible for students to complete the requirements for an engineering minor. A minor signifies that a student has gained an enhanced understanding of a specific field of study. For more information on the various minors, please see the sections of the Calendar relating to these programs.

Graduate Programs in Chemical Engineering

The Department of Chemical Engineering & Applied Chemistry provides exciting opportunities for students who would like to pursue advanced studies beyond the undergraduate level toward the MEng, MASc or PhD degrees. The Department offers more than 20 graduate-level courses toward the study requirements of the degree programs. Financial support is provided to graduate students through research grants and/or fellowships, together with some undergraduate teaching in the laboratories. Undergraduate students interested in postgraduate programs are invited to discuss research activities and graduate studies in the Department with any staff member at any stage of their undergraduate programs. Further information may also be obtained from the Coordinator of Graduate Studies, Department of Chemical Engineering & Applied Chemistry, Room 212, Wallberg Building, and from the Calendar of the School of Graduate Studies.

UNDERGRADUATE PROGRAM IN CHEMICAL ENGINEERING (AECHEBASC)

First Year Chemical Engineering

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	-	2	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session - Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
CHE112H1: Physical Chemistry	S	3	1	1	0.50
CHE113H1: Concepts in Chemical Engineering	S	3	2	2	0.50
CHE191H1: Introduction to Chemical Engineering and Applied Chemistry	S	1	-	-	0.15
MAT187H1: Calculus II	S	3	-	1	0.50

Approved Course Substitution

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

Second Year Chemical Engineering

Fall Session - Year 2		Lect.	Lab.	Tut.	Wgt.
CHE204H1: Chemical Engineering and Applied Chemistry-Laboratory I	F	2	6	-	0.25
CHE208H1: Process Engineering	F	3	-	2	0.50
CHE211H1: Fluid Mechanics	F	3	-	2	0.50
CHE220H1: Applied Chemistry I - Inorganic Chemistry	F	3	-	1	0.50
CHE221H1: Calculus III	F	3	-	1	0.50
CHE249H1: Engineering Economic Analysis	F	3	-	1	0.50
CHE299H1: Communication	F	-	-	2	0.25
Winter Session - Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE205H1: Chemical Engineering and Applied Chemistry-Laboratory II	S	2	6	-	0.25
CHE210H1: Heat and Mass Transfer	S	3	-	2	0.50
CHE213H1: Applied Chemistry II - Organic Chemistry	S	3	-	1	0.50
CHE222H1: Process Dynamics: Modeling, Analysis and Simulation	S	3	2	1	0.50
CHE223H1: Statistics	S	2	-	1	0.50
CHE230H1: Environmental Chemistry	S	3	-	2	0.50

Practical Experience Requirement

- As described in the beginning of this chapter, students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods).

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enroll and participate in the Professional Experience Year (PEY) program. The PEY program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating industry. Details are described in the beginning of this chapter. For more information, consult the Professional Experience Year Office, 45 Willcocks Street 2nd Floor early in session 2F or 3F.

Third Year Chemical Engineering

Fall Session - Year 3		Lect.	Lab.	Tut.	Wgt.
CHE304H1: Chemical Engineering and Applied Chemistry-Laboratory III	F	-	6	-	0.50
CHE323H1: Engineering Thermodynamics	F	3	-	2	0.50
CHE324H1: Process Design	F	3	-	1	0.50
CHE332H1: Reaction Kinetics	F	3	-	2	0.50
CHE399H1: Professional Engineering Consultancy	F	1	-	2	0.25
Technical Elective	F				0.50
Complementary Studies/Humanities and Social Sciences Elective	F				0.50
Winter Session - Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE305H1: Chemical Engineering and Applied Chemistry-Laboratory IV	S	-	6	-	0.50
CHE311H1: Separation Processes	S	3	-	2	0.50
CHE322H1: Process Control	S	3	-	2	0.50
CHE333H1: Chemical Reaction Engineering	S	3	-	2	0.50
CHE334H1: Team Strategies for Engineering Design	S	1	-	2	0.50
and one of:					
Technical Elective	S				0.50
Complementary Studies/Humanities and Social Sciences Elective	S				0.50

Fourth Year Chemical Engineering

Fall Session - Year 4		Lect.	Lab.	Tut.	Wgt.
CHE430Y1: Chemical Plant Design	F	2	-	6	1.00
Complementary Studies/Humanities and Social Sciences Elective	F				0.50
Technical Elective	F/S/Y				0.50
and one of:					
CHE499Y1: Thesis	Y	-	7	-	1.00
Technical Elective	F				0.50
Winter Session - Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE403H1: Professional Practice	S	2	-	-	0.00
Technical Elective	S				0.50
Technical Elective	S				0.50
Free Elective	S				0.50
Complementary Studies/Humanities and Social Sciences Elective	S				0.50
and one of:					
CHE499Y1: Thesis	Y	-	7	-	1.00
Technical Elective	S				0.50

1. In years 3 and 4, students must complete a total of 6 Technical Electives (or 4 Technical Electives and CHE499Y1: Thesis). See section below for more information.
2. In years 3 and 4, students must complete a total of 4 Complementary Studies/Humanities and Social Sciences (CS/HSS) Electives, at least 2 of which must be Humanities and Social Sciences. Refer to the Registrar's Office website for a list of pre-approved CS/HSS Electives.
3. In years 3 and 4, students must complete 1 Free Elective. A Free Elective has few restrictions: any degree credit course listed in the current calendars of the Faculty of Applied Science and Engineering, the Faculty of Arts and Science, and the School of Graduate Studies is acceptable as a Free Elective provided it does not duplicate material covered in courses taken or to be taken.

THESIS

The thesis (CHE499Y1) is a full-year (Fall and Winter Sessions) thesis that requires approval from the department and research project supervisor.

TECHNICAL ELECTIVES

Students may take any of the Technical Elective courses listed in the table below, or from any of the technical Engineering Minors (excluding the Minor in Engineering Business). Students wishing to pursue an Engineering Minor should take their core courses as technical electives in terms 3F and 3S. For more information on the various Minors, please see the sections of the Calendar relating to these programs.

Technical Electives

Courses Offered in Fall		Lect.	Lab.	Tut.	Wgt.
BME440H1: Biomedical Engineering Technology and Investigation	F	2	4	-	0.50
BME455H1: Cellular and Molecular Bioengineering II	F	3	1.50	1	0.50
CHE353H1: Engineering Biology	F	2	-	2	0.50
CHE441H1: Engineering Materials	F	3	-	1	0.50
CHE450H1: Bioprocess Technology and Design	F	3	0.66	1	0.50
CHE451H1: Petroleum Processing	F	3	-	-	0.50
CHE467H1: Environmental Engineering	F	3	-	1	0.50
CHE470H1: Special Topics in Chemical Engineering	F	3	-	1	0.50
CHE562H1: Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering	F	3	-	-	0.50
CHE565H1: Aqueous Process Engineering	F	3	-	1	0.50
CHE566H1: Elements of Nuclear Engineering	F	3	-	2	0.50
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
CIV375H1: Building Science	F	3	0.33	2	0.50
CIV549H1: Groundwater Flow and Contamination	F	3	-	1	0.50
CIV550H1: Water Resources Engineering	F	3	-	2	0.50
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
MIE516H1: Combustion and Fuels	F	3	-	1	0.50
MSE440H1: Biomaterial Processing and Properties	F	3	-	1	0.50
Courses Offered in Winter		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME331H1: Physiological Control Systems	S	3	1	1	0.50
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
CHE412H1: Advanced Reactor Design	S	3	-	1	0.50
CHE460H1: Environmental Pathways and Impact Assessment	S	3	-	2	0.50
CHE462H1: Food Engineering	S	3	-	1	0.50

Courses Offered in Winter		Lect.	Lab.	Tut.	Wgt.
CHE469H1: Fuel Cells and Electrochemical Conversion Devices	S	3	-	1	0.50
CHE470H1: Special Topics in Chemical Engineering	S	3	-	1	0.50
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.50
CHE561H1: Risk Based Safety Management	S	3	-	1	0.50
CHE564H1: Pulp and Paper Processes	S	3	-	1	0.50
CHE568H1: Nuclear Engineering	S	3	-	1	0.50
CHM415H1: Topics in Atmospheric Chemistry	S	2	-	-	0.50
CIV250H1: Hydraulics and Hydrology	S	3	1.50	1	0.50
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
FOR310H1	S	2	-	1	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50
MIE304H1: Introduction to Quality Control	S	3	1	2	0.50
MIE517H1: Fuel Cell Systems	S	3	-	1	0.50

Chemical Engineering and Applied Chemistry Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS106H1 - Fundamentals of Computer Programming

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the Python programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

Biomaterials and Biomedical Engineering

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

BME440H1 - Biomedical Engineering Technology and Investigation

Credit Value: 0.50
Hours: 25.6L/51.2P

Fundamental biomedical research technologies with specific focus on cellular and molecular methodologies. Examples include DNA and protein analysis and isolation, microscopy, cell culture and cellular assays. Combines both theoretical concepts and hand-on practical experience via lectures and wet labs, respectively. Specific applications as applied to biotechnology and medicine will also be outlined and discussed.

Prerequisite: CHE353H1
Total AUs: 51.20

BME455H1 - Cellular and Molecular Bioengineering II

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Engineering and biophysical tools are used to integrate and enhance our understanding of animal cell behaviour from the molecular to the tissue level. Quantitative methods are used to mathematically model the biology of cell growth, division and differentiation to tissue formation. Specific topics include receptor-ligand interactions, cell adhesion and migration, signal transduction, cell growth and differentiation. Examples from the literature are used to highlight applications in cellular and tissue engineering.

Prerequisite: CHE353H1 and CHE354H1
Total AUs: 54.40

Chemical Engineering and Applied Chemistry

CHE112H1 - Physical Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

A course in physical chemistry. Topics discussed include systems and their states, stoichiometry, the properties of gases, the laws of chemical thermodynamics (calculations involving internal energy, enthalpy, free energy, and entropy), phase equilibrium, chemical equilibrium, ionic equilibrium, acids and bases, solutions, colligative properties, electrochemistry, and corrosion.

Total AUs: 51.20

CHE113H1 - Concepts in Chemical Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

This course provides first year students with an overview of the chemical industry, the chemical engineering profession, and introduces key concepts for the upcoming years of study. The chemical industry is the interface between natural resources (minerals, oil, gas, agricultural products, etc.) and the consumers of the higher value products derived therefrom. This diverse industry has both high volume-low unit value and low volume-high unit value products, and the manufacture of each type of product has its own challenges. The chemical engineering profession applies the scientific fundamentals through two key concepts: Unit Operations as well as Flux. The fundamental elements of stoichiometry and reaction kinetics are further extended to cover the concepts of yield, conversion and their specific applications to continuous and batch reactor systems. Analysis of electrical circuits is introduced, leading to nodal analysis of circuits. The application of resistance in series and capacitance is extended into chemical engineering problems involved, heat transfer, mass transfer and momentum transfer, as well as reaction engineering. The laboratory will reinforce these key chemical engineering principles.

Total AUs: 64.00

CHE191H1 - Introduction to Chemical Engineering and Applied Chemistry

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will introduce students to the community, upper-year experience, and core fields of Chemical Engineering and Applied Chemistry. Seminar presenters will represent the major areas in Chemical Engineering and Applied Chemistry and will also be drawn from an array of groups, including students, staff, faculty, and alumni. The format will vary and may include application examples, case studies, career opportunities, and research talks. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Department to enable them to make educated choices as they progress through the program. This course will be offered on a credit/no credit basis.

Total AUs: 12.80

CHE204H1 - Chemical Engineering and Applied Chemistry- Laboratory I

Credit Value: 0.50
Hours: 12.8L/37.6P

This laboratory course will survey aspects of inorganic, organic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. Theory, where applicable, will be interwoven within the laboratories or given as self-taught modules. Topics to be covered are inorganic and organic synthesis and analysis and will include elements of process and industrial chemistry and practice (including Green Chemistry).

Total AUs: 32.00

CHE205H1 - Chemical Engineering and Applied Chemistry- Laboratory II

Credit Value: 0.50
Hours: 12.8L/37.6P

This laboratory course will survey aspects of inorganic, organic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. Theory, where applicable, will be interwoven within the laboratories or given as self-taught modules. Topics to be covered are inorganic and organic synthesis and analysis and will include elements of process and industrial chemistry and practice (including Green Chemistry).

Total AUs: 32.00

CHE208H1 - Process Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to mass and energy (heat) balances in open systems. A quantitative treatment of selected processes of fundamental industrial and environmental significance involving phase equilibria, reaction and transport phenomena under both steady state and unsteady state conditions. Examples will be drawn from the chemical and materials processing industries, the energy and resource industries and environmental remediation and waste management.

Prerequisite: MAT188H1
Total AUs: 51.20

CHE210H1 - Heat and Mass Transfer

Credit Value: 0.50
Hours: 38.4L/25.6T

Fundamentals of heat and transfer, including conduction, convective heat transfer, natural convection, design of heat exchangers, Fick's law of diffusion, analysis of mass transfer problems using Fick's law and mass balances, and effect of chemical reactions on mass transfer. Particular attention is focused on convective heat and mass transfer coefficients as obtained in laminar flow, or from turbulent heat transfer correlations and analogies.

Prerequisite: CHE221H1
Total AUs: 51.20

CHE211H1 - Fluid Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

Fundamentals of fluid mechanics including hydrostatics, manometry, Bernoulli's equation, integral mass, linear momentum and energy balances, engineering energy equation, Moody chart, pipe flow calculations, flow measurement instruments and pumps, dimensional analysis, differential analysis of laminar viscous flow, and brief introductions to particle systems, turbulent 1low, non-Newtonian fluids and flow in porous systems.

Total AUs: 51.20

CHE213H1 - Applied Chemistry II - Organic Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include the structure, bonding and characteristic reactions of organic compounds including additions, eliminations, oxidations, reductions, radical reactions, condensation/hydrolysis and rearrangements. The chemical relationships and reactivities of simple functional groups are discussed with an emphasis placed on reaction mechanisms involving the formation of organic intermediates, chemicals and polymers. An introduction will be given on biologically relevant compounds such as carbohydrates, proteins, lipids and nucleic acids. Examples will be discussed which outline the usefulness of these reactions and chemicals within the broader chemical industry.

Corequisite: CHE204H1
Total AUs: 44.80

CHE220H1 - Applied Chemistry I - Inorganic Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T

The Chemistry and physical properties of inorganic compounds are discussed in terms of atomic structure and molecular orbital treatment of bonding. Topics include acid-base and donor-acceptor chemistry, crystalline solid state, chemistry of main group elements and an introduction to coordination chemistry. Emphasis is placed on second row and transition metal elements.

Total AUs: 44.80

CHE221H1 - Calculus III

Credit Value: 0.50
Hours: 37.8L/12.8T

Introduces concepts used in developing mathematical models of common chemical engineering processes, concepts of process dynamics and methods for analyzing the process response to different perturbations, and the numerical methods required for solving and analyzing the mathematical models. The course will also introduce applications of modeling to biochemical engineering.

Prerequisite: MAT186H1, MAT187H1
Total AUs: 44.80

CHE222H1 - Process Dynamics: Modeling, Analysis and Simulation

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Introduces concepts used in developing mathematical models of common chemical engineering processes, concepts of process dynamics and methods for analyzing the process response to different perturbations, and the numerical methods required for solving and analyzing the mathematical models. The course will also introduce applications of modeling to biochemical engineering.

Prerequisite: MAT186H1, MAT187H1
Total AUs: 57.60

CHE223H1 - Statistics

Credit Value: 0.50
Hours: 38.4L/12.8T

Analysis of data using statistics and design of experiments. Topics include probability, properties of the normal distribution, confidence intervals, hypothesis testing, fitting equations to data, analysis of variance and design of experiments. The tutorial involves, in part, the application of commercial software to interpret experimental data, as obtained in Chemical Engineering laboratories.

Prerequisite: MAT186H1, MAT187H1
Total AUs: 44.80

CHE230H1 - Environmental Chemistry

Credit Value: 0.50
Hours: 38.4L/25.6T

The chemical phenomena occurring in environmental systems are examined based on fundamental principles of organic, inorganic and physical chemistry. The course is divided into sections describing the chemistry of the atmosphere, natural waters and soils. The principles applied in the course include reaction kinetics and mechanisms, complex formation, pH and solubility equilibria and adsorption phenomena. Molecules of biochemical importance and instrumental methods of analysis relevant to environmental systems are also addressed. (formerly EDC230H1S)

Total AUs: 51.20

CHE249H1 - Engineering Economic Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering analysis and design are not ends in themselves, but they are a means for satisfying human wants. Thus, engineering concerns itself with the materials used and forces and laws of nature, and the needs of people. Because of scarcity of resources and constraints at all levels, engineering must be closely associated with economics. It is essential that engineering proposals be evaluated in terms of worth and cost before they are undertaken. In this course we emphasize that an essential prerequisite of a successful engineering application is economic feasibility. Hence, investment proposals are evaluated in terms of economic cost concepts, including break even analysis, cost estimation and time value of money. Effective interest rates, inflation and deflation, depreciation and income tax all affect the viability of an investment. Successful engineering projects are chosen from valid alternatives considering such issues as buy or lease, make or buy, cost and benefits and financing alternatives. Both public sector and for-profit examples are used to illustrate the applicability of these rules and approaches.

Total AUs: 44.80

CHE298H1 - Communication

Credit Value: 0.25
Hours: 25.6T

Each student will make a large number of very short speeches developing skills for speaking to large and small groups. Many elements of public speaking are explored: voice, body language, timing, word selection, speech preparation, speech structure, audience and surroundings. Students will prepare and present overheads. Extemporaneous speeches. Questions and answers. Interviewing.

Total AUs: 12.80

CHE299H1 - Communication

Credit Value: 0.25
Hours: 25.6T

Each student will learn to identify the central message they wish to communicate. They will learn to articulate this message through effective argumentation. Students will analyze their audience and purpose to select the most effective mode of communication. Students will summarize and synthesize information from external sources and effectively organize information and prioritize it in each mode of communication. They will apply effective strategies to the design of text, visuals and oral presentations.

Total AUs: 12.80

CHE304H1 - Chemical Engineering and Applied Chemistry- Laboratory III

Credit Value: 0.50
Hours: 12.8L/37.6P

This laboratory course involves experiments investigating thermodynamics and kinetics, complimenting two courses this term. Thermodynamic experiments include phase equilibrium and calorimetry, and kinetics experiment include investigations of rate constants and Arrhenius behvaiour. Experimental applications of physical and chemical principles using pilot scale equipment. Experiments illustrating major unit operations: distillation; absorption; reactors; extraction; humidification; heat exchange.

Total AUs: 38.40

CHE305H1 - Chemical Engineering and Applied Chemistry- Laboratory IV

Credit Value: 0.50
Hours: 12.8L/37.6P

This laboratory course involves experiments investigating thermodynamics and kinetics, complimenting two courses this term. Thermodynamic experiments include phase equilibrium and calorimetry, and kinetics experiment include investigations of rate constants and Arrhenius behvaiour. Experimental applications of physical and chemical principles using pilot scale equipment. Experiments illustrating major unit operations: distillation; absorption; reactors; extraction; humidification; heat exchange.

Total AUs: 38.40

CHE311H1 - Separation Processes

Credit Value: 0.50
Hours: 38.4L/25.6T

Staged equilibrium and rate governed separation processes for gases and liquids. Topics include equilibrium stage calculations, cascade separation, binary distillation, gas absorption and stripping, liquid-liquid extraction, membrane processes, adsorption and ion exchange. Experiments in fluid mechanics, heat transfer and related unit operations.

Total AUs: 51.20

CHE322H1 - Process Control

Credit Value: 0.50
Hours: 38.4L/25.6T

The major goal of this course is to teach students how to design control strategies for chemical processes. The first part of the course focuses on the types of interconnections encountered in chemical engineering, namely feedback, parallel and series connections, and their effect on the process dynamics. The second part of the course looks at the design of feedback, feedforward, cascade and multivariable control strategies for these processes and interprets these types of engineered interconnections in terms of the effect they have on the performance of the overall system. This course makes extensive use of active learning through computer simulation based on MATLAB/Simulink and Aspen Plus Dynamics software.

Total AUs: 51.20

CHE323H1 - Engineering Thermodynamics

Credit Value: 0.50
Hours: 38.4L/25.6T

Classical thermodynamics and its applications to engineering processes are introduced. Topics include: the concepts of energy, work and entropy; the first and second laws of thermodynamics; properties of pure substances and mixtures; the concepts of thermal equilibrium, phase equilibrium and chemical equilibrium; and heat engines and refrigeration cycles.

Total AUs: 51.20

CHE324H1 - Process Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course presents the philosophy and typical procedures of chemical engineering design projects. The course begins at the design concept phase. Material and energy balances are reviewed along with the design of single unit operations and equipment specification sheets. The impact of recycles on equipment sizing is covered. Safety, health and environmental regulations are presented. These lead to the development of safe operating procedures. The systems for developing Piping and Instrumentation diagrams are presented. Process safety studies such as HAZOPS are introduced. Typical utility systems such as steam, air and vacuum are discussed. Project economics calculations are reviewed.

Total AUs: 44.80

CHE332H1 - Reaction Kinetics

Credit Value: 0.50
Hours: 38.4L/25.6T

The rates of chemical processes. Topics include: measurement of reaction rates, reaction orders and activation energies; theories of reaction rates; reaction mechanisms and networks; development of the rate law for simple and complex kinetic schemes; approach to equilibrium; homogeneous and heterogeneous catalysis. Performance of simple chemical reactor types.

Total AUs: 51.20

CHE333H1 - Chemical Reaction Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Covers the basics of simple reactor design and performance, with emphasis on unifying the concepts in kinetics, thermodynamics and transport phenomena. Topics include flow and residence time distributions in various reactor types as well as the influence of transport properties (bulk and interphase) on kinetics and reactor performance. The interplay of these facets of reaction engineering is illustrated by use of appropriate computer simulations.

Total AUs: 51.20

CHE334H1 - Team Strategies for Engineering Design

Credit Value: 0.50
Hours: 12.8L/25.6T

In this course, team strategies including how teams work, how to lead and manage teams, and decision making methodologies for successful teams will be taught in the context of engineering design. The development of problem solving and design steps will be undertaken. This course will be taught with an emphasis on team development and problem solving as it relates to the practice of process safety management in engineering and engineering design. The teams will develop a PFD and P&ID's, as well as an operating procedure for a portion of the process. Thus, environmental and occupational health and safety becomes the vehicle through which the teamwork is performed.

Total AUs: 25.60

CHE341H1 - Engineering Materials

Credit Value: 0.50
Hours: 38.4L/12.8T

This course advances the understanding of the use of materials in engineering design, with special emphasis on corrosion and the effect of chemical environment on long term failure modes. Students will learn how to apply material property data to specify materials for load bearing applications, thermal and other non-structural applications, and chemical containment and transport. Topics will include strength of materials concepts, an introduction to computerized materials databases, material failure modes and criteria, principles of corrosion, and practical applications of corrosion prediction and mitigation. Students are required to design a component of their choice and do a detailed materials selection as a major design project.

Total AUs: 44.80

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

CHE399H1 - Professional Engineering Consultancy

Credit Value: 0.50
Hours: 12.8L/25.6T

Students are provided with an open-ended and iterative learning experience through a consulting engineering project. Students tackle an authentic design challenge with limited background knowledge, while being guided by instructors who simulate the client-consultant relationship. The project brings together technical and professonal competencies from across eight graduate attributes to enable holistic learning: problem analysis; investigation; design; individual and team work; communication skills; professionalism; economics and project management; lifelong learning.

Total AUs: 25.60

CHE403H1 - Professional Practice

Credit Value: 0.00
Hours: 25.6L

In this course, lectures and seminars will be given by practicing engineers who will cover the legal and ethical responsibility an engineer owes to an employer, a client and the public with particular emphasis on environmental issues.

Total AUs: 25.60

CHE412H1 - Advanced Reactor Design

Credit Value: 0.50
Hours: 38.4L/12.8T

Heterogeneous reactors. Mass and heat transport effects including intraparticle transport effects (Thiele modulus). Stability for various rate laws, transport regimes. Time dependent issues - deactivation/regeneration strategies. Emerging processes.

Total AUs: 44.80

CHE430Y1 - Chemical Plant Design

Credit Value: 1.00
Hours: 25.6L/76.8T

Students work in teams to design plants for the chemical and process industries and examine their economic viability. Lectures concern the details of process equipment and design.

Prerequisite: CHE249H1, CHE324H1, and two of CHE311H1, CHE322H1, CHE333H1 or equivalent)
Exclusion: APS490Y1
Total AUs: 101.60

CHE441H1 - Engineering Materials

Credit Value: 0.50
Hours: 38.4L/12.8T

This course advances the understanding of the use of materials in engineering design, with special emphasis on corrosion and the effect of chemical environment on long term failure modes. Students will learn how to apply material property data to specify materials for load bearing applications, thermal and other non-structural applications, and chemical containment and transport. Topics will include strength of materials concepts, an introduction to computerized materials databases, material failure modes and criteria, principles of corrosion, and practical applications of corrosion prediction and mitigation. Students are required to design a component of their choice and do a detailed materials selection as a major design project.

Total AUs: 44.80

CHE450H1 - Bioprocess Technology and Design

Credit Value: 0.50
Hours: 38.4L/12.8T/8.448P

Building upon CHE353 and CHE354, the aim of this course is to learn and apply engineering principles relevant to bioprocess engineering, including energetics and stoichiometry of cell growth, cell and enzyme kinetics, metabolic modeling, bioreactor design, and bioseparation processes. In addition to course lectures, students will complete two laboratory exercises that will provide hands-on learning in bioreactor set-up and use.

Prerequisite: CHE353H1 and CHE354H1
Total AUs: 49.02

CHE451H1 - Petroleum Processing

Credit Value: 0.50
Hours: 38.4L

This course is aimed at surveying the oil industry practices from the perspective of a block flow diagram. Oil refineries today involve the large scale processing of fluids through primary separation techniques, secondary treating plus the introduction of catalyst for molecular reforming in order to meet the product demands of industry and the public. Crude oil is being shipped in increasing quantities from many parts of the world and refiners must be aware of the properties and specifications of both the crude and product slates to ensure that the crude is a viable source and that the product slate meets quality and quantity demands thus assuring a profitable operation. The course content will examine refinery oil and gas operations from feed, through to products, touching on processing steps necessary to meet consumer demands. In both course readings and written assignments, students will be asked to consider refinery operations from a broad perspective and not through detailed analysis and problem solving.

Total AUs: 38.40

CHE460H1 - Environmental Pathways and Impact Assessment

Credit Value: 0.50
Hours: 38.4L/25.6T

Review of the nature, properties and elementary toxicology of metallic and organic contaminants. Partitioning between environmental media (air, aerosols, water, particulate matter, soils, sediments and biota) including bioaccumulation. Degradation processes, multimedia transport and mass balance models. Regulatory approaches for assessing possible effects on human health and ecosystems.

Total AUs: 51.20

CHE462H1 - Food Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The quantitative application of chemical engineering principles to the large-scale production of food. Food processing at the molecular and unit operation levels. The chemistry and kinetics of specific food processes. The application of chemical engineering unit operations (distillation, extraction, drying) and food specific unit operations such as extrusion, thermal processing refrigeration/freezing.

Total AUs: 44.80

CHE467H1 - Environmental Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor A course which treats environmental engineering from a broad based but quantitative perspective and covers the driving forces for engineering activities as well as engineering principles. Models which are used for environmental impact, risk analysis, health impact, pollutant dispersion, and energy system analysis are covered.

Total AUs: 44.80

CHE469H1 - Fuel Cells and Electrochemical Conversion Devices

Credit Value: 0.50
Hours: 38.4L/12.8T

The objective of this course is to provide a foundation for understanding the field of electrochemical conversion devices with particular emphasis on fuel cells. The topics will proceed from the fundamental thermodynamic in-system electodics and ionic interaction limitations to mass transfer and heat balance effects,t o the externalities such as economics and system integration challenges. Guest lecturers from the fuel cell industry will be invited to procide an industrial perspective. Participants will complete a paper and in-class presentation.

Exclusion: MIE517H1
Total AUs: 44.80

CHE470H1 - Special Topics in Chemical Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

A course covering selected topics in Chemical Engineering, not covered in other electives. Different topics may be covered each year depending on the interest of the Staff and students. May not be offered every year. Limited enrolment: permission of the Department required.

Total AUs: 44.80

CHE471H1 - Modelling in Biological and Chemical Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course outlines the methodology for the modelling of biological systems and its applications. Topics will include a review of physical laws, selection of balance space, compartmental versus distributed models, and applications of the conservation laws for both discrete and continuous systems at the level of algebraic and ordinary differential equations. The course covers a wide range of applications including environmental issues, chemical and biochemical processes and biomedical systems.

Total AUs: 44.80

CHE475H1 - Biocomposites: Mechanics and Bioinspiration

Credit Value: 0.50
Hours: 38.4L/12.8T

An overview on structure, processing and application of natural and biological materials, biomaterials for biomedical applications, and fibre-reinforced eco-composites based on renewable resources will be provided. Fundamental principles related to linear elasticity, linear viscoelasticity, dynamic mechanical response, composite reinforcement mechanics, and time-temperature correspondence will be introduced. Novel concepts in comparative biomechanics, biomimetic and bio-inspired material design, and materials' ecological and environmental impact will be discussed. In addition, key material processing methods and testing and characterization techniques will be presented. Structure-property relationships for materials broadly ranging from natural materials, including wood, bone, cell, and soft tissue, to synthetic composite materials for industrial and biomedical applications will be covered.

Total AUs: 44.80

CHE499Y1 - Thesis

Credit Value: 1.00
Hours: 89.6P

The course consists of a research project conducted under the supervision of a senior staff member. The project may have an experimental, theoretical or design emphasis. Each thesis will contain a minimum 60% combined Engineering Science and Engineering Design (with a minimum of 10% in each component). This course is open to students with permission of the Department and research project supervisor.

Total AUs: 101.59

CHE507H1 - Data-based Modelling for Prediction and Control

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will teach students how to build mathematical models of dynamic systems and how to use these models for prediction and control purposes. The course will deal primarily with a system identification approach to modelling (using observations from the system to build a model). Both continuous time and discrete time representations will be treated along with deterministic and stochastic models. This course will make extensive use of interactive learning by having students use computer based tools available in the Matlab software package (e.g. the System Identification Toolbox and the Model Predictive Control Toolbox).

Total AUs: 44.80

CHE561H1 - Risk Based Safety Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an introduction to Process Safety Management. The historical drivers to improve safety performance are reviewed and the difference between safety management and occupational health and safety is discussed. National and international standards for PSM are reviewed. Risk analysis is introduced along with techniques for process hazard analysis and quantification. Consequence and frequency modelling is introduced. Rsik based decision making is introduced, and the course concludes with a discussio of the key management systems required for a successful PSM system.

Total AUs: 44.80

CHE562H1 - Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering

Credit Value: 0.50
Hours: 38.4L

This course serves as an introduction to concepts in polymer chemistry, polymer science and polymer engineering. This includes a discussion of the mechanisms of step growth, chain growth and ring-opening polymerizations with a focus on industrially relevant polymers and processes. The description of polymers in solution as well as the solid state will be explored. Several modern polymer characterization techniques are introduced including gel permeation chromatography, differential scanning calorimetry, thermal gravimetric analysis and others.

Exclusion: CHM426H1
Recommended Preparation: CHE213H1, CHE220H1 or equivalents
Total AUs: 38.40

CHE564H1 - Pulp and Paper Processes

Credit Value: 0.50
Hours: 38.4L/12.8T

The processes of pulping, bleaching and papermaking are used to illustrate and integrate chemical engineering principles. Chemical reactions, phase changes and heat, mass and momentum transfer are discussed. Processes are examined on four scales: molecular, diffusional, unit operations and mill. In the tutorial each student makes several brief presentations on selected topics and entertains discussion.

Total AUs: 44.80

CHE565H1 - Aqueous Process Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2) treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

Total AUs: 44.80

CHE566H1 - Elements of Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

A first course in nuclear engineering intended to introduce students to all aspects of this interdisciplinary field. Topics covered include nuclear technology, atomic and nuclear physics, thermonuclear fusion, nuclear fission, nuclear reactor theory, nuclear power plants, radiation protection and shielding, environment and nuclear safety, and the nuclear fuel cycle.

Total AUs: 51.20

CHE568H1 - Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamental and applied aspects of nuclear engineering. The structure of the nucleus; nuclear stability and radioactive decay; the interaction of radiation with matter including radiological health hazards; the interaction of neutrons including cross-sections, flux, moderation, fission, neutron diffusion and criticality. Poison buildup and their effects on criticality. Nuclear engineering of reactors, reactor accidents, and safety issues.

Exclusion: MIE414H1
Total AUs: 44.80

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

CIV250H1 - Hydraulics and Hydrology

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The hydrologic processes of precipitation and snowmelt, evapotranspiration, ground water movement, and surface and subsurface runoff are examined. Water resources sustainability issues are discussed, including water usage and water shortages, climate change impacts, land use impacts, and source water protection. Conceptual models of the hydrologic cycle and basics of hydrologic modelling are developed, including precipitation estimation, infiltration and abstraction models, runoff hydrographs, the unit hydrograph method and the Rational method. Methods for statistical analysis of hydrologic data, concepts of risk and design, and hydrological consequences of climate change for design are introduced. Principles of open channel hydraulics are introduced. Energy and momentum principles are studied with application to channel transitions, critical flow, choked flow, and hydraulic jumps.

Prerequisite: CME270H1
Total AUs: 54.40

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

CIV375H1 - Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T/4.224000168P

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.

Exclusion: CIV575H1
Total AUs: 53.31

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

CIV549H1 - Groundwater Flow and Contamination

Credit Value: 0.50
Hours: 38.4L/12.8T

Mechanics of saturated and unsaturated fluid flow in porous media. Confined and unconfined flow. Flow to wells. Analytical and numerical solutions of groundwater flow equations. Non-reactive and reactive contaminant transport on groundwater systems. Analytical and numerical solutions of contaminant transport equations. Flow and solute transport in fractured porous media. Assessment of environmental impacts of waste disposal operations. Remediation of contaminated groundwater.

Prerequisite: CME270H1, CIV250H1 or equivalent
Total AUs: 44.80

CIV550H1 - Water Resources Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Global and national water problems, law and legislation. Hydraulic structures. Reservoir analysis. Urban drainage and runoff control: meteorologic data analysis, deterministic and stochastic modelling techniques. Flood control: structural and nonstructural alternatives. Power generation: hydro and thermal power generation. Low flow augmentation. Economics and decision making.

Prerequisite: CIV250H1, CIV340H1 or equivalent
Total AUs: 51.20

Forestry

FOR424H1 - Innovation and Manufacturing of Sustainable Materials

Credit Value: 0.50
Hours: 25.6L/12.8T

Sustainable materials are a mandate for sustainable societies. This course will explore the manufacturing, engineering principles and design fundamentals for creating sustainable materials from renewable resources. Special emphasis will be on bioplastics, biofibre, nanobiofibre, biocomposites and nanobiocomposites. Written communication and design skills will be developed through tutorials and assignments.

Exclusion: FOR423H1
Recommended Preparation: Basic knowledge of materials science.
Total AUs: 32.00

FOR425H1 - Bioenergy and Biorefinery Technology

Credit Value: 0.50
Hours: 25.6L/25.6T

Technological advances and approaches in deriving biofuels, chemical feedstocks from forest and other biomass resources. Fundamental chemical attributes of biomass, as they affect the fuel value and potential for deriving liquid, solid and gaseous fuels and valuable chemicals for other applications will be explored.

Exclusion: FOR410H1
Total AUs: 38.40

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

Mechanical and Industrial Engineering

MIE304H1 - Introduction to Quality Control

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Introduction to quality engineering. Quality standards and certification. TQM. Modeling processes with simulation. Making inferences about product quality from real or simulation output data. Introduction to statistical process control. Control charts for variables and attributes. Process capability analysis. Lot Acceptance Sampling.

Prerequisite: MIE231 or equivalent
Total AUs: 57.60

MIE515H1 - Alternative Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers the basic principles, current technologies and applications of selected alternative energy systems. Specific topics include solar thermal systems, solar photovoltaic systems, wind, wave, and tidal energy, energy storage, and grid connections issues. Limited enrolment.

Prerequisite: MIE210H1,MIE312H1 and MIE313H1 (or equivalent courses).
Total AUs: 44.80

MIE516H1 - Combustion and Fuels

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to combustion theory. Chemical equilibrium and the products of combustion. Combustion kinetics and types of combustion. Pollutant formation. Design of combustion systems for gaseous, liquid and solid fuels. The use of alternative fuels (hydrogen, biofuels, etc.) and their effect on combustion systems.

Total AUs: 44.80

MIE517H1 - Fuel Cell Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation, including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

Total AUs: 44.80

Materials Science and Engineering

MSE440H1 - BIomaterial Processing and Properties

Credit Value: 0.50
Hours: 39L/13T

Currently used biomaterials for formation of surgical implants and dental restorations include selected metals, polymers, ceramics, and composites. The selection and processing of these materials to satisfy biocompatibility and functional requirements for applications in selected areas will be presented. Materials used for forming scaffolds for tissue engineering, and strategies for repair, regeneration and augmentation of degenerated or traumatized tissues will be reviewed with a focus on biocompatibility issues and required functionality for the intended applications.

Prerequisite: MSE343H1
Total AUs: 44.80

Civil Engineering

Undergraduate Program in Civil Engineering (AECIVBASC)

Undergraduate Advisor
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Civil Engineering exists at the intersection of the human, built and natural environments. Historically, civil engineers have been the professionals leading the design, construction, maintenance and eventual decommissioning of society's physical infrastructures, including transportation networks, water supply and wastewater treatment systems, structures for energy generation and distribution systems, buildings and other works, land and water remediation and more.

Although civil engineering is a highly technical profession, responsible engineering requires that engineers understand the impact of their decisions and their constructed works on society at large, including issues of environmental stewardship and life-cycle economic responsibility. For example, significant proportions of the world's energy and raw materials production go into the construction and operations of our buildings and transportation systems. Civil engineers have a significant role to play in making these systems more sustainable for future generations. The undergraduate program is designed to complement technical training with learning opportunities that address these challenges.

Students enhance their undergraduate experience through a number of enriched programs. The Department's undergraduate courses have been deliberately sequenced so that students can take advantage of the minors in bioengineering, environmental engineering or sustainable energy; the certificate programs in preventative engineering and social development or in entrepreneurship, innovation and small business; co-op work opportunities through the Professional Experience Year Co-op Program; and post-graduate academic opportunities through the Jeffrey Skoll BASc / MBA Program or through fast-tracked Master's degree programs.

Graduate Program in Civil Engineering

Qualified candidates may apply for graduate studies in the MEng, MASc and PhD Programs. The MEng program is course-based (although a one or two course-equivalent projects may be taken), whereas the MASc and PhD programs are research-intensive and require a thesis. More information about the Department's graduate programs will be provided in information sessions and can be found online at civmin.utoronto.ca.

UNDERGRADUATE PROGRAM IN CIVIL ENGINEERING (AECIVBASC)

FIRST YEAR CIVIL ENGINEERING

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
CIV100H1: Mechanics	F	4	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session – Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
CHE112H1: Physical Chemistry	S	3	1	1	0.50
CIV185H1: Earth Systems Science	S	3	2	1	0.50
CIV191H1: Introduction to Civil Engineering	S	1	-	-	0.15
MAT187H1: Calculus II	S	3	-	1	0.50

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

CIV201 - INTRODUCTION TO CIVIL ENGINEERING

CIV201 is a three-day field-based course. The course will be held on the Tuesday, immediately after Labour Day. Students are required to bring and wear their Personal Protective Equipment (PPE). The results of this course are used in computing the student's Second Year Fall Session average. An extra fee is charged to cover a transportation and accommodation.

CS/HSS REQUIREMENT

Students are required to complete 4 half-courses of CS/HSS, at least two of which must be HSS, before graduation. The second year core course APS301H1 - Technology in Society and the Biosphere I, counts as one half-course (0.50) towards an HSS requirement. Note that valid HSS courses are more restrictive in scope than are CS courses. A list of pre-approved CS and HSS courses can be found on the Faculty of Engineering's Registrar's Office website.

PRACTICAL EXPERIENCE REQUIREMENT

Students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods). Satisfactory completion of CME358H1 - Survey Camp (Civil and Mineral Practicals), will contribute 100 hours towards this requirement. Satisfactory completion of the Professional Experience Year (PEY) will also completely fulfill the Practical Experience Requirement.

SECOND YEAR CIVIL ENGINEERING

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
CIV201H1: Introduction to Civil Engineering	F	-	-	-	0.20
CIV220H1: Urban Engineering Ecology	F	3	-	1	0.50
CIV235H1: Civil Engineering Graphics	F	-	6	-	0.50
CIV280H1: Management of Construction	F	3	-	2	0.50
CIV282H1: Engineering Communications I	F	1	-	1	0.20
CME210H1: Solid Mechanics I	F	3	1.50	1.50	0.50
CME261H1: Engineering Mathematics I	F	3	1	1	0.50
CME270H1: Fluid Mechanics I	F	3	1.50	1	0.50
Winter Session – Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CIV209H1: Civil Engineering Materials	S	3	2	2	0.50

Winter Session – Year 2		Lect.	Lab.	Tut.	Wgt.
CIV214H1: Structural Analysis I	S	3	-	2	0.50
CIV250H1: Hydraulics and Hydrology	S	3	1.5	1	0.50
CME259H1: Technology in Society and the Biosphere I	S	3	-	1	0.50
CME263H1: Probability Theory for Civil and Mineral Engineers	S	3	-	2	0.50
CME262H1: Engineering Mathematics II	S	3	-	2	0.50

CME358H1 - Survey Camp (Civil and Mineral Practicals), is a two-week field-based course taken in the month prior to starting Third Year. The results of this course are used in computing the student's Third Year Fall Session Average. An extra fee is charged to cover part of the costs of food and accommodation.

THIRD YEAR CIVIL ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CIV312H1: Steel and Timber Design	F	3	-	2	0.50
CIV331H1: Transport I - Introduction to Urban Transportation Systems	F	3	-	1	0.50
CIV342H1: Water and Wastewater Treatment Processes	F	3	1	1	0.50
CIV375H1: Building Science	F	3	0.33	2	0.50
CIV382Y1: Civil Engineering Communication Portfolio	Y	-	-	0.25	0.00
CME321H1: Geotechnical Engineering I	F	3	1	1	0.50
CME358H1: Survey CAMP (Civil and Mineral Practicals)	F	-	-	-	0.50
CME368H1: Engineering Economics and Decision Making	F	3	-	1	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CIV313H1: Reinforced Concrete I	S	3	-	2	0.50
CIV324H1: Geotechnical Engineering II	S	3	1	1	0.50
CIV332H1: Transport II - Performance	S	3	-	1	0.50
CIV340H1: Municipal Engineering	S	3	-	2	0.50
CIV380H1: Sustainable Energy Systems	S	3	-	1	0.50
CIV382Y1: Civil Engineering Communication Portfolio	Y	-	-	0.25	0.00
CS/HSS Elective	S				0.50

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enrol and participate in the Professional Experience Year (PEY) program. The PEY program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating company. Details are described in the beginning of this chapter. For more information, consult the Professional Experience Year Office, 222 College Street, Suite 106 early in session 2F or 3F.

JEFFREY SKOLL BASC/MBA PROGRAM

The Jeffrey Skoll Combined BASc/MBA Program allows qualified and selected students in the Faculty of Applied Science and Engineering to complete both a BASc and an MBA in a reduced time. Students will be admitted to the program prior to entering their fourth year of studies in the BASc program. Interested students should contact the Rotman School of Management.

MINORS AND CERTIFICATE PROGRAMS

Several Engineering Minors and Certificate Programs are available and generally require the student to successfully complete a carefully selected slate of electives in their Fourth Year. Late in the Third Year Winter Session, students use an online pre-registration tool to indicate their preferred fourth-year electives. Students should review the various minor and certificate program requirements and attend the department's information sessions in Third Year to ensure that the appropriate electives are taken in Fourth Year. Students should note that they can also complete the requirements of a minor or certificate program even after they have graduated, as long as the additional requirements are met within nine years of their initial registration in the BASc program. If completed after graduation, additional fees will be assessed. A transcript will be issued with the amended courses and indication of completed minor or certificate program requirements.

FOURTH YEAR CIVIL ENGINEERING

Fall Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Free Elective	F				0.50
Free Elective	F/Y				0.50
CS/HSS Elective	F/Y				0.50
Choose two technical electives from the following list:					
CHE353H1: Engineering Biology	F	2	-	2	0.50
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
CIV416H1: Reinforced Concrete II	F	3	-	2	0.50
CIV420H1: Construction Engineering	F	3	-	2	0.50
CIV477H1: Special Studies in Civil Engineering	F	3	-	1	0.50
CME499Y1: Individual Project	Y	-	-	3	1.00
CME499H1: Individual Project	F	-	-	3	0.50
CIV514H1: Concrete Technology	F	3	-	2	0.50
CIV515H1: Introduction to Structural Dynamics	F	3	-	1	0.50
CIV517H1: Prestressed Concrete	F	3	-	-	0.50
CIV519H1: Structural Analysis II	F	3	-	2	0.50
CIV521H1: Rock Mechanics	F	3	1	-	0.50
CIV531H1: Transport Planning	F	3	-	1	0.50
CIV536H1: Urban Activity, Air Pollution, and Health	F	3	-	-	0.50
CIV541H1: Environmental Biotechnology	F	3	-	-	0.50
CIV549H1: Groundwater Flow and Contamination	F	3	-	1	0.50
CIV550H1: Water Resources Engineering	F	3	-	2	0.50
CIV578H1: Design of Building Enclosures	F	3	-	2	0.50
CME525H1: Tunneling and Urban Excavation	F	3	-	1	0.50
MIN329H1: Engineering Rock Mechanics	F	3	1	1	0.50
MIN511H1: Integrated Mine Waste Engineering	F	3	-	1	0.50
Winter Session - Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CIV498H1: Group Design Project	S	-	-	3	0.50
Free Elective	S/Y				0.50
CS/HSS Elective	S/Y				0.50
Choose two technical electives from the following list:					
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
CIV477H1: Special Studies in Civil Engineering	S	3	-	1	0.50
CME499Y1: Individual Project	Y	-	-	3	1.00
CME499H1: Individual Project	S	-	-	3	0.50
CIV510H1: Solid Mechanics II	S	3	-	2	0.50
CIV516H1: Public Transit Operations and Planning	S	3	-	1	0.50
CIV518H1: Behaviour and Design of Steel Structures	S	3	-	2	0.50
CIV523H1: Geotechnical Design	S	3	-	1	0.50
CIV576H1: Sustainable Buildings	S	3	-	0	0.50
CIV577H1: Infrastructure for Sustainable Cities	S	3	-	1	0.50
CIV580H1: Engineering and Management of Large Projects	S	3	-	-	0.50
CME500H1: Fundamentals of Acid Rock Drainage	S	3	2	1	0.50

Winter Session - Year 4		Lect.	Lab.	Tut.	Wgt.
BME331H1: Physiological Control Systems	S	3	1	1	0.50
MIN330H1: Mining Environmental Management	S	3	-	1	0.50
MIN470H1: Ventilation and Occupational Health	S	3	-	1	0.50

* Students may take either a half credit CME499 OR a full year credit CME499 but not both.

OTHER ELECTIVE COURSES

Elective courses in addition to those listed above may be considered based on the following general guidelines. Students wishing to take elective courses from other departments need to ensure that they have the appropriate background and prerequisites. Students with an overall average of 75% or greater in their third year may take up to two graduate level (1000-series) courses, depending upon availability. In all cases the interested student should consult with the Civil Engineering Office of Student Services (GB116) to obtain further information and the appropriate permission.

Civil Engineering Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS106H1 - Fundamentals of Computer Programming

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the Python programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and

Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

Biomaterials and Biomedical Engineering

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

Chemical Engineering and Applied Chemistry

CHE112H1 - Physical Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

A course in physical chemistry. Topics discussed include systems and their states, stoichiometry, the properties of gases, the laws of chemical thermodynamics (calculations involving internal energy, enthalpy, free energy, and entropy), phase equilibrium, chemical equilibrium, ionic equilibrium, acids and bases, solutions, colligative properties, electrochemistry, and corrosion.

Total AUs: 51.20

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

CIV185H1 - Earth Systems Science

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

This course introduces students to the basic earth sciences with an emphasis on understanding the impact of humans on the natural earth systems. Beginning with a study of the lithosphere, principles of physical geology will be examined including the evolution and internal structure of the earth, dynamic processes that affect the earth, formation of minerals and rocks and soil, ore bodies and fossil- energy sources. Next, the biosphere will be studied, including the basic concepts of ecology including systems ecology and biogeochemical cycles. The influence of humans and the built environment on these natural systems will also be examined with a view to identifying more sustainable engineering practices. Finally, students will study the oceans and the atmosphere and the physical, chemical and thermodynamic processes involved in climate change.

Total AUs: 57.60

CIV191H1 - Introduction to Civil Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will preview the core fields in Engineering. Each seminar will highlight one of the major areas of Engineering. The format will vary and may include application examples, challenges, case studies, career opportunities, etc. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Faculty to enable them to make educated choices for second year. This course will be offered on a credit/no credit basis.

Total AUs: 12.80

CIV201H1 - Introduction to Civil Engineering

Credit Value: 0.20

A field-based course introducing students to current and historical civil engineering works in the urban and natural environments, highlighting the role of the Civil Engineer in developing sustainable solutions. It will run the Tuesday through Thursday immediately following Labour Day, with follow-up assignments coordinated with the course CIV282 Engineering Communications I. Students must have their own personal protective equipment (PPE). One night will be spent at the University of Toronto Survey Camp near Minden, Ontario.

Total AUs: 20.20

CIV209H1 - Civil Engineering Materials

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Deals with the basic principles necessary for the use and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed. The laboratory time is devoted to demonstrations illustrating the fundamentals covered in lectures.

Prerequisite: APS104H1 or MSE101H1
Total AUs: 64.00

CIV214H1 - Structural Analysis I

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides an introduction to the nature of loads and restraints and types of structural elements, and then reviews the analysis of statically determinate structures. Shear and moment diagrams for beams and frames are considered, along with influence lines, cantilever structures, three-pin arches, cables and fatigue. Virtual work principles are viewed and applied to various structural systems. An introduction to the analysis of indeterminate structures is made, and the Portal method is applied to the analysis of building frames under lateral loads. Displacement methods of an analysis including moment distribution are also studied.

Prerequisite: MAT188H1, CME210H1
Total AUs: 51.20

CIV220H1 - Urban Engineering Ecology

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor
Basic concepts of ecology within the context of urban environments. Response of organisms, populations,

dynamic predator-prey and competition processes, and ecosystems to human activities. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Biogeochemical cycles, habitat fragmentation and bioaccumulation. Introduction to industrial ecology and life cycle assessment principles. Urban metabolism and material flow analysis of cities. Response of receiving waters to pollution and introduction to waste water treatment. Emphasis is on identifying the environment/engineering interface and minimizing environmental impacts.

Prerequisite: CHE112H1
Total AUs: 44.80

CIV235H1 - Civil Engineering Graphics

Credit Value: 0.50
Hours: 76.8P

Fluency in graphical communication skills as part of the civil engineering design process is emphasized. Drawings are prepared making use of freehand sketching, drafting equipment and commercially available computer drafting programs. Topics in descriptive geometry are covered to develop spatial visualization skills. Drawing procedures and standards relevant to Civil Engineering projects to be covered include layout and development of multiple orthographic views, sectional views, dimensioning, and pictorial views. Class projects, assignments, and examples demonstrate how graphical skills fit into the overall design process.

Total AUs: 38.40

CIV250H1 - Hydraulics and Hydrology

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The hydrologic processes of precipitation and snowmelt, evapotranspiration, ground water movement, and surface and subsurface runoff are examined. Water resources sustainability issues are discussed, including water usage and water shortages, climate change impacts, land use impacts, and source water protection. Conceptual models of the hydrologic cycle and basics of hydrologic modelling are developed, including precipitation estimation, infiltration and abstraction models, runoff hydrographs, the unit hydrograph method and the Rational method. Methods for statistical analysis of hydrologic data, concepts of risk and design, and hydrological consequences of climate change for design are introduced. Principles of open channel hydraulics are introduced. Energy and momentum principles are studied with application to channel transitions, critical flow, choked flow, and hydraulic jumps.

Prerequisite: CME270H1
Total AUs: 54.40

CIV280H1 - Management of Construction

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the management of construction projects including: the nature of the industry, project delivery alternatives, legal and ethical considerations, the Safety Act and construction regulations, labour relations, construction contracts, risk distribution, project planning and scheduling, estimating and bidding, controlling of time, cost and quality, accounting leading to financial statements, dispute resolution, as well as new and evolving concepts in managing construction.

Total AUs: 51.20

CIV282H1 - Engineering Communications I

Credit Value: 0.20
Hours: 12.8L/12.8T

This course develops students' communications skills focusing on the specific skills required for work in foundational civil engineering. Target communication areas include: Oral Presentation; Logical Argument; Document Development; Sentence and Discourse Control; and Visual Design. The course will build capacity in support of specific assignments delivered in other courses in the same term.

Total AUs: 19.20

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

CIV312H1 - Steel and Timber Design

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to structural engineering design. Topics discussed include safety and reliability, load and resistance, probability of failure, performance factors, and material properties. A study of basic steel design examines tension members, compression members, beams, framing concepts and connections. Plasticity and composite action in steel structural systems are also discussed. Timber design aspects include beams, compression members and connections.

Prerequisite: CIV214H1, CIV235H1
Total AUs: 51.20

CIV313H1 - Reinforced Concrete I

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides an introduction to the design of reinforced concrete structures. Concrete technology, properties of concrete and reinforcing steel, construction practice, and general code requirements are discussed. Analysis and design of members under axial load, flexure, shear, and restraint force are examined in detail. Other aspects of design covered include control of cracks, minimum and maximum reinforcement ratios, fire resistance, durability, distress and failure. A major design project, done in teams of two and accounting for 15% of the final mark, requires students to formulate a complete design for a structural system such as a pedestrian bridge or floor system. Project requirements include consideration of alternative designs in terms of structural efficiency and total costs.

Prerequisite: CIV312H1
Total AUs: 51.20

CIV324H1 - Geotechnical Engineering II

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Building on CME321, more complex aspects of geotechnical analysis and design are considered. Topics include: mineralogy; soil identification and classification; laboratory- and field-based soil index tests; correlations of index test results to engineering properties; vertical stress distribution; soil-foundation interaction; volume change and consolidation of clay and settlement. Shear strength of soil and slope stability analysis are also discussed. Laboratories are held for soil identification and classification, and confined triaxial compression tests of clay and sand.

Prerequisite: CME321H1
Total AUs: 51.20

CIV331H1 - Transport I - Introduction to Urban Transportation Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course introduces the fundamentals of transportation systems and the application of engineering, mathematical and economic concepts and principles to address a variety of transportation issues in Canada. Several major aspects of transportation engineering will be addressed, including transportation planning, public transit, traffic engineering, geometric design, pavement design and the economic, social and environmental impacts of transportation. The course focuses on urban transportation engineering problems.

Total AUs: 44.80

CIV332H1 - Transport II - Performance

Credit Value: 0.50
Hours: 38.4L/12.8T

This course focuses on the fundamental techniques of transportation systems performance analysis with emphasis on congested traffic networks. Topics include transportation demand, supply and equilibrium, traffic assignment, network equilibrium, and system optimality, traffic flow theory, shockwaves, highway capacity analysis, introduction to deterministic and stochastic queuing analyses, intersection signal control types and related timing methods, and traffic simulation. The course also provides an introduction to basic elements of Intelligent Transportation Systems (ITS).

Total AUs: 44.80

CIV340H1 - Municipal Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Municipal service systems for water supply and wastewater disposal, land development, population forecasting, and demand analysis. Water supply: source development, transmission, storage, pumping, and distribution networks. Sewerage and drainage, sewer and culvert hydraulics, collection networks, and storm water management. Maintenance and rehabilitation of water and wastewater systems, and optimization of network design. Design projects.

Prerequisite: CIV250H1
Total AUs: 51.20

CIV342H1 - Water and Wastewater Treatment Processes

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Principles involved in the design and operation of water and wastewater treatment facilities are covered, including physical, chemical and biological unit operations, advanced treatment and sludge processing.

Total AUs: 51.20

CIV375H1 - Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T/4.224000168P

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.

Exclusion: CIV575H1
Total AUs: 53.31

CIV380H1 - Sustainable Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will provide students with knowledge of energy demand and supply from local to national scales. Topics include energy demands throughout the economy, major energy technologies, how these technologies work, how they are evaluated quantitatively, their economics and their impacts on the environment. In addition, the ever changing context in which these technologies (and emerging technologies) are being implemented will be outlined. Systems approaches including life cycle assessment, will be refined and applied to evaluate energy systems. A particular focus will be placed on analysis of energy alternatives within a carbon constrained economy.

Prerequisite: CIV375H1, CIV220H1, CME368H1
Total AUs: 44.80

CIV382Y1 - Civil Engineering Communication Portfolio

Credit Value: 0.00
Hours: 3.2T

Students will assemble a portfolio of communication assignments drawn from their second and third year Civil Engineering courses as a showcase of their ability to meet the graduate attributes for communication. The student will demonstrate competence in discipline specific written, oral, and visual communication through the selection of assignments for the portfolio. Each entry will be framed by a short introduction speaking to the context of the work and its significance in the portfolio. Students whose communication work is not up to standard will be provided with opportunities for revision. The course will be offered on a credit/no credit basis; students who receive no credit must retake the course in year 4.

Total AUs: 1.60

CIV416H1 - Reinforced Concrete II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. An introduction to the seismic design of reinforced concrete structures is made. Emphasis is given to the relationship between recent research results and current building codes. A brief treatment of the behaviour and design of masonry walls is included.

Prerequisite: CIV313H1
Total AUs: 51.20

CIV420H1 - Construction Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

This course considers the engineering aspects of construction including earthmoving, equipment productivity, fleet balancing, formwork design, shoring, hoisting, aggregate production, equipment operating costs, and modular construction. Several construction projects will be reviewed to demonstrate methods and processes. Students will be expected to visit construction sites, so safety boots and hard hats are required.

Total AUs: 51.20

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

CIV477H1 - Special Studies in Civil Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

A course covering selected topics in Civil Engineering not covered in other electives. The topics, which may be different every year, are selected by Staff. Course may not be offered every year and there may be limited enrolment in particular years.

Total AUs: 44.80

CIV498H1 - Group Design Project

Credit Value: 0.50
Hours: 38.4T

The Group Design Project is a significant design experience that integrates the mathematics, basic sciences, engineering sciences, complementary studies, and detailed design aspects of the different civil engineering sub-disciplines.

Exclusion: APS490Y1
Total AUs: 50.20

CIV499H1 - Individual Project

Credit Value: 0.50
Hours: 38.4T

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project and MIN466 Mineral Project Design experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken only once, either in the Fall (F) or Winter (S) Session (0.5 weight), or as a full year (Y) course (1.0 weight).

Total AUs: 19.20

CIV510H1 - Solid Mechanics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides a continuing study of the mechanics of deformable solids. Stress and equilibrium conditions, strain and compatibility conditions, stress-strain relations and yield/failure criteria are considered in the context of civil engineering materials. Two-and three-dimensional elasticity theory is developed, with an introduction to the use of tensor notation. Advanced topics in bending, shear and torsion of beams are also covered, as is elementary plate bending theory. The course concludes with a further development and application of energy methods including virtual work, potential energy, strain energy, and related approaches.

Prerequisite: CME210H1
Total AUs: 51.20

CIV513H1 - Collaborative Engineering and Architectural Design Studio

Credit Value: 0.50
Hours: 12.8L/64P

Engineering and Architecture students are paired to form a design team for a specified building design project. Lectures are given on design development, aspects of structural system design, the relationship of structure to program and function, modeling and drawing, digital modeling, as well as topics related to the specific term design project. Studio design experience to familiarize students with both the synergistic and divergent goals of the engineering and architectural design and to develop collaboration skills for optimizing the outcome of the interdisciplinary professional interaction. Architecture students in this joint studio are enrolled in ARC3016Y S.

Prerequisite: CIV313H1/CIV352H1, CIV357H1
Total AUs: 44.80

CIV514H1 - Concrete Technology

Credit Value: 0.50
Hours: 38.4L/25.6T

Material aspects of concrete production will be dealt with in the context of various performance criteria with emphasis on durability. The process of material selection, proportioning, mixing, transporting, placing and curing concrete will be the framework within which topics such as: the use of admixtures, choice of cements, environmental influences, methods of consolidation and testing techniques will be studied.

Prerequisite: CIV209H1
Total AUs: 51.20

CIV515H1 - Introduction to Structural Dynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

The concept of dynamic equilibrium and corresponding equation of motion will be introduced. The theoretical solution of a songle degree of freedom system will be derived and the effects of verious types of loads, such as impulse load, sinusoidal load, or random vibration on the structural response will be discussed. To solve dynamic problems of multi-degree of freedom (MDOF) systems, concepts of mass, stiffness, and damping matrix will be introduced, which will be followed by eigen value analysis and modal analysis. The concepts of Fourier Transformation will be introduced, which will be used to interpret dynamic responses of structures or dynamic nature of applied loads. Dynamic experiments of elastic systems will be demonstrated using an educational shaking table.

Prerequisite: CIV312H1 and CIV313H1 or equivalent
Total AUs: 44.80

CIV516H1 - Public Transit Operations and Planning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers a broad range of topics in urban transit operations and planning, with special emphasis on best-practice strategies of modern transit systems. The course will help students: Learn the history of transit and its relationship to urban development, emerging challenges, transit role in society, and new trends and issues; Understand and analyze the factors that affect transit performance and demand; Identify and analyze transit operational and planning problems; Identify possible solutions at the operational level (mostly short-term and line-based) and the strategic level (mostly long-term and network-based), and assess alternative solutions; Understand the relative performance of various transit modes (both conventional and new modes) and their domains of application; and gain knowledge of best-practice transit systems planning and emerging innovations.

Total AUs: 44.80

CIV517H1 - Prestressed Concrete

Credit Value: 0.50
Hours: 38.4L

An introduction to procedures for predicting the load-deformation response of prestressed concrete elements and structures with emphasis on how these procedures can be used in the design of new structures and in the evaluation of existing structures. Topics include: prestressing technology; control of cracking; response to axial load and flexure; response to shear and torsion; disturbed regions; restraint of deformations; design codes.

Prerequisite: CIV313H1/CIV357H1 or equivalent
Total AUs: 38.40

CIV518H1 - Behaviour and Design of Steel Structures

Credit Value: 0.50
Hours: 38.4L/25.6T

The behaviour and design of trusses, frames, members and connections in steel building and bridge structures is presented and design methods are developed. Ultimate strength, stability, and postbuckling are emphasized in topical examples including: plate girders, composite steel/concrete girders, second-order frame behaviour, high-strength bolted and welded framing connections. Design applications considering metal fatigue and brittle fracture, and methods of plastic analysis are also introduced. Canadian design standards and the Limit States Design concepts are used.

Total AUs: 51.20

CIV519H1 - Structural Analysis II

Credit Value: 0.50
Hours: 38.4L/25.6T

The general flexibility and stiffness methods of analysis; multispan beams, trusses, frames and grids; loadings due to force, support displacement, temperature change and member prestrain; axial and flexural stability; basic plasticity. Topics in this course represent the basis for the finite element method of analysis.

Prerequisite: CIV214H1
Total AUs: 51.20

CIV521H1 - Rock Mechanics

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course provides general analytical tools and experimental methods that are used in rock mechanics. The lectures are complemented with laboratory experiments. Theoretical topics include: stress and strain, linear elasticity, failure modes and models of rocks, fracture of rocks, inelastic behavior of rock, seismic waves in rocks.
Experiments include: preparation of rock samples, uniaxial compressive strength measurements, Brazilian disc tests for rock tensile strength, fracture toughness measurements with core-based rock samples.

Prerequisite: CME210H1
Total AUs: 51.20

CIV523H1 - Geotechnical Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is built around a transportation project that contains all the essential geotechnical investigation and design elements and illustrates how they all come together on a project. The students will be taken through the entire design process from project initiation to construction. In essence, the project will include a bridge over a river with some property constraints requiring the use of a retaining wall as well as deep and shallow foundations and some groundwater control. The highway will require a soil cut. One section crosses a low-lying swampy area that will require embankment construction over deep soft soils. A short tunnel section is planned beneath a railway that cannot be taken out of service. A pavement design will be required along the entire route as well as materials testing and construction monitoring.

Prerequisite: CME321H1; equivalent or permission of instructor
Total AUs: 44.80

CIV531H1 - Transport Planning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is intended to provide the student with the following: the ability to design and execute an urban transportation planning study; a working knowledge of transportation planning analysis skills including introductions to travel demand modelling, analysis of environmental impacts, modelling transportation - land use interactions and transportation project evaluation; an understanding of current transportation planning issues and policies; and an understanding of the overall process of transportation planning and its role within the wider context of transportation decision-making and the planning and design of urban areas. Person-based travel in urban regions is the focus of this course, but a brief introduction to freight and intercity passenger transportation is also provided. A "systems" approach to transportation planning and analysis is introduced and maintained throughout the course. Emphasis is placed throughout on designing transportation systems for long-run environmental, social, and economic sustainability.

Prerequisite: CME368H1 or equivalent
Total AUs: 44.80

CIV536H1 - Urban Activity, Air Pollution, and Health

Credit Value: 0.50
Hours: 38.4L

This is an interdisciplinary course where the challenge of air pollution is introduced with a focus on urban areas. The interdependencies between transportation, air quality, and health are demonstrated. The city and the behaviour of its inhabitants constitute the context for the following course topics: overview of air pollutants in urban areas, urban air quality monitoring networks, mobile source emissions, air pollution and meteorology, atmospheric dispersion, chemical processes specific to cities, personal mobility and exposure to traffic-related air pollution, epidemiology of air pollution.

Total AUs: 38.40

CIV541H1 - Environmental Biotechnology

Credit Value: 0.50
Hours: 38.4L

Principles involved in the design and operation of biologically-based treatment facilities are covered with considerations for energy efficiency and sustainability. The course includes water / wastewater biological unit operations, advanced treatment, sludge processing and composting, natural treatment systems and specialized bioengineered systems such as groundwater remediation and biological air treatment.

Prerequisite: CIV342H1 or equivalent
Total AUs: 38.40

CIV549H1 - Groundwater Flow and Contamination

Credit Value: 0.50
Hours: 38.4L/12.8T

Mechanics of saturated and unsaturated fluid flow in porous media. Confined and unconfined flow. Flow to wells. Analytical and numerical solutions of groundwater flow equations. Non-reactive and reactive contaminant transport on groundwater systems. Analytical and numerical solutions of contaminant transport equations. Flow and solute transport in fractured porous media. Assessment of environmental impacts of waste disposal operations. Remediation of contaminated groundwater.

Prerequisite: CME270H1, CIV250H1 or equivalent
Total AUs: 44.80

CIV550H1 - Water Resources Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Global and national water problems, law and legislation. Hydraulic structures. Reservoir analysis. Urban drainage and runoff control: meteorologic data analysis, deterministic and stochastic modelling techniques. Flood control: structural and nonstructural alternatives. Power generation: hydro and thermal power generation. Low flow augmentation. Economics and decision making.

Prerequisite: CIV250H1, CIV340H1 or equivalent
Total AUs: 51.20

CIV576H1 - Sustainable Buildings

Credit Value: 0.50
Hours: 38.4L/12.8T

Building systems including the thermal envelope, heating and cooling systems, as well as water and lighting systems are examined with a view to reducing the net energy consumed within the building. Life-cycle economic and assessment methods are applied to the evaluation of various design options including considerations of embodied energy and carbon sequestration. Green building strategies including natural ventilation, passive solar, photovoltaics, solar water heaters, green roofs and geothermal energy piles are introduced. Following the application of these methods, students are introduced to efficient designs including LEED designs that lessen the impact of buildings on the environment. Exemplary building designs will be presented and analyzed.

Prerequisite: CIV375H1/CIV575H1 or equivalent
Total AUs: 44.80

CIV577H1 - Infrastructure for Sustainable Cities

Credit Value: 0.50
Hours: 38.4L/12.8T

Developing infrastructure for sustainable cities entails understanding the connection between urban morphology and physiology. This course uses a systems approach to analyzing anthropogenic material flow and other components of urban metabolism, linking them to the design of urban infrastructure. Elements of sustainable transportation, green buildings, urban climatology, urban vegetation, water systems and local energy supply are integrated in the design of sustainable urban neighbourhoods.

Prerequisite: CIV340H1, [CIV375H1/CIV575H1]
Total AUs: 44.80

CIV578H1 - Design of Building Enclosures

Credit Value: 0.50
Hours: 38.4L/25.6T

A brief summary of the science involved in controlling heat, moisture and air movement in buildings is presented at the outset of the course. With this background, methods of designing enclosures for cold, mixed, and hot climates are examined. Design principles related to the design of walls, windows and roofs are presented and applied. In particular, topics related to the control of rain penetration, air movement, and interstitial condensation are studied in detail. Emphasis is placed on developing designs based on fundamentals which can be verified with computer modelling solutions.

Prerequisite: CIV375H1/CIV575H1 or equivalent
Total AUs: 51.20

CIV580H1 - Engineering and Management of Large Projects

Credit Value: 0.50
Hours: 38.4L

This technical elective course will investigate the role of stakeholders in major civil engineering projects; the complexities of managing project stages, multiple stakeholders, and technical challenges, and, social and environmental factors.

Each week includes a different speaker who can address issues related to technical, social, and environmental challenges in the project and how they were overcome.

Total AUs: 38.40

Civil and Mineral Engineering

CME210H1 - Solid Mechanics I

Credit Value: 0.50
Hours: 38.4L/19.2T/19.2P

An introduction to the mechanics of deformable bodies. General biaxial and triaxial stress conditions in continua are studied, as are elastic stress, strain and deformation relations for members subjected to axial load, bending and shear. Properties of plane sections, moment-area theorems for calculating deflection, and Mohr's circle representation of stress and of moment of inertia are examined, followed by a look at stability.

Prerequisite: CIV100H1, MAT186H1, MAT187H1
Exclusion: CIV210H1
Total AUs: 57.60

CME259H1 - Technology in Society and the Biosphere I

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science Elective
This course teaches future engineers to look beyond their specialized domains of expertise in order to understand how technology functions within human life, society and the biosphere. By providing this context for design and decision-making, students will be enabled to do more than achieve the desired results by also preventing or significantly reducing undesired consequences. A more preventively-oriented mode of practicing engineering will be developed in four areas of application: materials and production, energy, work and cities. The emphasis within these topics will reflect the interests of the class.

Exclusion: ESC203H1
Total AUs: 44.80

CME261H1 - Engineering Mathematics I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course deals with both numerical methods for engineering analysis (solution of linear and non-linear equations, interpolation, numerical integration) and advanced topics in analytical calculus (multiple integrals and vector analysis). Within the numerical methods portion of the course emphasis is placed on problem formulation, solution algorithm design and programming applications. Within the analytical calculus portion emphasis is placed on the mathematical foundations of engineering practice and the interrelationship between analytical and numerical solution methods.

Prerequisite: MAT188H1, MAT187H1
Total AUs: 51.20

CME262H1 - Engineering Mathematics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course continues the study of numerical and analytical methods for civil engineering analysis. Analytical and numerical methods for solving ordinary differential equations are treated in some detail, followed by numerical solution methods for partial differential equations. The final major topic of the course deals with an introduction to optimization. Emphasis is placed throughout the course on problem formulation, solution algorithm design and programming applications.

Prerequisite: CME261H1
Exclusion: CME362H1
Total AUs: 51.20

CME263H1 - Probability Theory for Civil and Mineral Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

Probability theory as the study of random phenomena in Civil and Mineral Engineering systems, including the definition of probability, conditional probability, Bayes' theorem in discrete and continuous sample spaces. Common single and multivariate distributions. Mathematical expectation including mean and variance. Independence. An introduction to realizations of probability models and parameter estimation.

Total AUs: 51.20

CME270H1 - Fluid Mechanics I

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Fluid and flow characteristics, applications, dimensions and units. Fluid statics. One-dimensional flow including conservation of mass, energy and momentum. Introduction to dimensional analysis and similitude, laminar and turbulent flow, boundary layer concept, and flow about immersed objects. Calculation of flow in closed conduits and open channels.

Total AUs: 54.40

CME321H1 - Geotechnical Engineering I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

An introduction to elements of geotechnical analysis and design. Basic site investigation techniques and quantitative descriptions of soil properties and behaviour. Permeability, seepage analysis, and internal stability of granular soil; granular filter design for internal hydraulic stability. Compaction of granular soil; engineered fills for earth dams, road bases, and backfills. Soil shear strength at constant volume; ultimate limit state design of retaining walls, shallow footings, natural slopes and constructed embankments. Groundwater flow analysis and slope stability analysis using commercial software. Physical laboratories for basic soil identification, model groundwater flow analysis, direct shear strength tests, and reinforced earth models.

Prerequisite: CME270H1, CME210H1
Total AUs: 51.20

CME358H1 - Survey CAMP (Civil and Mineral Practicals)

Credit Value: 0.50
Hours: 12.8T

This two-week August field camp provides students with the opportunity to further their understanding of the vital interactions between the natural and the built environments. Through fieldwork, students gain hands-on experience in the use of various field instruments used by Civil and Mineral Engineers. The essentials of land surveying and the use of surveying instruments including Global Positioning Systems are taught as students carry out a series of field exercises that include route surveys, topographic surveys and construction surveys. Survey calculations, sources of error, corrections and adjustments are also introduced. In order to better understand our impact on the natural environment, students also perform several additional exercises. These may include the measurement of river flows, remote sensing of soil and rock, remediation of a borrow pit, and the evaluation of the renewable energy potential of the wind and solar radiation. Note: This course requires payment of an extra fee for room and board.

Total AUs: 5.28

CME362H1 - Engineering Mathematics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course continues the study of numerical and analytical methods for civil engineering analysis. Analytical and numerical methods for solving ordinary differential equations are treated in some detail, followed by numerical solution methods for partial differential equations. The final major topic of the course deals with an introduction to optimization. Emphasis is placed throughout the course on problem formulation, solution algorithm design and programming applications.

Exclusion: CIV362H1
Total AUs: 51.20

CME368H1 - Engineering Economics and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

The incorporation of economic and non-monetary considerations for making decision about public and private sector engineering systems in urban and other contexts. Topics include rational decision making; cost concepts; time value of money and engineering economics; microeconomic concepts; treatment of risk and uncertainty; and public project evaluation techniques incorporating social and environmental impacts including benefit cost analysis and multi-objective analysis.

Total AUs: 44.80

CME499H1 - Individual Project

Credit Value: 0.50
Hours: 38.4T

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project and MIN466 Mineral Project Design experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken only once, either in the Fall (F) or Winter (S) Session (0.5 weight), or as a full year (Y) course (1.0 weight).

Total AUs: 19.20

CME499Y1 - Individual Project

Credit Value: 1.00
Hours: 38.4T

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken in either the Fall (F) or Winter (S) Session, but not both (i.e., the Individual Project carries a maximum weight of 0.5; it cannot be made into a full year course)

Total AUs: 19.20

CME500H1 - Fundamentals of Acid Rock Drainage

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Geochemistry of acid rock / acid mine drainage (ARD/AMD) which covers the role of bacteria in generating this global mining pollution issue and how mines currently treat and attempt to prevent it. An introduction to the underlying chemical reactions involved, the role of microbes in these processes and the mitigation and treatment strategies currently available.

* Course offering pending Faculty Council approval for 2018-19 academic year.

Prerequisite: APS110H1/CHE112H1 or equivalent
Total AUs: 57.60

CME525H1 - Tunneling and Urban Excavation

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces fundamental concepts of underground tunneling and its impact on surrounding urban environment. Topics: role of geology on the choice of tunneling methodology; classical and mechanized tunneling excavation methods; interaction between tunnel and surrounding structures; tunnel support methodologies; innovation and current research in tunneling and underground construction.

Total AUs: 44.80

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

Mineral Engineering

MIN225H1 - Introduction to the Resource Industries

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

This course introduces the global resource industries in three parts. In Module 1, students learn about mineral resources in the economy, the origin of ore deposits, mineral exploration and processing techniques, land ownership and environmental issues. Engineering applications are emphasized. Exploration and development topics are investigated. Module 2 presents an introduction to modern mining engineering. The basics of both surface (open pit) and sub-surface mining is covered. Module 3 presents an introduction on the processing of mineral resources into metals. The course helps to develop communication skills through student presentations on current issues in the industry and through training in technical communications by faculty from the Engineering Communications Program. Training for AutoCad and an extensive communications module are provided in the laboratory section. Students will participate in a field trip to an operating mine.
*Only students enrolled in the Lassonde Mineral Engineering program are eligible to participate in the 2nd year field trip.

Total AUs: 57.60

MIN329H1 - Engineering Rock Mechanics

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces students to the fundamental concepts of rock mechanics and their application to rock engineering. The following rock mechanics topics are covered: stress and strain; in situ stress; intact rock strength; discontinuity geometry, strength and stiffness; rock mass behavious; anisotropy, heterogeneity and the size effect; rock mass classifcation schemes. Rock engineering topics include: rock excavation; rock stabilisation; instability mechanisms in foundationas and slopes; rock slope design methods; underground openings in discontinuous and continuous rocks; rock-support interaction; synopsis of numerical methods. Associated laboratory sessions involve stress measurement, core logging, compressive strength determination and index testing.

Exclusion: CIV529H1
Total AUs: 64.00

MIN330H1 - Mining Environmental Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

Total AUs: 44.80

MIN401H1 - Mineral Reserve and Mineral Resource Estimation

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to Mineral Resource and Mineral Reserve Estimation is an advanced level course that focuses on the stages of a mineral resource and mineral reserve estimation program from assembling the database through to reporting under industry guidelines. Major course topics include: statistical analysis of sampling data, geologic interpretation and deposit models; mineral resources estimation approaches and methods, mineral reserve estimation, classification of resources and reserves, and reporting under regulatory standards and industry guidelines for professional practice.

Total AUs: 44.80

MIN430H1 - Mining Environmental Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

Total AUs: 44.80

MIN470H1 - Ventilation and Occupational Health

Credit Value: 0.50
Hours: 38.4L/12.8T

Hydraulics of air flow through underground openings is studied leading to mine ventilation design calculations and ventilation network analysis. Related topics discussed in the course include: statutory regulations and engineering design criteria; application and selection of ventilation fans; auxiliary fan design; air conditioning (heating and cooling); dust and fume control; ventilation economics. Health hazards related to mine gasses, dust and radiation along with relevant statutory requirements are reviewed. Air quality and quantity measurement and survey techniques are presented.

Prerequisite: CIV270H1/CME270H1
Total AUs: 44.80

MIN511H1 - Integrated Mine Waste Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The engineering design of conventional mine waste management systems, including tailings ponds, rock dumps, and underground mine backfill systems, is considered first. Emerging trends in integrated mine waste management systems, including paste stacking and "paste rock" on surface, and cemented paste backfill forunderground mining will then be covered. Engineering case studies will be used throughout, and each case study will be evaluated in terms of how the mine waste systems used contribute to the economic and environmental sustainability of the mining operation.

Prerequisite: CME321H1
Total AUs: 44.80

MIN540H1 - Borehole Geophysics for Engineers and Geoscientists

Credit Value: 0.50
Hours: 38.4L/12.8T

The process of wireline logging of boreholes for mineral, hydrocarbon and groundwater exploration, geotechnical and environmental studies involve a number of measurement devices, or sondes. Some of these are passive measurement devices; others exert some influence over the rock formation being traversed. Their measurements are transmitted to the surface by means of wire line. Logging applications include the identification of geological environment, reservoir fluid contact location, fracture detection, estimate of hydrocarbon or water in place, determination of water salinity, reservoir pressure determination, porosity/pore size distribution determination, and reservoir fluid movement monitoring.

Total AUs: 44.80

Electrical and Computer Engineering

Undergraduate Program in Computer Engineering (AECPEBASC)

Undergraduate Office

Professor Ravi Adve, Associate Chair, Undergraduate Studies
Leanne Dawkins, Program Manager & Academic Advisor
Lina McDonald, Undergraduate Program & Payroll Officer
Karen Irving, Student Advisor
Neena Peterson, Information Services Assistant

Room B600, Sandford Fleming Building
416-946-7179
askece@utoronto.ca

The Computer Engineering undergraduate program is distinctive as it is based on the broad areas of electrical engineering and computer science. These foundations are used in the design and organization of computer systems, design of programs that turn these systems into useful applications and the use of computers in communication and control systems. Design includes hardware, operating systems and software. Computer engineering students will learn how computer systems work and how they can be integrated into larger systems that serve a wide range of users and businesses. As a result, the program also ensures that our students will gain experience in communications, problem-solving and team management.

A computer engineer may be involved in the design of computers and computer systems. They may also be engaged in the design of computer-based communications and control systems or in the design of microelectronic circuits, including computer-aided design and manufacturing. Computer system analysis and the design of both hardware and software for applications, such as artificial intelligence and expert systems, database systems, wireless networks, computer security and robotics, are included in the scope of the computer engineer’s work.

The first two years of study provide the essential background in basic science and mathematics and introduce students to important concepts in electrical and computer engineering, such as circuits, digital systems, electronics and communication systems. These two years of study are identical to those in electrical engineering.

In third and fourth year, the curriculum allows flexibility in students' course selections, subject to the program and accreditation requirements. An online program called "Magellan" helps students facilitate the course selection process. All second-year students have access to Magellan by the end of their fall term. If students have questions regarding their curriculum, they should contact the Department's undergraduate office.

Graduates may decide to go directly into the workforce or pursue studies at the graduate level. Detailed information on graduate studies in the Department can be found online at www.ece.utoronto.ca/graduates-home/.

Graduate Programs in Computer Engineering

Graduate study and research in computer engineering may be pursued through either the Department of Electrical & Computer Engineering or the Department of Computer Science. Both theoretical and applied topics are encouraged. Programs lead to the MEng or MASc degrees in engineering or the MSc in computer science and PhD in either department. Prospective graduate students should consult the appropriate department (ECE or Computer Science) early to determine the most appropriate department to register in.

Undergraduate Program in Electrical Engineering (AEELEBASC)

Undergraduate Office

Professor Ravi Adve, Associate Chair, Undergraduate Studies
Leanne Dawkins, Program Manager and Academic Advisor
Lina McDonald, Undergraduate Program & Payroll Officer
Karen Irving, Student Advisor
Neena Peterson, Information Services Assistant

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Electrical engineering is an exciting and extensive field that applies the principles of science and mathematics with engineering fundamentals which are then used to develop a student's skills needed to analyze, design and build electrical, electronic and photonics systems. The program includes diverse areas of study such as microelectronics, digital communications, wireless systems, photonics systems, signal processing, control, microprocessors, computer technology, energy systems and electronic device fabrication. This breadth is unique to electrical engineering and opens a wide range of career opportunities. As a result, the program also ensures that through their course work, students gain experience in communications, problem-solving and team management.

An electrical engineer may be involved in the design, development and testing of electrical and electronic equipment such as telecommunication systems, industrial process controls, signal processing, navigation systems, power generation, transmission systems, wireless and optical communications and integrated circuit engineering.

The first two years of study provide the essential background in basic science and mathematics and also introduce students to the important concepts in electrical and computer engineering, such as circuits, digital systems, electronics and communication systems. These two years of study are identical to those in computer engineering.

In third and fourth year, the curriculum allows flexibility in students' course selections, subject to the program and accreditation requirements. An online program called "Magellan" helps students facilitate the course selection process. All second-year students have access to Magellan by the end of their fall term. If students have questions regarding their curriculum, they should contact the Department's undergraduate office.

Graduates may decide to go directly into the workforce or pursue studies at the graduate level. Detailed information on graduate studies in the Department can be found online at www.ece.utoronto.ca/graduates-home/.

Graduate Programs in Electrical Engineering

Graduate study and research in electrical engineering may be pursued in either the Department of Electrical & Computer Engineering or the Department of Computer Science. Both theoretical and applied topics are encouraged. Programs lead to the MEng or MASc degrees in engineering or the MSc in computer science and the PhD in either department. Prospective graduate students should consult the appropriate department (ECE or Computer Science) early to determine the most appropriate department to register in.

UNDERGRADUATE PROGRAM IN COMPUTER ENGINEERING (AECPEBASC)

FIRST YEAR COMPUTER ENGINEERING

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session – Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS105H1: Computer Fundamentals	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
ECE191H1: Introduction to Electrical and Computer Engineering	S	1	-	-	0.15
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MIE100H1: Dynamics	S	3	-	2	0.50

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR COMPUTER ENGINEERING

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
ECE201H1: Electrical and Computer Engineering Seminar	F	1	-	-	0.15
ECE212H1: Circuit Analysis	F	3	1.50	2	0.50
ECE241H1: Digital Systems	F	3	3	-	0.50
ECE244H1: Programming Fundamentals	F	3	2	1	0.50
MAT290H1: Advanced Engineering Mathematics	F	3	-	2	0.50
MAT291H1: Calculus III	F	3	-	2	0.50
Winter Session – Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE216H1: Signals and Systems	S	3	1	2	0.50
ECE221H1: Electric and Magnetic Fields	S	3	1	2	0.50
ECE231H1: Introductory Electronics	S	3	1.50	2	0.50
ECE243H1: Computer Organization	S	3	3	-	0.50
One of the following:					
ECE295H1: Hardware Design and Communication	S	2	2m	2m	0.50
ECE297H1: COMMUNICATION AND DESIGN	S	2	2m	2m	0.50

THIRD AND FOURTH YEAR COMPUTER ENGINEERING

Required Course – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
ECE472H1: Engineering Economic Analysis & Entrepreneurship	F/S	3	-	2	0.50
Required Course – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE496Y1: Design Project	Y	1	-	1	1.00

AREA 1 - PHOTONICS & SEMICONDUCTOR PHYSICS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE335H1: Introduction to Electronic Devices	F	3	-	2	0.50
TECHNICAL ELECTIVES					
ECE427H1: Photonic Devices	F	3	-	2	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE318H1: Fundamentals of Optics	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE330H1: Quantum and Semiconductor Physics	S	3	-	2	0.50
ECE437H1: VLSI Technology	S	3	3	-	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50

AREA 2 – ELECTROMAGNETICS & ENERGY SYSTEMS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE314H1: Fundamentals of Electrical Energy Systems	F	3	1.50	1	0.50
ECE320H1: Fields and Waves	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE424H1: Microwave Circuits	F	3	1.50	1	0.50
ECE520H1: Power Electronics	F	3	1.50	1	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE313H1: Energy Systems and Distributed Generation	S	3.	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE422H1: Radio and Microwave Wireless Systems	S	3	1.50	1	0.50
ECE463H1: Electric Drives	S	3	1.50	1	0.50
ECE526H1: Power System Protection and Automation	S	3	1	1	0.50

AREA 3 – ANALOG & DIGITAL ELECTRONICS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE331H1: Analog Electronics	F	3	1.50	1	0.50
ECE334H1: Digital Electronics	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE424H1: Microwave Circuits	F	3	1.50	1	0.50
ECE430H1: Analog Integrated Circuits	F	3	1.50	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE334H1: Digital Electronics	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE412H1: Analog Signal Processing Circuits	S	3	-	2	0.50
ECE437H1: VLSI Technology	S	3	3	-	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50

AREA 4 – CONTROL, COMMUNICATIONS & SIGNAL PROCESSING

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE311H1: Introduction to Control Systems	F	3	1.50	1	0.50
ECE316H1: Communication Systems	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE410H1: Linear Control Systems	F	3	1.50	1	0.50
ECE417H1: Digital Communication	F	3	1.50	1	0.50
ECE421H1: Introduction to Machine Learning	F	3	-	2	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
ECE470H1: Robot Modeling and Control	F	3	1.50	1	0.50
ECE516H1: Intelligent Image Processing	F	3	1.50	1	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE311H1: Introduction to Control Systems	S	3	1.50	1	0.50
ECE316H1: Communication Systems	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	S	3	-	2	0.50
ECE368H1: Probabilistic Reasoning	S	3	1.50	3	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
ECE422H1: Radio and Microwave Wireless Systems	S	3	1.50	1	0.50
ECE462H1: Multimedia Systems	S	3	2	-	0.50
ECE464H1: Wireless Communication	S	3	1.50	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
ECE470H1: Robot Modeling and Control	S	3	1.50	1	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50

AREA 5 – COMPUTER HARDWARE & COMPUTER NETWORKS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE361H1: Computer Networks I	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
ECE552H1: Computer Architecture	F	3	1.50	1	0.50
ECE568H1: Computer Security	F	3	3	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE342H1: Computer Hardware	S	3	3	-	0.50
ECE361H1: Computer Networks I	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	S	3	-	2	0.50

Winter Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
ECE462H1: Multimedia Systems	S	3	2	-	0.50
ECE464H1: Wireless Communication	S	3	1.50	1	0.50
ECE466H1: Computer Networks II	S	3	1.50	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50
ECE568H1: Computer Security	S	3	3	-	0.50

AREA 6 – SOFTWARE

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE344H1: Operating Systems	F	3	3	-	0.50
ECE345H1: Algorithms and Data Structures	F	3	-	2	0.50
TECHNICAL ELECTIVES					
APS360H1: Applied Fundamentals of Machine Learning	F	2	-	2	0.50
CSC343H1: Introduction to Databases	F	2	-	1	0.50
CSC317H1: Computer Graphics	F	2	-	1	0.50
ECE326H1: Programming Languages	F	3	1.50	1	0.50
ECE444H1: Software Engineering	F	3	3	-	0.50
ECE454H1: Computer Systems Programming	F	3	3	-	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE467H1: Compilers & Interpreters	F	3	1.50	1	0.50
ECE568H1: Computer Security	F/S	3	3	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE344H1: Operating Systems	S	3	3	-	0.50
ECE345H1: Algorithms and Data Structures	S	3	-	2	0.50
TECHNICAL ELECTIVES					
APS360H1: Applied Fundamentals of Machine Learning	F	2	-	2	0.50
CSC343H1: Introduction to Databases	S	2	-	1	0.50
CSC317H1	S	2	-	1	0.50
ECE419H1: Distributed Systems	S	3	1.50	1	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
ECE568H1: Computer Security	S	3	3	-	0.50

SCIENCE/MATH ELECTIVES

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
BME440H1: Biomedical Engineering Technology and Investigation	F	2	4	-	0.50
BME455H1: Cellular and Molecular Bioengineering II	F	3	1.50	1	0.50
CHE353H1: Engineering Biology	F	2	-	2	0.50
CIV220H1: Urban Engineering Ecology	F	3	-	1	0.50
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE367H1: Matrix Algebra and Optimization	F	3	-	2	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50

Winter Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
ECE302H1: Probability and Applications	S	3	-	2	0.50
ECE368H1: Probabilistic Reasoning	S	3	-	1	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50

ECE Program Requirements

There are nine requirements:

1. **BREADTH REQUIREMENT**: A minimum of four kernel courses, each in a different area, must be chosen.
2. **DEPTH REQUIREMENT**: Select at least two areas from which one kernel course has been chosen. In each of these two areas, two additional technical courses must be chosen. Kernel courses may also be chosen to meet this requirement.
3. **ENGINEERING ECONOMICS REQUIREMENTS**: ECE472H1 must be chosen. Course can be taken in either third or fourth year.
4. **CAPSTONE REQUIREMENT**: The Design Project, ECE496Y1, must be taken in fourth year. To be eligible to register for the capstone course, you must have at least 7 technical electives or 6 technical electives plus ECE472H1.
5. **MATH/SCIENCE REQUIREMENT**: At least one course from the Math/Science area must be chosen.
6. **TECHNICAL ELECTIVE REQUIREMENT**: A minimum of three additional ECE technical courses must be chosen from any of the six areas of study. With approval from ECE, one of the technical electives can be taken from another department. Only 300, 400 and 500 level courses can be used as a technical elective.
7. **FREE ELECTIVE REQUIREMENT**: One is required, and may be a technical or a non-technical course.
8. **COMPLEMENTARY STUDIES REQUIREMENT**: In each of terms 3F, 3S, 4F, and 4S, a complementary studies course must be taken. Of the four complementary studies courses, a minimum of two must be humanities and social science (HSS) courses chosen from an approved list on the Registrar's website: http://www.undergrad.engineering.utoronto.ca/Office_of_the_Registrar/Electives.htm
9. **PRACTICAL EXPERIENCE REQUIREMENT**: Students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods). Students registered within this program, may elect to enrol and participate in the Professional Experience Year (PEY Co-op) program. The PEY Co-op program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a participating company. Details are described at the beginning of this chapter. For more information, consult the PEY Office early in session 2F or 3F.

A sample course selection arrangement for third and fourth year is shown in the table below.

3F	Technical Elective	Other Science/Math	Area Kernel	Area Kernel	Complementary Studies
3S	Engineering Economics	Depth	Area Kernel	Area Kernel	Complementary Studies
4F	Technical Elective	Depth	Depth	4th Year Design Project	Humanities & Social Science
4S	Free Elective	Technical Elective	Depth	4th Year Design Project	Humanities & Social Science

Degree Designation

If, among the eight courses required to satisfy the Breadth requirement (1) and the Depth requirement (2), at least four are selected from Areas 5 and 6, then the student is eligible for the B.A.Sc. degree in Computer Engineering. If, among these eight courses, at least five are selected from Areas 1 to 4, then the student is eligible for the B.A.Sc. degree in Electrical Engineering. By appropriate choice of kernel courses as technical or free electives, it may be possible to satisfy these requirements simultaneously; in this case, the student must choose one of the two designations.

In addition to the above program requirements, all CEAB requirements, including the minimum number of accreditation units (AU's) in the various CEAB categories, must be met in order to graduate.

CEAB Requirements

To satisfy CEAB requirements, students must accumulate, during four years of study, a minimum number of academic units in six categories: complementary studies, mathematics, basic science, engineering science, engineering design, combined engineering science and design. For details on how to verify satisfaction of CEAB requirements, students are referred to the ECE Undergraduate website:
https://magellan.ece.toronto.edu.

It is recognized that the course selection process can be complex in the flexible curriculum for third and fourth year. Students are advised to consult the ECE Undergraduate Office on questions related to course selection. In addition, tools will be provided to assist students to ensure satisfaction of all requirements in their course selection. For complete details, students are referred to the ECE Department Undergraduate Studies office at askece@utoronto.ca.

A student who selects a course of study that does not meet ECE and CEAB requirements will not be eligible to graduate.

UNDERGRADUATE PROGRAM IN ELECTRICAL ENGINEERING (AEELEBASC)

FIRST YEAR ELECTRICAL ENGINEERING

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session – Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS105H1: Computer Fundamentals	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
ECE191H1: Introduction to Electrical and Computer Engineering	S	1	-	-	0.15
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MIE100H1: Dynamics	S	3	-	2	0.50

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR ELECTRICAL ENGINEERING

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
ECE201H1: Electrical and Computer Engineering Seminar	F	1	-	-	0.15
ECE212H1: Circuit Analysis	F	3	1.50	2	0.50
ECE241H1: Digital Systems	F	3	3	-	0.50
ECE244H1: Programming Fundamentals	F	3	2	1	0.50

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
MAT290H1: Advanced Engineering Mathematics	F	3	-	2	0.50
MAT291H1: Calculus III	F	3	-	2	0.50
Winter Session – Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE216H1: Signals and Systems	S	3	1	2	0.50
ECE221H1: Electric and Magnetic Fields	S	3	1	2	0.50
ECE231H1: Introductory Electronics	S	3	1.50	2	0.50
ECE243H1: Computer Organization	S	3	3	-	0.50
One of the following:					
ECE295H1: Hardware Design and Communication	S	2	2m	2m	0.50
ECE297H1: COMMUNICATION AND DESIGN	S	2	2m	2m	0.50

THIRD AND FOURTH YEAR ELECTRICAL ENGINEERING

Required Course – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
ECE472H1: Engineering Economic Analysis & Entrepreneurship	F/S	3	-	2	0.50
Required Course – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE496Y1: Design Project	Y	1	-	1	1.00

AREA 1 - PHOTONICS & SEMICONDUCTOR PHYSICS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE335H1: Introduction to Electronic Devices	F	3	-	2	0.50
TECHNICAL ELECTIVES					
ECE427H1: Photonic Devices	F	3	-	2	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE318H1: Fundamentals of Optics	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE330H1: Quantum and Semiconductor Physics	S	3	-	2	0.50
ECE437H1: VLSI Technology	S	3	3	-	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50

AREA 2 - ELECTROMAGNETICS & ENERGY SYSTEMS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE314H1: Fundamentals of Electrical Energy Systems	F	3	1.50	1	0.50
ECE320H1: Fields and Waves	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE424H1: Microwave Circuits	F	3	1.50	1	0.50
ECE520H1: Power Electronics	F	3	1.50	1	0.50
Winter Term - Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE313H1: Energy Systems and Distributed Generation	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE422H1: Radio and Microwave Wireless Systems	S	3	1.50	1	0.50
ECE463H1: Electric Drives	S	3	1.50	1	0.50
ECE526H1: Power System Protection and Automation	F	3	1.50	1	0.50

AREA 3 – ANALOG & DIGITAL ELECTRONICS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE331H1: Analog Electronics	F	3	1.50	1	0.50
ECE334H1: Digital Electronics	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE424H1: Microwave Circuits	F	3	1.50	1	0.50
ECE430H1: Analog Integrated Circuits	F	3	1.50	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE334H1: Digital Electronics	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE412H1: Analog Signal Processing Circuits	S	3	-	2	0.50
ECE437H1: VLSI Technology	S	3	3	-	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50

AREA 4 – CONTROL, COMMUNICATIONS & SIGNAL PROCESSING

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE311H1: Introduction to Control Systems	F	3	1.50	1	0.50
ECE316H1: Communication Systems	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE410H1: Linear Control Systems	F	3	1.50	1	0.50
ECE417H1: Digital Communication	F	3	1.50	1	0.50
ECE421H1: Introduction to Machine Learning	F/S	3	-	2	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
ECE470H1: Robot Modeling and Control	F	3	1.50	1	0.50
ECE516H1: Intelligent Image Processing	F	3	1.50	1	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE311H1: Introduction to Control Systems	S	3	1.50	1	0.50
ECE316H1: Communication Systems	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	S	3	-	2	0.50
ECE368H1: Probabilistic Reasoning	S	3	1.50	1	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE421H1: Introduction to Machine Learning	F/S	3	-	2	0.50
ECE422H1: Radio and Microwave Wireless Systems	S	3	1.50	1	0.50
ECE462H1: Multimedia Systems	S	3	2	-	0.50
ECE464H1: Wireless Communication	S	3	1.50	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
ECE470H1: Robot Modeling and Control	S	3	1.50	1	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50

AREA 5 – COMPUTER HARDWARE & COMPUTER NETWORKS

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE361H1: Computer Networks I	F	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
ECE552H1: Computer Architecture	F	3	1.50	1	0.50
ECE568H1: Computer Security	F	3	3	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE342H1: Computer Hardware	S	3	3	-	0.50
ECE361H1: Computer Networks I	S	3	1.50	1	0.50
TECHNICAL ELECTIVES					
ECE302H1: Probability and Applications	S	3	-	2	0.50
ECE462H1: Multimedia Systems	S	3	2	-	0.50
ECE464H1: Wireless Communication	S	3	1.50	1	0.50
ECE466H1: Computer Networks II	S	3	1.50	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50
ECE568H1: Computer Security	S	3	3	-	0.50

AREA 6 – SOFTWARE

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES					
ECE344H1: Operating Systems	F	3	3	-	0.50
ECE345H1: Algorithms and Data Structures	F	3	-	2	0.50
TECHNICAL ELECTIVES					
APS360H1: Applied Fundamentals of Machine Learning	F	2	-	2	0.50
CSC343H1: Introduction to Databases	F	2	-	1	0.50
CSC317H1	F	2	-	1	0.50
ECE326H1: Programming Languages	F	3	1.50	1	0.50
ECE444H1: Software Engineering	F	3	3	-	0.50
ECE454H1: Computer Systems Programming	F	3	3	-	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE467H1: Compilers & Interpreters	F	3	1.50	1	0.50
ECE568H1: Computer Security	F/S	3	3	-	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
KERNEL COURSES					
ECE344H1: Operating Systems	S	3	3	-	0.50
ECE345H1: Algorithms and Data Structures	S	3	-	2	0.50
TECHNICAL ELECTIVES					
APS360H1: Applied Fundamentals of Machine Learning	S	2	-	2	0.50
CSC343H1: Introduction to Databases	S	2	-	1	0.50
CSC317H1	S	2	-	1	0.50
ECE419H1: Distributed Systems	S	3	1.50	1	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
ECE568H1: Computer Security	S	3	3	-	0.50

SCIENCE/MATH ELECTIVES

Fall Term – Year 3 or 4		Lect.	Lab.	Tut.	Wgt.
BME440H1: Biomedical Engineering Technology and Investigation	F	2	4	-	0.50
BME455H1: Cellular and Molecular Bioengineering II	F	3	1.50	1	0.50
CHE353H1: Engineering Biology	F	2	-	2	0.50
CIV220H1: Urban Engineering Ecology	F	3	-	1	0.50
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
ECE302H1: Probability and Applications	F	3	-	2	0.50
ECE357H1: Electromagnetic Fields	S	3	1.50	1	0.50
ECE367H1: Matrix Algebra and Optimization	F	3	-	2	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
Winter Term – Year 3 or 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
ECE302H1: Probability and Applications	S	3	-	2	0.50
ECE368H1: Probabilistic Reasoning	S	3	-	1	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50

ECE Program Requirements

There are nine requirements:

1. **BREADTH REQUIREMENT:** A minimum of four kernel courses, each in a different area, must be chosen.
2. **DEPTH REQUIREMENT:** Select at least two areas from which one kernel course has been chosen. In each of these two areas, two additional technical courses must be chosen. Kernel courses may also be chosen to meet this requirement.
3. **ENGINEERING ECONOMICS REQUIREMENTS:** ECE472H1 must be chosen. Course can be taken in either third or fourth year.
4. **CAPSTONE REQUIREMENT:** The Design Project, ECE496Y1, must be taken in fourth year. To be eligible to register for the capstone course, you must have at least 7 technical electives or 6 technical electives plus ECE472H1.
5. **MATH/SCIENCE REQUIREMENT:** At least one course from the Math/Science area must be chosen.
6. **TECHNICAL ELECTIVE REQUIREMENT:** A minimum of three additional ECE technical courses must be chosen from any of the six areas of study. With approval from ECE, one of the technical electives can be taken from another department. Only 300, 400 and 500 level courses can be used as a technical elective.
7. **FREE ELECTIVE REQUIREMENT:** One is required, and may be a technical or a non-technical course.
8. **COMPLEMENTARY STUDIES REQUIREMENT:** In each of terms 3F, 3S, 4F, and 4S, a complementary studies course must be taken. Of the four complementary studies courses, a minimum of two must be humanities and social science (HSS) courses chosen from an approved list on the Registrar's website: http://www.undergrad.engineering.utoronto.ca/Office_of_the_Registrar/Electives.htm
9. **PRACTICAL EXPERIENCE REQUIREMENT:** Students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods). Students registered within this program, may elect to enrol and participate in the Professional Experience Year (PEY Co-op) program. The PEY Co-op program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a participating company. Details are described at the beginning of this chapter. For more information, consult the PEY Office early in session 2F or 3F.

A sample course selection arrangement for third and fourth year is shown in the table below.

3F	Technical Elective	Other Science/Math	Area Kernel	Area Kernel	Complementary Studies
3S	Engineering Economics	Depth	Area Kernel	Area Kernel	Complementary Studies
4F	Technical Elective	Depth	Depth	4th Year Design Project	Humanities & Social Science

4S	Free Elective	Technical Elective	Depth	4th Year Design Project	Humanities & Social Science

Degree Designation

If, among the eight courses required to satisfy the Breadth requirement (1) and the Depth requirement (2), at least four are selected from Areas 5 and 6, then the student is eligible for the B.A.Sc. degree in Computer Engineering. If, among these eight courses, at least five are selected from Areas 1 to 4, then the student is eligible for the B.A.Sc. degree in Electrical Engineering. By appropriate choice of kernel courses as technical or free electives, it may be possible to satisfy these requirements simultaneously; in this case, the student must choose one of the two designations.

CEAB Requirements

To satisfy CEAB requirements, students must accumulate, during four years of study, a minimum number of academic units in six categories: complementary studies, mathematics, basic science, engineering science, engineering design, combined engineering science and design. For details on how to verify satisfaction of CEAB requirements, students are referred to the ECE Undergraduate website:
https://magellan.ece.toronto.edu.

It is recognized that the course selection process can be complex in the flexible curriculum for third and fourth year. Students are advised to consult the ECE Undergraduate Office on questions related to course selection. In addition, tools will be provided to assist students to ensure satisfaction of all requirements in their course selection. For complete details, students are referred to the ECE Department Undergraduate Studies office at askece@utoronto.ca.

A student who selects a course of study that does not meet ECE and CEAB requirements will not be eligible to graduate.

Electrical and Computer Engineering Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS105H1 - Computer Fundamentals

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and problem solving using computers. Topics include: the representation of information, programming techniques, programming style, basic loop structures, functions, arrays, strings, pointer-based data structures and searching and sorting algorithms. The laboratories reinforce the lecture topics and develops essential programming skills.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

APS360H1 - Applied Fundamentals of Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T

A basic introduction to the history, technology, programming and applications of the fast evolving field of machine learning. Topics to be covered may include neural networks, autoencoders/decoders, recurrent neural networks, natural language processing, and generative adversarial networks. Special attention will be paid to fairness and ethics issues surrounding machine learning. An applied approach will be taken, where students get hands-on exposure to the covered techniques through the use of state-of-the-art machine learning software frameworks.

Prerequisite:
APS105H1/APS106H1/ESC180H1/CSC180H1; APS163/MAT187H1/ESC195H1; MAT185H1/MAT188H1
Recommended Preparation:
CHE223H1/CME263H1/ECE302H1/MIE231H1/MIE236H1/MSE238H1/STA286H1/ECE286H1
Total AUs: 44.80

Biomaterials and Biomedical Engineering

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

BME440H1 - Biomedical Engineering Technology and Investigation

Credit Value: 0.50
Hours: 25.6L/51.2P

Fundamental biomedical research technologies with specific focus on cellular and molecular methodologies. Examples include DNA and protein analysis and isolation, microscopy, cell culture and cellular assays. Combines both theoretical concepts and hand-on practical experience via lectures and wet labs, respectively. Specific applications as applied to biotechnology and medicine will also be outlined and discussed.

Prerequisite: CHE353H1
Total AUs: 51.20

BME445H1 - Neural Bioelectricity

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Generation, transmission and the significance of bioelectricity in neural networks of the brain. Topics covered include: (i) Basic features of neural systems. (ii) Ionic transport mechanisms in cellular membranes. (iii) Propagation of electricity in neural cables. (iv) Extracellular electric fields. (v) Neural networks, neuroplasticity and biological clocks. (vi) Learning and memory in artificial neural networks. Laboratory experiences include: (a) Biological measurements of body surface potentials (EEG and EMG). (b) Experiments on computer models of generation and propagation of neuronal electrical activities. (c) Investigation of learning in artificial neural networks. This course was previously offered as ECE445H1.

Prerequisite: ECE159H1/ECE110H1
Total AUs: 54.40

BME455H1 - Cellular and Molecular Bioengineering II

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Engineering and biophysical tools are used to integrate and enhance our understanding of animal cell behaviour from the molecular to the tissue level. Quantitative methods are used to mathematically model the biology of cell growth, division and differentiation to tissue formation. Specific topics include receptor-ligand interactions, cell adhesion and migration, signal transduction, cell growth and differentiation. Examples from the literature are used to highlight applications in cellular and tissue engineering.

Prerequisite: CHE353H1 and CHE354H1
Total AUs: 54.40

BME595H1 - Medical Imaging

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

An introductory course to medical imaging and is designed as a final year course for engineers. The main clinical imaging modalities are covered: magnetic resonance imaging, ultrasound imaging, x-ray and computed tomography, nuclear medicine, and clinical optical imaging. Emphasis is placed on the underlying physical and mathematical concepts behind each modality, and applications are discussed in the context of how different modalities complement one another in the clinical setting. Early year engineering concepts are extensively used, including: basic electromagnetics theory, fields and waves, signals and systems, digital signal processing, differential equations and calculus, and probability and random processes. The laboratories involve image reconstruction and analysis for the various imaging modalities and a live animal imaging session.

Total AUs: 51.20

Chemical Engineering and Applied Chemistry

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

CIV220H1 - Urban Engineering Ecology

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor Basic concepts of ecology within the context of urban environments. Response of organisms, populations, dynamic predator-prey and competition processes, and ecosystems to human activities. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Biogeochemical cycles, habitat fragmentation and bioaccumulation. Introduction to industrial ecology and life cycle assessment principles. Urban metabolism and material flow analysis of cities. Response of receiving waters to pollution and introduction to waste water treatment. Emphasis is on identifying the environment/engineering interface and minimizing environmental impacts.

Prerequisite: CHE112H1
Total AUs: 44.80

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

Computer Science

CSC326H1 - Programming Languages

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Study of programming styles and paradigms. Included are object-oriented scripting functional and logic-based approaches. Languages that support these programming styles will be introduced. Languages treated include Python, Lisp or Scheme and Prolog.

Exclusion: CSC324H1
Total AUs: 53.60

CSC343H1 - Introduction to Databases

Credit Value: 0.50
Hours: 36L

Introduction to database management systems. The relational data model. Relational algebra. Querying and updating databases: the query language SQL. Application programming with SQL. Integrity constraints, normal forms, and database design. Elements of database system technology: query processing, transaction management.

Prerequisite: CSC111H1/ CSC165H1/ CSC240H1/ (MAT135H1, MAT136H1)/ MAT135Y1/ MAT137Y1/ MAT157Y1/ (MAT186H1, MAT187H1)/ (MAT194H1, MAT195H1)/ (ESC194H1, ESC195H1); CSC207H1/ CSC207H5/ CSCB07H3/ ECE345H1/ ESC190H1
Exclusion: CSC443H1. NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Total AUs: 34.00

CSC467H1 - Compilers and Interpreters

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Compiler organization, compiler writing tools, use of regular expressions, finite automata and context-free grammars, scanning and parsing, runtime organization, semantic analysis, implementing the runtime model, storage allocation, code generation.

Prerequisite: ECE243H1 or ECE352H1
Total AUs: 54.40

Electrical and Computer Engineering

ECE110H1 - Electrical Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An overview of the physics of electricity and magnetism: Coulomb's law, Gauss' law, Ampere's law, Faraday's law. Physics of capacitors, resistors and inductors. An introduction to circuit analysis: resistive circuits, nodal and mesh analysis, 1st order RC and RL transient response and sinusoidal steady-state analysis.

Total AUs: 57.60

ECE191H1 - Introduction to Electrical and Computer Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will introduce first year students to the wealth of subjects within the field of Electrical and Computer Engineering. Instructors will be drawn from the various research groups within the Department. This course will be offered on a credit/no-credit basis. Credit will not be given to students who attend fewer than 70% of the seminars. Students who receive no credit for the course must re-take it in their 2F session. Students who have not received credit for this course at the end of their 2F session will not be permitted to register in session 2S.

Total AUs: 12.80

ECE201H1 - Electrical and Computer Engineering Seminar

Credit Value: 0.15
Hours: 12.8L

This seminar introduces second year students to the various career pathways within the field of Electrical and Computer Engineering. Instructors from various areas will talk about third and fourth year ECE courses in weekly seminars to guide students with the selection of upper year courses. The course also offers talks and advice to aid students transitioning into second year, as well as enhance students' skills such as stress management and time management. This course will be offered on a credit/no credit basis. Credit will not be given to students who attend fewer than 70% of the seminars. Students who receive no credit for the course must re-take it in their 3F session. Students who have not received credit for this course at the end of their 3F session will not be permitted to register for their 3S session.

Total AUs: 12.80

ECE212H1 - Circuit Analysis

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Nodal and loop analysis and network theorems. Natural and forced response of RL, RC, and RLC circuits. Sinusoidal steady-state analysis. Frequency response; resonance phenomena; poles and zeros; applications of the Laplace transform.

Total AUs: 57.90

ECE216H1 - Signals and Systems

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Fundamental discrete- and continuous-time signals, definition and properties of systems, linearity and time invariance, convolution, impulse response, differential and difference equations, Fourier analysis, sampling and aliasing, applications in communications.

Total AUs: 57.60

ECE221H1 - Electric and Magnetic Fields

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

The fundamental laws of electromagnetics are covered, including Coulomb's law, Gauss' law, Poisson's and Laplace's equations, the Biot-Savart law, Ampere's law, Faraday's law, and Maxwell's equations. Vector calculus is applied to determine the relationship between the electric and magnetic fields and their sources (charges and currents). The interaction of the fields with material media will be discussed, including resistance, polarization in dielectrics, magnetization in magnetic materials, properties of magnetic materials and boundary conditions. Other topics include: electric and magnetic forces, the electric potential, capacitance and inductance, electric and magnetic energy, magnetic circuits, and boundary-value problems.

Total AUs: 56.40

ECE231H1 - Introductory Electronics

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

An introduction to electronic circuits using operational amplifiers, diodes, bipolar junction transistors and field-effect transistors.

Total AUs: 60.80

ECE241H1 - Digital Systems

Credit Value: 0.50
Hours: 38.4L/15P

Digital logic circuit design with substantial hands-on laboratory work. Algebraic and truth table representation of logic functions and variables. Optimizations of combinational logic, using "don't cares." Multi-level logic optimization. Transistor-level design of logic gates; propagation delay and timing of gates and circuits. The Verilog hardware description language. Memory in digital circuits, including latches, clocked flip-flops, and Static Random Access Memory. Set-up and hold times of sequential logic. Finite state machines - design and implementation. Binary number representation, hardware addition and multiplication. Tri-state gates, and multiplexers. There is a major lab component using Field-Programmable Gate Arrays (FPGAs) and associated computer-aided design software.

Total AUs: 53.40

ECE243H1 - Computer Organization

Credit Value: 0.50
Hours: 38.4L/38.4P

Basic computer structure. Design of central processing unit. Hardwired control. Input-output and the use of interrupts. Assembly language programming. Main memory organization and caches. Peripherals and interfacing. System design considerations. The laboratory will consist of experiments involving logic systems and microprocessors and a large open project. Design activity constitutes a major portion of laboratory work.

Total AUs: 57.60

ECE244H1 - Programming Fundamentals

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Provides a foundation in programming using an object-oriented programming language. Topics include: classes and objects, inheritance, exception handling, basic data structures (lists, tree, etc.), big-O complexity analysis, and testing and debugging. The laboratory assignments emphasize the use of object-oriented programming constructs in the design and implementation of reasonably large programs.

Prerequisite: APS105H1
Total AUs: 56.40

ECE295H1 - Hardware Design and Communication

Credit Value: 0.50
Hours: 25.6L/12.8T/12.8P

By the end of this course, students will be able to:
1. Work in a team environment in developing a complex hardware project;
2. Intepret design specifications and translate them into a design that attempts to achieve them;
3. Be familiar with agile methods in hardware development, and apply ideas from these methods in their own design process with their team;
4. Demonstrate proficiency using computer aided design (CAD) and electronic design automation (EDA) techniques for hardware development, in particular, schematic capture and printed circuit board layout tools;
5. Demonstrate ability to solder components, familiarity with surface-mount technology, and awareness of the restriction of hazardous substances directive (RoHS);
6. Be familiar with electrostatic discharge (ESD) handling guidelines and protection;
7. Confidently use using laboratory instruments and apply them for testing circuits and systems;
8. Assemble instruments and controlling software for the purpose of automated hardware testing (test automation);
9. Be aware of standards and regulatory compliance when pursuing industrial design; and
10. Demonstrate confidence preparing oral presentations and written documents on technical engineering hardware design.

Prerequisite: ECE212H1, ECE241H1, ECE244H1
Exclusion: ECE297H1
Total AUs: 38.40

ECE297H1 - COMMUNICATION AND DESIGN

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to engineering design processes, illustrated by the design and implementation of a software system, and to effective oral and written communication in a team context. Principles of software design, project management and teamwork are developed in the lectures and tutorials, and students apply these concepts in the laboratories as they work in a team to design and implement a complex software system. Students learn and practice oral and written communication techniques in lectures and in meetings with their communication instructor, and apply these techniques in a variety of documents and presentations, such as short status reports and longer design proposals and design reviews.

Prerequisite: APS105H1, ECE244H1
Exclusion: ECE295H1
Total AUs: 49.60

ECE302H1 - Probability and Applications

Credit Value: 0.50
Hours: 38.4L/25.6T

Events, sample space, axioms of probability. Discrete and continuous random variables, distribution and density functions. Bernoulli trials, Binomial, geometric, Poisson, exponential and Gaussian distributions.
Expectation, moments, characteristic function and correlation coefficient. Functions of random variables. Random vectors, joint distributions, transformations. Applications will be chosen from communication theory, estimation and hypothesis testing, predictive analytics and other areas of electrical and computer engineering.

Prerequisite: MAT290H1 and MAT291H1 and ECE216H1
Exclusion: ECE286H1
Total AUs: 50.40

ECE311H1 - Introduction to Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to dynamic systems and their control. Differential equation models of mechanical, electrical, and electromechanical systems. State variable form. Linearization of nonlinear models and transfer functions. Use of Laplace transform to solve ordinary differential equations. Conversion of models from state variable form to transfer function representation and vice versa. Block diagrams and their manipulation. Time response: transient analysis and performance measures. Properties of feedback control systems. Steady state tracking:the notion of system type. The concept of stability of feedback systems, Routh-Hurwitz stability criterion. Frequency response and stability in the frequency domain. Root locus. Bode and Nyquist plots and their use in feedback control design.

Prerequisite: MAT290H1, MAT291H1, ECE216H1
Total AUs: 54.40

ECE313H1 - Energy Systems and Distributed Generation

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Three-phase systems; steady-state transmission line model; symmetrical three-phase faults; power system stability; symmetrical components; unsymmetrical faults and fault current calculation; distribution network; equivalent steady-state model of voltage-sourced converter; distributed energy resources (DR); distributed energy storage; interface between DR and power system.

Exclusion: ECE413H1
Total AUs: 70.40

ECE314H1 - Fundamentals of Electrical Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Introduction to 3-phase systems, single line diagrams and complex power flow. Energy conversion via switch-mode power electronic circuits: DC/DC converters, DC/AC converters. Energy conversions via magnetic devices: Faraday's law for time varying fields, characterization of hysteresis and eddy current losses in magnetic materials, modelling of magnetic circuits, transformer and inductor modelling and design. Introduction to electromechanical energy conversion: Lorentz Force, concepts of energy, co-energy, forces between ferromagnetic materials carrying flux, simple magnetic actuators.

Prerequisite: ECE212H1 and ECE221H1 and ECE231H1
Exclusion: ECE315H1
Total AUs: 54.40

ECE316H1 - Communication Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in analog and digital communication systems. Analog and digital signals. Signal representation and Fourier transforms; energy and power spectral densities; bandwidth. Distortionless analog communication; amplitude, frequency and phase modulation systems; frequency division multiplexing. Sampling, quantization and pulse code modulation (PCM). Baseband digital communication; intersymbol interference (ISI); Nyquist's ISI criterion; eye diagrams. Passband digital communications; amplitude-, phase- and frequency-shift keying; signal constellations. Performance analysis of analog modulation schemes in the presence of noise. Performance analysis of PCM in noise.

Prerequisite: (MAT290H1, ECE216H1) /(MAT389H1, ECE355H1)
Total AUs: 53.40

ECE318H1 - Fundamentals of Optics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Geometric Optics: Spherical surfaces, lenses and mirrors, optical imaging systems, matrix method, and aberrations. Polarization: Polarizer and polarizations, anisotropic materials, dichroism, birefringence, index ellipsoid, waveplates, optical activity, Faraday effect. Interference: superposition of waves, longitudinal and transverse coherence, Young's double-slit experiment, Michelson and Fabry-Perot interferometer, thin-films. Diffraction and Fourier Optics: diffraction theory, single and double slits, diffraction gratings, spatial filtering, basic optical signal processing. (Background preparation in ECE320H1 F - Fields and Waves, or ECE357H1 S - Electromagnetic Fields, is strongly recommended.)

Prerequisite: ECE221H1 or ECE259H1
Total AUs: 54.40

ECE320H1 - Fields and Waves

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Voltage and current waves on a general transmission line, reflections from the load and source, transients on the line, and Smith's chart. Maxwell's equations, electric and magnetic fields wave equations, boundary conditions, plane wave propagation, reflection and transmission at boundaries, constitutive relations, dispersion, polarization; Poynting vector; waveguides.

Prerequisite: ECE221H1
Total AUs: 53.40

ECE326H1 - Programming Languages

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Study of programming styles and paradigms. Included are object-oriented scripting functional and logic-based approaches. Languages that support these programming styles will be introduced. Languages treated include Python, Lisp or Scheme and Prolog.

Exclusion: CSC324H1, CSC326H1
Total AUs: 54.40

ECE330H1 - Quantum and Semiconductor Physics

Credit Value: 0.50
Hours: 38.4L/25.6T

The course introduces the principles of quantum physics and uses them to understand the behaviour of semiconductors. Topics to be covered include wave-particle duality, Schrodinger's equation, energy quantization, quantum mechanical tunnelling, electrons in crystalline semiconductors and other physical concepts that form the basis for nanotechnology, microelectronics, and optoelectronics.

Prerequisite: ECE221H1/ECE231H1
Exclusion: MSE235H1
Total AUs: 51.20

ECE331H1 - Analog Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Transistor amplifiers, including: differential and multistage amplifiers, integrated circuit biasing techniques, output stage design and IC amplifier building blocks. Frequency response of amplifiers at low, medium and high frequencies. Feedback amplifier analysis. Stability and compensation techniques for amplifiers using negative feedback.

Prerequisite: ECE212H1, ECE231H1
Total AUs: 53.40

ECE334H1 - Digital Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Digital design techniques for integrated circuits. The emphasis will be on the design of logic gates at the transistor level. A number of different logic families will be described, but CMOS will be emphasized. Review of: device modeling, IC processing, and Spice simulation, simplified layout rules, inverter noise margins, transient response, and power dissipation, traditional CMOS logic design, transmission gates, RC timing approximations, input-output circuits, latches and flipflops, counters and adders, decoders and muxes, dynamic gates, SRAMs, DRAMs, and EEPROMs.

Prerequisite: ECE241H1 and ECE231H1 or ECE253H1 and ECE360H1
Total AUs: 54.40

ECE335H1 - Introduction to Electronic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

Electrical behaviour of semiconductor structures and devices. Metal-semiconductor contacts; pn junctions, diodes, photodetectors, LED's; bipolar junction transistors, Ebers-Moll and hybrid-pi models; field effect transistors, MOSFET, JFET/MESFET structures and models; thyristors and semiconductor lasers.

Prerequisite: MAT291H1 and ECE221H1 and ECE231H1
Exclusion: MSE235H1
Total AUs: 51.20

ECE342H1 - Computer Hardware

Credit Value: 0.50
Hours: 38.4L/38.4P

Arithmetic circuits, cubical representation of logic functions, digital system design, timing analysis, design of asynchronous circuits, testing of logic circuits.

Prerequisite: ECE241H1 and ECE243H1
Total AUs: 57.60

ECE344H1 - Operating Systems

Credit Value: 0.50
Hours: 38.4L/38.4P

Operating system structures, concurrency, synchronization, deadlock, CPU scheduling, memory management, file systems. The laboratory exercises will require implementation of part of an operating system.

Prerequisite: ECE244H1 and ECE243H1
Exclusion: ECE353H1
Total AUs: 53.40

ECE345H1 - Algorithms and Data Structures

Credit Value: 0.50
Hours: 38.4L/25.6T

Design and analysis of algorithms and data structures that are essential to engineers in every aspect of the computer hardware and software industry. Recurrences, asymptotics, summations, trees and graphs. Sorting, search trees and balanced search trees, amortized analysis, hash functions, dynamic programming, greedy algorithms, basic graph algorithms, minimum spanning trees, shortest paths, introduction to NP completeness and new trends in algorithms and data structures.

Prerequisite: ECE244H1 or equivalent with the permission of the Chair of the AI certificate/minor.
Total AUs: 50.40

ECE357H1 - Electromagnetic Fields

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to transmission line theory: voltage and current waves, characteristic impedance, reflections from the load and source, transients on the line, Smith's chart, impedance matching. Fundamentals of electromagnetic theory: Maxwell's equations, Helmholtz's theorem, time retarded scalar and vector potentials, gauges, boundary conditions, electric and magnetic fields wave equations and their solutions in lossless and lossy medium. Plane wave propagation, reflection and transmission at boundaries. Constitutive relations and dispersion. Radiating dipole and waveguides.

Prerequisite: ECE259H1
Exclusion: ECE320H1
Total AUs: 54.40

ECE361H1 - Computer Networks I

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Layered network architectures; overview of TCP/IP protocol suite. Introduction to sockets; introduction to application layer protocols. Peer-to-Peer Protocols: ARQ; TCP reliable stream service; flow control. Data Link Controls: Framing; PPP; HDLC. Medium access control and LANs: Aloha; Ethernet; Wireless LANs; Bridges. Packet Switching: Datagram and virtual circuit switching; Shortest path algorithms; Distance vector and link state algorithms.

Prerequisite: ECE286H1 or ECE302H1
Corequisite: ECE302H1. (Students must take the co-requisite, ECE302H1 in the same term as ECE361H, OR in a term before taking ECE361H1.)
Total AUs: 53.40

ECE367H1 - Matrix Algebra and Optimization

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will provide students with a grounding in optimization methods and the matrix algebra upon which they are based. The first past of the course focuses on fundamental building blocks in linear algebra and their geometric interpretation: matrices, their use to represent data and as linear operators, and the matrix decompositions (such as eigen-, spectral-, and singular-vector decompositions) that reveal structural and geometric insight. The second part of the course focuses on optimization, both unconstrained and constrained, linear and non-linear, as well as convex and nonconvex; conditions for local and global optimality, as well as basic classes of optimization problems are discussed. Applications from machine learning, signal processing, and engineering are used to illustrate the techniques developed.

Prerequisite: AER210H1/MAT290H1, MAT185H1/MAT188H1
Total AUs: 51.20

ECE368H1 - Probabilistic Reasoning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will focus on different classes of probabilistic models and how, based on those models, one deduces actionable information from data. The course will start by reviewing basic concepts of probability including random variables and first and second-order statistics. Building from this foundation the course will then cover probabilistic models including vectors (e.g., multivariate Gaussian), temporal (e.g., stationarity and hidden Markov models), and graphical (e.g., factor graphs). On the inference side topics such as hypothesis testing, marginalization, estimation, and message passing will be covered. Applications of these tools cover a vast range of data processing domains including machine learning, communications, search, recommendation systems, finance, robotics and navigation.

Prerequisite: ECE286H1/ECE302H1
Exclusion: CSC412H1
Total AUs: 44.80

ECE410H1 - Linear Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

State space analysis of linear systems, the matrix exponential, linearization of nonlinear systems. Structural properties of linear systems: stability, controllability, observability, stabilizability, and detectability. Pole assignment using state feedback, state estimation using observers, full-order and reduced-order observer design, design of feedback compensators using the separation principle, control design for tracking. Control design based on optimization, linear quadratic optimal control, the algebraic Riccati equation. Laboratory experiments include computer-aided design using MATLAB and the control of an inverted pendulum on a cart.

Prerequisite: ECE311H1
Exclusion: ECE557H1
Total AUs: 53.40

ECE411H1 - Real-Time Computer Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Digital Control analysis and design by state-space methods. Introduction to scheduling of control tasks using fixed-priority protocols. Labs include control design using MATLAB and Simulink, and computer control of the inverted pendulum using a PC with real-time software.

Prerequisite: ECE311H1 or ECE356H1
Total AUs: 54.40

ECE412H1 - Analog Signal Processing Circuits

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will provide students with an overview of continuous-time and discrete-time signal processing techniques, and the analysis and design of analog and mixed-signal circuit building blocks used in modern electronic systems. Topics covered include: analysis, specification, simulation, and design of continuous-time filters with linear transconductors and op-amps; phase-domain model, noise model, and design methodology for low phase noise Phase Lock Loops and associated building blocks (VCO, phase-frequency detector, charge pump); discrete-time signal analysis using z-transform; discrete-time filter design based on switched capacitors; as well as fundamentals, architectures, building blocks, and characterization techniques for digital-to-analog and analog-to-digital converters.

Prerequisite: ECE331H1 or ECE354H1
Exclusion: ECE512H1
Total AUs: 51.20

ECE417H1 - Digital Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Basic concepts of digital communication. Baseband data transmission, intersymbol interference, Nyquist pulse shaping, equalization, line coding, multi-path fading, diversity. Binary and M-ary modulation schemes, synchronization. Signal space concepts, optimum receivers, coherent and noncoherent detectors. Information theory, source encoding, error control coding, block and convolutional codes.

Prerequisite: ECE302H1 and ECE316H1, or ECE286H1
Total AUs: 54.40

ECE419H1 - Distributed Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Design issues in distributed systems: heterogeneity, security, transparency, concurrency, fault-tolerance; networking principles; request-reply protocol; remote procedure calls; distributed objects; middleware architectures; CORBA; security and authentication protocols; distributed file systems; name services; global states in distributed systems; coordination and agreement; transactions and concurrency control; distributed transactions; replication.

Prerequisite: ECE344H1 or ECE353H1
Total AUs: 53.40

ECE421H1 - Introduction to Machine Learning

Credit Value: 0.50
Hours: 38.4L/25.6T

An Introduction to the basic theory, the fundamental algorithms, and the computational toolboxes of machine learning. The focus is on a balanced treatment of the practical and theoretical approaches, along with hands on experience with relevant software packages. Supervised learning methods covered in the course will include: the study of linear models for classification and regression, neural networks and support vector machines. Unsupervised learning methods covered in the course will include: principal component analysis, k-means clustering, and Gaussian mixture models. Theoretical topics will include: bounds on the generalization error, bias-variance tradeoffs and the Vapnik-Chervonenkis (VC) dimension. Techniques to control overfitting, including regularization and validation, will be covered.

Prerequisite: ECE286H1/STA286H1, ECE302H1/MIE231H1/CHE223H1/MIE236H1/MSE238H1
Exclusion: CSC411H1, ECE521H1
Total AUs: 51.20

ECE422H1 - Radio and Microwave Wireless Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Analysis and design of systems employing radio waves, covering both the underlying electromagnetics and the overall system performance aspects such as signal-to-noise ratios. Transmission/reception phenomena include: electromagnetic wave radiation and polarization; elementary and linear dipoles; directivity, gain, efficiency; integrated, phased-array and aperture antennas; beam-steering; Friis transmission formula and link budget. Propagation phenomena include: diffraction and wave propagation over obstacles; multipath propagation; atmospheric and ionospheric effects. Receiver design aspects include: radio receiver architectures, receiver figures of merit, noise in cascaded systems, noise figure, and noise temperature. System examples are: terrestrial communication systems; satellite communications; radar; radiometric receivers; software-defined radio.

Prerequisite: ECE320H1 or ECE357H1
Total AUs: 54.40

ECE424H1 - Microwave Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Losses in conductors and dielectrics; RF and microwave transmission lines; transients on transmission lines; matching networks; planar transmission lines (microstrip, stripline, coplanar waveguide); design with scattering parameters; 3- and 4-port RF devices (power dividers/combiners, couplers, isolators & circulators); coupled lines and devices; microwave active circuits (RF amplifiers, mixers, and receiver front ends); RF and microwave filters. The hands-on laboratories engage students in the design, simulation, fabrication, and test of practical passive and active microwave circuits using industry-standard RF/microwave simulation tools and measurement systems.

Exclusion: ECE524H1
Total AUs: 54.40

ECE427H1 - Photonic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

The human visual interface is rapidly evolving with the emergence of smart glasses, AR/VR wearable display, and autonomous vehicles. This course examines the photonic devices and integrated systems that underline such technologies, and how they are shaped by human visual perception and acuity. Advanced integrated photonic systems in optical display and sensing will be deconstructed and the underlying fundamental concepts studied. Topics include introduction to: heads up and wearable display, optical lidar, optical fiber, waveguide circuits, holography, optical switches, light sources (LED, laser), detectors and imaging sensors.

Prerequisite: ECE318H1/ECE320H1/ECE357H1
Total AUs: 51.20

ECE430H1 - Analog Integrated Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Review of MOSFET semiconductor device equations. Noise in electronic devices. Review of single-stage amplifiers and frequency response, including noise analysis. Basic CMOS op amp. Op amp compensation. Advanced op amp circuits: telescopic and folded-cascode op amps. Fully-differential op amps. Common mode feedback.

Prerequisite: ECE331H1 or ECE354H1
Exclusion: ECE530H1
Total AUs: 54.40

ECE431H1 - Digital Signal Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in digital filtering and applications. Introduction to real world signal processing. Review of sampling and quantization of signals. Introduction to the discrete Fourier transform and its properties. The fast Fourier transform. Fourier analysis of signals using the discrete Fourier transform. Structures for discrete-time systems. Design and realization of digital filters: finite and infinite impulse response filters. DSP applications in areas such as communications, multimedia, video coding, human computer interaction and medicine.

Total AUs: 54.40

ECE437H1 - VLSI Technology

Credit Value: 0.50
Hours: 38.4L/38.4P

The introduction to VLSI fabrication techniques, integrated circuit designs and advanced semiconductor devices will give a proper perspective of the past, present and future trends in the VLSI industry. Following the evolution of MOS and bipolar devices, digital and analog CMOS, BiCMOS, deep submicron CMOS, SOI-CMOS, RF-CMOS and HV-CMOS technologies will be studied. Special attention will be given to the physical scaling limits such as short channel effects. In addition, CAD tools and design methodology for the development of advanced semiconductor devices and integrated circuits will be introduced in the laboratory environment. These include the simulation of device fabrication, device characteristics, device modeling, circuit layout, design verification. Finally, advanced technology such as GaN HEMTs, graphene devices, carbon nano-tube devices, power devices, heterojunctions, InP and GaSb HBTs will also be studied.

Prerequisite: (ECE331H1 or ECE334H1 or ECE354H1) and (ECE335H1 or ECE350H1)
Exclusion: ECE535H1 and ECE534H1
Total AUs: 57.60

ECE444H1 - Software Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

The software development process. Software requirements and specifications. Software design techniques. Techniques for developing large software systems; CASE tools and software development environments. Software testing, documentation and maintenance.

Prerequisite: ECE344H1 or ECE353H1
Exclusion: CSC444H1
Total AUs: 64.00

ECE445H1 - Neural Bioelectricity

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Generation, transmission and the significance of bioelectricity in neural networks of the brain. Topics covered include: (i) Basic features of neural systems. (ii) Ionic transport mechanisms in cellular membranes. (iii) Propagation of electricity in neural cables. (iv) Extracellular electric fields. (v) Neural networks, neuroplasticity and biological clocks. (vi) Learning and memory in artificial neural networks. Laboratory experiences include: (a) Biological measurements of body surface potentials (EEG and EMG). (b) Experiments on computer models of generation and propagation of neuronal electrical activities. (c) Investigation of learning in artificial neural networks.

Total AUs: 54.40

ECE446H1 - Sensory Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Physical acoustics, acoustic measurements, electroacoustic transducers, and physiological acoustics. Speech processing, speech recognition algorithms and signal processing by the auditory system. Engineering aspects of acoustic design. Electrical models of acoustic systems. Noise, noise-induced hearing loss, and noise control. Introduction to vision and other modalities. Musical and psychoacoustics.

Total AUs: 54.40

ECE448H1 - Biocomputation

Credit Value: 0.50
Hours: 38.4L/25.6T

Modern technologies in the biosciences generate tremendous amounts of biological data ranging from genomic sequences to protein structures to gene expression. Biocomputations are the computer algorithms used to reveal the hidden patterns within this data. Course topics include basic concepts in molecular cell biology, pairwise sequence alignment, multiple sequence alignment, fast alignment algorithms, deep learning approaches, phylogentic prediction, structure-based computational methods, gene finding and annotation.

Total AUs: 51.20

ECE454H1 - Computer Systems Programming

Credit Value: 0.50
Hours: 38.4L/38.4P

Fundamental techniques for programming computer systems, with an emphasis on obtaining good performance. Topics covered include: how to measure and understand program and execution and behaviour, how to get the most out of an optimizing compiler, how memory is allocated and managed, and how to exploit caches and the memory hierarchy. Furthermore, current trends in multicore, multithreaded and data parallel hardware, and how to exploit parallelism in their programs will be covered.

Total AUs: 53.40

ECE461H1 - Internetworking

Credit Value: 0.50
Hours: 38.4L/6.4T/19.2P

This course will cover the fundamentals of protocols for packet switching networks with emphasis on Internet type of networks including the following topics: the Internetworking concept and architectural model; data link layer (Ethernet and PPP); service interface; Internet addresses; address resolution protocol; Internet protocol (connectionless datagram delivery); routing IP datagrams; Internet control message protocol (error and control messages); subnet and supernet address extensions; ping program; traceroute program; user datagram protocol; reliable stream transport service (TCP); the socket interface; routing (GGP, EGP, IP, OSPF, HELLO); Internet multicasting; domain name system; applications such as HTTP, electronic mail, and SNMP; Internet security and firewall design; Ipv6, RSVP, flows, and ISIP.

Prerequisite: ECE361H1
Total AUs: 51.20

ECE462H1 - Multimedia Systems

Credit Value: 0.50
Hours: 38.4L/25.6P

Topics in the engineering area of multimedia systems with particular emphasis on the theory, design features, performance, complexity analysis, optimization and application of multimedia engineering technologies. Topics include sound/audio, image and video characterization, compression, source entropy and hybrid coding, transform coding, wavelet-based coding, motion estimation, JPEG coding, digital video coding, MPEG-1/2 coding, content-based processing, and MPEG-7.

Total AUs: 48.40

ECE463H1 - Electric Drives

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Electro-mechanical mechanisms for force and torque production in rotating machines. DC machine theory and DC machine dynamics, synchronous machines and their dynamics, stepper motors. Introduction to space vectors and vector control of AC machines. Steady state and variable speed operation of the induction machine via V/f control.

Prerequisite: ECE314H1/ECE315H1/ECE349H1/ECE359H1, ECE311H1/ECE356H1/AER372H1
Corequisite: ECE311H1/ECE356H1/AER372H1
Total AUs: 53.40

ECE464H1 - Wireless Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The radio medium, radio communication system examples. Link budget: cable losses, propagation loss, antenna gains. Basic concepts of propagation: path loss, multi-path propagation and fading. Raleigh and Rician fading models, Doppler shift, delay spread, coherence time and coherence bandwidth of the channel. Analog modulation schemes and their bandwidths. Digital modulation schemes and their bandwidths and bit rates: BPSK, QPSK, MSK, GMSK. Basic concepts of speech coding. Error correction coding, interleaving, and multiple access frame structure. The physical layer description of the AMPS, IS-54, and GSM cellular systems. The cellular concept: frequency re-use, re-use cluster concept. Channel allocation. Cellular system architecture for AMPS, IS-54, and GSM. Hand-offs and transmitter power control. Cellular traffic, call blocking, concept of Erlangs. Basic ideas in spread spectrum modulation, spreading codes, bit error probability. Orthogonal and non-orthogonal CDMA Basic concepts in CDMA networks.

Prerequisite: ECE302H1 and ECE316H1 and ECE417H1, or ECE286H1 and ECE417H1
Total AUs: 54.40

ECE466H1 - Computer Networks II

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Traffic modeling; network calculus; traffic classification; traffic regulation: shaping, filtering, policing, leaky bucket; queueing systems; scheduling; quality of service: Diffserv and IntServ/RSVP; multi-protocol label switching; call admission control / congestion control; switching; pricing; optical networks.

Prerequisite: ECE361H1
Total AUs: 54.40

ECE467H1 - Compilers & Interpreters

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Compiler organization, compiler writing tools, use of regular expressions, finite automata and context-free grammars, scanning and parsing, runtime organization, semantic analysis, implementing the runtime model, storage allocation, code generation.

Prerequisite: ECE243H1/ECE352H1
Exclusion: CSC467H1
Total AUs: 54.40

ECE469H1 - Optical Communications and Networks

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course provides an introduction to optical communication systems and networks at the system and functional level. Applications range from telecommunication networks (short to long haul) to computing networks (chip-to-chip, on chip communications, optical backplanes). Basic principles of optical transmission and associated components used for transmission of light and optical networks; system design tools for optical links; multi-service system requirements; optical network design tools (routing and wavelength assignment), network management and survivability.

Total AUs: 54.40

ECE470H1 - Robot Modeling and Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Classification of robot manipulators, kinematic modeling, forward and inverse kinematics, velocity kinematics, path planning, point-to-point trajectory planning, dynamic modeling, Euler-Lagrange equations, inverse dynamics, joint control, computed torque control, passivity-based control, feedback linearization.

Prerequisite: ECE311H1 or ECE356H1
Exclusion: AER525H1
Total AUs: 53.40

ECE472H1 - Engineering Economic Analysis & Entrepreneurship

Credit Value: 0.50
Hours: 38.4L/25.6T

The economic evaluation and justification of engineering projects and investment proposals are discussed. Cost concepts; financial and cost accounting; depreciation; the time value of money and compound interest; inflation; capital budgeting; equity, bond and loan financing; income tax and after-tax cash flow in engineering project proposals; measures of economic merit in the public sector; sensitivity and risk analysis. Applications: evaluations of competing engineering project alternatives; replacement analysis; economic life of assets; lease versus buy decisions; break-even and sensitivity analysis. Entrepreneurship and the Canadian business environment will be discussed.

Total AUs: 50.40

ECE496Y1 - Design Project

Credit Value: 1.00
Hours: 12.8L/12.8T

A full year capstone design project course intended to give students an opportunity to apply their technical knowledge and communication skills. Working in teams under the direct supervision of a faculty member, students develop a design project of their choice from an initial concept to a final working prototype. In the first session, a project proposal is submitted early on, followed by a project requirements specification. A design review meeting is then held to review the proposed design. Lectures given during the first session will develop expertise in various areas related to design and technical communication. In the second session, the teams present their work in a number of ways, including an oral presentation, a poster presentation, a final demonstration at the Design Fair, an individual progress report, and a group final report. Course deliverables are evaluated by both the team's supervisor and one of several course administrators.

Exclusion: APS490Y1
Total AUs: 107.80

ECE516H1 - Intelligent Image Processing

Credit Value: 0.50
Hours: 38.4L/38.4P

This course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics, including "Wearable Computing", "Personal Technologies", "Human Computer Interaction (HCI)," "Mobile Multimedia," "Augmented Reality," "Mediated Reality," CyborgLogging," and the merging of communications devices such as portable telephones with computational and imaging devices. The focus is on fundamental aspects and new inventions for human-computer interaction. Topics to be covered include: mediated reality, Personal Safety Devices, lifelong personal video capture, the Eye Tap principle, collinearity criterion, comparametric equations, photoquantigraphic imaging, lightvector spaces, anti-homomorphic imaging, application of personal imaging to the visual arts, and algebraic projective geometry.

Total AUs: 57.60

ECE520H1 - Power Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Focuses on power electronic converters utilized in applications ranging from low-power mobile devices to higher power applications such as electric vehicles, server farms, microgrids, and renewable energy systems. Concepts covered include the principles of efficient electrical energy processing (dc-dc, dc/ac, and ac/ac) through switch-mode energy conversion, converter loss analysis, large- and small-signal modeling of power electronic circuits and controller design.

Prerequisite: ECE314H1/ECE349H1/ECE359H1
Exclusion: ECE514H1, ECE533H1
Total AUs: 52.90

ECE525H1 - Lasers and Detectors

Credit Value: 0.50
Hours: 38.4L/25.6T

This course focuses on photonic components which generate or absorb light. Lasers: spontaneous and stimulated emission, gain and absorption, gain broadening; modulation dynamics, mode-locking, Q-switching; semiconductor lasers. Photodetectors: absorption, photo-generated currents, noise in detection.

Not offered in 2015/16.

Prerequisite: One of ECE330H1/ECE350H1 or PHY335H1/PHY355H1, and one of ECE318H1/ECE320H1/ECE357H1. ECE318H1 can also be taken as a co-requisite instead of a pre-requisite.
Total AUs: 51.20

ECE526H1 - Power System Protection and Automation

Hours: 38.4L/12.8T/16.2P

Presents the concepts of short-circuit fault analysis, protective relaying, and automation in power systems. The course starts by discussing the causes and types of short-circuit faults using real-world examples. The consequences of faults for different power system components will be reviewed using event reports from field data. The method of symmetrical components for analyzing unbalanced three-phase systems will be introduced. Analytical methods and computer-based approaches for deriving fault voltages and currents will be discussed and the effect of system grounding during transient conditions, including faults, will be introduced. Students will also learn the concept of power system automation and its role in monitoring, protection. and control of modern power systems. Critical devices used in an automation system, such as breakers, relays, reclosers, capacitor bank controllers, and tap changer controllers will be presented.

Prerequisite: ECE313H1/ECE314H1/ECE349H1
Total AUs: 52.90

ECE532H1 - Digital Systems Design

Credit Value: 0.50
Hours: 38.4L/38.4P

Advanced digital systems design concepts including project planning, design flows, embedded processors, hardware/software interfacing and interactions, software drivers, embedded operating systems, memory interfaces, system-level timing analysis, clocking and clock domains. A significant design project is undertaken and implemented on an FPGA development board.

Prerequisite: ECE342H1 or ECE352H1
Total AUs: 57.60

ECE537H1 - Random Processes

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to the principles and properties of random processes, with applications to communications, control systems, and computer science. Random vectors, random convergence, random processes, specifying random processes, Poisson and Gaussian processes, stationarity, mean square derivatives and integrals, ergodicity, power spectrum, linear systems with stochastic input, mean square estimation, Markov chains, recurrence, absorption, limiting and steady-state distributions, time reversibility, and balance equations.

Prerequisite: ECE286H1 and ECE355H1 or ECE302H1
Corequisite: ECE355H1 (can be taken at the same time as ECE537H1)
Total AUs: 50.40

ECE552H1 - Computer Architecture

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Performance analysis and metrics and cost. Instruction set architectures. Instruction-level parallelism: pipelining, superscalar, dynamic scheduling, VLIW processors. Data-level prallelism: vector processors, GPUs. Thread-level parallelism: multiprocessors, multi-core, coherence, simultaneous multi-threading. Memory hierarchies: caches and virtual memory support. Simulation tools and methods. Limited Enrollment.

Prerequisite: ECE243H1 or ECE352H1
Total AUs: 54.40

ECE568H1 - Computer Security

Credit Value: 0.50
Hours: 38.4L/38.4P

As computers permeate our society, the security of such computing systems is becoming of paramount importance. This course covers principles of computer systems security. To build secure systems, one must understand how attackers operate. This course starts by teaching students how to identify security vulnerabilities and how they can be exploited. Then techniques to create secure systems and defend against such attacks will be discussed. Industry standards for conducting security audits to establish levels of security will be introduced. The course will include an introduction to basic cryptographic techniques as well as hardware used to accelerate cryptographic operations in ATM's and webservers.

Prerequisite: ECE344H1 or ECE353H1
Total AUs: 53.40

Engineering Science

ESC384H1 - Partial Differential Equations

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces techniques to analyze and solve partial differential equations (PDEs). Concepts covered include Fourier series, Sturm-Liouville theory, separation of variables, fundamental solutions, Green's functions, method of characteristics, and numerical methods. Applications are in model PDEs in continuum mechanics: heat, Laplace's, wave, and transport equations.

Prerequisite: MAT290H1/MAT292H1
Total AUs: 44.80

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

MAT290H1 - Advanced Engineering Mathematics

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to complex variables and ordinary differential equations. Topics include: Laplace transforms, ordinary higher-order linear differential equations with constant coefficients; transform methods; complex numbers and the complex plane; complex functions; limits and continuity; derivatives and integrals; analytic functions and the Cauchy-Riemann equations; power series as analytic functions; the logarithmic and exponential functions; Cauchy's integral theorem, Laurent series, residues, Cauchy's integral formula, the Laplace transform as an analytic function. Examples are drawn from electrical systems.

Total AUs: 50.40

MAT291H1 - Calculus III

Credit Value: 0.50
Hours: 38.4L/25.6T

The chain rule for functions of several variables; the gradient. Multiple integrals; change of variables, Jacobians, line integrals, the divergence and curl of a vector field. Surface integrals; parametric and explicit representations, Divergence theorem and Stokes' theorem and applications from electromagnetic fields and Green's theorem.

Total AUs: 50.40

Mechanical and Industrial Engineering

MIE100H1 - Dynamics

Credit Value: 0.50
Hours: 38.4L/25.6T

This course on Newtonian mechanics considers the interactions which influence 2-D, curvilinear motion. These interactions are described in terms of the concepts of force, work, momentum and energy. Initially the focus is on the kinematics and kinetics of particles. Then, the kinematics and kinetics of systems of particles and solid bodies are examined. Finally, simple harmonic motion is discussed. The occurrence of dynamic motion in natural systems, such as planetary motion, is emphasized. Applications to engineered systems are also introduced.

Exclusion: APS161H1
Total AUs: 51.20

Engineering Science

Undergraduate Program in Engineering Science (AEESCBASE)

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Engineering Science is an enriched program that provides excellent preparation for postgraduate studies in engineering and science as well as for other professional degree programs such as business, law and medicine. Program graduates are also well qualified to immediately embark on professional engineering-related careers.

The Engineering Science program shares elements of the Faculty's engineering programs, but the program is distinct in many respects. Key differences include:

- The Engineering Science program is designed and delivered at a level that is more academically demanding.
- The Engineering Science program contains more mathematics, science and engineering science, with a greater focus on deriving results using a first-principles approach.
- The Engineering Science program has a distinct "2+2" curriculum structure, namely a two-year foundation curriculum followed by a two-year specialization curriculum in a diverse range of fields, many of which are unique to the Engineering Science program.
- The Engineering Science program requires that all students complete an independent research-based thesis project.

Engineering Science students in years one, two and three are required to maintain a full course load unless they obtain permission from their academic advisor to pursue part-time studies or less than a full course load. Students entering year four are expected to maintain a full course load, but students with medical or personal reasons or who have completed program requirements prior to year four may go part-time or less than a full course load in 4F and / or 4W. This is subject to the approval of the student's academic advisor. A reduced course load in 4F or 4W may impact award assessments. Please refer to the academic calendar under "Academic Regulations VII: Academic Standing" for Honours Standing criteria as related to course load and consult your academic advisor for more information.

Transfers from first-year Engineering Science to one of the Faculty's Core 8 engineering programs are permitted early in the Fall Term (typically within the first two weeks of the Fall Term), the end of the Fall Term and the end of the Winter Term. Continuation into the Winter Term of year one requires a minimum average of 55% in the Fall Term; continuation into year two requires a minimum average of 65% in the Winter Term of year one. Students who do not meet these requirements are required to transfer into one of the Faculty's Core 8 programs, subject to the requirements and provisions outlined in the section on Academic Regulations in this Calendar.

Engineering Science Curriculum

The first two years of the curriculum focus on the foundations of both engineering and science. The courses in the first two years of the program are common for all students and are only offered to students in the program. At the end of second year, each student selects one of the following majors (represents their major field of specialization) to pursue in their final two years:

- Aerospace Engineering
- Biomedical Systems Engineering
- Electrical & Computer Engineering
- Energy Systems Engineering
- Machine Intelligence
- Engineering Mathematics, Statistics & Finance
- Engineering Physics
- Robotics Engineering

The curriculum for the first two years and the curricula for the eight majors are presented below.

Degree Designation

An Engineering Science student graduates with the degree "Bachelor of Applied Science in Engineering Science." On their official transcript, their chosen Option is indicated as their Major (e.g. Major in Aerospace Engineering).

Degree Requirements

To graduate, students must meet all of the degree requirements outlined in the section on Academic Regulations in this Calendar. In addition to these requirements, students must also complete their chosen Program of Study in Engineering Science as described on the following pages of this Calendar, as well as the curriculum requirements of the Canadian Engineering Accreditation Board (CEAB).

To complete their chosen Program of Study, students are responsible for ensuring that they have taken all of the required courses and the correct number of technical electives for their Major. Students may request elective course substitutions, but any such substitutions must be approved in advance by the Division of Engineering Science through the student's academic advisor. This also applies to any course listed as "Other Technical Elective." Students must also meet the Complementary Studies (CS) requirements of the program. This includes 2.0 credits, of which 1.0 credit must be in Humanities and Social Sciences (HSS). More information on CS and HSS electives may be found in the Curriculum & Programs section of this Calendar. Students may change the term in which they take Technical and CS/HSS Electives (for example, switch a CS/HSS elective in year three Fall with a Technical Elective in Year four Fall), as long as they meet the elective requirements for their Major.

To satisfy CEAB requirements, students must accumulate during their program of study a minimum total number of accreditation units (AU) as well as a minimum number of AU in six categories: complementary studies, mathematics, natural science, engineering science, engineering design and combined engineering science and design. The Division of Engineering Science provides students with a planning tool called the AU Tracker to help students ensure that they satisfy these requirements. The AU Tracker, which lists all successfully completed courses as well as all of the courses they are enrolled in for the current academic year, confirms whether students are on track to meet or exceed the CEAB requirements.

If a student is deficient in terms of the Program of Study or falls short in any of the CEAB categories, the student must adjust their course selection accordingly to graduate.

Practical Experience Requirement

Students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods). Satisfactory completion of the Professional Experience Year (PEY) Co-op Program will also completely fulfil the Practical Experience Requirement.

Undergraduate: Common First Two Years

UNDERGRADUATE PROGRAM IN ENGINEERING SCIENCE (AEESCBASE)

YEAR 1 CURRICULUM- ENGINEERING SCIENCE

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
CIV102H1: Structures and Materials - An Introduction to Engineering Design	F	3	1	1	0.50
ESC101H1: Praxis I	F	3	1	2	0.50
ESC103H1: Engineering Mathematics and Computation	F	2	-	2	0.50
ESC180H1: Introduction to Computer Programming	F	3	3	-	0.50
ESC194H1: Calculus I	F	3	-	1	0.50
PHY180H1: Classical Mechanics	F	3	2	-	0.50
Winter Session - Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE159H1: Fundamentals of Electric Circuits	S	3	1.50	1	0.50
ESC102H1: Praxis II	S	3	1	2	0.50
ESC190H1: Computer Algorithms and Data Structures	S	3	3	-	0.50
ESC195H1: Calculus II	S	3	-	1	0.50
MAT185H1: Linear Algebra	S	3	-	1	0.50
MSE160H1: Molecules and Materials	S	3	-	1	0.50

YEAR 2 CURRICULUM - ENGINEERING SCIENCE

Fall Session - Year 2		Lect.	Lab.	Tut.	Wgt.
AER210H1: Vector Calculus & Fluid Mechanics	F	3	0.50	2	0.50
CHE260H1: Thermodynamics and Heat Transfer	F	3	0.50	1	0.50
ECE253H1: Digital and Computer Systems	F	3	3	-	0.50
ESC203H1: Engineering and Society	F	2	-	2	0.50
MAT292H1: Ordinary Differential Equations	F	3	-	2	0.50
PHY293H1: Waves and Modern Physics	F	3	1	1	0.50
Winter Session - Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME205H1: Fundamentals of Biomedical Engineering	S	2	1.50	1	0.50
ECE259H1: Electromagnetism	S	3	-	1	0.50
ECE286H1: Probability and Statistics	S	3	-	1	0.50
ESC204H1: Praxis III	S	1	5	-	0.50
PHY294H1: Quantum and Thermal Physics	S	3	1	1	0.50
Complementary Studies Elective	S				0.50

1. All students must graduate with 1.0 credit in Humanities & Social Sciences (HSS). Students will gain 0.5 HSS credit from ESC203H1.
2. Please note that additional lectures may be scheduled for ESC204H1 in place of laboratory and test times in the first few weeks of the Winter Session.

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enrol and participate in the Professional Experience Year (PEY) program. The PEY program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating industry. Details are described in the beginning of this calendar. For more information, consult the Professional Experience Year Office early in session 2F or 3F: http://engineeringcareers.utoronto.ca/internships-overview/pey/. The PEY Office is located in the Fields Institute Building at 222 College Street, Suite 106.

Majors in Engineering Science

AEROSPACE ENGINEERING (AEESCBASEA)

YEAR 3 AEROSPACE ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
AER301H1: Dynamics	F	3	-	1	0.50
AER303H1: Aerospace Laboratory I	F	-	1	-	0.15
AER307H1: Aerodynamics	F	3	-	1	0.50
AER315H1: Combustion Processes	F	3	-	1	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
One of:					
MAT389H1: Complex Analysis	F	3	-	1	0.50
ROB310H1: Mathematics for Robotics	F	3	-	1	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER302H1: Aircraft Flight	S	3	-	1	0.50
AER304H1: Aerospace Laboratory II	S	-	1	-	0.15
AER310H1: Gasdynamics	S	3	-	1	0.50
AER336H1: Scientific Computing	S	3	-	1	0.50
AER372H1: Control Systems	S	3	1.50	1	0.50
AER373H1: Mechanics of Solids and Structures	S	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25

YEAR 4 AEROSPACE ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
AER407H1: Space Systems Design	F	-	3	-	0.50
AER501H1: Computational Structural Mechanics and Design Optimization	F	3	-	1	0.50
Complementary Studies Elective	F				0.50
Two courses in:					
AER506H1: Spacecraft Dynamics and Control	F	3	-	1	0.50
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
AER525H1: Robotics	F	3	1.50	1	0.50
ECE557H1: Linear Control Theory	F	3	1.50	1	0.50
ESC499H1: Thesis	F	3	2	-	0.50

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
PHY492H1	F	2	-	-	0.50
Other Technical Elective	F				0.50
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER406H1: Aircraft Design	S	-	-	3	0.50
Complementary Studies Elective	S				0.50
Three courses in:					
AER503H1: Aeroelasticity	S	3	-	1	0.50
AER510H1: Aerospace Propulsion	S	3	-	1	0.50
ESC499H1: Thesis	S	3	2	-	0.50
ESC499Y1: Thesis	Y	3	2	-	1.00
ROB521H1: Mobile Robotics and Perception	S	3	1.50	1	0.50
APM446H1: Applied Nonlinear Equations	S	3	-	-	0.50
Other Technical Elective	S				0.50

1. Students must take a half-year thesis in 4F or 4S, or take a full-year thesis.
2. Students must take at least two of AER503H1, AER506H1, AER510H1, ROB521H1 or AER525H1.
3. The Technical Elective may be chosen from any 400 or 500 level technical course offered in Engineering provided students have taken the pre-requisite course(s). Other non-Engineering courses may be taken with the approval of the Division of Engineering Science.

BIOMEDICAL SYSTEMS ENGINEERING (AEESCBASET)

YEAR 3 BIOMEDICAL SYSTEMS ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
BME344H1: Modeling, Dynamics, and Control of Biological Systems	F	3	-	1	0.50
BME350H1: Biomedical Systems Engineering I: Organ Systems	F	3	1	2	0.50
BME395H1: Biomedical Systems Engineering II: Cells and Tissues	F	2	1	2	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CHE391H1: Organic Chemistry and Biochemistry	F	3	1.50	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME346H1: Biomedical Engineering and Omics Technologies	S	2	4	-	0.50
BME358H1: Molecular Biophysics	S	3	-	1	0.50
BME396H1: Biomedical Systems Engineering III: Molecules and Cells	S	3	3	1	0.50
BME352H1: Biomaterials and Biocompatibility	S	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
CS/HSS or Technical Elective	S				0.50

1. Students may take a CS/HSS or Technical Elective in 3F and take CHE374H1 in 4F.
2. Technical electives can be taken in Year 3 or Year 4 provided that course pre-requisites have been met. Contact the Division of Engineering Science for clarification of course pre-requisites.

YEAR 4 BIOMEDICAL SYSTEMS ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
BME428H1: Biomedical Systems Engineering IV: Computational Systems Biology	F	3	-	2	0.50
BME489H1: Biomedical Systems Engineering Design	F	1	-	4	0.50
CS/HSS or Technical Elective	F				0.50
CS/HSS or Technical Elective	F				0.50
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ESC499Y1: Thesis	Y	3	2	-	1.00
MIE439H1: Biomechanics I	S	3	2	-	0.50
CS/HSS or Technical Elective	S				0.50
CS/HSS or Technical Elective	S				0.50
CS/HSS or Technical Elective	S				0.50

1. Students who completed MIE439H1 in Year 3 are required to take a Technical Elective.
2. Students must complete 2.0 credits of Technical Electives, and 1.0 Credit of Complementary Studies (CS)/Humanities and Social Sciences (HSS) electives in years 3 and 4. All students must fulfill the Faculty graduation requirement of 2.0 CS/HSS credits, at least 1.0 of which must be HSS. ESC203 is 0.5 HSS. Technical and CS/HSS Electives may be taken in any sequence.

TECHNICAL ELECTIVES

Technical Electives		Lect.	Lab.	Tut.	Wgt.
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
MAT389H1: Complex Analysis	F	3	-	1	0.50

1. Students are required to take a minimum of two technical electives from one focus area (Systems and Synthetic Biology; Regenerative Medicine and Biomaterials; Neuro, Sensory and Rehab Engineering; or Sensors, Nano/Microsystems and Instrumentation).

Systems and Synthetic Biology

Omic technologies for the measurement of biological systems (genomics, proteomics, metabolomics, networks), and tools and methods to analyze ‘omic data (databases, computational biology, pattern recognition, machine learning); multiscale modelling and related mathematical tools: ordinary and partial differential equations, advanced statistical methods.

Fall Session		Lect.	Lab.	Tut.	Wgt.
CSB450H1: Proteomics in Systems Biology	F	2	-	-	0.50
CSC343H1: Introduction to Databases	F	2	-	1	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CSB435H1: Regulatory Networks and Systems in Molecular Biology	S	2	-	-	0.50
CSC343H1: Introduction to Databases	S	2	-	1	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50

Regenerative Medicine and Biomaterials

Stem cells and stem cell biology; tools and techniques to regulate stem cell behaviour; design, characterization, and application of materials for manipulation, repair, or replacement of biological systems.

Fall Session		Lect.	Lab.	Tut.	Wgt.
BME460H1: Biomaterial and Medical Device Product Development	F	2	-	2	0.50

Fall Session		Lect.	Lab.	Tut.	Wgt.
CHE562H1: Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering	F	3	-	-	0.50
MIE440H1: * Design of Innovative Products	F	2	2	1	0.50
MIE520H1: Biotransport Phenomena	F	3	-	1	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME330H1: Patents in Biology and Medical Devices	S	3	-	-	0.50
BME410H1: Regenerative Engineering	S	3	-	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50

Neuro Sensory and Rehab Engineering

Neural pathways and sensory communications, including brain and nervous system biology, sensing and interpreting neural signals, and human-computer interfaces; technologies and rehabilitation solutions for the elderly, disabled, and those affected by chronic disease, with an emphasis on bioelectric signal manipulation and robotic applications

Fall Session		Lect.	Lab.	Tut.	Wgt.
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
CSC318H1: The Design of Interactive Computational Media	F	2	-	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
MIE440H1: * Design of Innovative Products	F	2	2	1	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME530H1: Human Whole Body Biomechanics	S	2	2	-	0.50
CHJ332H1: Cellular and Molecular Neurobiology of the Synapse	S	2	-	-	0.50
CSC318H1: The Design of Interactive Computational Media	S	2	-	1	0.50
CSC428H1: Human-Computer Interaction	S	2	-	1	0.50
ECE363H1: Communication Systems	S	3	1.50	1	0.50
ECE470H1: Robot Modeling and Control	S	3	1.50	1	0.50
HMB200H1: Introduction to Neuroscience	S	2	-	1	0.50

Sensors, Nano/Microsystems and Instrumentation

Tools and methods to detect molecular dynamics, cellular behaviours, and tissue-scale changes in biological systems under normal physiological conditions and disease; optics and optical systems; microscopy; molecular imaging; medical imaging; signal processing; image processing and analysis.

Fall Session		Lect.	Lab.	Tut.	Wgt.
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE355H1: Signal Analysis and Communication	F	3	-	2	0.50
ECE442H1	F	3	2	1	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME520H1: Imaging Case Studies in Clinical Engineering	S	2	2	1	0.50
ECE318H1: Fundamentals of Optics	S	3	1.50	1	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
MIE506H1: * MEMS Design and Microfabrication	S	3	1.50	1	0.50

ELECTRICAL AND COMPUTER ENGINEERING (AEESCBASER)

YEAR 3 ELECTRICAL AND COMPUTER ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ECE349H1: Introduction to Energy Systems	F	3	1.50	1	0.50
ECE352H1: Computer Organization	F	3	3	-	0.50
ECE355H1: Signal Analysis and Communication	F	3	-	2	0.50
ECE360H1: Electronics	F	3	1.50	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
MAT389H1: Complex Analysis	F	3	-	1	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE353H1: Systems Software	S	3	3	-	0.50
ECE356H1: Introduction to Control Theory	S	3	1.50	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
One ECE Elective	S				0.50

Students Must Also Take Three Of:

Fall Session - Year 3		Lect.	Lab.	Tut.	Wgt.
ECE358H1: Foundations of Computing	F	3	-	1	0.50
Winter Session - Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE350H1: Semiconductor Electronic Devices	S	3	1.50	1	0.50
ECE354H1: Electronic Circuits	S	3	1.50	1	0.50
ECE357H1: Electromagnetic Fields	S	3	1.50	1	0.50
ECE363H1: Communication Systems	S	3	1.50	1	0.50

1. Students may take CHE374H1 in 4F, particularly to accommodate ECE358H1.

YEAR 4 ELECTRICAL AND COMPUTER ENGINEERING

Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
Two (2) Complementary Studies Electives	F/S/Y				1.00
Three (3) ECE Electives and Two (2) ECE or Technical Electives	F/S				2.50
and one of:					
ESC472H1: Electrical and Computer Capstone Design	S	-	-	5	0.50
BME498Y1: Biomedical Engineering Capstone Design	Y	2	3	-	1.00

1. While a full-year thesis is recommended, students may substitute with a half-year thesis and an ECE or Technical Elective.
2. ECE Electives or Technical Electives can be taken in Year 3 or Year 4 provided that course pre-requisites have been met. Contact the Division of Engineering Science for clarification of course pre-requisites.
3. Students enrolled in the Electrical and Computer Engineering Major may take a maximum of four (4) 300- or 400-series courses in the Department of Computer Science (CSC).
4. Students who choose to take BME498Y1Y will take only one (1) ECE or Technical Elective.

ECE Electives

ECE Electives		Lect.	Lab.	Tut.	Wgt.
Photonics and Semiconductor Physics					

ECE Electives		Lect.	Lab.	Tut.	Wgt.
ECE318H1: Fundamentals of Optics	S	3	1.50	1	0.50
ECE350H1: Semiconductor Electronic Devices	S	3	1.50	1	0.50
ECE427H1: Photonic Devices	F	3	-	2	0.50
ECE442H1	F	3	2	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
PHY356H1: Quantum Mechanics I	F	2	-	1	0.50
PHY456H1: Quantum Mechanics II	F	2	-	1	0.50
PHY487H1: Condensed Matter Physics	F	2	-	-	0.50
Control, Communications, Signal Processing					
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
BME520H1: Imaging Case Studies in Clinical Engineering	S	2	2	1	0.50
BME595H1: Medical Imaging	F	2	3	1	0.50
ECE363H1: Communication Systems	S	3	1.50	1	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE417H1: Digital Communication	F	3	1.50	1	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
ECE462H1: Multimedia Systems	S	3	2	-	0.50
ECE464H1: Wireless Communication	S	3	1.50	1	0.50
ECE470H1: Robot Modeling and Control	S	3	1.50	1	0.50
ECE516H1: Intelligent Image Processing	S	3	3	-	0.50
ECE537H1: Random Processes	F	3	-	2	0.50
ECE557H1: Linear Control Theory	F	3	1.50	1	0.50
Electromagnetics and Energy Systems					
ECE357H1: Electromagnetic Fields	S	3	1.50	1	0.50
ECE313H1: Energy Systems and Distributed Generation	S	3	1.50	1	0.50
ECE422H1: Radio and Microwave Wireless Systems	S	3	1.50	1	0.50
ECE424H1: Microwave Circuits	F	3	1.50	1	0.50
ECE463H1: Electric Drives	S	3	1.50	1	0.50
ECE520H1: Power Electronics	F	3	1.50	1	0.50
Computer Hardware and Computer Networks					
ECE361H1: Computer Networks I	F/S	3	1.50	1	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE466H1: Computer Networks II	S	3	1.50	1	0.50
ECE552H1: Computer Architecture	F	3	1.50	1	0.50
Analog and Digital Electronics					
ECE334H1: Digital Electronics	F/S	3	1.50	1	0.50
ECE350H1: Semiconductor Electronic Devices	S	3	1.50	1	0.50
ECE354H1: Electronic Circuits	S	3	1.50	1	0.50
ECE412H1: Analog Signal Processing Circuits	S	3	-	2	0.50
ECE430H1: Analog Integrated Circuits	F	3	1.50	1	0.50
ECE437H1: VLSI Technology	F	3	3	-	0.50
Software					
CSC309H1: Programming on the Web	F/S	2	-	1	0.50
CSC311H1: Introduction to Machine Learning	F/S	2	-	1	0.50
CSC318H1: The Design of Interactive Computational Media	F/S	2	-	1	0.50

ECE Electives		Lect.	Lab.	Tut.	Wgt.
CSC343H1: Introduction to Databases	F/S	2	-	1	0.50
CSC384H1: Introduction to Artificial Intelligence	F/S	2	-	1	0.50
CSC401H1: Natural Language Computing	S	2	-	1	0.50
CSC317H1: Computer Graphics	F/S	2	-	1	0.50
CSC428H1: Human-Computer Interaction	S	2	-	1	0.50
ECE326H1: Programming Languages	F	3	1.50	1	0.50
ECE358H1: Foundations of Computing	F	3	-	1	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
CSC443H1: Database System Technology	S	2	-	1	0.50
ECE358H1: Foundations of Computing	F	3	-	1	0.50
ECE419H1: Distributed Systems	S	3	1.50	1	0.50
ECE444H1: Software Engineering	F	3	3	-	0.50
ECE454H1: Computer Systems Programming	F	3	3	-	0.50
ECE461H1: Internetworking	F	3	1.50	0.50	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
ECE467H1: Compilers & Interpreters	F	3	1.50	1	0.50
ECE568H1: Computer Security	F/S	3	3	-	0.50

Technical Electives

Technical Electives		Lect.	Lab.	Tut.	Wgt.
ECE Electives, or any of the following:					
AER336H1: Scientific Computing	S	3	-	1	0.50
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
AER525H1: Robotics	F	3	1.50	1	0.50
ECE368H1: Probabilistic Reasoning	S	3	-	1	0.50
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
MAT301H1: Groups and Symmetries	F/S	3	-	-	0.50
MAT336H1: Elements of Analysis	S	3	-	-	0.50
JPE395H1: Physics of the Earth	S	-	-	-	0.50
ROB521H1: Mobile Robotics and Perception	S	3	1.50	1	0.50

ENERGY SYSTEMS ENGINEERING (AEESCBASEJ)

YEAR 3 ENERGY SYSTEMS ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ECE349H1: Introduction to Energy Systems	F	3	1.50	1	0.50
ECE367H1: Matrix Algebra and Optimization	F	3	-	2	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
MIE303H1: Mechanical and Thermal Energy Conversion Processes	F	3	1.50	1	0.50
One of:					
CHE566H1: Elements of Nuclear Engineering	F	3	-	2	0.50
CIV375H1: Building Science	F	3	0.33	2	0.50
ECE360H1: Electronics	F	3	1.50	1	0.50

Winter Session – Year 3		Lect.	Lab.	Tut.	Wgt.
APS305H1: Energy Policy	S	3	-	1	0.50
CHE469H1: Fuel Cells and Electrochemical Conversion Devices	S	3	-	1	0.50
ECE313H1: Energy Systems and Distributed Generation	S	3	1.50	1	0.50
ECE356H1: Introduction to Control Theory	S	3	1.5	1	0.50
ECE463H1: Electric Drives	S	3	1.50	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25

YEAR 4 ENERGY SYSTEMS ENGINEERING

Core Courses		Lect.	Lab.	Tut.	Wgt.
CIV401H1: Design and Optimization of Hydro and Wind Electric Plants	F	3	-	2	0.50
ESC470H1: Energy Systems Capstone Design	S	-	-	5	0.50
ESC499Y1: Thesis	Y	3	2	-	1.00
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
Three (3) Technical Electives					
One (1) HSS/CS Elective					
One (1) Free Elective					

TECHNICAL ELECTIVES

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
CHE451H1: Petroleum Processing	F	3	-	-	0.50
CHE565H1: Aqueous Process Engineering	F	3	-	1	0.50
CHE566H1: Elements of Nuclear Engineering	F	3	-	2	0.50
CIV575H1: Studies in Building Science	F	3	-	2	0.50
ECE520H1: Power Electronics	F	3	1.50	1	0.50
ECE427H1: Photonic Devices	F	3	-	2	0.50
MIE407H1: Nuclear Reactor Theory and Design	F	3	-	2	0.50
MIE442H1: Machine Design	F	3	1.50	3	0.50
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
MIE516H1: Combustion and Fuels	F	3	-	1	0.50
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CHE333H1: Chemical Reaction Engineering	S	3	-	2	0.50
CHE412H1: Advanced Reactor Design	S	3	-	1	0.50
CHE469H1: Fuel Cells and Electrochemical Conversion Devices	S	3	-	1	0.50
CHE568H1: Nuclear Engineering	S	3	-	1	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
CIV576H1: Sustainable Buildings	S	3	-	1	0.50
ECE357H1: Electromagnetic Fields	S	3	1.50	1	0.50
FOR310H1: Bioenergy from Sustainable Forest Management	S	2	-	1	0.50
FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50
JPE395H1: Physics of the Earth	S	-	-	-	0.50
MIE315H1: Design for the Environment	S	3	-	1	0.50
* MIE408H1: * Thermal and Machine Design of Nuclear Power Reactors	S	3	-	2	0.50

Winter Session – Year 4		Lect.	Lab.	Tut.	Wgt.
MIE517H1: Fuel Cell Systems	S	3	-	1	0.50
MSE458H1: Nanotechnology in Alternate Energy Systems	S	3	-	2	0.50

1. Students who completed CIV301H1 in Year 3 are required to take a technical elective in place of CIV401H1.
2. APS305H1, a core course within the Energy curriculum, counts towards the Complementary Studies requirement.
3. Students may substitute a CS/HSS or free elective for the technical elective in 3S by taking an additional technical elective in place of the CS/HSS or free elective in the fourth year.

ENGINEERING MATHEMATICS, STATISTICS & FINANCE (AEESCBASEF)

Year 3 ENGINEERING MATHEMATICS, STATISTICS & FINANCE

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
MIE375H1: Financial Engineering	F	3	-	1	0.50
STA302H1: Methods of Data Analysis I	F	3	-	-	0.50
STA347H1: Probability	F	3	-	-	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ACT370H1: Financial Principles for Actuarial Science II	S	3	-	-	0.50
CHE375H1: Engineering Finance and Economics	S	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
MAT336H1: Elements of Analysis	S	3	-	-	0.50
MIE376H1: Mathematical Programming (Optimization)	S	3	2	1	0.50
MIE377H1: Financial Optimization Models	S	3	1	1	0.50

Year 4 ENGINEERING MATHEMATICS, STATISTICS & FINANCE

Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
ACT460H1: Stochastic Methods for Actuarial Science	F	3	-	-	0.50
MIE479H1: Engineering Mathematics, Statistics and Finance Capstone Design	F	-	-	5	0.50
Two (2) Complementary Studies Electives	F/S/Y				1.00
Four (4) Technical Electives	F/S/Y				2.00

1. Students may take a half-year thesis ESC499H1 and an additional 0.5 credit from the electives list instead of a full-year thesis ESC499Y1.

Technical Electives

Electives – Fall Term		Lect.	Lab.	Tut.	Wgt.
CSC343H1: Introduction to Databases	F	2	-	1	0.50
ECE358H1: Foundations of Computing	F	3	-	1	0.50
MIE360H1: Systems Modelling and Simulation	F	3	2	1	0.50
MIE365H1: Operations Research III: Advanced OR	F	3	2	1	0.50

Electives – Fall Term		Lect.	Lab.	Tut.	Wgt.
MIE424H1: Optimization in Machine Learning	F	3	1	-	0.50
MIE562H1: Scheduling	F	3	-	2	0.50
MIE566H1: Decision Making Under Uncertainty	F	3	-	2	0.50
RSM430H1: Fixed Income Securities	F	2	-	-	0.50
STA410H1: Statistical Computation	F	3	-	-	0.50
Other Technical Elective	F				0.50
Electives – Winter Term		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER336H1: Scientific Computing	S	3	-	1	0.50
APM466H1: Mathematical Theory of Finance	S	3	-	-	0.50
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.50
CSC263H1	S	2	-	1	0.50
CSC343H1: Introduction to Databases	S	2	-	1	0.50
CSC311H1: Introduction to Machine Learning	S	2	-	1	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
MIE367H1: Cases in Operations Research	S	3	-	2	0.50
MIE368H1: Analytics in Action	F	2	3	1	0.50
MIE457H1: Knowledge Modelling and Management	S	3	1	1	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
RSM432H1: Risk Management for Financial Managers	S	2	-	-	0.50
RSM434H1: Financial Trading Strategies (formerly RSM412H1)	S	2	-	-	0.50
STA447H1: Stochastic Processes (formerly STA348H1)	S	3	-	-	0.50
STA457H1: Time Series Analysis	S	3	-	-	0.50
Other Technical Elective	F/S/Y				

ENGINEERING PHYSICS (AEESCBASEP)

YEAR 3 ENGINEERING PHYSICS

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ECE360H1: Electronics	F	3	1.50	1	0.50
PHY327H1: Advanced Physics Laboratory	F	-	6	-	0.50
PHY356H1: Quantum Mechanics I	F	2	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
At least one of:					
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
MAT389H1: Complex Analysis	F	3	-	1	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE357H1: Electromagnetic Fields	S	3	1.50	1	0.50
PHY354H1: Classical Mechanics	S	2	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
Four (4) Group A Electives	S				2.00

1. It is highly recommended that students take one of ECE342H1, ECE350H1, ECE431H1 or CHE568H1 to reduce accreditation constraints in Year 4.
2. Students who take 3 Group A electives in the Winter Session must complete 1 Group A elective in the Fall Session. Students must obtain a total of 5.75 credits in Year 3.
3. Students must take PHY427H1 in 3S, 4F, or 4S.
4. Students may take APM346H1 in place of ESC384H1.
5. Students may take MAT334H1 in place of MAT389H1.
6. Students may take CHE374H1 in 4F.

YEAR 4 ENGINEERING PHYSICS

YEAR 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
ESC471H1: Engineering Science Capstone Design	F/S	-	-	5	0.50
Two (2) Complementary Studies Electives	F/S/Y				1.00
Three (3) Electives from Group B	F/S				1.50
Two (2) Electives from Groups A or B	F/S				1.00

Group A and B Electives

Group A Electives		Lect.	Lab.	Tut.	Wgt.
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
AST320H1: Introduction to Astrophysics	S	2	-	-	0.50
AST325H1: Introduction to Practical Astronomy	F	-	3	-	0.50
BME520H1: Imaging Case Studies in Clinical Engineering	S	2	2	1	0.50
BME595H1: Medical Imaging	F	2	3	1	0.50
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.50
CHE568H1: Nuclear Engineering	S	3	-	1	0.50
ECE318H1: Fundamentals of Optics	S	3	1.50	1	0.50
ECE342H1: Computer Hardware	S	3	3	-	0.50
ECE350H1: Semiconductor Electronic Devices	S	3	1.50	1	0.50
ECE355H1: Signal Analysis and Communication	F	3	-	2	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
ECE442H1	F	3	2	1	0.50
ECE469H1: Optical Communications and Networks	S	3	1.50	1	0.50
ECE427H1: Photonic Devices	F	3	-	2	0.50
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
MAT301H1: Groups and Symmetries	F/S	3	-	-	0.50
MAT336H1: Elements of Analysis	S	3	-	-	0.50
MAT389H1: Complex Analysis	F	3	-	1	0.50
MAT401H1: Polynomial Equations and Fields	F	3	-	-	0.50
MAT402H1: Classical Geometries	S	3	-	-	0.50
PHY357H1: Nuclear and Particle Physics	S	2	-	1	0.50
PHY358H1: Atoms, Molecules and Solids	S	2	-	1	0.50
PHY392H1: Physics of Climate	S	2	-	-	0.50
JGA305H1: Environmental and Archaeological Geophysics	F	2	1	-	0.50
JPE395H1: Physics of the Earth (Formerly PHY395H1)	S	-	-	-	0.50

Group A Electives		Lect.	Lab.	Tut.	Wgt.
PHY408H1: Time Series Analysis	S	1	2	-	0.50
PHY427H1: Advanced Physics Laboratory	F/S	-	6	-	0.50
PHY428H1: Advanced Practical Physics II	F/S	-	6	-	0.50
PHY429H1: Advanced Practical Physics III	F/S	-	6	-	0.50
PHY484H1: Relativity Theory II	S	2	-	-	0.50
Group B Electives		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ESS445H1: Global Tectonics	S	3	-	-	0.50
ESS450H1: Geophysical Field Techniques	F/S	-	-	-	0.50
ESS452H1: Geophysical Imaging with Non-seismic Methods	F	2	-	-	0.50
JPE493H1: Seismology	F	-	-	-	0.50
PHY407H1: Computational Physics	F	1	3	-	0.50
PHY450H1: Relativistic Electrodynamics	S	2	-	1	0.50
PHY452H1: Statistical Mechanics	S	2	-	-	0.50
PHY454H1: Continuum Mechanics	S	2	-	1	0.50
PHY456H1: Quantum Mechanics II	F	2	-	1	0.50
PHY460H1: Nonlinear Physics	S	2	-	-	0.50
PHY483H1: Relativity Theory I	F	2	-	-	0.50
PHY485H1: Advanced Classical Optics	F	2	-	-	0.50
PHY487H1: Condensed Matter Physics	F	2	-	-	0.50
PHY489H1: Introduction to High Energy Physics	F	2	-	-	0.50
PHY492H1: Advanced Atmospheric Physics	F	2	-	-	0.50

INFRASTRUCTURE ENGINEERING (AEESCBASEI)

*** Please note:** The Engineering Science Major in Infrastructure is closing. Students who enter Year 1 of the Engineering Science program after Fall 2018 will not be allowed to select this major.

YEAR 3 INFRASTRUCTURE ENGINEERING

Fall Session - Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CIV355H1	F	3	-	2	0.50
CIV531H1: Transport Planning	F	3	-	1	0.50
CME321H1: Geotechnical Engineering I	F	3	1	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
Complementary Studies Elective	F				0.50
Winter Session - Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER373H1: Mechanics of Solids and Structures	S	3	-	1	0.50
CIV214H1: Structural Analysis I	S	3	-	2	0.50
CIV313H1: Reinforced Concrete I	S	3	-	2	0.50
CIV332H1: Transport II - Performance	S	3	-	1	0.50
CIV516H1: Public Transit Operations and Planning	S	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25

YEAR 4 INFRASTRUCTURE ENGINEERING

Fall Session - Year 4		Lect.	Lab.	Tut.	Wgt.
CIV460H1: Engineering Project Finance and Management	F	3	-	1	0.50

Fall Session - Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499H1: Thesis	F	3	2	-	0.50
Specialty Elective 1	F				0.50
Technical Elective	F				0.50
Technical Elective	F				0.50
Take any one from the following:					
CME358H1: Survey CAMP (Civil and Mineral Practicals)	F	-	-	-	0.50
Transportation Specialty					
APS301H1	F	3	-	1	0.50
CIV280H1: Management of Construction	F	3	-	2	0.50
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
Structures Specialty					
CIV416H1: Reinforced Concrete II	F	3	-	2	0.50
CIV514H1: Concrete Technology	F	3	-	2	0.50
CIV515H1: Introduction to Structural Dynamics	F	3	-	1	0.50
CIV517H1: Prestressed Concrete	F	3	-	-	0.50
CIV575H1: Studies in Building Science	F	3	-	2	0.50
Winter Session - Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CIV498H1: Group Design Project	S	-	-	3	0.50
Specialty Elective 2	S				0.50
Specialty Elective 3	S				0.50
Specialty Elective 4	S				0.50
Complementary Studies Elective	S				0.50
Take any three from the following:					
Transportation Specialty					
CIV380H1: Sustainable Energy Systems	S	3	-	1	0.50
CIV577H1: Infrastructure for Sustainable Cities	S	3	-	1	0.50
Structures Specialty					
CIV510H1: Solid Mechanics II	S	3	-	2	0.50
CIV518H1: Behaviour and Design of Steel Structures	S	3	-	2	0.50
CIV523H1: Geotechnical Design	S	3	-	1	0.50
CIV576H1: Sustainable Buildings	S	3	-	0	0.50

1. Students who do not wish to specialize may take courses from either the Transportation or Structures List.
2. Students may take a half year thesis in the spring term, if they shift a specialty elective into the fall term. Students may opt for a full-year thesis by replacing 0.5 Specialty Elective credit with the additional 0.5 credit for Thesis.
3. Senior students may take 1000-series (graduate level) courses as Specialty Electives, provided they obtain the approval of the Department of Civil Engineering and the Division of Engineering Science. In particular, courses on Transportation and Air Quality, Mechanics of Reinforced Concrete, Infrastructure Economics, Simulation, Freight Transportation and ITS Applications, Airport Planning, Transportation and Development, Transportation Demand Analysis, Modelling Transport Emissions, Bridge Engineering, Principles of Earthquake Engineering and Seismic Design, and Finite Element Methods in Structural Mechanics may be of interest to Infrastructure Major students.
4. The Technical Elective may be chosen from any 400 or 500 level technical course offered in Engineering provided students have taken the pre-requisite course(s). Other non-Engineering courses may be taken with the approval of the Division of Engineering Science.
5. CME358H1 is offered during the summer and may be taken to satisfy a Specialty Elective for either the Fall or Winter semester in Year 4. CME358H1 may be taken in the summer following Year 2 or Year 3. Enrolment in the course is limited; priority is given to currently registered Civil and Mineral students, and is available to Engineering Science Infrastructure Majors on a space-available basis. Note: There is an additional fee associated with CME358H1 to cover room and board during the survey camp.

MACHINE INTELLIGENCE (AEESCBASEL)

YEAR 3 MACHINE INTELLIGENCE

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
ECE355H1: Signal Analysis and Communication	F	3	-	2	0.50
ECE358H1: Foundations of Computing	F	3	-	1	0.50
ECE367H1: Matrix Algebra and Optimization	F	3	-	2	0.50
ECE421H1: Introduction to Machine Learning	F	3	-	2	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE324H1: Machine Intelligence, Software and Neural Networks	S	3	-	1	0.50
ECE353H1: Systems Software	S	3	3	-	0.50
ECE368H1: Probabilistic Reasoning	S	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
ROB311H1: Artificial Intelligence	S	3	-	1	0.50
One (1) Technical Elective	S				0.50

YEAR 4 MACHINE INTELLIGENCE

Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
MIE429H1: Machine Intelligence Capstone Design	F/S	-	-	5	0.50
MIE451H1: Decision Support Systems	F	3	1	1	0.50
Two (2) HSS/CS Electives	F/S/Y				1.00
Three (3) Technical Electives	F/S				1.50
One of:					
ECE352H1: Computer Organization	F	3	3	-	0.50
ECE419H1: Distributed Systems	S	3	1.50	1	0.50

1. Machine Intelligence Major students must complete 2.0 credits of Technical Electives, and 1.0 credit of Complementary Studies (CS) / Humanities and Social Sciences (HSS) electives in years 3 and 4. All students must fulfill the Faculty graduation requirement of 2.0 CS/HSS credits, at least 1.0 of which must be HSS. ESC203H1 is 0.5 HSS. Technical and CS/HSS Electives may be taken in any sequence.
2. Some courses have limited enrolment. Availability of elective courses for timetabling purposes is not guaranteed. It is the student's responsibility to ensure a conflict-free timetable. Technical Electives outside of the group of courses below must be approved in advance by the Division of Engineering Science.
3. Students enrolled in the Machine Intelligence Major may take a maximum of four (4) 300- or 400- series courses in the Department of Computer Science (CSC).
4. Students may take Computer Systems Programming (ECE454H1) in year 3 by moving Economic Analysis and Decision Making (CHE374H1) to year 4.

Technical Electives

Students may select their technical electives from any combination of the above groupings, which exist to help students with their course selection. New elective options will be considered on an annual basis, in particular as Machine Learning and related disciplines grow at the University of Toronto:

Technical Electives		Lect.	Lab.	Tut.	Wgt.
Artificial Intelligence					
CSC310H1: Information Theory	F	2	-	1	0.50

Technical Electives		Lect.	Lab.	Tut.	Wgt.
CSC421H1: Neural Networks & Deep Learning	S	2	-	1	0.50
CSC401H1: Natural Language Computing	S	2	-	1	0.50
CSC420H1: Introduction to Image Understanding	F	2	1	-	0.50
CSC485H1: Computational Linguistics	F	3	-	-	0.50
CSC486H1: Knowledge Representation and Reasoning	S	2	-	1	0.50
MIE424H1: Optimization in Machine Learning	F	3	1	-	0.50
MIE457H1: Knowledge Modelling and Management	S	3	1	1	0.50
MIE566H1: Decision Making Under Uncertainty	F	3	-	2	0.50
Software					
CSC343H1: Introduction to Databases	F/S	2	-	1	0.50
CSC444H1: Software Engineering	F	3	1.50	1	0.50
ECE352H1: Computer Organization	F	3	3	-	0.50
ECE568H1: Computer Security	F/S	3	3	-	0.50
ECE419H1: Distributed Systems	S	3	1.50	1	0.50
ECE454H1: Computer Systems Programming	F	3	3	-	0.50
Hardware					
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE470H1: Robot Modeling and Control	F/S	3	1.50	1	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50
ROB501H1: Computer Vision for Robotics	F	3	-	1	0.50
Mathematics and Modelling					
AER336H1: Scientific Computing	S	3	-	1	0.50
BME595H1: Medical Imaging	S	2	3	1	0.50
ECE356H1: Introduction to Control Theory	S	3	1.50	1	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
ECE557H1: Linear Control Theory	F	3	1.50	1	0.50
MAT336H1: Elements of Analysis	S	3	-	-	0.50
MAT389H1: Complex Analysis	F	3	-	1	0.50
STA302H1: Methods of Data Analysis I	F	3	-	-	0.50
STA410H1: Statistical Computation	F	3	-	-	0.50

ROBOTICS ENGINEERING (AEESCBASEZ)

Year 3 ROBOTICS ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
AER301H1: Dynamics	F	3	-	1	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CSC263H1: Data Structures and Analysis	F	2	-	1	0.50
MIE366H1: Electronics for Robotics	F	3	1.50	2	0.50
ROB301H1: Introduction to Robotics	F	3	1.50	1	0.50
ROB310H1: Mathematics for Robotics	F	3	-	1	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER372H1: Control Systems	S	3	1.50	1	0.50

Winter Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CSC384H1: Introduction to Artificial Intelligence	S	2	-	1	0.50
ROB313H1: Introduction to Learning from Data	S	3	-	2	0.50
MIE438H1: Microprocessors and Embedded Microcontrollers	S	2	3	-	0.50
ESC301H1: Engineering Science Option Seminar	Y	1	-	-	0.25
CS/HSS or Technical Elective	S				0.50

Year 4 ROBOTICS ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
ESC499Y1: Thesis	Y	3	2	-	1.00
ECE470H1: Robot Modeling and Control	F	3	1.50	1	0.50
ECE557H1: Linear Control Theory	F	3	1.50	1	0.50
ROB501H1: Computer Vision for Robotics	F	3	-	1	0.50
CS/HSS or Technical Elective	F				0.50
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ESC499Y1: Thesis	Y	3	2	-	1.00
ROB521H1: Mobile Robotics and Perception	S	3	1.50	1	0.50
ROB498H1: Robotics Capstone Design	S	-	-	5	0.50
CS/HSS or Technical Elective	S				0.50
CS/HSS or Technical Elective	S				0.50

1. Robotics Major students must complete 1.0 credit of Technical Electives, and 1.0 credit of Complementary Studies (CS)/Humanities and Social Sciences (HSS) electives in Years 3 and 4. All students must fulfill the Faculty graduation requirement of 2.0 CS/HSS credits, at least 1.0 of which must be HSS. ESC203 is 0.5 HSS. Technical and CS/HSS Electives may be taken in any sequence.
2. Students enrolled in the Robotics Major may take a maximum of four (4) 300- or 400-series courses in the Department of Computer Science (CSC), including the two core courses.

Students are required to select their technical electives from the list of approved courses below. Some courses have limited enrolment. Availability of elective courses for timetabling purposes is not guaranteed. It is the student's responsibility to ensure a conflict-free timetable. Technical Electives outside of the group of courses below must be approved in advance by the Division of Engineering Science.

TECHNICAL ELECTIVES

TECHNICAL ELECTIVES		Lect.	Lab.	Tut.	Wgt.
Functional Courses					
AER336H1: Scientific Computing	S	3	-	1	0.50
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
ESC384H1: Partial Differential Equations	F	3	-	1	0.50
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.50
CSC421H1: Introduction to Neural Networks and Machine Learning	S	-	-	-	0.50
CSC401H1: Natural Language Computing	S	2	-	1	0.50
CSC412H1: Probabilistic Learning and Reasoning	S	-	-	-	0.50
CSC485H1: Computational Linguistics	F	3	-	-	0.50
CSC486H1: Knowledge Representation and Reasoning	S	-	-	-	0.50
ECE352H1: Computer Organization	F	3	3	-	0.50
ECE353H1: Systems Software	S	3	3	-	0.50
ECE355H1: Signal Analysis and Communication	F	3	-	2	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50

TECHNICAL ELECTIVES		Lect.	Lab.	Tut.	Wgt.
ECE516H1: Intelligent Image Processing	S	3	3	-	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50
MAT363H1	S	3	-	-	0.50
MAT389H1: Geometry of Curves and Surfaces	F	3	-	1	0.50
MIE444H1: * Mechatronics Principles	F	2	3	-	0.50
Other technical elective	F/S				0.50
Application Courses					
AER302H1: Aircraft Flight	S	3	-	1	0.50
AER307H1: Aerodynamics	F	3	-	1	0.50
AER407H1: Space Systems Design	F	-	3	-	0.50
BME530H1: Human Whole Body Biomechanics	S	3	2	-	0.50
MIE422H1: Automated Manufacturing	F	2	3	-	0.50
MIE439H1: Biomechanics I	S	3	2	-	0.50
MIE505H1: Micro/Nano Robotics	S	3	3	-	0.50

Engineering Science Courses

Aerospace Science and Engineering

AER210H1 - Vector Calculus & Fluid Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T/6.4P

The first part of this course covers multiple integrals and vector calculus. Topics covered include: double and triple integrals, derivatives of definite integrals, surface area, cylindrical and spherical coordinates, general coordinate transformations (Jacobians), Taylor series in two variables, line and surface integrals, parametric surfaces, Green's theorem, the divergence and gradient theorems, Stokes's theorem. The second part of the course provides a general introduction to the principles of continuum fluid mechanics. The basic conservation laws are derived in both differential and integral form, and the link between the two is demonstrated. Applications covered include hydrostatics, incompressible and compressible frictionless flow, the speed of sound, the momentum theorem, viscous flows, and selected examples of real fluid flows.

Prerequisite: MAT195H1
Corequisite: MAT292H1
Exclusion: CHE211H1, CHE221H1, CME261H1, CME270H1, MAT291H1 or MIE312H1
Recommended Preparation: PHY180H1

AER301H1 - Dynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. D'Alembert's and Hamilton's principle. Orbital dynamics. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Model analysis. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Goldstein, Classical Mechanics.

Prerequisite: AER210H1, MAT185H1 and PHY180H1
Exclusion: MIE301H1

AER302H1 - Aircraft Flight

Credit Value: 0.50
Hours: 38.4L/12.8T

Basics of aircraft performance with an introduction to static stability and control. Topics covered include: Equations of Motion; Characteristics of the Atmosphere; Airspeed Measurement; Drag (induced drag, total airplane drag); Thurst and Power (piston engine characteristics, gas turbine performance); Climb (range payload); Tunrs; Pull-up; Takeoff; Landing (airborne distance, ground roll); Flight envelope (maneuvering envelope, gust load factors); Longitudinal and lateral static stability and control; Introduction to dynamic stability.

Prerequisite: AER307H1 and AER301H1

AER303H1 - Aerospace Laboratory I

Credit Value: 0.15
Hours: 12.8P

Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.

Corequisite: AER307H1

AER304H1 - Aerospace Laboratory II

Credit Value: 0.15
Hours: 12.8P

Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.

Corequisite: AER373H1

AER307H1 - Aerodynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

Review of fundamentals of fluid dynamics, potential-flow, Euler, and Navier-Stokes equations; incompressible flow over airfoils, incompressible flow over finite wings; compressibility effects; subsonic compressible flow over airfoils; supersonic flow; viscous flow; laminar layers and turbulent boundary layers and unsteady aerodynamics. Textbook: Anderson, J.D., Fundamentals of Aerodynamics, 3rd Edition, McGraw Hill, 2001.

Prerequisite: AER210H1 or MIE312H1

AER310H1 - Gasdynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

Basic introduction to compressible gasdynamics. Includes some fundamental thermodynamics, thermal and caloric equations of state, derivation of Euler's equations by control volume approach. Also, includes the theory of steady flows in ducts with area changes, adiabatic frictional flows, duct flows with heat transfer, normal and oblique shock waves, Prandtl-Meyer expansion wave, moving shock and rarefaction waves, shock tubes, and wind tunnels. The lectures are supplemented by problem sets. Reference book: Anderson, J.D., Modern Compressible Flow with Historical Perspective.

Prerequisite: AER307H1

AER315H1 - Combustion Processes

Credit Value: 0.50
Hours: 38.4L/12.8T

Scope and history of combustion, and fossil fuels; thermodynamics and kinetics of combustion including heats of formation and reaction, adiabatic flame temperature, elementary and global reactions, equilibrium calculations of combustion products, and kinetics of pollutant formation mechanisms; propagation of laminar premixed flames and detonations, flammability limits, ignition and quenching; gaseous diffusion flames and droplet burning; introduction to combustion in practical devices such as rockets, gas turbines, reciprocating engines, and furnaces; environmental aspects of combustion.

Prerequisite: CHE260H1
Exclusion: MIE516H1

AER336H1 - Scientific Computing

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces numerical methods for scientific computation which are relevant to the solution of a wide range of engineering problems. Topics addressed include interpolation, integration, linear systems, least-squares fitting, nonlinear equations and optimization, initial value problems, and partial differential equations. The assignments require programming of numerical algorithms.

Prerequisite: ESC103H1 and MAT185H1

AER372H1 - Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to dynamic systems and control. Models of physical systems. Stability and feedback control theory. Analysis and synthesis of linear feedback systems by "classical" and state space techniques. Introduction to nonlinear and optimal control systems. Digital computer control. Multivariable feedback system design.

Prerequisite: MAT185H1 and MAT292H1
Exclusion: CHE322H1, ECE356H1 or MIE404H1

AER373H1 - Mechanics of Solids and Structures

Credit Value: 0.50
Hours: 38.4L/12.8T

An Introduction to Solid and Structural Mechanics. Continuum Mechanics: Stress, strain and constitutive relations for continuous systems, Equilibrium equations, Force and Flexibility methods, Introduction to Cartesian Tensors. Variational Principles: Virtual Work, Complementary Virtual Work, Strain Energy and Work, Principle of Stationary Value of the Total Potential Energy, Complementary Potential Energy, Reissner's Principle, Calculus of Variations, Hamilton's Principle. Beam and Plate theory. Dynamics of discrete and continuous systems.

Prerequisite: CIV102H1

AER406H1 - Aircraft Design

Credit Value: 0.50
Hours: 38.4T

Teams of 3 or 4 students design, build, and fly a remotely piloted aircraft. The aircraft is designed and built to maximize a flight score, which is a complex function of many factors - payload fraction, payload type, flight time, takeoff distance, etc. Teams are provided with identical motors, batteries, radio equipment, and flight instrumentation. Weekly sessions consist of a combination of lectures and one-on-one meetings with the tutors and professor to discuss each teams' progress. Evaluations are based on the weekly reports, preliminary and final design presentations and reports, an as-built report, and measured flight performance.

Prerequisite: AER302H1, AER307H1 and AER373H1

AER407H1 - Space Systems Design

Credit Value: 0.50
Hours: 38.4P

Introduction to the conceptual and preliminary design phases for a space system currently of interest in the Aerospace industry. A team of visiting engineers provide material on typical space systems design methodology and share their experiences working on current space initiatives through workshops and mock design reviews. Aspects of operations, systems, electrical, mechanical, software, and controls are covered. The class is divided into project teams to design a space system in response to a Request for Proposals (RFP) formulated by the industrial team. Emphasis is placed on standard top-down design practices and the tradeoffs which occur during the design process. Past projects include satellites such as Radarsat, interplanetary probes such as a solar sailer to Mars, a Mars surface rover and dextrous space robotic systems.

Prerequisite: AER301H1, AER372H1

AER501H1 - Computational Structural Mechanics and Design Optimization

Hours: 38.4L/12.8T

Introduction to the Finite Element Method and Structural Optimization. Review of linear elasticity: stress, strain and material constitutive laws, Variational Principles. The Finite Element technique: problem formulation - methods of Ritz and Galerkin, element properties - C0 and C1 formulations, static and dynamic problems: applications to bar, beam, membrane and plate problems. Structural Optimization: Overview of problems, Optimal Design problem formulation, solution strategies - gradient search techniques, Sensitivity analysis for static and dynamic problems, Optimization problems using commercial finite element codes. Text: Shames & Dym, Energy and Finite Element Methods in Structural Mechanics.

Prerequisite: AER373H1

AER503H1 - Aeroelasticity

Credit Value: 0.50
Hours: 38.4L/12.8T

Static aeroelastic phenomena are studied, including divergence of 2D sections and slender 3D wings, as well as control reversal of 3D wings. Various methods of solution are considered such as closed form, discrete element, and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters that affect flutter speed. Classical, k, and p-k methods for flutter estimation are presented.

Prerequisite: AER307H1 and AER501H1

AER506H1 - Spacecraft Dynamics and Control

Credit Value: 0.50
Hours: 38.4L/12.8T

Planar "central force" motion; elliptical orbits; energy and the major diameter; speed in terms of position; angular momentum and the conic parameter; Kepler's laws. Applications to the solar system; applications to Earth satellites. Launch sequence; attaining orbit; plane changes; reaching final orbit; simple theory of satellite lifetime. Simple (planar) theory of atmospheric entry. Geostationary satellite; adjustment of perigee and apogee; east-west stationkeeping. Attitude motion equations for a torque-free rigid body; simple spins and their stability; effect of internal energy dissipation; axisymmetric spinning bodies. Spin-stabilized satellites; long-term effects; sample flight data. Dual-spin satellites; basic stability criteria; example-CTS. "active" attitude control; reaction wheels; momentum wheels; controlmoment gyros; simple attitude control systems.

Prerequisite: AER301H1 and AER372H1

AER507H1 - Introduction to Fusion Energy

Credit Value: 0.50
Hours: 38.4L/12.8T

Nuclear reactions between light elements provide the energy source for the sun and stars. On earth, such reactions could form the basis of an essentially inexhaustible energy resource. In order for the fusion reactions to proceed at a rate suitable for the generation of electricity, the fuels (usually hydrogen) must be heated to temperatures near 100 million Kelvin. At these temperatures, the fuel will exist in the plasma state. This course will cover: (i) the basic physics of fusion, including reaction cross-sections, particle energy distributions, Lawson criterion and radiation balance, (ii) plasma properties including plasma waves, plasma transport, heating and stability, and (iii) fusion plasma confinement methods (magnetic and inertial). Topics will be related to current experimental research in the field.

AER510H1 - Aerospace Propulsion

Credit Value: 0.50
Hours: 38.4L/12.8T

Scope and history of jet and rocket propulsion; fundamentals of air-breathing and rocket propulsion; fluid mechanics and thermodynamics of propulsion including boundary layer mechanics and combustion; principles of aircraft jet engines, engine components and performance; principles of rocket propulsion, rocket performance, and chemical rockets; environmental impact of aircraft jet engines.

Prerequisite: AER310H1

AER525H1 - Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course addresses fundamentals of analytical robotics as well as design and control of industrial robots and their instrumentation. Topics include forward, inverse, and differential kinematics, screw representation, statics, inverse and forward dynamics, motion and force control of robot manipulators, actuation schemes, task-based and workspace design, mobile manipulation, and sensors and instrumentation in robotic systems. A series of experiments in the Robotics Laboratory will illustrate the course subjects.

Prerequisite: AER301H1 and AER372H1
Exclusion: ECE470H1

Applied Mathematics

APM446H1 - Applied Nonlinear Equations

Credit Value: 0.50
Hours: 36L

Partial differential equations appearing in physics, material sciences, biology, geometry, and engineering. Nonlinear evolution equations. Existence and long-time behaviour of solutions. Existence of static, traveling wave, self-similar, topological and localized solutions. Stability. Formation of singularities and pattern formation. Fixed point theorems, spectral analysis, bifurcation theory. Equations considered in this course may include: Allen-Cahn equation (material science), Ginzburg-Landau equation (condensed matter physics), Cahn-Hilliard (material science, biology), nonlinear Schroedinger equation (quantum and plasma physics, water waves, etc). mean curvature flow (geometry, material sciences), Fisher-Kolmogorov-Petrovskii-Piskunov (combustion theory, biology), Keller-Segel equations (biology), and Chern-Simmons equations (particle and condensed matter physics).

Joint undergraduate/graduate course - APM446H1/MAT1508H

Prerequisite: APM346H1/MAT351Y1

APM466H1 - Mathematical Theory of Finance

Credit Value: 0.50
Hours: 36L

Introduction to the basic mathematical techniques in pricing theory and risk management: Stochastic calculus, single-period finance, financial derivatives (tree-approximation and Black-Scholes model for equity derivatives, American derivatives, numerical methods, lattice models for interest-rate derivatives), value at risk, credit risk, portfolio theory.

Joint undergraduate/graduate course - APM466H1/MAT1856H

Prerequisite: APM346H1, STA347H1
Corequisite: STA457H1

Applied Science and Engineering (Interdepartmental)

APS305H1 - Energy Policy

Credit Value: 0.50
Hours: 38.4L/12.8T

Complimentary Studies Elective
Core Course in the Sustainable Energy Minor
Introduction to public policy including the role and interaction of technology and regulation, policy reinforcing/feedback cycles; procedures for legislation and policy setting at the municipal, provincial and federal levels; dimensions of energy policy; energy planning and forecasting including demand management and conservation incentives; policy institution, analysis, implementation, evaluation and evolution; Critical analyses of case studies of energy and associated environmental policies with respect to conservation and demand management for various utilities and sectors; policy derivatives for varied economic and social settings, developing countries and associated impacts.

Exclusion: ENV350H1

Biomaterials and Biomedical Engineering

BME205H1 - Fundamentals of Biomedical Engineering

Credit Value: 0.50
Hours: 25.6L/12.8T/19.2P

Introduction to connecting engineering and biological approaches to solve problems in medicine, science, and technology. Emphasis is placed on demonstrating the connection between organ level function with cellular mechanisms. Topics may include, but are not limited to: design principles of biological systems, medical devices, overviews of anatomy and physiology, and cellular mechanisms as they relate to biotechnological and medical technology applications. Laboratories will provide hands-on experiences with selected concepts and encourage students to understand how to connect their own vital and physiologic signs to current medical technologies.

Exclusion: CHE353H1 or BIO130H1

BME330H1 - Patents in Biology and Medical Devices

Credit Value: 0.50
Hours: 38.4L

The emphasis of the course is on applying the logic of patents to diverse cases of products through biology and biomedical engineering. A commercial context will be ever present the case studies. Students will work in teams on these problems in class. Students will learn to apply tests for obviousness, inventiveness, novelty and enablement based on the use of these tests in technology patents in the past. Claim construction will be introduced towards the end of the course to learn how technologies can be protected in considering a patent. There will be papers for reading in this course but no textbook. This course is designed for senior undergraduate students (3-4 year).

Prerequisite: CHE353H1 or BME205H1

BME344H1 - Modeling, Dynamics, and Control of Biological Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to modeling of physiological control systems present in the human body, combining physiology, linear system modeling and linear control theory. Topics include: representation of physical systems using differential equations and linearization of these dynamic models; graphical representation of the control systems/plants; Laplace transforms; transfer functions; performance of dynamic systems; time and frequency analysis; observability and controllability; and close-loop controller design.

Prerequisite: MAT185H1 or equivalent;MAT292H1 or equivalent
Corequisite: BME350H1

BME346H1 - Biomedical Engineering and Omics Technologies

Credit Value: 0.50
Hours: 25.6L/51.2P

An introduction to the principles and design of fundamental technologies used in biomedical engineering and "omics" research. Topics may include but are not limited to tissue culture; spectroscopy; electrophoresis; PCR, genomics, sequencing technologies, and gene expression measurement; protein expression assays and tagging strategies; fluorescence labeling tools, microscopy, and high content imaging; DNA manipulation and transfection, RNAi, and other genetic and molecular tools for transformation of organisms. Laboratories will provide hands-on experience with selected technologies. Students will engage in a major design project in which they will design an experimental plan to investigate a specific research question, also of their design, utilizing available laboratory technologies.

Prerequisite: BME205H1
Exclusion: BME340H1, BME440H1

BME350H1 - Biomedical Systems Engineering I: Organ Systems

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An introduction to human anatomy and physiology with selected focus on the nervous, cardiovascular, respiratory, renal, and endocrine systems. The structures and mechanisms responsible for proper function of these complex systems will be examined in the healthy and diseased human body. The integration of different organ systems will be stressed, with a specific focus on the structure-function relationship. Application of biomedical engineering technologies in maintaining homeostasis will also be discussed.

Prerequisite: BME205H1
Corequisite: BME395H1

BME352H1 - Biomaterials and Biocompatibility

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to the science of biomaterials, focusing on polymeric biomaterials and biocompatibility. Topics include biomaterial surface analysis, hydrogel rheology and swelling, protein adsorption, cell adhesion and migration and the foreign body response. Primary focus is on implantable biomaterials but some attention will be given to applications of biomaterials in biotechnology and drug delivery. Specific device or other examples as well as the research literature will be used to illustrate the topic at hand.

Prerequisite: BME205H1/CHE353H1
Exclusion: MSE452H1

BME358H1 - Molecular Biophysics

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics to be covered will include: Building blocks of the living cell; thermodynamics of living systems: interactions and kinetic energy, equilibrium and non-equilibrium processes, entropy, temperature, free energy and chemical potential ; diffusion and friction in liquids, Brownian motion; membrane potential, ion pumps and nerve cells; light and molecules: photon absorption and fluorescence; light microscope, fluorescence as a window into cells, optogenetics and fluorescent reporters; two-photon excitation and fluorescence resonance energy transfer; the eye, image formation, and color vision; structural color in animals.

Prerequisite: BME205H1

BME395H1 - Biomedical Systems Engineering II: Cells and Tissues

Credit Value: 0.50
Hours: 25.6L/25.6T/12.8P

Tissue engineering is largely based on concepts that emerged from developmental biology. This course provides an introduction to the study of animal development, both at the cellular and molecular levels. Topics include developmental patterning, differential gene expression, morphogenesis, stem cells, repair and regeneration.

Corequisite: BME350H1
Exclusion: CHE353H1

BME396H1 - Biomedical Systems Engineering III: Molecules and Cells

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

Understanding diversity of cell behaviour at the molecular level. Through discussion of molecular dynamics in living cells in the context of varied microenvironments, develop an understanding of cellular behaviour based on intracellular events in response to extracellular stimuli. Specific topics include receptor-ligand interatctions, morphogens, signal transduction, cell growth & differentiation, cell adhesion and migration, trafficking, and mechanotransduction. Examples from in vitro culture systems and model organisms in vivo are used to support discussions.

Prerequisite: BME350H1, BME395H1
Recommended Preparation: BME225H1

BME410H1 - Regenerative Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The course encompasses the new multidisciplinary area of Regenerative Engineering by integrating various components of Regenerative Medicine, Clinical Engineering, Human Biology & Physiology, Advanced Biomaterials, Tissue Engineering, and Stem Cell and Developmental Biology, bringing all these disciplines into the clinical perspective of translational medicine. The course starts with the key concepts of stem cell biology and their properties at the cellular and subcellular levels working our way to complex tissues and organs. In the first half of the course, 2D and 3D tissue and organ formation will be our main focus. In the second half, we will discuss the integration of medical devices, technologies and treatments into healthcare as well as clinical trial logistics, ethics and processes. The course materials will integrate cutting-edge research in regenerative medicine and current clinical trials by inviting scientists and clinicians as guest lecturers. Students will be given the rare opportunity to incorporate into their written assignments experiment-based learning via participation in workshops, tours of research facilities, seminars and independent projects integrated into the course during the semester.

Prerequisite: BME396H1

BME428H1 - Biomedical Systems Engineering IV: Computational Systems Biology

Credit Value: 0.50
Hours: 38.4L/25.6T

Through systematic mathematical analysis of biological networks, this course derives design principles that are cornerstones for the understanding of complex natural biological systems and the engineering of synthetic biological systems. Course material includes: transcriptional networks, autoregulation, feed-forward loops, global network structure, protein networks, robustness, kinetic proofreading and optimality. After completion of the course, students should be able to use quantitative reasoning to analyze biological systems and construct mathematical models to describe biological systems.

Prerequisite: BME350H1, BME395H1, BME396H1

BME445H1 - Neural Bioelectricity

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Generation, transmission and the significance of bioelectricity in neural networks of the brain. Topics covered include: (i) Basic features of neural systems. (ii) Ionic transport mechanisms in cellular membranes. (iii) Propagation of electricity in neural cables. (iv) Extracellular electric fields. (v) Neural networks, neuroplasticity and biological clocks. (vi) Learning and memory in artificial neural networks. Laboratory experiences include: (a) Biological measurements of body surface potentials (EEG and EMG). (b) Experiments on computer models of generation and propagation of neuronal electrical activities. (c) Investigation of learning in artificial neural networks. This course was previously offered as ECE445H1.

Prerequisite: ECE159H1/ECE110H1

BME460H1 - Biomaterial and Medical Device Product Development

Credit Value: 0.50
Hours: 25.6L/25.6T

The objective of this course is to provide students with strategies by which they can "reverse engineer" medical device products intended for use as implantable devices or in contact with body tissue and fluids. A top down approach will be taken where the regulatory path for product approval and associated costs with product development and validation are reviewed for different biomaterials and devices. This path is then assessed in the context of product specific reimbursement, safety, competitive positioning and regulatory concerns. Students will be required to use their existing knowledge of biomaterials and biocompatibility to frame the questions, challenges and opportunities with a mind to re-engineering products in order to capitalize on niche regulatory pathways. The resulting regulatory path gives a good idea of the kind of trial design the product must prevail in and ultimately the design characteristics of the device itself. The United States and Europe will be contrasted with respect to both their regulatory environment and reimbursement. Lastly, quantitative product development risks estimates are considered in choosing a product path strategy for proof of concept and approval.

Prerequisite: MSE352H1

BME479H1 - Introduction to Biomedical Systems Engineering Design Concepts

Credit Value: 0.10
Hours: 12.8T

A seminar to introduce students to concepts in biomedical systems engineering design in preparation for BME489H1 - Biomedical Systems Engineering Design. Review of general design concepts in the context of biodesign practice. Discussion of issues related to biodesign, including regulatory processes, intellectual property, and global health. Students will be introduced to clients, identify a design project, and define their design problem. At the end of the term, students will deliver a draft "elevator pitch" for their project.

BME489H1 - Biomedical Systems Engineering Design

Credit Value: 0.50
Hours: 12.8L/51.2T

A capstone design project that provides students in the Biomedical Systems Engineering option with an opportunity to intergrate and apply their technical knowledge and communication skills to solve real-world biomedical engineering design challenges. Students will work in small groups on projects that evolve from clinical partners, biomedical/clinical research and teaching labs, and commercial partners. At the end of the course, students submit a final design report and a poster for public exhibition.

Prerequisite: BME205H1
Recommended Preparation: BME225H1

BME498Y1 - Biomedical Engineering Capstone Design

Credit Value: 1.00
Hours: 25.6L/12.8T/38.4P

In this project-based design course, teams of students from diverse engineering disciplines (enrolled in the biomedical engineering minor) will engage in the biomedical technology design process to identify, invent and implement a solution to an unmet clinical need defined by external clients and experts. This course emphasizes "hands-on" practicums and lectures to support a student-driven design project. The UG Office will reach out in the summer to 4th year BME Minor students regarding course registration. For A&S students, approval to register in the course must be obtained from the course instructor by completing the application available through the BME UG Office.

BME520H1 - Imaging Case Studies in Clinical Engineering

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

An introduction to current practices in modern radiology - the detection and assessment of various human diseases using specialized imaging tools (e.g., MRI, CT, ultrasound, and nuclear imaging) from the perspective of the end-user, the clinician. Course content will include lectures delivered by radiologists describing normal anatomy and physiology as well as tissue pathophysiology (i.e., disease). Visualization and characterization using medical imaging will be described, with core lecture material complemented by industry representative guest lectures where challenges and opportunities in the development of new medical imaging technologies for niche applications will be discussed.

Note: BME520H1 will not be offered for the 2018-19 academic year.

Prerequisite: BME595H1

BME530H1 - Human Whole Body Biomechanics

Credit Value: 0.50
Hours: 25.6L/38.4P

An introduction to the principles of human body movement. Specific topics include the dynamics of human motion and the neural motor system, with a focus on the positive/negative adaptability of the motor system. Students will experience basic techniques of capturing and analyzing human motion. Engineering applications and the field of rehabilitation engineering will be emphasized using other experimental materials. This course is designed for senior undergraduate and graduate students.

BME595H1 - Medical Imaging

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

An introductory course to medical imaging and is designed as a final year course for engineers. The main clinical imaging modalities are covered: magnetic resonance imaging, ultrasound imaging, x-ray and computed tomography, nuclear medicine, and clinical optical imaging. Emphasis is placed on the underlying physical and mathematical concepts behind each modality, and applications are discussed in the context of how different modalities complement one another in the clinical setting. Early year engineering concepts are extensively used, including: basic electromagnetics theory, fields and waves, signals and systems, digital signal processing, differential equations and calculus, and probability and random processes. The laboratories involve image reconstruction and analysis for the various imaging modalities and a live animal imaging session.

Chemical Engineering and Applied Chemistry

CHE260H1 - Thermodynamics and Heat Transfer

Credit Value: 0.50
Hours: 38.4L/12.8T/6.4P

Classical thermodynamics and its applications to engineering processes. Concepts of energy, heat, work and entropy. First and second laws of thermodynamics. Properties of pure substances and mixtures. Phase equilibrium. Ideal heat engines and refrigerators. Mechanisms of heat transfer: conduction, convection and radiation. Steady state heat transfer. Solution of conduction equation. Convective heat transfer coefficients. Momentum and heat transfer analogies. Basics of radiative heat transfer..

Exclusion: CHE210H1, CHE323H1, CHE326H1, CHE119H1, MSE202H1 or MIE210H1
Recommended Preparation: MAT195H1

CHE308H1 - Energy Systems and Fuels: Global Needs, Challenges, and Technological Opportunities

Credit Value: 0.50
Hours: 38.4L/12.8T

The chemistry and chemical engineering involved in various forms of power generation and storage: alternative liquid fuels, nuclear power, fuel cells, solar cells/photovoltaics. A team-taught course with instruction from leading experts within the Faculty. Lectures will be focused around the presentation and analysis of recent published accounts or a review of the state of the art, while providing the necessary background within each field to enable the students to make objective critiques of the topics discussed. Where applicable, the design of facilities and devices for the forms of generation or storage will be discussed.

CHE333H1 - Chemical Reaction Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Covers the basics of simple reactor design and performance, with emphasis on unifying the concepts in kinetics, thermodynamics and transport phenomena. Topics include flow and residence time distributions in various reactor types as well as the influence of transport properties (bulk and interphase) on kinetics and reactor performance. The interplay of these facets of reaction engineering is illustrated by use of appropriate computer simulations.

CHE374H1 - Economic Analysis and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

Economic evaluation and justification of engineering projects and investment proposals. Cost estimation; financial and cost accounting; depreciation; inflation; equity, bond and loan financing; after tax cash flow; measures of economic merit in the private and public sectors; sensitivity and risk analysis; single and multi-attribute decisions. Introduction to micro-economic. Applications: retirement and replacement analysis; make-buy and buy-lease decisions; economic life of assets; capital budgeting; selection from alternative engineering proposals; production planning; investment selection.

Prerequisite: MAT194H1, ESC103H1
Exclusion: CHE249H1, CME368H1/MIE258H1

CHE375H1 - Engineering Finance and Economics

Credit Value: 0.50
Hours: 38.4L/12.8T

This course consists of three modules: 1) managerial accounting, 2) corporate finance and 3) macro economics. The first module, managerial accounting, will consist of an introduction to financial statements and double entry recordkeeping, then delve deeper into aspects of revenue, expenses, assets, debt and equity.The second module, corporate finance, will introduce the concept of risk and return, and the Capital Asset Pricing Model, and then delve deeper into capital budgeting, corporate financing, financial statement analysis and financial valuation. The third model, macro economics, will introduce global aspects of business, including economic, political, societal and technological, then discuss factors such as GDP, inflation, unemployment, interest rates, foreign exchange rates, fiscal debt/surplus and balance of payments, and their impact on the financials of a given country.

Prerequisite: MAT194H1, ESC103H1
Exclusion: JRE300H1

CHE391H1 - Organic Chemistry and Biochemistry

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course examines the sources, structures, properties and reactions of organic chemicals with reference to their interactions with the environment. Industrial organic chemistry, biochemical compounds and relevant biochemical reactions will be discussed.

CHE412H1 - Advanced Reactor Design

Credit Value: 0.50
Hours: 38.4L/12.8T

Heterogeneous reactors. Mass and heat transport effects including intraparticle transport effects (Thiele modulus). Stability for various rate laws, transport regimes. Time dependent issues - deactivation/regeneration strategies. Emerging processes.

CHE451H1 - Petroleum Processing

Credit Value: 0.50
Hours: 38.4L

This course is aimed at surveying the oil industry practices from the perspective of a block flow diagram. Oil refineries today involve the large scale processing of fluids through primary separation techniques, secondary treating plus the introduction of catalyst for molecular reforming in order to meet the product demands of industry and the public. Crude oil is being shipped in increasing quantities from many parts of the world and refiners must be aware of the properties and specifications of both the crude and product slates to ensure that the crude is a viable source and that the product slate meets quality and quantity demands thus assuring a profitable operation. The course content will examine refinery oil and gas operations from feed, through to products, touching on processing steps necessary to meet consumer demands. In both course readings and written assignments, students will be asked to consider refinery operations from a broad perspective and not through detailed analysis and problem solving.

CHE469H1 - Fuel Cells and Electrochemical Conversion Devices

Credit Value: 0.50
Hours: 38.4L/12.8T

The objective of this course is to provide a foundation for understanding the field of electrochemical conversion devices with particular emphasis on fuel cells. The topics will proceed from the fundamental thermodynamic in-system electodics and ionic interaction limitations to mass transfer and heat balance effects,t o the externalities such as economics and system integration challenges. Guest lecturers from the fuel cell industry will be invited to procide an industrial perspective. Participants will complete a paper and in-class presentation.

Exclusion: MIE517H1

CHE471H1 - Modelling in Biological and Chemical Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course outlines the methodology for the modelling of biological systems and its applications. Topics will include a review of physical laws, selection of balance space, compartmental versus distributed models, and applications of the conservation laws for both discrete and continuous systems at the level of algebraic and ordinary differential equations. The course covers a wide range of applications including environmental issues, chemical and biochemical processes and biomedical systems.

CHE475H1 - Biocomposites: Mechanics and Bioinspiration

Credit Value: 0.50
Hours: 38.4L/12.8T

An overview on structure, processing and application of natural and biological materials, biomaterials for biomedical applications, and fibre-reinforced eco-composites based on renewable resources will be provided. Fundamental principles related to linear elasticity, linear viscoelasticity, dynamic mechanical response, composite reinforcement mechanics, and time-temperature correspondence will be introduced. Novel concepts in comparative biomechanics, biomimetic and bio-inspired material design, and materials' ecological and environmental impact will be discussed. In addition, key material processing methods and testing and characterization techniques will be presented. Structure-property relationships for materials broadly ranging from natural materials, including wood, bone, cell, and soft tissue, to synthetic composite materials for industrial and biomedical applications will be covered.

CHE507H1 - Data-based Modelling for Prediction and Control

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will teach students how to build mathematical models of dynamic systems and how to use these models for prediction and control purposes. The course will deal primarily with a system identification approach to modelling (using observations from the system to build a model). Both continuous time and discrete time representations will be treated along with deterministic and stochastic models. This course will make extensive use of interactive learning by having students use computer based tools available in the Matlab software package (e.g. the System Identification Toolbox and the Model Predictive Control Toolbox).

CHE562H1 - Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering

Credit Value: 0.50
Hours: 38.4L

This course serves as an introduction to concepts in polymer chemistry, polymer science and polymer engineering. This includes a discussion of the mechanisms of step growth, chain growth and ring-opening polymerizations with a focus on industrially relevant polymers and processes. The description of polymers in solution as well as the solid state will be explored. Several modern polymer characterization techniques are introduced including gel permeation chromatography, differential scanning calorimetry, thermal gravimetric analysis and others.

Exclusion: CHM426H1
Recommended Preparation: CHE213H1, CHE220H1 or equivalents

CHE565H1 - Aqueous Process Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2) treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

CHE566H1 - Elements of Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

A first course in nuclear engineering intended to introduce students to all aspects of this interdisciplinary field. Topics covered include nuclear technology, atomic and nuclear physics, thermonuclear fusion, nuclear fission, nuclear reactor theory, nuclear power plants, radiation protection and shielding, environment and nuclear safety, and the nuclear fuel cycle.

CHE568H1 - Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamental and applied aspects of nuclear engineering. The structure of the nucleus; nuclear stability and radioactive decay; the interaction of radiation with matter including radiological health hazards; the interaction of neutrons including cross-sections, flux, moderation, fission, neutron diffusion and criticality. Poison buildup and their effects on criticality. Nuclear engineering of reactors, reactor accidents, and safety issues.

Exclusion: MIE414H1

Civil Engineering

CIV102H1 - Structures and Materials - An Introduction to Engineering Design

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

An introduction to the art and science of designing structures. Topics include: 1) material bodies that sustain or resist force, work, energy, stress and strain; 2) the properties of engineering materials (strength, stiffness, ductility); 3) simple structural elements; 4) engineering beam theory; 5) stability of columns; 6) the practical problems which constrain the design of structures such as bridges, towers, pressure vessels, dams, ships, aircraft, bicycles, birds and trees; and 7) design methods aimed at producing safe, functional, efficient and elegant structures.

Corequisite: PHY180H1
Exclusion: CIV100H1

CIV214H1 - Structural Analysis I

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides an introduction to the nature of loads and restraints and types of structural elements, and then reviews the analysis of statically determinate structures. Shear and moment diagrams for beams and frames are considered, along with influence lines, cantilever structures, three-pin arches, cables and fatigue. Virtual work principles are viewed and applied to various structural systems. An introduction to the analysis of indeterminate structures is made, and the Portal method is applied to the analysis of building frames under lateral loads. Displacement methods of an analysis including moment distribution are also studied.

Prerequisite: MAT188H1, CME210H1

CIV280H1 - Management of Construction

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the management of construction projects including: the nature of the industry, project delivery alternatives, legal and ethical considerations, the Safety Act and construction regulations, labour relations, construction contracts, risk distribution, project planning and scheduling, estimating and bidding, controlling of time, cost and quality, accounting leading to financial statements, dispute resolution, as well as new and evolving concepts in managing construction.

CIV301H1 - Design of Hydro and Wind Electric Plants

Credit Value: 0.50
Hours: 3*12.8L/25.6T

Introduction to the applications of turbo-machinery. Description of typical wind and hydroelectric plants; different types of turbo-machines. Fundamental fluid mechanics equations, efficiency coefficients, velocity triangles, characteristic curves, similarity laws, specific speed, vibration, cavitation of hydraulic turbines, pump/turbines; variable speed machines. Estimation of main dimensions of machine units, machine house, waterways, electrical and civil structure; transients and stability. Layout of electric and storage plants. Major and auxiliary equipments and systems. Small and mini plants. Case studies.

Exclusion: EDV301H1

CIV313H1 - Reinforced Concrete I

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides an introduction to the design of reinforced concrete structures. Concrete technology, properties of concrete and reinforcing steel, construction practice, and general code requirements are discussed. Analysis and design of members under axial load, flexure, shear, and restraint force are examined in detail. Other aspects of design covered include control of cracks, minimum and maximum reinforcement ratios, fire resistance, durability, distress and failure. A major design project, done in teams of two and accounting for 15% of the final mark, requires students to formulate a complete design for a structural system such as a pedestrian bridge or floor system. Project requirements include consideration of alternative designs in terms of structural efficiency and total costs.

Prerequisite: CIV312H1

CIV332H1 - Transport II - Performance

Credit Value: 0.50
Hours: 38.4L/12.8T

This course focuses on the fundamental techniques of transportation systems performance analysis with emphasis on congested traffic networks. Topics include transportation demand, supply and equilibrium, traffic assignment, network equilibrium, and system optimality, traffic flow theory, shockwaves, highway capacity analysis, introduction to deterministic and stochastic queuing analyses, intersection signal control types and related timing methods, and traffic simulation. The course also provides an introduction to basic elements of Intelligent Transportation Systems (ITS).

CIV375H1 - Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T/4.224000168P

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.

Exclusion: CIV575H1

CIV380H1 - Sustainable Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will provide students with knowledge of energy demand and supply from local to national scales. Topics include energy demands throughout the economy, major energy technologies, how these technologies work, how they are evaluated quantitatively, their economics and their impacts on the environment. In addition, the ever changing context in which these technologies (and emerging technologies) are being implemented will be outlined. Systems approaches including life cycle assessment, will be refined and applied to evaluate energy systems. A particular focus will be placed on analysis of energy alternatives within a carbon constrained economy.

Prerequisite: CIV375H1, CIV220H1, CME368H1

CIV401H1 - Design and Optimization of Hydro and Wind Electric Plants

Credit Value: 0.50
Hours: 38.4L/25.6T

The application of turbo-machinery including the design and operation of typical wind and hydroelectric plants from first principles to the various types of turbo-machines choices. Fundamental fluid mechanics equations, efficiency coefficients, momentum exchanges, characteristic curves, similarity laws, specific speed, vibration, cavitation of hydraulic turbines, pump/turbines; variable speed machines including transients and hydraulic stability. An introduction to overall system configuration and both component and system optimization. Case studies.

Exclusion: EDV301H1, CIV301H1

CIV416H1 - Reinforced Concrete II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. An introduction to the seismic design of reinforced concrete structures is made. Emphasis is given to the relationship between recent research results and current building codes. A brief treatment of the behaviour and design of masonry walls is included.

Prerequisite: CIV313H1

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

CIV460H1 - Engineering Project Finance and Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course deals with the structuring, valuing, managing and financing of infrastructure projects. The financing portion builds on material covered in Engineering Economics. Key topics include; structuring projects, valuing projects, the rationale for project financing (types of funds and financing), project viability and financial modeling, risk analysis, externalities and social cost benefit analyses. Financing of large scale projects by the public and private sectors as well as through public/private partnerships is treated in detail. Project management concepts, issues, and procedures are introduced. A series of case studies analyzing both successful and unsuccessful projects are examined.

Prerequisite: CHE374H1

CIV498H1 - Group Design Project

Credit Value: 0.50
Hours: 38.4T

The Group Design Project is a significant design experience that integrates the mathematics, basic sciences, engineering sciences, complementary studies, and detailed design aspects of the different civil engineering sub-disciplines.

Exclusion: APS490Y1

CIV510H1 - Solid Mechanics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides a continuing study of the mechanics of deformable solids. Stress and equilibrium conditions, strain and compatibility conditions, stress-strain relations and yield/failure criteria are considered in the context of civil engineering materials. Two-and three-dimensional elasticity theory is developed, with an introduction to the use of tensor notation. Advanced topics in bending, shear and torsion of beams are also covered, as is elementary plate bending theory. The course concludes with a further development and application of energy methods including virtual work, potential energy, strain energy, and related approaches.

Prerequisite: CME210H1

CIV514H1 - Concrete Technology

Credit Value: 0.50
Hours: 38.4L/25.6T

Material aspects of concrete production will be dealt with in the context of various performance criteria with emphasis on durability. The process of material selection, proportioning, mixing, transporting, placing and curing concrete will be the framework within which topics such as: the use of admixtures, choice of cements, environmental influences, methods of consolidation and testing techniques will be studied.

Prerequisite: CIV209H1

CIV515H1 - Introduction to Structural Dynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

The concept of dynamic equilibrium and corresponding equation of motion will be introduced. The theoretical solution of a songle degree of freedom system will be derived and the effects of verious types of loads, such as impulse load, sinusoidal load, or random vibration on the structural response will be discussed. To solve dynamic problems of multi-degree of freedom (MDOF) systems, concepts of mass, stiffness, and damping matrix will be introduced, which will be followed by eigen value analysis and modal analysis. The concepts of Fourier Transformation will be introduced, which will be used to interpret dynamic responses of structures or dynamic nature of applied loads. Dynamic experiments of elastic systems will be demonstrated using an educational shaking table.

Prerequisite: CIV312H1 and CIV313H1 or equivalent

CIV516H1 - Public Transit Operations and Planning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers a broad range of topics in urban transit operations and planning, with special emphasis on best-practice strategies of modern transit systems. The course will help students: Learn the history of transit and its relationship to urban development, emerging challenges, transit role in society, and new trends and issues; Understand and analyze the factors that affect transit performance and demand; Identify and analyze transit operational and planning problems; Identify possible solutions at the operational level (mostly short-term and line-based) and the strategic level (mostly long-term and network-based), and assess alternative solutions; Understand the relative performance of various transit modes (both conventional and new modes) and their domains of application; and gain knowledge of best-practice transit systems planning and emerging innovations.

CIV517H1 - Prestressed Concrete

Credit Value: 0.50
Hours: 38.4L

An introduction to procedures for predicting the load-deformation response of prestressed concrete elements and structures with emphasis on how these procedures can be used in the design of new structures and in the evaluation of existing structures. Topics include: prestressing technology; control of cracking; response to axial load and flexure; response to shear and torsion; disturbed regions; restraint of deformations; design codes.

Prerequisite: CIV313H1/CIV357H1 or equivalent

CIV518H1 - Behaviour and Design of Steel Structures

Credit Value: 0.50
Hours: 38.4L/25.6T

The behaviour and design of trusses, frames, members and connections in steel building and bridge structures is presented and design methods are developed. Ultimate strength, stability, and postbuckling are emphasized in topical examples including: plate girders, composite steel/concrete girders, second-order frame behaviour, high-strength bolted and welded framing connections. Design applications considering metal fatigue and brittle fracture, and methods of plastic analysis are also introduced. Canadian design standards and the Limit States Design concepts are used.

CIV523H1 - Geotechnical Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is built around a transportation project that contains all the essential geotechnical investigation and design elements and illustrates how they all come together on a project. The students will be taken through the entire design process from project initiation to construction. In essence, the project will include a bridge over a river with some property constraints requiring the use of a retaining wall as well as deep and shallow foundations and some groundwater control. The highway will require a soil cut. One section crosses a low-lying swampy area that will require embankment construction over deep soft soils. A short tunnel section is planned beneath a railway that cannot be taken out of service. A pavement design will be required along the entire route as well as materials testing and construction monitoring.

Prerequisite: CME321H1; equivalent or permission of instructor

CIV531H1 - Transport Planning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is intended to provide the student with the following: the ability to design and execute an urban transportation planning study; a working knowledge of transportation planning analysis skills including introductions to travel demand modelling, analysis of environmental impacts, modelling transportation - land use interactions and transportation project evaluation; an understanding of current transportation planning issues and policies; and an understanding of the overall process of transportation planning and its role within the wider context of transportation decision-making and the planning and design of urban areas. Person-based travel in urban regions is the focus of this course, but a brief introduction to freight and intercity passenger transportation is also provided. A "systems" approach to transportation planning and analysis is introduced and maintained throughout the course. Emphasis is placed throughout on designing transportation systems for long-run environmental, social, and economic sustainability.

Prerequisite: CME368H1 or equivalent

CIV575H1 - Studies in Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T

This course examines the basic principles governing the control of heat, moisture and air movement in buildings and presents the fundamentals of building enclosure design. With this background, students are required to research advanced topics related to emerging areas of Building Science, and to write and present to the class an individual comprehensive paper related to their research. Lectures for this course will be jointly offered with those of CIV375H1.

Exclusion: CIV375H1

CIV576H1 - Sustainable Buildings

Credit Value: 0.50
Hours: 38.4L/12.8T

Building systems including the thermal envelope, heating and cooling systems, as well as water and lighting systems are examined with a view to reducing the net energy consumed within the building. Life-cycle economic and assessment methods are applied to the evaluation of various design options including considerations of embodied energy and carbon sequestration. Green building strategies including natural ventilation, passive solar, photovoltaics, solar water heaters, green roofs and geothermal energy piles are introduced. Following the application of these methods, students are introduced to efficient designs including LEED designs that lessen the impact of buildings on the environment. Exemplary building designs will be presented and analyzed.

Prerequisite: CIV375H1/CIV575H1 or equivalent

CIV577H1 - Infrastructure for Sustainable Cities

Credit Value: 0.50
Hours: 38.4L/12.8T

Developing infrastructure for sustainable cities entails understanding the connection between urban morphology and physiology. This course uses a systems approach to analyzing anthropogenic material flow and other components of urban metabolism, linking them to the design of urban infrastructure. Elements of sustainable transportation, green buildings, urban climatology, urban vegetation, water systems and local energy supply are integrated in the design of sustainable urban neighbourhoods.

Prerequisite: CIV340H1, [CIV375H1/CIV575H1]

Civil and Mineral Engineering

CME321H1 - Geotechnical Engineering I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

An introduction to elements of geotechnical analysis and design. Basic site investigation techniques and quantitative descriptions of soil properties and behaviour. Permeability, seepage analysis, and internal stability of granular soil; granular filter design for internal hydraulic stability. Compaction of granular soil; engineered fills for earth dams, road bases, and backfills. Soil shear strength at constant volume; ultimate limit state design of retaining walls, shallow footings, natural slopes and constructed embankments. Groundwater flow analysis and slope stability analysis using commercial software. Physical laboratories for basic soil identification, model groundwater flow analysis, direct shear strength tests, and reinforced earth models.

Prerequisite: CME270H1, CME210H1

CME358H1 - Survey CAMP (Civil and Mineral Practicals)

Credit Value: 0.50
Hours: 12.8T

This two-week August field camp provides students with the opportunity to further their understanding of the vital interactions between the natural and the built environments. Through fieldwork, students gain hands-on experience in the use of various field instruments used by Civil and Mineral Engineers. The essentials of land surveying and the use of surveying instruments including Global Positioning Systems are taught as students carry out a series of field exercises that include route surveys, topographic surveys and construction surveys. Survey calculations, sources of error, corrections and adjustments are also introduced. In order to better understand our impact on the natural environment, students also perform several additional exercises. These may include the measurement of river flows, remote sensing of soil and rock, remediation of a borrow pit, and the evaluation of the renewable energy potential of the wind and solar radiation. Note: This course requires payment of an extra fee for room and board.

Computer Science

CSC180H1 - Introduction to Computer Programming

Credit Value: 0.50
Hours: 38.4L/38.4P

The first of two courses that introduces students to programming and computational thinking, and prepares them for additional study across a breadth of programming fields. Students will learn to use the Python programming language to design and implement computational solutions to problems drawn from their 1F courses, with specific focus on algorithms, data structures, problem decomposition, and the use of programming paradigms appropriate to the problems being solved. Specifically, this course aims to have students work with and understand profiling and runtime analysis, searching and sorting algorithms, and the use of recursion.

Exclusion: APS105H1, APS106H1 or CSC192H1

CSC343H1 - Introduction to Databases

Credit Value: 0.50
Hours: 36L

Introduction to database management systems. The relational data model. Relational algebra. Querying and updating databases: the query language SQL. Application programming with SQL. Integrity constraints, normal forms, and database design. Elements of database system technology: query processing, transaction management.

Prerequisite: CSC111H1/ CSC165H1/ CSC240H1/ (MAT135H1, MAT136H1)/ MAT135Y1/ MAT137Y1/ MAT157Y1/ (MAT186H1, MAT187H1)/ (MAT194H1, MAT195H1)/ (ESC194H1, ESC195H1); CSC207H1/ CSC207H5/ CSCB07H3/ ECE345H1/ ESC190H1
Exclusion: CSC443H1. NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.

CSC384H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 24L/12T

Theories and algorithms that capture (or approximate) some of the core elements of computational intelligence. Topics include: search; logical representations and reasoning, classical automated planning, representing and reasoning with uncertainty, learning, decision making (planning) under uncertainty. Assignments provide practical experience, in both theory and programming, of the core topics.

Prerequisite: (CSC263H1/ CSC265H1/ CSC263H5/ CSCC63H3/ ECE345H1/ ECE358H1/ MIE335H1, STA237H1/ STA247H1/ STA255H1/ STA257H1/ STA237H1/ STAB57H3/ STAB52H3/ ECE302H1/ STA286H1/ CHE223H1/ CME263H1/ MIE231H1/ MIE236H1/ MSE238H1/ ECE286H1)
Exclusion: NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Recommended Preparation: CSC324H1

Electrical and Computer Engineering

ECE159H1 - Fundamentals of Electric Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Topics include: DC linear circuit elements; DC linear circuit analysis; Kirchhoff's Laws and superposition; Thevenin and Norton equivalents; nodal analysis; operational amplifier; transient response of linear circuits; sinusoidal steady state analysis; phasors; power in AC circuits; frequency response; and resonance phenomena.

Exclusion: ECE110H1 or ECE212H1
Recommended Preparation: MAT194H1 and ESC103H1

ECE253H1 - Digital and Computer Systems

Credit Value: 0.50
Hours: 38.4L/38.4P

Digital system design principles. Logic circuits, logic synthesis. Registers, arithmetic circuits, counters, finite state machines, and programmable logic devices. Verilog hardware description language. Computer structure, machine language instruction execution and sequencing, addressing techniques. Processors, input/output techniques, and memory hierarchy. The laboratory work consists of exercises involving the design of logic circuits, and microprocessor systems. Modern computer-aided design tools and FPGA technology are used. Design aspects constitute a major portion of laboratory work.

Exclusion: ECE241H1

ECE259H1 - Electromagnetism

Credit Value: 0.50
Hours: 38.4L/12.8T

The fundamental laws of electromagnetics are covered; including Coulomb's law, Gauss' law, Poisson's and Laplace's equations, the Biot-Savart's law, Ampere's law, Faraday's law, and Maxwell's equations. Vector calculus is applied to determine the relationship between the electric and magnetic fields and their sources (charges and currents). Field-matter interaction is studied, including polarization in dielectric materials and magnetization in magnetic materials. Circuit elements such as the resistor, capacitor and inductor are introduced from an electromagnetic point of view. Other topics include: electric and magnetic forces, the electric potential, capacitance and inductance, electric and magnetic energy, magnetic circuits, boundary-value problems and transmission-lines.

Prerequisite: ECE159H1, AER210H1
Exclusion: MAT291H1/ECE221H1
Recommended Preparation: MAT292H1 and MAT185H1

ECE286H1 - Probability and Statistics

Credit Value: 0.50
Hours: 38.4L/12.8T

A course in probability and statistics for Engineering Science students focusing on building solid probabilistic and statistical foundations both mathematically and in terms of engineering application. Topics include: sample space, events, definitions of probability, conditional probability, Bayes' theorem, important classes of discrete and continuous random variables and their distributions, joint, conditional, and marginal distributions, expectation, moment generating and characteristic functions, transformations of random variables, central limit theorem and approximations. Graphical methods, quantile plots, point and interval estimation of population parameters, method of maximum likelihood. Hypothesis testing, simple and multiple regression, correlation analysis, and introduction to Bayesian statistics.

Exclusion: CHE223H1, CME263H1, MSE238H1, MIE236H1, MIE237H1, MIE231H1, STA286H1 or STA257H1

ECE313H1 - Energy Systems and Distributed Generation

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Three-phase systems; steady-state transmission line model; symmetrical three-phase faults; power system stability; symmetrical components; unsymmetrical faults and fault current calculation; distribution network; equivalent steady-state model of voltage-sourced converter; distributed energy resources (DR); distributed energy storage; interface between DR and power system.

Exclusion: ECE413H1

ECE318H1 - Fundamentals of Optics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Geometric Optics: Spherical surfaces, lenses and mirrors, optical imaging systems, matrix method, and aberrations. Polarization: Polarizer and polarizations, anisotropic materials, dichroism, birefringence, index ellipsoid, waveplates, optical activity, Faraday effect. Interference: superposition of waves, longitudinal and transverse coherence, Young's double-slit experiment, Michelson and Fabry-Perot interferometer, thin-films. Diffraction and Fourier Optics: diffraction theory, single and double slits, diffraction gratings, spatial filtering, basic optical signal processing. (Background preparation in ECE320H1 F - Fields and Waves, or ECE357H1 S - Electromagnetic Fields, is strongly recommended.)

Prerequisite: ECE221H1 or ECE259H1

ECE324H1 - Machine Intelligence, Software and Neural Networks

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will focus on machine learning engineering, through the sense of neural networks, dealing with the data collection and software development as an engineering descipline. After reviewing the essentials of the neural network approach, including convolutional and recurrent neural networks, the course will focus on applications of classification, regression and various kinds of prediction. Practical techniques in machine learning will be covered, including data collection, data augmentation, the use of pre-trained networks, auto encoders and generative adversarial networks. A key topic will include natural language processing, attention and Transformer networks. There will be reflection on ethics in machine learning. A significant component of the course will be hands-on exposure to machine-learning software framework through assignments and a major design project.

Prerequisite: ESC190H1/ECE286H1/ECE421H1
Exclusion: APS360H1

ECE326H1 - Programming Languages

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Study of programming styles and paradigms. Included are object-oriented scripting functional and logic-based approaches. Languages that support these programming styles will be introduced. Languages treated include Python, Lisp or Scheme and Prolog.

Exclusion: CSC324H1, CSC326H1

ECE334H1 - Digital Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Digital design techniques for integrated circuits. The emphasis will be on the design of logic gates at the transistor level. A number of different logic families will be described, but CMOS will be emphasized. Review of: device modeling, IC processing, and Spice simulation, simplified layout rules, inverter noise margins, transient response, and power dissipation, traditional CMOS logic design, transmission gates, RC timing approximations, input-output circuits, latches and flipflops, counters and adders, decoders and muxes, dynamic gates, SRAMs, DRAMs, and EEPROMs.

Prerequisite: ECE241H1 and ECE231H1 or ECE253H1 and ECE360H1

ECE342H1 - Computer Hardware

Credit Value: 0.50
Hours: 38.4L/38.4P

Arithmetic circuits, cubical representation of logic functions, digital system design, timing analysis, design of asynchronous circuits, testing of logic circuits.

Prerequisite: ECE241H1 and ECE243H1

ECE349H1 - Introduction to Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Established and emerging sources of electrical energy: hydroelectric, thermal, wind, and solar. Three-phase AC systems and complex power. Mechanisms for electrical-electrical energy conversion: power electronic systems for DC-DC conversion, single-phase DC-AC and three-phase DC-AC conversion, transformers for single-phase and three-phase AC-AC conversion. Electro-mechanical energy conversion via the synchronous machine. Fundamentals of AC electrical energy networks: frequency regulation, voltage regulation, and protection.

Prerequisite: ECE259H1
Exclusion: ECE314H1

ECE350H1 - Semiconductor Electronic Devices

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An explanation of the basic operation, design and limitations of semiconductor electronic devices, such as diodes and transistors. The topics covered include: electrons in semiconductors, semiconductors in equilibrium, transport of carriers, p-n diodes, metal-semiconductor contacts, bipolar junction transistors, metal-oxide-semiconductor (MOS) capacitors, and MOS field effect transistors. In addition, optoelectronic devices (e.g. photodiodes, light emitting diodes and lasers), semiconductor heterostructures, nanostructures (quantum dots, qubits) and transistor scaling will be discussed.

Prerequisite: PHY294H1
Exclusion: ECE335H1, ECE330H1

ECE352H1 - Computer Organization

Credit Value: 0.50
Hours: 38.4L/38.4P

A continuation of some of the topics introduced in ECE253H1. Embedded system design: Input-output and the use of interrupts, peripherals and interfacing. Processor design: pipelining, integer and floating point arithmetic, cache hierarchies and memory organization. Design of combinational and sequential circuits in Verilog.

Prerequisite: ECE253H1
Exclusion: ECE342H1

ECE353H1 - Systems Software

Credit Value: 0.50
Hours: 38.4L/38.4P

Operating system structure, processes, threads, synchronization, CPU scheduling, memory management, file systems, input/output, multiple processor systems, virtualization, protection, and security. The laboratory exercises will require implementation of part of an operating system.

Prerequisite: ESC190H1
Exclusion: ECE344H1, CSC369H1

ECE354H1 - Electronic Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

A course on analog and digital electronic circuits. Topics include single-stage amplifiers, current mirrors, cascode amplifiers and differential pairs. Amplifier frequency response, feedback and stability are also covered. Digital CMOS logic circuits are introduced.

Prerequisite: ECE360H1
Exclusion: ECE331H1

ECE355H1 - Signal Analysis and Communication

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to continuous-time and discrete-time signals and systems. Topics include characterization of linear time-invariant systems, Fourier analysis, linear filtering, sampling of continuous-time signals, and modulation techniques for communication systems.

Prerequisite: ECE286H1
Exclusion: ECE216H1

ECE356H1 - Introduction to Control Theory

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to dynamic systems and their control. Differential equation models of physical systems using transfer functions and state space models. Linearization. Initial and input response. Stability theory. Principle of feedback. Internal Model Principle. Frequencey response. Nyquist stability. Loop shaping theory. Computer aided design using MATLAB and Simulink.

Prerequisite: MAT292H1
Exclusion: ECE311H1, AER372H1

ECE357H1 - Electromagnetic Fields

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to transmission line theory: voltage and current waves, characteristic impedance, reflections from the load and source, transients on the line, Smith's chart, impedance matching. Fundamentals of electromagnetic theory: Maxwell's equations, Helmholtz's theorem, time retarded scalar and vector potentials, gauges, boundary conditions, electric and magnetic fields wave equations and their solutions in lossless and lossy medium. Plane wave propagation, reflection and transmission at boundaries. Constitutive relations and dispersion. Radiating dipole and waveguides.

Prerequisite: ECE259H1
Exclusion: ECE320H1

ECE358H1 - Foundations of Computing

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamentals of algorithm design and computational complexity, including: analysis of algorithms, graph algorithms, greedy algorithms, divide-and-conquer, dynamic programming, network flow, approximation algorithms, the theory of NP-completeness, and various NP-complete problems.

Prerequisite: ESC190H1
Exclusion: ECE345H1

ECE360H1 - Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to electronics. Basic electronic circuits: introductory frequency-domain analysis, operational amplifiers, diodes, field-effect transistors, bipolar junction transistors, small-signal analysis, single-stage amplifiers.

Prerequisite: ECE159H1
Exclusion: ECE231H1

ECE361H1 - Computer Networks I

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Layered network architectures; overview of TCP/IP protocol suite. Introduction to sockets; introduction to application layer protocols. Peer-to-Peer Protocols: ARQ; TCP reliable stream service; flow control. Data Link Controls: Framing; PPP; HDLC. Medium access control and LANs: Aloha; Ethernet; Wireless LANs; Bridges. Packet Switching: Datagram and virtual circuit switching; Shortest path algorithms; Distance vector and link state algorithms.

Prerequisite: ECE286H1 or ECE302H1
Corequisite: ECE302H1. (Students must take the co-requisite, ECE302H1 in the same term as ECE361H, OR in a term before taking ECE361H1.)

ECE363H1 - Communication Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in analog and digital communication systems. Analog and digital signals. Probability and random processes. Energy and power spectral densities; bandwidth. Distortionless analog communication; amplitude, frequency and phase modulation systems; frequency division multiplexing. Sampling, quantization and pulse code modulation (PCM). Baseband digital communication; intersymbol interference (ISI); Nyquist's ISI criterion; eye diagrams. Passband digital communications; amplitude-, phase- and frequency-shift keying; signal constellations. Performance analysis of analog modulation schemes in the presence of noise. Performance analysis of PCM in noise.

Prerequisite: MAT389H1, ECE355H1
Exclusion: ECE316H1

ECE367H1 - Matrix Algebra and Optimization

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will provide students with a grounding in optimization methods and the matrix algebra upon which they are based. The first past of the course focuses on fundamental building blocks in linear algebra and their geometric interpretation: matrices, their use to represent data and as linear operators, and the matrix decompositions (such as eigen-, spectral-, and singular-vector decompositions) that reveal structural and geometric insight. The second part of the course focuses on optimization, both unconstrained and constrained, linear and non-linear, as well as convex and nonconvex; conditions for local and global optimality, as well as basic classes of optimization problems are discussed. Applications from machine learning, signal processing, and engineering are used to illustrate the techniques developed.

Prerequisite: AER210H1/MAT290H1, MAT185H1/MAT188H1

ECE368H1 - Probabilistic Reasoning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will focus on different classes of probabilistic models and how, based on those models, one deduces actionable information from data. The course will start by reviewing basic concepts of probability including random variables and first and second-order statistics. Building from this foundation the course will then cover probabilistic models including vectors (e.g., multivariate Gaussian), temporal (e.g., stationarity and hidden Markov models), and graphical (e.g., factor graphs). On the inference side topics such as hypothesis testing, marginalization, estimation, and message passing will be covered. Applications of these tools cover a vast range of data processing domains including machine learning, communications, search, recommendation systems, finance, robotics and navigation.

Prerequisite: ECE286H1/ECE302H1
Exclusion: CSC412H1

ECE411H1 - Real-Time Computer Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Digital Control analysis and design by state-space methods. Introduction to scheduling of control tasks using fixed-priority protocols. Labs include control design using MATLAB and Simulink, and computer control of the inverted pendulum using a PC with real-time software.

Prerequisite: ECE311H1 or ECE356H1

ECE412H1 - Analog Signal Processing Circuits

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will provide students with an overview of continuous-time and discrete-time signal processing techniques, and the analysis and design of analog and mixed-signal circuit building blocks used in modern electronic systems. Topics covered include: analysis, specification, simulation, and design of continuous-time filters with linear transconductors and op-amps; phase-domain model, noise model, and design methodology for low phase noise Phase Lock Loops and associated building blocks (VCO, phase-frequency detector, charge pump); discrete-time signal analysis using z-transform; discrete-time filter design based on switched capacitors; as well as fundamentals, architectures, building blocks, and characterization techniques for digital-to-analog and analog-to-digital converters.

Prerequisite: ECE331H1 or ECE354H1
Exclusion: ECE512H1

ECE417H1 - Digital Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Basic concepts of digital communication. Baseband data transmission, intersymbol interference, Nyquist pulse shaping, equalization, line coding, multi-path fading, diversity. Binary and M-ary modulation schemes, synchronization. Signal space concepts, optimum receivers, coherent and noncoherent detectors. Information theory, source encoding, error control coding, block and convolutional codes.

Prerequisite: ECE302H1 and ECE316H1, or ECE286H1

ECE419H1 - Distributed Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Design issues in distributed systems: heterogeneity, security, transparency, concurrency, fault-tolerance; networking principles; request-reply protocol; remote procedure calls; distributed objects; middleware architectures; CORBA; security and authentication protocols; distributed file systems; name services; global states in distributed systems; coordination and agreement; transactions and concurrency control; distributed transactions; replication.

Prerequisite: ECE344H1 or ECE353H1

ECE421H1 - Introduction to Machine Learning

Credit Value: 0.50
Hours: 38.4L/25.6T

An Introduction to the basic theory, the fundamental algorithms, and the computational toolboxes of machine learning. The focus is on a balanced treatment of the practical and theoretical approaches, along with hands on experience with relevant software packages. Supervised learning methods covered in the course will include: the study of linear models for classification and regression, neural networks and support vector machines. Unsupervised learning methods covered in the course will include: principal component analysis, k-means clustering, and Gaussian mixture models. Theoretical topics will include: bounds on the generalization error, bias-variance tradeoffs and the Vapnik-Chervonenkis (VC) dimension. Techniques to control overfitting, including regularization and validation, will be covered.

Prerequisite: ECE286H1/STA286H1, ECE302H1/MIE231H1/CHE223H1/MIE236H1/MSE238H1
Exclusion: CSC411H1, ECE521H1

ECE422H1 - Radio and Microwave Wireless Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Analysis and design of systems employing radio waves, covering both the underlying electromagnetics and the overall system performance aspects such as signal-to-noise ratios. Transmission/reception phenomena include: electromagnetic wave radiation and polarization; elementary and linear dipoles; directivity, gain, efficiency; integrated, phased-array and aperture antennas; beam-steering; Friis transmission formula and link budget. Propagation phenomena include: diffraction and wave propagation over obstacles; multipath propagation; atmospheric and ionospheric effects. Receiver design aspects include: radio receiver architectures, receiver figures of merit, noise in cascaded systems, noise figure, and noise temperature. System examples are: terrestrial communication systems; satellite communications; radar; radiometric receivers; software-defined radio.

Prerequisite: ECE320H1 or ECE357H1

ECE424H1 - Microwave Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Losses in conductors and dielectrics; RF and microwave transmission lines; transients on transmission lines; matching networks; planar transmission lines (microstrip, stripline, coplanar waveguide); design with scattering parameters; 3- and 4-port RF devices (power dividers/combiners, couplers, isolators & circulators); coupled lines and devices; microwave active circuits (RF amplifiers, mixers, and receiver front ends); RF and microwave filters. The hands-on laboratories engage students in the design, simulation, fabrication, and test of practical passive and active microwave circuits using industry-standard RF/microwave simulation tools and measurement systems.

Exclusion: ECE524H1

ECE427H1 - Photonic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

The human visual interface is rapidly evolving with the emergence of smart glasses, AR/VR wearable display, and autonomous vehicles. This course examines the photonic devices and integrated systems that underline such technologies, and how they are shaped by human visual perception and acuity. Advanced integrated photonic systems in optical display and sensing will be deconstructed and the underlying fundamental concepts studied. Topics include introduction to: heads up and wearable display, optical lidar, optical fiber, waveguide circuits, holography, optical switches, light sources (LED, laser), detectors and imaging sensors.

Prerequisite: ECE318H1/ECE320H1/ECE357H1

ECE430H1 - Analog Integrated Circuits

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Review of MOSFET semiconductor device equations. Noise in electronic devices. Review of single-stage amplifiers and frequency response, including noise analysis. Basic CMOS op amp. Op amp compensation. Advanced op amp circuits: telescopic and folded-cascode op amps. Fully-differential op amps. Common mode feedback.

Prerequisite: ECE331H1 or ECE354H1
Exclusion: ECE530H1

ECE431H1 - Digital Signal Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in digital filtering and applications. Introduction to real world signal processing. Review of sampling and quantization of signals. Introduction to the discrete Fourier transform and its properties. The fast Fourier transform. Fourier analysis of signals using the discrete Fourier transform. Structures for discrete-time systems. Design and realization of digital filters: finite and infinite impulse response filters. DSP applications in areas such as communications, multimedia, video coding, human computer interaction and medicine.

ECE437H1 - VLSI Technology

Credit Value: 0.50
Hours: 38.4L/38.4P

The introduction to VLSI fabrication techniques, integrated circuit designs and advanced semiconductor devices will give a proper perspective of the past, present and future trends in the VLSI industry. Following the evolution of MOS and bipolar devices, digital and analog CMOS, BiCMOS, deep submicron CMOS, SOI-CMOS, RF-CMOS and HV-CMOS technologies will be studied. Special attention will be given to the physical scaling limits such as short channel effects. In addition, CAD tools and design methodology for the development of advanced semiconductor devices and integrated circuits will be introduced in the laboratory environment. These include the simulation of device fabrication, device characteristics, device modeling, circuit layout, design verification. Finally, advanced technology such as GaN HEMTs, graphene devices, carbon nano-tube devices, power devices, heterojunctions, InP and GaSb HBTs will also be studied.

Prerequisite: (ECE331H1 or ECE334H1 or ECE354H1) and (ECE335H1 or ECE350H1)
Exclusion: ECE535H1 and ECE534H1

ECE444H1 - Software Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

The software development process. Software requirements and specifications. Software design techniques. Techniques for developing large software systems; CASE tools and software development environments. Software testing, documentation and maintenance.

Prerequisite: ECE344H1 or ECE353H1
Exclusion: CSC444H1

ECE446H1 - Sensory Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Physical acoustics, acoustic measurements, electroacoustic transducers, and physiological acoustics. Speech processing, speech recognition algorithms and signal processing by the auditory system. Engineering aspects of acoustic design. Electrical models of acoustic systems. Noise, noise-induced hearing loss, and noise control. Introduction to vision and other modalities. Musical and psychoacoustics.

ECE448H1 - Biocomputation

Credit Value: 0.50
Hours: 38.4L/25.6T

Modern technologies in the biosciences generate tremendous amounts of biological data ranging from genomic sequences to protein structures to gene expression. Biocomputations are the computer algorithms used to reveal the hidden patterns within this data. Course topics include basic concepts in molecular cell biology, pairwise sequence alignment, multiple sequence alignment, fast alignment algorithms, deep learning approaches, phylogentic prediction, structure-based computational methods, gene finding and annotation.

ECE454H1 - Computer Systems Programming

Credit Value: 0.50
Hours: 38.4L/38.4P

Fundamental techniques for programming computer systems, with an emphasis on obtaining good performance. Topics covered include: how to measure and understand program and execution and behaviour, how to get the most out of an optimizing compiler, how memory is allocated and managed, and how to exploit caches and the memory hierarchy. Furthermore, current trends in multicore, multithreaded and data parallel hardware, and how to exploit parallelism in their programs will be covered.

ECE455H1 - Digital Signal Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Review of sampling and discrete-time signals in one or more dimensions; linear shift-invariant systems; the Z-transform; the discrete-time Fourier transform; the discrete Fourier transform and computationally efficient implementations (fast Fourier transforms); general orthogonal representations; wavelet bases; discrete-time filters: finite and infinite impulse response filters; fixed-point implementations and finite word-length effects; multidimensional filters and multidimensional signal processing. Illustrative applications are drawn from audio and biomedical signal processing, communication systems, and image and video signal processing.

Prerequisite: ECE355H1
Exclusion: ECE362H1, ECE431H1

ECE461H1 - Internetworking

Credit Value: 0.50
Hours: 38.4L/6.4T/19.2P

This course will cover the fundamentals of protocols for packet switching networks with emphasis on Internet type of networks including the following topics: the Internetworking concept and architectural model; data link layer (Ethernet and PPP); service interface; Internet addresses; address resolution protocol; Internet protocol (connectionless datagram delivery); routing IP datagrams; Internet control message protocol (error and control messages); subnet and supernet address extensions; ping program; traceroute program; user datagram protocol; reliable stream transport service (TCP); the socket interface; routing (GGP, EGP, IP, OSPF, HELLO); Internet multicasting; domain name system; applications such as HTTP, electronic mail, and SNMP; Internet security and firewall design; Ipv6, RSVP, flows, and ISIP.

Prerequisite: ECE361H1

ECE462H1 - Multimedia Systems

Credit Value: 0.50
Hours: 38.4L/25.6P

Topics in the engineering area of multimedia systems with particular emphasis on the theory, design features, performance, complexity analysis, optimization and application of multimedia engineering technologies. Topics include sound/audio, image and video characterization, compression, source entropy and hybrid coding, transform coding, wavelet-based coding, motion estimation, JPEG coding, digital video coding, MPEG-1/2 coding, content-based processing, and MPEG-7.

ECE463H1 - Electric Drives

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Electro-mechanical mechanisms for force and torque production in rotating machines. DC machine theory and DC machine dynamics, synchronous machines and their dynamics, stepper motors. Introduction to space vectors and vector control of AC machines. Steady state and variable speed operation of the induction machine via V/f control.

Prerequisite: ECE314H1/ECE315H1/ECE349H1/ECE359H1, ECE311H1/ECE356H1/AER372H1
Corequisite: ECE311H1/ECE356H1/AER372H1

ECE464H1 - Wireless Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The radio medium, radio communication system examples. Link budget: cable losses, propagation loss, antenna gains. Basic concepts of propagation: path loss, multi-path propagation and fading. Raleigh and Rician fading models, Doppler shift, delay spread, coherence time and coherence bandwidth of the channel. Analog modulation schemes and their bandwidths. Digital modulation schemes and their bandwidths and bit rates: BPSK, QPSK, MSK, GMSK. Basic concepts of speech coding. Error correction coding, interleaving, and multiple access frame structure. The physical layer description of the AMPS, IS-54, and GSM cellular systems. The cellular concept: frequency re-use, re-use cluster concept. Channel allocation. Cellular system architecture for AMPS, IS-54, and GSM. Hand-offs and transmitter power control. Cellular traffic, call blocking, concept of Erlangs. Basic ideas in spread spectrum modulation, spreading codes, bit error probability. Orthogonal and non-orthogonal CDMA Basic concepts in CDMA networks.

Prerequisite: ECE302H1 and ECE316H1 and ECE417H1, or ECE286H1 and ECE417H1

ECE466H1 - Computer Networks II

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Traffic modeling; network calculus; traffic classification; traffic regulation: shaping, filtering, policing, leaky bucket; queueing systems; scheduling; quality of service: Diffserv and IntServ/RSVP; multi-protocol label switching; call admission control / congestion control; switching; pricing; optical networks.

Prerequisite: ECE361H1

ECE467H1 - Compilers & Interpreters

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Compiler organization, compiler writing tools, use of regular expressions, finite automata and context-free grammars, scanning and parsing, runtime organization, semantic analysis, implementing the runtime model, storage allocation, code generation.

Prerequisite: ECE243H1/ECE352H1
Exclusion: CSC467H1

ECE469H1 - Optical Communications and Networks

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course provides an introduction to optical communication systems and networks at the system and functional level. Applications range from telecommunication networks (short to long haul) to computing networks (chip-to-chip, on chip communications, optical backplanes). Basic principles of optical transmission and associated components used for transmission of light and optical networks; system design tools for optical links; multi-service system requirements; optical network design tools (routing and wavelength assignment), network management and survivability.

ECE470H1 - Robot Modeling and Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Classification of robot manipulators, kinematic modeling, forward and inverse kinematics, velocity kinematics, path planning, point-to-point trajectory planning, dynamic modeling, Euler-Lagrange equations, inverse dynamics, joint control, computed torque control, passivity-based control, feedback linearization.

Prerequisite: ECE311H1 or ECE356H1
Exclusion: AER525H1

ECE516H1 - Intelligent Image Processing

Credit Value: 0.50
Hours: 38.4L/38.4P

This course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics, including "Wearable Computing", "Personal Technologies", "Human Computer Interaction (HCI)," "Mobile Multimedia," "Augmented Reality," "Mediated Reality," CyborgLogging," and the merging of communications devices such as portable telephones with computational and imaging devices. The focus is on fundamental aspects and new inventions for human-computer interaction. Topics to be covered include: mediated reality, Personal Safety Devices, lifelong personal video capture, the Eye Tap principle, collinearity criterion, comparametric equations, photoquantigraphic imaging, lightvector spaces, anti-homomorphic imaging, application of personal imaging to the visual arts, and algebraic projective geometry.

ECE520H1 - Power Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Focuses on power electronic converters utilized in applications ranging from low-power mobile devices to higher power applications such as electric vehicles, server farms, microgrids, and renewable energy systems. Concepts covered include the principles of efficient electrical energy processing (dc-dc, dc/ac, and ac/ac) through switch-mode energy conversion, converter loss analysis, large- and small-signal modeling of power electronic circuits and controller design.

Prerequisite: ECE314H1/ECE349H1/ECE359H1
Exclusion: ECE514H1, ECE533H1

ECE532H1 - Digital Systems Design

Credit Value: 0.50
Hours: 38.4L/38.4P

Advanced digital systems design concepts including project planning, design flows, embedded processors, hardware/software interfacing and interactions, software drivers, embedded operating systems, memory interfaces, system-level timing analysis, clocking and clock domains.

A significant design project is undertaken and implemented on an FPGA development board.

Prerequisite: ECE342H1 or ECE352H1

ECE537H1 - Random Processes

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to the principles and properties of random processes, with applications to communications, control systems, and computer science. Random vectors, random convergence, random processes, specifying random processes, Poisson and Gaussian processes, stationarity, mean square derivatives and integrals, ergodicity, power spectrum, linear systems with stochastic input, mean square estimation, Markov chains, recurrence, absorption, limiting and steady-state distributions, time reversibility, and balance equations.

Prerequisite: ECE286H1 and ECE355H1 or ECE302H1
Corequisite: ECE355H1 (can be taken at the same time as ECE537H1)

ECE552H1 - Computer Architecture

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Performance analysis and metrics and cost. Instruction set architectures. Instruction-level parallelism: pipelining, superscalar, dynamic scheduling, VLIW processors. Data-level prallelism: vector processors, GPUs. Thread-level parallelism: multiprocessors, multi-core, coherence, simultaneous multi-threading. Memory hierarchies: caches and virtual memory support. Simulation tools and methods. Limited Enrollment.

Prerequisite: ECE243H1 or ECE352H1

ECE557H1 - Linear Control Theory

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

State-space approach to linear system theory. Mathematical background in linear algebra, state space equations vs. transfer functions, solutions of linear ODE's, state transition matrix, Jordan form, controllability, eigenvalue assignment using state feedback, observability, designing observers, separation principle, Kalman filters, tracking and the regulator problem, linear quadratic optimal control, stability. Laboratories cover the state space control design methodology.

Prerequisite: ECE356H1/AER362H1
Exclusion: ECE410H1

ECE568H1 - Computer Security

Credit Value: 0.50
Hours: 38.4L/38.4P

As computers permeate our society, the security of such computing systems is becoming of paramount importance. This course covers principles of computer systems security. To build secure systems, one must understand how attackers operate. This course starts by teaching students how to identify security vulnerabilities and how they can be exploited. Then techniques to create secure systems and defend against such attacks will be discussed. Industry standards for conducting security audits to establish levels of security will be introduced. The course will include an introduction to basic cryptographic techniques as well as hardware used to accelerate cryptographic operations in ATM's and webservers.

Prerequisite: ECE344H1 or ECE353H1

Environment

ENV346H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 36L/24T

Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large-scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Prerequisite: (MAT135H1, MAT136H1)/ MAT137Y1/ JMB170Y1; BIO120H1/ CHM136H1/ CHM138H1/ CHM135H1/ CHM139H1/ CHM151Y1/ PHY131H1/ PHY132H1/ PHY151H1/ PHY152H1

Engineering Science

ESC101H1 - Praxis I

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Praxis I is the cornerstone course of the Engineering Science Foundation Design sequence and introduces the foundational models and tools of engineering design, communication, teamwork, and professionalism that underlie design education within Engineering Science. In Praxis I students work both individually and in small teams to develop their knowledge and skills in through a combination of active lectures, structured interactive studios, and hands-on practical sessions. The design projects in Praxis I are scoped to the individual student and the broader University community. Each student and team is responsible for both defining and resolving their own opportunities. Praxis I also supports students as they transition into their engineering studies and into the Engineering Science learning community. This support integrates conceptual models, concrete techniques, and University resources, and addresses both academic and non-academic concerns. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

Exclusion: APS111H1

ESC102H1 - Praxis II

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Praxis II develops the models and tools of design, communication, teamwork, and professionalism introduced in Praxis I. The course also introduces additional complementary considerations including ethics and equity. In Praxis II students work primarily in small teams to develop and refine their knowledge and skills in through a combination of active lectures, structured interactive studios, and hands-on practical sessions. The design projects in Praxis II are scoped to communities within the broader City of Toronto. Student teams are responsible for identifying and engaging with these communities, and for first framing and then resolving a collaboratively identified opportunity.Praxis II culminates in a public showcase where teams present and demonstrate their designs to their stakeholders and to the general public. Praxis II also continues to support students as they integrate more fully into the Engineering Science learning community. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

Prerequisite: ESC101H1
Exclusion: APS112H1

ESC103H1 - Engineering Mathematics and Computation

Credit Value: 0.50
Hours: 25.6L/25.6T

This course is designed to introduce students to mathematics in an engineering context, while exposing students to computational techniques. Topics include: vectors, lines and planes; 3-D visualization; matrices and transformations; matrix inverses, eigenvalues and determinants; solving linear systems; curve fitting and least squares; numerical integration and numerical solutions to differential equations. Course content is complemented with the use of MATLAB computational software.

ESC180H1 - Introduction to Computer Programming

Credit Value: 0.50
Hours: 38.4L/38.4P

The first of two courses that introduces students to programming and computational thinking, and prepares them for additional study across a breadth of programming fields. Students will learn to use the Python programming language to design and implement computational solutions to problems drawn from their 1F courses, with specific focus on algorithms, data structures, problem decomposition, and the use of programming paradigms appropriate to the problems being solved. Specifically, this course aims to have students work with and understand profiling and runtime analysis, searching and sorting algorithms, and the use of recursion.

Exclusion: APS105H1, APS106H1 or CSC192H1

ESC190H1 - Computer Algorithms and Data Structures

Credit Value: 0.50
Hours: 38.4L/25.6T/38.4P

The second of two courses that introduces students to programming and computational thinking, and prepares them for additional study across a breadth of programming fields. Students will develop an understanding of data structures and fundamental algorithms. The emphasis will be on (a) further refining their multiple introductory programming languages, and (b) understanding why diverse data structures exist, and how algorithms can be analyzed for their time and space complexity. Specifically, this course aims to have students work with and understand the list, stack, queue, tree, hash table, and graph data structures; a look at searching, sorting, and analysis of complexity will complement the presentation on the algorithms side.

Prerequisite: ESC180H1
Exclusion: APS106H1, CSC192H1, ECE244H1 or MIE250H1

ESC194H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: theory and applications of differential and integral calculus, limits, basic theorems and elementary functions. An introduction to differential equations is also included.

ESC195H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, improper integrals, sequences, series, Taylor's theorem, as well as an introduction to vector functions, functions of several variables, partial derivatives and the optimization of multivariable functions.

Prerequisite: ESC194H1
Exclusion: MAT187H1/APS163H1

ESC203H1 - Engineering and Society

Credit Value: 0.50
Hours: 25.6L/25.6T

Through this course, students will examine the relationship between engineering and society, emphasizing a humanities and social sciences perspective. Building on the Praxis courses, students will develop and apply an understanding of ethics and equity to broader sociotechnical systems and challenges. Using models of critical thinking, active learning activities and discussion seminars, students will develop an understanding of the social and environmental impacts of technology. Students will further develop their communication, teamwork and professional skills through persuasive writing, facilitation and formal debate. Upon completion of the course, students will have an appreciation for the complex interaction between human society and technology, and will be able to analyze and evaluate the social, technological, political, and ethical dimensions of technology.

Humanities and Social Science elective.

Exclusion: CME259H1
Recommended Preparation: ESC102H1

ESC204H1 - Praxis III

Credit Value: 0.50
Hours: 12.8L/12.8T/64P

Praxis III is the capstone course of the Engineering Science Foundation Design sequence and challenges students to apply the models of engineering design, communication, teamwork, and professionalism introduced and developed in Praxis I and II to the design and testing of a functioning product prototype.The course requires students to integrate the design, technical, and complementary knowledge gained across the Engineering Science Foundation in the context of a single, major, full-term design project.

Teams in Praxis III choose from a curated set of opportunities that integrate technical and complementary considerations. They are responsible both for framing the opportunity and for designing and testing a product prototype that addresses the opportunity. Praxis III culminates in a public showcase where teams present and demonstrate their designs to their stakeholders and to the general public. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

Recommended Preparation: ESC102H1, ESC190H1 and ECE159H1

ESC301H1 - Engineering Science Option Seminar

Credit Value: 0.25
Hours: 12.8L

The Option seminar supports discipline specific discussions of ethics, professionalism, safety and standards and research in a seminar-based setting. Guest speakers, presentations and other activities will highlight various topics of interest, including the present and future research related to the Option. This course will be offered on a credit/no credit basis and the assessment will be through a combination of written assignments, presentations and tests. Concepts in Engineering Communication will be emphasized to support discussion and the development of the course deliverables.

ESC301Y1 - Engineering Science Option Seminar

Credit Value: 0.10
Hours: 6.4T

The Option seminar supports option-related curriculum through discussion of ethics, philosophy and research in a seminar-based setting. Guest speakers, presentations and other special activities will highlight various topics of interest, including the present and future research related to the Option. This course will be offered on a pass/fail basis and the assessment will be based on active discussion within the seminar. Students will be encouraged to discuss their viewpoints on philosophical and ethical issues facing the Option, as well as future directions and opportunities. Occasionally, students from across options will be brought together for special discussions and activities related to research and the engineering profession.

ESC384H1 - Partial Differential Equations

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces techniques to analyze and solve partial differential equations (PDEs). Concepts covered include Fourier series, Sturm-Liouville theory, separation of variables, fundamental solutions, Green's functions, method of characteristics, and numerical methods. Applications are in model PDEs in continuum mechanics: heat, Laplace's, wave, and transport equations.

Prerequisite: MAT290H1/MAT292H1

ESC401H1 - Technology & Society Student Directed Seminar

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science elective.

Through this course, students have the opportunity to propose a topic for exploration in the realm of technology and society studies to run as a student-led seminar course. Accepted course topics in any given year will be based on student interest. The student course leader(s) are expected to work with the course coordinator to create a full course plan, including learning objectives, course topics and methods of assessment. All participants are expected to contribute to the learning experience, through presentations, suggestions of readings and subtopics. The student directed seminar provides an opportunity to explore a topic of interest, and gain experience in course planning and delivery in a collaborative learning environment. Suggested topics may include engineering & international development, engineering education & outreach, the politicization of science, gender & technology, or cross-profession collaboration; however, students may propose any topic in the broad realm of technology and society studies. Deadlines for student directed seminar proposals and seminar registration will be publicized by the Division of Engineering Science.

ESC470H1 - Energy Systems Capstone Design

Credit Value: 0.50
Hours: 64T

A half-year capstone design course in which students work in teams to apply the engineering design, technical, and communication skills learned previously, while refining their skills in teamwork and project management. The course focus is on context-appropriate energy systems design and simulation, incorporating generation, transmission and storage of energy from across a range of traditional and alternative energy sources. Students identify, frame, and design solutions to problems that align with that focus, and the resulting designs are assessed on their engineering quality and design credibility. In addition, each student engages in individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. Students are supported by a teaching team comprising both design and domain experts.

Exclusion: APS490Y1

ESC471H1 - Engineering Science Capstone Design

Credit Value: 0.50
Hours: 64T

A half-year capstone design course in which students work in small teams to apply the engineering design, technical, and communication skills learned previously, while refining their skills in teamwork and project management. The course focus is the (re)design and implementation of experiments suitable for the undergraduate classroom or laboratory. Students identify, frame, and design solutions to problems that align with that focus, and the resulting designs are assessed on their engineering quality and design credibility. In addition, each student engages in individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. Students are supported by a teaching team comprising both design and domain experts.

Exclusion: APS490Y1

ESC472H1 - Electrical and Computer Capstone Design

Credit Value: 0.50
Hours: 64T

A half-year capstone design course in which students work in small teams to apply the engineering design, technical, and communication skills learned previously, while refining their skills in teamwork and project management. Each team is expected to design a complex engineered system, implemented (a) fully in software, (b) fully in hardware or (c) in a mixture of hardware and software, using concepts drawn from the ECE Major curriculum and resulting in a functional prototype. Teams are expected to integrate their design, technical, and complementary knowledge, to design for safety, and to consider relevant interdisciplinary factors such as economic, health, environmental, social, and similar concerns.

In addition, each student will complete an individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. This reflection is intended to prepare the student for the next stage of their engineering career

Exclusion: APS490Y1

ESC490H1 - Engineering Science Independent Study

Credit Value: 0.50
Hours: 76.8T

Independent study courses are student initiated projects, open to Engineering Science students, which allow students to work one-on-one with a division faculty member. The student and supervising faculty member will develop a learning plan for the semester within the first week of term (Limited Enrollment).

ESC499H1 - Thesis

Credit Value: 0.50
Hours: 38.4L/25.6P

Every student in Fourth Year Engineering Science is required to conduct a thesis on an approved subject under the supervision of any faculty member at the University of Toronto. The thesis provides students with an opportunity to conduct, document, and experience engineering related research as an undergraduate student. This course is structured to provide resources to support that process, in particular the documentation of research, through a series of lectures and workshops. While the final thesis document is the main deliverable, students are also required to submit a set of interim deliverables to support ongoing documentation and reflection.

Exclusion: CHE499Y1
Recommended Preparation: Recommended Preparation: ESC301H1

ESC499Y1 - Thesis

Credit Value: 1.00
Hours: 38.4L/25.6P

Every student in Fourth Year Engineering Science is required to conduct a thesis on an approved subject under the supervision of any faculty member at the University of Toronto. The thesis provides students with an opportunity to conduct, document, and experience engineering related research as an undergraduate student. This course is structured to provide resources to support that process, in particular the documentation of research, through a series of lectures and workshops. While the final thesis document is the main deliverable, students are also required to submit a set of interim deliverables to support ongoing documentation and reflection.

Exclusion: CHE499Y1
Recommended Preparation: ESC301H1

Forestry

FOR425H1 - Bioenergy and Biorefinery Technology

Credit Value: 0.50
Hours: 25.6L/25.6T

Technological advances and approaches in deriving biofuels, chemical feedstocks from forest and other biomass resources. Fundamental chemical attributes of biomass, as they affect the fuel value and potential for deriving liquid, solid and gaseous fuels and valuable chemicals for other applications will be explored.

Exclusion: FOR410H1

Mathematics

MAT185H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: include: linear systems, matrix algebra, Rn as a vector space, a normed space and an inner-product space, linear transformations on Rn, eigenvalues, applications to circuits, mechanics and an introduction to computer methods.

Prerequisite: ESC103H1
Exclusion: MAT188H1

MAT292H1 - Ordinary Differential Equations

Credit Value: 0.50
Hours: 38.4L/25.6T

Existence and uniqueness of solution for first-order differential equations, general second-order linear ODEs, homogeneous equations, nonhomogeneous equations, variable coefficients, variation of parameters, Systems of ODEs, Fourier series, Laplace transform, interpretation of problems in mathematical terms, single-step numerical methods for ODEs. Introduction to Partial Differential Equations.

Prerequisite: MAT195H1
Exclusion: CHE222H1, CME261H1, CME362H1, MAT290H1, MAT291H1, MAT294H1 or MAT234H1

MAT336H1 - Elements of Analysis

Credit Value: 0.50
Hours: 36L/12T

This course provides the foundations of analysis and rigorous calculus for students who will take subsequent courses where these mathematical concepts are central of applications, but who have only taken courses with limited proofs. Topics include topology of Rn, implicit and inverse function theorems and rigorous integration theory.

Prerequisite: MAT223H1/MATA23H3/MAT223H5/MAT240H1/MAT240H5, MAT235Y1/MAT235Y5/(MAT232H5, MAT236H5)/(MATB41H3, MATB42H3)/MAT237Y1/(MATB41H3, MATB42H3, MATB43H3)/MAT237Y5; (for FASE students, MAT185H, MAT195H/ESC195H)
Exclusion: MAT257Y1, MAT337H1

MAT337H1 - Introduction to Real Analysis

Credit Value: 0.50
Hours: 36L

Construction of Real Numbers. Metric spaces; compactness and connectedness. Sequences and series of functions, power series; modes of convergence. Interchange of limiting processes; differentiation of integrals. Function spaces; Weierstrass approximation; Fourier series. Contraction mappings; existence and uniqueness of solutions of ordinary differential equations. Countability; Cantor set; Hausdorff dimension.

Prerequisite: MAT224H1/MATB24H3/MAT224H5/MAT247H1/MAT247H5, MAT235Y1/MAT235Y5/(MAT232H5, MAT236H5)/(MATB41H3, MATB42H3)/MAT237Y1/(MATB41H3, MATB42H3, MATB43H3)/MAT237Y5, MAT246H1/MAT157Y1; NOTE: These Prerequisites will be waived for students who have MAT257Y1
Exclusion: MAT357H1 & MAT378H5

MAT357H1 - Foundations of Real Analysis

Credit Value: 0.50
Hours: 36L

Function spaces; Arzela-Ascoli theorem, Weierstrass approximation theorem, Fourier series. Introduction to Banach and Hilbert spaces; contraction mapping principle, fundamental existence and uniqueness theorem for ordinary differential equations. Lebesgue integral; convergence theorems, comparison with Riemann integral, L^p spaces. Applications to probability.

Prerequisite: MAT257Y1/(MAT327H1 and permission of instructor)
Exclusion: MAT438H5

MAT389H1 - Complex Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Course examines the following: analytic functions, Cauchy-Reimann equations, contour integration, Cauchy's theorem, Taylor and Laurent series, singularities, residue calculus, conformal mapping, harmonic functions, Dirichlet and Neumann problems and Poisson integral formulas. Course includes studies of linear differential equations in the complex plane, including Bessel and Legendre functions.

Prerequisite: MAT195H1, MAT292H1
Exclusion: MAT290H1

Mechanical and Industrial Engineering

MIE201H1 - Essays in Technology and Culture

Credit Value: 0.50
Hours: 25.6L/12.8T

Humanities and Social Science elective

This course explores the relationship between changing technologies and cultural representations and teaches a methodology that bridges the world of the artist and the world of the engineer. It enables engineers to explore how the analysis of art has been used in the discussion of the social impacts of technological innovation and to use these methods as they develop new skills in essayistic argument and increase critical vocabulary.

MIE303H1 - Mechanical and Thermal Energy Conversion Processes

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework; Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Fossil fuel combustion, Alternative fuel combustions, fusion processes and introduction to advanced systems of fuel cells.

Prerequisite: CHE260H1
Exclusion: MIE311H1

MIE315H1 - Design for the Environment

Credit Value: 0.50
Hours: 38.4L/12.8T

Life Cycle Assessment for the measurement of environmental impacts of existing products and processes. Design for Environment principles for the reduction of environmental impacts in new product and process designs. Functional, economic, and societal analysis taught for use in a major team-written project to compare and contrast two product or process alternatives for a client.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

MIE360H1 - Systems Modelling and Simulation

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Principles for developing, testing and using discrete event simulation models for system performance improvement. Simulation languages, generating random variables, verifying and validating simulation models. Statistical methods for analyzing simulation model outputs, and comparing alternative system designs. Fitting input distributions, including goodness of fit tests. Role of optimization in simulation studies.

Prerequisite: MIE231H1/MIE236H1 or equivalent

MIE365H1 - Operations Research III: Advanced OR

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Design of operations research models to solve a variety of open-ended problems. Linear programming extensions are presented: goal programming, column generation, Dantzig-Wolfe decomposition, and interior point solution methods. Non-linear programming solution methods are developed: optimality conditions, quadratic programming and bi-level programming. Solutions to advanced stochastic models: stochastic programming, 2-person and n-person game theory, and Markov Decision Processes.

Prerequisite: MIE262H1, MIE263H1

MIE366H1 - Electronics for Robotics

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

The course provides an introduction to circuit analysis and design for mechatronics applications. The focus is on building a working knowledge of: (1) op-amp circuits, (2) step response, steady-state response, and frequency response, (3) passive and active filter design, and (4) applications of the above to mechatronics systems, including sensors and instrumentation. The course will continue with a study of the fundamental behaviour and specific applications of the major semiconductor devices, including (5) diodes and (6) field effect transistors. Additional ‘design assignments' will require students to design real-world viable circuits for mechatronics applications, and laboratory experiments will present additional applications for all circuits being studied.

MIE367H1 - Cases in Operations Research

Credit Value: 0.50
Hours: 38.4L/25.6T

This course focuses on the integration of the results from earlier operations research courses and an assessment of the different methods with regard to typical applications. The course is taught using the case method. Students are expected to analyze cases based on real applications on their own, in small groups and during lecture sessions, and solve them using commercial software packages.

Prerequisite: MIE263H1

MIE368H1 - Analytics in Action

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

This course showcases the impact of analytics focusing on real world examples and case studies. Particular focus on decision analytics, where data and models are combined to ultimately improve decision-making. Methods include: linear and logistic regression, classification and regression trees, clustering, linear and integer optimization. Application areas include: healthcare, business, sports, manufacturing, finance, transportation, public sector.

Prerequisite: MIE237H1/ECE286H1, MIE262H1/MIE376H1, MIE263H1/STA347H1, or permission of the instructor

MIE375H1 - Financial Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides a background in the fundamental areas in financial engineering including relevant concepts from financial economics. Major topics include interest rate theory, fixed income securities, bond portfolio construction term structure of interest rates, mean-variance optimization theory, the Capital Asset Pricing Model (CAPM), arbitrage pricing theory (APT), forwards and futures, and introduction to option pricing and structured finance.

Prerequisite: MAT185H1, MAT195H1, ECE286H1

MIE376H1 - Mathematical Programming (Optimization)

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

This course deals with the formulation of optimization models for the design and operation of systems that produce goods and services, and the solution of such problems with mathematical programming methods, including linear programming: the simplex method, sensitivity analysis, duality, the revised simplex, column generation, Dantzig-Wolfe decomposition and linear programming with recourse; minimum cost network flows; dynamic programming; integer programming; non-linear programming models.

Prerequisite: MAT185H1, MAT195H1

MIE377H1 - Financial Optimization Models

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course deals with the formulation of optimization models for the design and selection of an optimal investment portfolio. Topics include Risk Management, Mean Variance Analysis, Models for Fixed Income, Scenario Optimization, Dynamic Portfolio Optimization with Stochastic Programming, Index Funds, Designing Financial Products, and Scenario Generation. These concepts are also applied to International Asset Allocation, Corporate Bond Portfolios and Insurance Policies with Guarantees.

Prerequisite: MIE375H1
Corequisite: MIE376H1

MIE407H1 - Nuclear Reactor Theory and Design

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the neutronic design and analysis of nuclear fission reactors with a focus on Generation IV nuclear systems. Topics include radioactivity, neutron interactions with matter, neutron diffusion and moderation, the fission chain reaction, the critical reactor equation, reactivity effects and reactor kinetics. Multigroup neutron diffusion calculations are demonstrated using fast-spectrum reactor designs.

Prerequisite: MIE230H1 or equivalent
Recommended Preparation: CHE566H1

MIE408H1 - * Thermal and Machine Design of Nuclear Power Reactors

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.

Prerequisite: MIE407H1/MIE222H1, MIE312H1, MIE313H1 or equivalents
Recommended Preparation: CHE566H1

MIE422H1 - Automated Manufacturing

Credit Value: 0.50
Hours: 25.6L/38.4P

Introduction to Computer Integrated Manufactuing. Definitions, terminology. Organization of manufacturing systems. Introduction to NC machines. Introduction to robotics. Types of robot motion. Robot kinematics. Jacobians, singularities. Robot motion trajectories. Interpolation, spline fits. Robot joint control. Flexible manufacturing systems, justification. Robot cell design. Group technology. Design of group technology cell. Programmable logic controllers. Limited enrolment.

Prerequisite: MIE221H1 or equivalent

MIE424H1 - Optimization in Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

1. To enable deeper understanding and more flexible use of standard machine learning methods, through development of machine learning from an Optimization perspective.

2. To enable students to apply these machine learning methods to problems in finance and marketing, such as stock return forecasting, credit risk scoring, portfolio management, fraud detection and customer segmentation.

Prerequisite:
MIE365H1/MIE376H1/ECE367H1/ROB310H1, or equivalent

MIE429H1 - Machine Intelligence Capstone Design

Credit Value: 0.50
Hours: 64T

A half-year capstone design course in which students work in small teams to apply the engineering design, technical, and communication skills learned previously, while refining their skills in teamwork and project management. The course will take a "systems approach" to machine intelligence design, where students will identify, frame and design solutions to real-world problems in the field. Students will engage with industry partners, and work through a process that results in a functional prototype. The resulting designs are assessed on their engineering quality and design credibility. In addition, each student engages in individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. Students are supported by a teaching team comprising both design and domain experts.

MIE438H1 - Microprocessors and Embedded Microcontrollers

Credit Value: 0.50
Hours: 25.6L/38.4P

Review (number systems, CPU architecture, instruction sets and subroutines); Interfacing Memory; Interfacing Techniques; Transistors and TTL/CMOS Logic; Mechanical Switches & LED Displays; Interfacing Analog, A/D & D/A Conversions; Stepper Motors & DC Motors; RISC Technology and Embedded Processors; DAS Systems; Embedded Microcontroller System Design; CPU-based Control.

Exclusion: ECE243H1, ECE352H1

MIE439H1 - Biomechanics I

Credit Value: 0.50
Hours: 38.4L/25.6P

Introduction to the application of the principles of mechanical engineering - principally solid mechanics, fluid mechanics, and dynamics - to living systems. Topics include cellular mechanics, blood rheology, circulatory mechanics, respiratory mechanics, skeletal mechanics, and locomotion. Applications of these topics to biomimetic and biomechanical design are emphasized through a major, integrative group project.

MIE440H1 - * Design of Innovative Products

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Recently developed methods applied at different stages of the design process include: Identification of unmet/underserved user needs through a modified definition of lead users (those who experience needs in advance of the mainstream population) including identifying/studying lead users, identifying which lead-user needs are relevant to the general population; Roles of function and affordance in successful products; Obstacles of fixation and cognitive bias to creativity; Concept generation methods including TRIZ/TIPS (Theory of Inventive Problem Solving, use of unrelated stimuli and analogy (e.g., from biology); Configuration design methods including design for transformation, design for assembly and end-of-life, e.g., reuse, repair and recycling. Hands-on experience of these topics in lectures, tutorials, and labs support successful application of the methods for the course project, as well as future design activities.

MIE442H1 - Machine Design

Credit Value: 0.50
Hours: 38.4L/38.4T/19.2P

Introduction to the fundamental elements of mechanical design including the selection of engineering materials, load determination and failure analysis under static, impact, vibration and cyclic loads. Surface failure and fatigue under contact loads, lubrication and wear. Consideration is given to the characteristics and selection of machine elements such as bearings, shafts, power screws and couplings.

Prerequisite: MIE320H1

MIE444H1 - * Mechatronics Principles

Credit Value: 0.50
Hours: 25.6L/38.4P

This course provides students with the tools to design, model, analyze and control mechatronic systems (e.g. smart systems comprising electronic, mechanical, fluid and thermal components). This is done through the synergic combination of tools from mechanical and electrical engineering, computer science and information technology to design systems with built-in intelligence. The class provides techniques for the modeling of various system components into a unified approach and tools for the simulation of the performance of these systems. The class also presents the procedures and an analysis of the various components needed to design and control a mechatronic system including sensing, actuating, and I/O interfacing components.

Prerequisite: MIE342H1, MIE346H1

MIE451H1 - Decision Support Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Provides students with an understanding of the role of a decision support system in an organization, its components, and the theories and techniques used to construct them. Focuses on information analysis to support organizational decision-making needs and covers topics including information retrieval, descriptive and predictive modeling using machine learning and data mining, recommendation systems, and effective visualization and communication of analytical results.

Prerequisite: MIE253H1, MIE350H1

MIE457H1 - Knowledge Modelling and Management

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course explores both the modelling of knowledge and its management within and among organizations. Knowledge modelling will focus on knowledge types and their semantic representation. It will review emerging representations for knowledge on the World Wide Web (e.g., schemas, RDF). Knowledge management will explore the acquisition, indexing, distribution and evolution of knowledge within and among organizations. Emerging Knowledge Management System software will be used in the laboratory.

Prerequisite: MIE253H1, MIE350H1

MIE469H1 - Reliability and Maintainability Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the life-cycle costing concept for equipment acquisition, operation, and replacement decision-making. Designing for reliability and determination of optimal maintenance and replacement policies for both capital equipment and components. Topics include: identification of an items failure distribution and reliability function, reliability of series, parallel, and redundant systems design configurations, time-to-repair and maintainability function, age and block replacement policies for components, the economic life model for capital equipment, provisioning of spare parts.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE258H1

MIE479H1 - Engineering Mathematics, Statistics and Finance Capstone Design

Credit Value: 0.50
Hours: 64T

This will be a group project oriented course that focuses on the development of tools for solving a practical financial engineering problem. In particular, a decision support system will be developed that integrates both the mathematical and statistical modeling techniques learned in the option along with relevant computing technologies. Problems that contain a real-time economic decision making component will be emphasized, but does not necessarily or explicitly involve financial markets. An important goal of the capstone is the articulation of the requirements to non-specialists as an exercise in communication with non-technical members of an organization.

Prerequisite: ACT370H1, MIE375H1, MIE376H1, MIE377H1, STA302H1

MIE505H1 - Micro/Nano Robotics

Credit Value: 0.50
Hours: 38.4L/38.4P

This course will cover the design, modeling, fabrication, and control of miniature robot and micro/nano-manipulation systems for graduate and upper level undergraduate students. Micro and Nano robotics is an interdisciplinary field which draws on aspects of microfabrication, robotics, medicine and materials science.

In addition to basic background material, the course includes case studies of current micro/nano-systems, challenges and future trends, and potential applications. The course will focus on a team design project involving novel theoretical and/or experimental concepts for micro/nano-robotic systems with a team of students. Throughout the course, discussions and lab tours will be organized on selected topics.

MIE506H1 - * MEMS Design and Microfabrication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course will present the fundamental basis of microelectromechanical systems (MEMS). Topics will include: micromachining/microfabrication techniques, micro sensing and actuation principles and design, MEMS modeling and simulation, and device characterization and packaging. Students will be required to complete a MEMS design term project, including design modeling, simulation, microfabrication process design, and photolithographic mask layout.

Prerequisite: MIE222H1, MIE342H1

MIE515H1 - Alternative Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers the basic principles, current technologies and applications of selected alternative energy systems. Specific topics include solar thermal systems, solar photovoltaic systems, wind, wave, and tidal energy, energy storage, and grid connections issues. Limited enrolment.

Prerequisite: MIE210H1,MIE312H1 and MIE313H1 (or equivalent courses).

MIE516H1 - Combustion and Fuels

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to combustion theory. Chemical equilibrium and the products of combustion. Combustion kinetics and types of combustion. Pollutant formation. Design of combustion systems for gaseous, liquid and solid fuels. The use of alternative fuels (hydrogen, biofuels, etc.) and their effect on combustion systems.

MIE517H1 - Fuel Cell Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation, including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

MIE520H1 - Biotransport Phenomena

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of conservation relations and momentum balances, dimensional analysis and scaling, mass transfer, heat transfer, and fluid flow to biological systems, including: transport in the circulation, transport in porous media and tissues, transvascular transport, transport of gases between blood and tissues, and transport in organs and organisms.

Prerequisite: MIE312H1 /AER210H1 /equivalent

MIE562H1 - Scheduling

Credit Value: 0.50
Hours: 38.4L/25.6T

This course takes a practical approach to scheduling problems and solution techniques, motivating the different mathematical definitions of scheduling with real world scheduling systems and problems. Topics covered include: job shop scheduling, timetabling, project scheduling, and the variety of solution approaches including constraint programming, local search, heuristics, and dispatch rules. Also covered will be information engineering aspects of building scheduling systems for real world problems.

Prerequisite: MIE262H1

MIE566H1 - Decision Making Under Uncertainty

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

The purpose of this course is to provide a working knowledge of methods of analysis of problem and of decision making in the face of uncertainty. Topics include decision trees, subjective probability assessment, multi-attribute utility approaches, goal programming, Analytic Hierarchy Process and the psychology of decision making.

Prerequisite: MIE231H1/MIE236H1 or equivalent

Materials Science and Engineering

MSE160H1 - Molecules and Materials

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will cover both the fundamentals and applications of molecular chemistry as it relates to the properties of materials. Fundamental topics will include: (1) the design of chemical structures and their relationship to optical and electronic properties; (2) the chemistry and physics of covalent and non-covalent bonding; (3) the relationship of atomic bonding to molecular geometry and local symmetry; (4) crystal structures of extended solids; and (5) extension of these principles to electronic structure, elasticity, and vector and tensor descriptions of materials properties. Applications to diverse areas of engineering will be discussed.

Exclusion: MSE101H1 or APS104H1
Recommended Preparation: CIV102H1

MSE458H1 - Nanotechnology in Alternate Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

The unique surface properties and the ability to surface engineer nanocrystalline structures renders these materials to be ideal candidates for use in corrosion, catalysis and energy conversion devices. This course deals with the fabrication of materials suitable for use as protective coatings, and their specific exploitation in fields of hydrogen technologies (electrolysis, storage, and fuel cells) linked to renewables. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nanocrystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A major team design project along with demonstrative laboratory exercises constitutes a major portion of this course. Limited Enrolment.

Physics

PHY180H1 - Classical Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6P

Mechanics forms the basic background for the understanding of physics. This course on Classical, or Newtonian mechanics, considers the interactions which influence motion. These interactions are described in terms of the concepts of force, momentum and energy. Initially the focus is on the mechanics of a single particle, considering its motion in a particular frame of reference, and transformations between reference frames. Then the dynamics of systems of particles is examined.

Corequisite: MAT194H1
Exclusion: MIE100H1

PHY293H1 - Waves and Modern Physics

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

The first half of the semester will give an introduction to the basic ideas of classical oscillations and waves. Topics include simple harmonic motion, forced and damped harmonic motion, coupled oscillations, normal modes, the wave equation, travelling waves and reflection and transmission at interfaces. The second half of the semester will first give an introduction to Einstein's special relativity, including evidence for the frame-independence of the speed of light, time dilation, length contraction, causality, and the relativistic connection between energy and momentum. Then we will follow the historical development of quantum mechanics with the photo-electric and Compton effects, the Bohr atom, wave-particle duality, leading to Schrödinger's equation and wave functions with a discussion of their general properties and probabilistic interpretation.

Corequisite: MAT292H1
Exclusion: MIE333H1
Recommended Preparation: MAT195H1

PHY294H1 - Quantum and Thermal Physics

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

The first half of the semester will continue with the development of quantum mechanics. Topics will include Shrödinger's wave mechanics, tunneling, bound states in potential wells, the quantum oscillator, and atomic spectra. The second half of the semester will give an introduction to the basic ideas of classical statistical mechanics and radiation, with applications to experimental physics. Topics will include Boltzmann's interpretation of entropy, Maxwell-Boltzman statistics, energy equipartition, the perfect gas laws, and blackbody radiation.

Prerequisite: PHY293H1
Exclusion: MIE333H1
Recommended Preparation: MAT292H1

PHY327H1 - Advanced Physics Laboratory

Credit Value: 0.50
Hours: 76.8P

Experiments in this course are designed to form a bridge to current experimental research. A wide range of experiments are available using contemporary techniques and equipment. In addition to the standard set of experiments a limited number of research projects are also available. Many of the experiments can be carried out with a focus on instrumentation.

PHY427H1 - Advanced Physics Laboratory

Credit Value: 0.50
Hours: 76.8P

Experiments in this course are designed to form a bridge to current experimental research. A wide range of experiments are available using contemporary techniques and equipment. In addition to the standard set of experiments, a limited number of research projects may be available. This laboratory is a continuation of PHY327H1.

Prerequisite: PHY327H1

Robotics

ROB301H1 - Introduction to Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course is intended to provide an introduction and a very interdisciplinary experience to robotics. The structure of the course is modular and reflects the perception-control-action paradigm of robotics. The course, however, aims for breadth, covering an introduction to the key aspects of general robotic systems, rather than depth, which is available in later more advanced courses. Applications addressed include robotics in space, autonomous terrestrial exploration, biomedical applications such as surgery and assistive robots, and personal robotics. The course culminates in a hardware project centered on robot integration.

Prerequisite: ESC204H1

ROB310H1 - Mathematics for Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T

The course addresses advanced mathematical concepts particularly relevant for robotics. The mathematical tools covered in this course are fundamental for understanding, analyzing, and designing robotics algorithms that solve tasks such as robot path planning, robot vision, robot control and robot learning. Topics include complex analysis, optimization techniques, signals and filtering, advanced probability theory, and numerical methods. Concepts will be studied in a mathematically rigorous way but will be motivated with robotics examples throughout the course.

Prerequisite: MAT185H1, MAT292H1
Recommended Preparation: ESC103H1, ECE286H1

ROB311H1 - Artificial Intelligence

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to the fundamental principles of artificial intelligence from a mathematical perspective. The course will trace the historical development of AI and describe key results in the field. Topics include the philosophy of AI, search methods in problem solving, knowledge representation and reasoning, logic, planning, and learning paradigms. A portion of the course will focus on ethical AI, embodied AI, and on the quest for artificial general intelligence.

Prerequisite: Prerequisite: ECE286H1/ECE302H1 and ECE345H1/ECE358H1/CSC263H1

ROB313H1 - Introduction to Learning from Data

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will introduce students to the topic of machine learning, which is key to the design of intelligent systems and gaining actionable insights from datasets that arise in computational science and engineering. The course will cover the theoretical foundations of this topic as well as computational aspects of algorithms for unsupervised and supervised learning. The topics to be covered include: The learning problem, clustering and k-means, principal component analysis, linear regression and classification, generalized linear models, bias-variance tradeoff, regularization methods, maximum likelihood estimation, kernel methods, the representer theorem, radial basis functions, support vector machines for regression and classification, an introduction to the theory of generalization, feedforward neural networks, stochastic gradient descent, ensemble learning, model selection and validation.

Prerequisite: ECE286H1, MAT185H1, MAT195H1, CSC263H1/ECE358H1
Exclusion: ECE421H1, CSC411H1, STA314H1

ROB498H1 - Robotics Capstone Design

Credit Value: 0.50
Hours: 64T

The Robotics Capstone Design course is structured to provide students with an opportunity to integrate and apply the technical knowledge gained throughout their degree program toward the solution of a challenging real-world robotics problem. During the half-year course, students work in small teams and have considerable freedom to explore the design space while developing a complete robotic hardware and software system. The challenge task incorporates all aspects of the "sense-plan-act" robot design paradigm, with designs assessed based on engineering quality and performance relative to a series of benchmarks. In addition, each student completes a critical reflection on their team's performance and the evolution of their experience with design during their undergraduate program. Students are supported by a teaching team comprised of domain experts.

ROB501H1 - Computer Vision for Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to aspects of computer vision specifically relevant to robotics applications. Topics include the geometry of image formation, basic image processing operations, camera models and calibration methods, image feature detection and matching, stereo vision, structure from motion and 3D reconstruction. Discussion of moving object identification and tracking as time permits.

Prerequisite: ROB301H1/ECE324H1
Exclusion: CSC420H1
Recommended Preparation: CSC263H1

ROB521H1 - Mobile Robotics and Perception

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course addresses fundamentals of mobile robotics and sensor-based perception for applications such as space exploration, search and rescue, mining, self-driving cars, unmanned aerial vehicles, autonomous underwater vehicles, etc. Topics include sensors and their principles, state estimation, computer vision, control architectures, localization, mapping, planning, path tracking, and software frameworks. Laboratories will be conducted using both simulations and hardware kits.

Prerequisite: ROB310H1, AER372H1

Commerce

RSM430H1 - Fixed Income Securities

Credit Value: 0.50
Hours: 24L

Describes important fixed income securities and markets. The course emphasizes traditional bond and term structure concepts crucial to understand the securities traded in these markets. Students are required to work in the Rotman Financial Research & Trading Lab to solve the assigned problems using real time data. Not eligible for CR/NCR option. Contact Rotman Commerce for details.

Prerequisite: Rotman Commerce: RSM332H1; Actuarial Science: ACT349H1

RSM432H1 - Risk Management for Financial Managers

Credit Value: 0.50
Hours: 24L

This course examines the ways in which risks are quantified and managed by financial institutions. The principal risks considered include market risk, credit risk and operational risk. The course also covers the evolution of bank regulation and the regulatory limits on risk taking. Not eligible for CR/NCR option. Contact Rotman Commerce for details.

Prerequisite: RSM333H1

RSM434H1 - Financial Trading Strategies

Credit Value: 0.50
Hours: 24L

This course will use finance theory applied with Excel applications to understand potential returns and risks inherent in particular investment/trading strategies. Learning-by-doing will be facilitated by simulation-based *Rotman Interactive Trader* cases focused on particular risks. This training will be analogous to using a flight simulator for learning to fly. Not eligible for CR/NCR option. Contact Rotman Commerce for details.

Prerequisite: RSM332H1
Exclusion: RSM412H1 Financial Trading Strategies

Statistics

STA286H1 - Probability and Statistics

Credit Value: 0.50
Hours: 38.4L/12.8T

A course in probability and statistics for Engineering Science students focusing on building solid probabilistic and statistical foundations. Topics include: sample space, events, definitions of probability, conditional probability, Bayes' theorem, important classes of discrete and continuous random variables and their distributions, joint, conditional, and marginal distributions, expectation, moment generating and characteristic functions, transformations of random variables, central limit theorem and approximations. Graphical methods, quantile plots, point and interval estimation of population parameters, method of maximum likelihood. Hypotheses testing, simple and multiple regression, correlation analysis, and introduction to Bayesian statistics. Minitab software is used to solve some assignment problems in the course.

Exclusion: CHE223H1, CME263H1, MSE238H1, MIE236H1, MIE237H1, MIE231H1 or STA257H1

STA302H1 - Methods of Data Analysis I

Credit Value: 0.50
Hours: 36L

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression.

Prerequisite:
STA238H1/STA248H1/STA255H1/STA261H1/ECO227Y1/STAB57H3/STA258H5/STA260H5/ECO227Y5; CSC108H1/CSC110Y1/CSC120H1/CSC148H1/CSCA08H3/CSCA20H3/CSCA48H3/CSC108H5/CSC148H5; MAT221H1(70%)/MAT223H1/MAT240H1/MATA22H3/MATA23H3/MAT223H5/MAT240H5
Exclusion: STAC67H3, STA302H5

STA347H1 - Probability

Credit Value: 0.50
Hours: 36L

An overview of probability from a non-measure theoretic point of view. Random variables/vectors; independence, conditional expectation/probability and consequences. Various types of convergence leading to proofs of the major theorems in basic probability. An introduction to simple stochastic processes such as Poisson and branching processes.

Prerequisite: STA247H1(70%)/STA255H1(70%)/STA237H1(70%)/STA257H1/ECO227Y1/STAB52H3/STA256H5; MAT223H1/MAT240H1/MATA22H3//MATA23H3/MAT223H5/MAT240H5; MAT235Y1/MAT237Y1/MAT257Y1/(MATB41H3, MATB42H3)/(MAT232H5, MAT236H5)/(MAT233H5, MAT236H5) (Note: STA257H1, MAT223H1/MAT240H1, MAT237Y1/MAT257Y1 are very strongly recommended)
Exclusion: MAT377H1/STAC62H3/STA348H5

STA410H1 - Statistical Computation

Credit Value: 0.50
Hours: 36L

Programming in an interactive statistical environment. Generating random variates and evaluating statistical methods by simulation. Algorithms for linear models, maximum likelihood estimation, and Bayesian inference. Statistical algorithms such as the Kalman filter and the EM algorithm. Graphical display of data.

Prerequisite: STA302H1/STAC67H3/STA302H5; CSC108H1/CSC110Y1/CSC120H1/CSC148H1/CSCA08H3/CSCA48H3/CSCA20H3/CSC108H5/CSC148H5; MAT223H1/MAT240H1/MATA22H3/MATA23H3/MAT223H5/MAT240H5

STA447H1 - Stochastic Processes

Credit Value: 0.50
Hours: 36L

Discrete and continuous time processes with an emphasis on Markov, Gaussian and renewal processes. Martingales and further limit theorems. A variety of applications taken from some of the following areas are discussed in the context of stochastic modeling: Information Theory, Quantum Mechanics, Statistical Analyses of Stochastic Processes, Population Growth Models, Reliability, Queuing Models, Stochastic Calculus, Simulation (Monte Carlo Methods).

Prerequisite: STA347H1/MAT377H1/STAC62H3
Exclusion: STA348H5, STAC63H5

Institute for Studies in Transdisciplinary Engineering Education & Practice (ISTEP)

ISTEP is U of T Engineering's newest extra-departmental unit and the first institute of its kind in Canada. Bringing together the strengths of several U of T Engineering programs in leadership, technical communication and entrepreneurship, ISTEP is a leader in pedagogical innovation and transdisciplinary engineering education.

ISTEP provides an academic home for the Engineering Communication Program (ECP), Troost Institute for Leadership Education in Engineering (Troost ILead), Collaborative Specialization in Engineering Education (EngEd), Certificate in Entrepreneurship, Innovation and Small Business, Engineering Business Minor and some first-year instruction.

At the undergraduate level, ISTEP's faculty deliver courses to support and enrich student learning which can culminate in minors and certificates in leadership, communication, entrepreneurship and business. These include the Engineering Business Minor, the Certificate in Entrepreneurship, Innovation and Small Business, the Certificate in Communication and the Certificate in Engineering Leadership. ISTEP is also working to integrate more opportunities for students to learn transdisciplinary competencies throughout the core curriculum of all the undergraduate engineering programs.

At the graduate level, ISTEP's faculty deliver the Collaborative Specialization in Engineering Education, the Prospective Professors in Training and OPTIONS programs along with courses in leadership and engineering education.

ISTEP Courses

TEP234H1 - Entrepreneurship and Small Business

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 1 of the 2 Part Entrepreneurship Program
The age of enterprise has arrived. Strategic use of technology in all sorts of businesses makes the difference between success and failure for these firms. Wealth creation is a real option for many and the business atmosphere is ready for you! Increasingly, people are seeing the advantages of doing their own thing, in their own way, in their own time. Entrepreneurs can control their own lives, structure their own progress and be accountable for their own success - they can fail, but they can not be fired! After all, engineers are the most capable people to be in the forefront of this drive to the business life of the next century. This course is the first of a series of two dealing with entrepreneurship and management of a small company. It is intended that the student would continue to take the follow up course APS432 as s/he progresses toward the engineering degree. Therefore, it is advisable that the descriptions of both courses be studied prior to deciding to take this one. This is a limited enrolment course. If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of the "Entrepreneur's Test". There will be a certificate awarded upon the successful completion of both courses attesting to the fact that the student has passed this Entrepreneurial Course Series at the University of Toronto. The course is based on real life issues, not theoretical developments or untried options. Topics covered include: Who is an entrepreneur; Canadian business environment; Acquisitions; Different business types (retail, wholesale, manufacturing, and services); Franchising; Human resources, Leadership, Business law; and many others. Several visitors are invited to provide the student with the opportunity to meet real entrepreneurs. There will be several assignments and a session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1/APS281H1
Total AUs: 57.60

TEP281H1 - Language and Meaning

Credit Value: 0.50
Hours: 28.2L/28.2T

Humanities and Social Science elective

As students study how language is used to make meaning in diverse contexts they will hone their own skills in deploying written and oral professional engineering language. The course explores the nature of language across linguistic, discipline and cultural boundaries and students apply the theoretical knowledge of language and language learning to their own written and oral language performances. In conjunction with this, theories of translation and bilingualism will be introduced to challenge assumptions about the universality of meanings. Weekly lecture and tutorial.

Exclusion: APS281H1
Total AUs: 38.40

TEP320H1 - Representing Science on Stage

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

An examination of representations of science/scientists in theatre. Reading and/or viewing of works by contemporary playwrights and related materials on science and culture. Critical essays; in-class discussion and scene study.

Total AUs: 38.40

TEP321H1 - Representing Science and Technology in Popular Media

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course analyzes popular scientific communication critically, starting by establishing a historical and theoretical foundation for understanding the complex relationship between science and the public. We apply this theoretical foundation to contemporary case studies in multiple media (mis)representations of climate, environmental, and biomedical sciences, as well as breakthroughs in engineering. We develop rhetorical strategies for delivering technical information to non-technical readers, including narrative and metaphor.

Total AUs: 38.40

TEP322H1 - Language and Power

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course explores Rhetoric historically to understand its development and practically to understand how ideas are constructed, disseminated, shared or imposed. The course explores worldview - the organizing structure by which we view the world - to position the student as rhetorically effective in multiple contexts. Students analyze political, cultural, and scientific discourse from great speeches to advertising to research papers. Students develop their rhetorical, communication, and persuasive abilities.

Total AUs: 38.40

TEP324H1 - Engineering and Social Justice

Credit Value: 0.50
Hours: 25.6L/25.6T

This course explores the relationship between engineering and the concepts of social justice to develop the skills needed to take practical action in a complex world. It develops personal responses to ideas of justice, bias and marginalization as these affect Engineers and Engineering in general, domestically as well as globally, in projects as well as in contexts such as the workplace and academic environment. Readings will be drawn from current writers on Engineering and Social Justice and students will rehearse action through theatre techniques developed to enable communities to practice and critique action.

Total AUs: 38.40

TEP325H1 - Engineering and Science in the Arts

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course examines the connections between engineers, scientists, and artists. Taking examples from architecture, sculpture, painting, and the performing arts, this course will show how these artistic disciplines have grown through their interplay with engineering and science.

Total AUs: 38.40

TEP326H1 - Special Topics in Creative Writing

Credit Value: 0.50
Hours: 25.6L/25.6T

In this course, students will explore the creative writing process, with an emphasis on the giving and receiving of critical feedback. This exploration will reinforce the iterative principles of the engineering design process and will provide students with flexible and transferable tools for them to apply to future engineering work. They will examine up to two genres of creative writing (fiction, science fiction, poetry, creative non-fiction, screenwriting, playwriting, etc.) in order to hone their own creative and critical thinking skills. Students will be introduced to relevant elements of craft, will analyze representative literary examples, will create original creative work both in generative weekly exercises and in longer at-home assignments, will give and receive feedback from their peers through structured in-class workshops, and will apply this feedback to their own writing.

Total AUs: 38.40

TEP327H1 - Engineering and Law

Credit Value: 0.50
Hours: 38.4L

Upon graduating university and entering the workforce, engineering students have little idea about how frequently in their professional lives their interactions, decisions, and actions will touch on various areas of law. This course is designed to highlight the amount of overlap between these two pillars in today's society. From acting as an expert witness, to preparing a patent, to creating a contract for supplies and beyond. By the end of this course, studentswill have a working understanding of the intersection between Engineering and Law, and be able to navigate themselves in that area.

Total AUs: 38.40

TEP343H1 - Engineering Leadership

Credit Value: 0.50
Hours: 12.8L/25.6P

Complementary Studies elective

This course is a practical approach to being a more productive engineer based on the premise that for technology to become a reality it must be translated through people. A key is to understand that engineers lead in ways that reflect their skills and mind set. The course begins with examining: 1) the meaning of leading (Why do something?); 2) the processes of leading (How do you do you create a vision and motivate others?); and 3) the tools of leading (What steps do you take to lead?). Learning frameworks and personal working styles inventories provide practical tools to assist the student to understand human nature and the logic of learning to become a competent leader of self, teams and organizations. The student prepares to become a competent leader by undertaking to learn (understand and integrate) key skills, character attributes and purposeful behaviours. The course presents strategies for development of high performance teams. Special attention is given to a number of subjects: transformational change, organizational culture, high performance work systems, and self-leadership. The course material is delivered through lectures, readings, in-class discussion and a team project. The project is based on the team interviewing the CEO of an engineering-intensive company or senior leader in the community. Students will be required to submit written reflections on course content and their personal experience.

Total AUs: 25.60

TEP432H1 - Entrepreneurship and Business Management

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 2 of the 2 Part Entrepreneurship Program

This is part two of the Entrepreneurship course series. The student considering taking this course would typically plan to pursue a career in small business started by themselves, or in a family enterprise. The skills acquired, however, are very useful in any business where a graduate might end up in their career, without the need for actually being an entrepreneur. Our approach to teaching is based on real-life business experiences and many years of successful practice of "what we preach". The course contains very little theoretical work or academic approaches. It is designed to familiarise you with the kinds of opportunities (problems) likely to be encountered in an entrepreneurial career. If you really want this lifestyle and are prepared to work hard, we will provide you with the practical knowledge and technical skills required to pursue this kind of career. Topics covered in this course include: Marketing and Sales; Legal issues; Financing the business; Human Resources challenges, the Business Plan and many other issues. Note that the course material may be adjusted between the two courses as required. We recognize the value of communication skills in both the classroom and in project reports. In fact, we require that you learn how to present yourself in a business-like manner. As and when appropriate, outside visitors from the business community will join in and contribute to the class discussions. The course deals with practical concepts, actual past and current events and is presented from the point of view of someone who has "done it all". This means that what you hear is the real stuff. There will be several assignments and the preparation of a full Business Plan as the session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Prerequisite: APS234H1
Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1
Total AUs: 57.60

TEP442H1 - Cognitive and Psychological Foundations of Effective Leadership

Credit Value: 0.50
Hours: 38.4L

Complementary Studies elective

This course investigates the cognitive and psychological foundations of effective leadership. Students will explore current theories driving effective leadership practice including models of leadership, neurophysiological correlates of leadership and psychodynamic approaches to leadership. Students will learn and apply skills including mental modeling, decision-making, teamwork and self-evaluation techniques. This course is aimed at helping Engineering students to gain practical skills that will enhance their impact as leaders throughout their careers.

Total AUs: 38.40

TEP444H1 - Positive Psychology for Engineers

Credit Value: 0.50
Hours: 38.4L

Humanities and Social Science elective

Many disciplines have explored happiness - philosophy, anthropology, psychology, sociology, neurobiology, film, art and literature - to name a few. Why not engineering? During the first part of the course we will play catch-up, examining the scholarly and creative ways that people have attempted to understand what makes for a happy life. Then we turn our attention to our own domain-expertise, applying engineering concepts like "balance", "flow", "amplitude", "dynamic equilibrium""momentum" and others to explore the ways that your technical knowledge can contribute to a deep understanding of happiness. This course is designed to challenge you academically as we analyze texts from a variety of disciplines, but it is also designed to challenge you personally to explore happiness as it relates to yourself, your own personal development and your success and fulfillment as an engineer.

If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of an in-class assessment completed during the first class.

Total AUs: 38.40

TEP445H1 - The Power of Story: Discovering Your Leadership Narrative

Credit Value: 0.50
Hours: 25.6L/12.8T

Humanities and Social Science elective

This course offers an introduction to relational, authentic and transformational leadership theory by focusing on narrative and the power of story telling. Students will practice story-telling techniques by learning about the mechanics of stories, improve their public speaking by engaging in regular storytelling practice, explore their personal history by reflecting on their identities, and develop critical thinking skills regarding the stories (meta-narratives) that surround us, particularly as they relate to engineering problems/ethics. This is a highly experiential course with a focus on reading, discussion, practice and reflection.

Total AUs: 38.40

TEP447H1 - The Art of Ethical & Equitable Decision Making in Engineering

Credit Value: 0.50
Hours: 38.4L

The primary objective of this course is to help engineering students navigate the ambiguous world of engineering ethics and equity using case studies drawn from the careers of Canadian engineers. In addition to being exposed to a range of ethical theories, the PEO code of ethics and the legal context of engineering ethics, students enrolled in this course will engage in ethical decision-making on a weekly basis.

Total AUs: 38.40

TEP448H1 - System Mapping

Credit Value: 0.50
Hours: 25.6L/25.6T

System mapping is a system thinking tool that is frequently used in fields such as public health and environmental policy to describe complex, multi-stakeholder problems. Students will apply system mapping techniques to describe complex problems with techical, social and environmental aspects. Students will explore fields outside of engineering that are critical to these challenges, including public policy, sociology, and law. Students will complete a team project to develop a system map of a complex problem. The emphasis will be on problem definition not problem solution, though it is expected that maps will point to potential paths for solution.

Enrolment Limits: 36
Total AUs: 38.40

Materials Science and Engineering

Undergraduate Program in Materials Engineering (AEMMSBASC)

Academic Advisor
Agnes Hsin
Room 140, Wallberg Building
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The goal of the materials engineering undergraduate curriculum is to provide an understanding of the underlying principles of synthesis, characterization and processing of materials and the interrelationships among structure, properties and processing. The program prepares students for professional careers in a wide variety of industries, as well as for advanced study in this field. It also provides students with the opportunity to broaden their education in engineering and science or to expand their knowledge in a particular technical area by offering course foundations in four core areas: biomaterials, manufacturing with materials, sustainable materials processing and design of materials (including nanomaterials).

The first year of the program establishes fundamentals in math, chemistry and physics with an introduction to design, communications and societal issues in Engineering. In second year, students are introduced to the structural and analytical characterization of materials, mechanics of solids, thermodynamics, diffusion and kinetics, fundamentals and processing of organic materials and engineering statistics. Third-year is devoted to core courses in electrical and quantum mechanical properties of matter, thermodynamics, heat and mass transfer, phase transformations, process design, mechanical behaviour along with a full year materials manufacturing and design laboratory. Fourth-year has core courses in environmental degradation of materials and materials selection in design plus technical electives in the four core areas (for technical electives outside the calendar list provided please consult with the Associate Chair, Undergraduate). The fourth year of study also culminates in a senior design course, which integrates what students have learned in their prior studies. The technical aspects of the curriculum are complemented by communications, humanities and social sciences courses and by materials on leadership, ethics, team building and environmental responsibility which are distributed throughout the curriculum.

For students interested in pursuing an engineering minor, review the information in the Calendar on minors. By selecting courses that meet both MSE requirements and the requirements of the respective minor, a student can complete a minor during their studies.

Students interested in pursuing the Jeffrey Skoll BASc / MBA (SKOLL) Program should review the information on the program in the Calendar.

Graduate Programs in Materials Science and Engineering

The Graduate Department of Materials Science & Engineering offers MEng, MASc, and PhD degrees in extractive and physical metallurgy, materials science, nanomaterials, electronic and photonic materials and biomaterials. Admission information is available from the Graduate Advisor.

Research equipment includes modern facilities for optical, electron and X-ray microscopy, mechanical testing, particle characterization, the production of high temperatures and controlled atmospheres, calorimetric and other thermodynamic measurements at high temperatures, crystal growth, etc.

Research interests in the Department include process development, computer-aided materials engineering, physical chemistry of metal extraction, mineral processing, hydrometallurgy, electrometallurgy, powder metallurgy, solidification and crystal growth, welding, structure and mechanical properties of metallic, ceramic and composite materials, high strength polymers, nuclear materials, battery and super-capacitor materials, biomimetic materials, electronic and photonic materials, nanostructured materials and synthesis and design of biomaterials.

MATERIALS ENGINEERING (AEMMSBASC)

FIRST YEAR MATERIALS ENGINEERING

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session - Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
CHE112H1: Physical Chemistry	S	3	1	1	0.50
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MSE120H1: Materials Engineering, Processing and Application	S	3	1a	1	0.50
MSE191H1: Introduction to Materials Science and Engineering	S	1	-	-	0.15

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR MATERIALS ENGINEERING

Fall Session - Year 2		Lect.	Lab.	Tut.	Wgt.
MAT294H1: Calculus and Differential Equations	F	3	-	2	0.50
MSE202H1: Thermodynamics I	F	3	-	2	0.50
MSE219H1: Structure and Characterization of Materials	F	3	3	1	0.50
MSE244H1: Inorganic Materials Chemistry and Processing	F	3	3	1	0.50
MSE296H1: Materials Paradigm at a Glance I	F	1a	-	-	0.15
MSE298H1: Communications	Y	1	1a	1	0.50
Humanities/Complementary Studies Elective	F				0.50
Winter Session - Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MSE222H1: Mechanics of Solid Materials	S	3	1.50	1.50	0.50
MSE217H1: Diffusion and Kinetics	S	3	-	2	0.50
MSE218H1: Phase Transformations	S	3	2	1	0.50
MSE238H1: Engineering Statistics and Numerical Methods	S	3	2	2	0.50
MSE245H1: Organic Materials Chemistry and Properties	S	3	3	1	0.50
MSE297H1: Materials Paradigm at a Glance II	S	1a	-	-	0.15
MSE298H1: Communications	Y	1	1a	1	0.50

Practical Experience Requirement - As described in the beginning pages of this chapter, students are required to have completed a total of 600 hours of acceptable practical experience, before graduation, (normally acquired during summer vacation periods).

ENGINEERING SUMMER INTERNSHIP PROGRAM (eSIP) PROGRAM

The Engineering Summer Internship Program (eSIP) is a paid summer co-op program offered through the Engineering Career Centre. It is available to eligible engineering students in year 2 or 3 of study, including engineering international students. eSIP is more akin to a traditional co-op placement, where students work for four months and thus serves as an introductory career development program for participants. Through formalized and interactive workshops and individual counseling appointments, students are introduced to concepts and tools to prepare them for the workplace. The majority of applicants are in their year 2 of study, for which eSIP holds particular value in preparing students to be competitive for future opportunities, such as the intensive model of the PEY internship.

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enrol and participate in the Professional Experience Year (PEY) program. The PEY program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating industry. Details are described in the beginning of this chapter. For more information, consult the Professional Experience Year Office, 222 College Street, Suite 106.

THIRD YEAR MATERIALS ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50
MSE302H1: Thermodynamics II	F	3	2	1	0.50
MSE316H1: Mechanical Behaviour of Materials	F	3	2	1	0.50
MSE351H1: Design and Sim of Materials Processes	F	3	2	1	0.50
MSE398Y1: Materials Manufacturing and Design	Y	2	4	-	1.00
CS/HSS or Technical Elective	F				0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MSE332H1: Heat and Mass Transfer for Materials Processing	S	3	-	2	0.50
MSE335H1: Materials Physics	S	3	-	1	0.50
MSE355H1: Materials Production	S	3	-	1	0.50
MSE398Y1: Materials Manufacturing and Design	Y	2	4	-	1.00
CS/HSS or Technical Elective	S				1.00

3rd Year Technical Electives

The flexibility for students to choose 1 course in each of the third year terms from the categories: Humanities and Social Sciences (HSS), Complementary Studies (CS) or Technical Electives (TE) offers the opportunity for early streamlining of individual course selections to accommodate students' preferences for areas of specialization. For example, the Faculty of Applied Science and Engineering offers several Minors and Certificate Programs which require third year Technical Electives courses in various programs. Similarly, students who wish to specialize in eligible 4th year subject areas offered by other programs should consult the calendar for third year prerequisite courses.

The Materials Department offers specialization in four Theme Areas: Biomaterials, Sustainable Materials Processing, Manufacturing with Materials and Design of Materials. In the table below several suggested third year Technical Electives are listed for each of the four Theme Areas. Other courses can also be considered and students should consult with the Associate Chair, Undergraduate Studies for approval. Students who do not select HSS/CS courses in third year must take these in fourth year to meet the minimum number of HSS/CS weight units required by the Canadian Engineering Accreditation Board (CEAB).

Biomaterials Theme - Year 3		Lect.	Lab.	Tut.	Wgt.
MSE343H1: Biomaterials	F	3	-	1	0.50

Biomaterials Theme - Year 3		Lect.	Lab.	Tut.	Wgt.
CHE353H1: Engineering Biology	F	2	-	2	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50

Design of Materials Theme – Year 3		Lect.	Lab.	Tut.	Wgt.
MSE459H1: Synthesis of Nanostructured Materials	F	3	2	-	0.50
CHM325H1: Introduction to Inorganic and Polymer Materials Chemistry	S	3	-	-	0.50
ECE335H1: Introduction to Electronic Devices	F	3	-	2	0.50

Sustainable Materials Processing Theme – Year 3		Lect.	Lab.	Tut.	Wgt.
CHE324H1: Process Design	F	3	-	1	0.50
CHE332H1: Reaction Kinetics	F	3	-	2	0.50
MSE437H1: Process Metallurgy of Iron and Steel	F	2	-	1	0.50
CHE333H1: Chemical Reaction Engineering	S	3	-	2	0.50
MSE301H1: Mineral Processing	S	3	1.50	1	0.50

Manufacturing with Materials Theme – Year 3		Lect.	Lab.	Tut.	Wgt.
MIE342H1: Circuits with Applications to Mechanical Engineering Systems	F	3	1.50	1	0.50
MIE243H1: Mechanical Engineering Design	F	3	2	2	0.50
MIE320H1: Mechanics of Solids II	S	3	1.50	2	0.50
MIE364H1: Quality Control and Improvement	S	3	1	2	0.50
MIE221H1: Manufacturing Engineering	S	3	2	1	0.50
MIE304H1: Introduction to Quality Control	S	3	1	2	0.50
MIE311H1: Thermal Energy Conversion	S	3	3	-	0.50

CS/HSS Requirement - In order to fulfill degree and Canadian Engineering Accreditation Board (CEAB) requirements, each student must take a total of 4 half year (or 2 full year) Complementary Studies (CS) Electives. Two of those CS electives must be Humanities/Social Sciences (HSS) courses. In MSE, these courses are taken in 2nd and 3rd years. (Note: Students may choose to take technical electives in 3rd year instead; and, then take their CS/HSS courses in 4th year.) Since students are responsible for ensuring that each CS/HSS elective taken is an approved course, be sure to consult the electives list on the Faculty of Engineering's Registrar's Office website.

Canadian Engineering Accreditation Board (CEAB) Requirements

In order to complete the MSE Program of Study, students are responsible for ensuring that they have taken all the required core courses, the correct number of Technical Electives, HSS/CS electives (total 1.0 credit of each) and a Free Elective.

To satisfy the CEAB requirements, students must accumulate, during their studies, a minimum total number of "accreditation units" (AUs) as well as a minimum number of AUs in six specific categories: complementary studies, mathematics, natural science, engineering science, engineering design, and combined engineering science & design.

FOURTH YEAR MATERIALS ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
MSE401H1: Materials Information in Design	F	2	2	1	0.50
MSE415H1: Environmental Degradation of Materials	F	3	-	2	0.50
MSE498Y1: Capstone Project: Design of Materials Processes	Y	2a	1	2	1.00
Technical Elective	F				0.50
CS/HSS or Technical Elective	F				0.50
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MSE498Y1: Capstone Project: Design of Materials Processes	Y	2a	1	2	1.00
MSE490H1: Professional Ethics and Practice	S	2	-	-	0.25
Technical Elective	S				0.50
Technical Elective	S				0.50
CS/HSS or Technical Elective	S				0.50
Free Elective	S				0.50

4th Year Technical Electives

Materials Department offers specialization in four Theme Areas: Biomaterials, Sustainable Materials Processing, Manufacturing with Materials and Design of Materials. In the table below several suggested fourth year Technical Electives are listed for each Theme Area. Other courses can be considered and students should consult with the Associate Chair, Undergraduate Studies for approval. Students who do not select HSS/CS courses in third year must take these in fourth year to meet the minimum number of HSS/CS weight units required by the Canadian Engineering Accreditation Board (CEAB). A total of five Technical Electives are required for graduation. Please note that all fourth-year technical electives may not be offered every year.

Students are able to substitute MSE498Y1 with one of the following courses: APS490Y1, BME498Y1, or BME499Y1.

Thesis Electives - Year 4		Lect.	Lab.	Tut.	Wgt.
MSE492H1: Research Thesis I	F	-	4	1	0.50
MSE493H1: Research Thesis II	S	-	4	1	0.50

Biomaterials Theme – Year 4		Lect.	Lab.	Tut.	Wgt.
CHE353H1: Engineering Biology	F	2	-	2	0.50
CHE562H1: Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering	F	3	-	-	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50
MSE440H1: BIomaterial Processing and Properties	F	3	-	1	0.50
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50

Design of Materials Theme – Year 4		Lect.	Lab.	Tut.	Wgt.
ECE442H1	F	3	2	1	0.50
MSE430H1: Electronic Materials	F	2	-	1	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50
MSE459H1: Synthesis of Nanostructured Materials	F	3	2	-	0.50
MSE435H1: Optical and Photonic Materials	S	3	2	2	0.50
MSE451H1: Advanced Physical Properties of Structural Nanomaterials	S	3	2	1	0.50
MSE458H1: Nanotechnology in Alternate Energy Systems	S	3	-	2	0.50
MSE462H1: Materials Physics II	S	2	-	1	0.50

Sustainable Materials Processing Theme - Year 4		Lect.	Lab.	Tut.	Wgt.
CHE565H1: Aqueous Process Engineering	F	3	-	1	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50
MSE455H1: Process Simulation and Computer Design	S	3	-	2	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
MSE301H1: Mineral Processing	S	3	1.50	1	0.50

Manufacturing with Materials Theme - Year 4		Lect.	Lab.	Tut.	Wgt.
ECE442H1	F	3	2	1	0.50
MSE419H1: Fracture and Failure Analysis	F	3	-	1	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50
MSE461H1: Engineered Ceramics	F	3	-	2	0.50
MSE421H1: Solid State Processing and Surface Treatment	S	3	-	2	0.50
MSE431H1: Forensic Engineering	S	3	-	1	0.50
MSE443H1: Composite Materials Engineering	S	3	-	-	0.50
MSE478H1: Materials Manufacturing and Design Laboratory II	S	1	4	-	0.50

Materials Science and Engineering Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS106H1 - Fundamentals of Computer Programming

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the Python programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

Biomaterials and Biomedical Engineering

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

Chemical Engineering and Applied Chemistry

CHE112H1 - Physical Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

A course in physical chemistry. Topics discussed include systems and their states, stoichiometry, the properties of gases, the laws of chemical thermodynamics (calculations involving internal energy, enthalpy, free energy, and entropy), phase equilibrium, chemical equilibrium, ionic equilibrium, acids and bases, solutions, colligative properties, electrochemistry, and corrosion.

Total AUs: 51.20

CHE324H1 - Process Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course presents the philosophy and typical procedures of chemical engineering design projects. The course begins at the design concept phase. Material and energy balances are reviewed along with the design of single unit operations and equipment specification sheets. The impact of recycles on equipment sizing is covered. Safety, health and environmental regulations are presented. These lead to the development of safe operating procedures. The systems for developing Piping and Instrumentation diagrams are presented. Process safety studies such as HAZOPS are introduced. Typical utility systems such as steam, air and vacuum are discussed. Project economics calculations are reviewed.

Total AUs: 44.80

CHE332H1 - Reaction Kinetics

Credit Value: 0.50
Hours: 38.4L/25.6T

The rates of chemical processes. Topics include: measurement of reaction rates, reaction orders and activation energies; theories of reaction rates; reaction mechanisms and networks; development of the rate law for simple and complex kinetic schemes; approach to equilibrium; homogeneous and heterogeneous catalysis. Performance of simple chemical reactor types.

Total AUs: 51.20

CHE333H1 - Chemical Reaction Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Covers the basics of simple reactor design and performance, with emphasis on unifying the concepts in kinetics, thermodynamics and transport phenomena. Topics include flow and residence time distributions in various reactor types as well as the influence of transport properties (bulk and interphase) on kinetics and reactor performance. The interplay of these facets of reaction engineering is illustrated by use of appropriate computer simulations.

Total AUs: 51.20

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

CHE562H1 - Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering

Credit Value: 0.50
Hours: 38.4L

This course serves as an introduction to concepts in polymer chemistry, polymer science and polymer engineering. This includes a discussion of the mechanisms of step growth, chain growth and ring-opening polymerizations with a focus on industrially relevant polymers and processes. The description of polymers in solution as well as the solid state will be explored. Several modern polymer characterization techniques are introduced including gel permeation chromatography, differential scanning calorimetry, thermal gravimetric analysis and others.

Exclusion: CHM426H1
Recommended Preparation: CHE213H1, CHE220H1 or equivalents
Total AUs: 38.40

CHE565H1 - Aqueous Process Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2) treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

Total AUs: 44.80

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

Electrical and Computer Engineering

ECE110H1 - Electrical Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An overview of the physics of electricity and magnetism: Coulomb's law, Gauss' law, Ampere's law, Faraday's law. Physics of capacitors, resistors and inductors. An introduction to circuit analysis: resistive circuits, nodal and mesh analysis, 1st order RC and RL transient response and sinusoidal steady-state analysis.

Total AUs: 57.60

ECE335H1 - Introduction to Electronic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

Electrical behaviour of semiconductor structures and devices. Metal-semiconductor contacts; pn junctions, diodes, photodetectors, LED's; bipolar junction transistors, Ebers-Moll and hybrid-pi models; field effect transistors, MOSFET, JFET/MESFET structures and models; thyristors and semiconductor lasers.

Prerequisite: MAT291H1 and ECE221H1 and ECE231H1
Exclusion: MSE235H1
Total AUs: 51.20

Forestry

FOR424H1 - Innovation and Manufacturing of Sustainable Materials

Credit Value: 0.50
Hours: 25.6L/12.8T

Sustainable materials are a mandate for sustainable societies. This course will explore the manufacturing, engineering principles and design fundamentals for creating sustainable materials from renewable resources. Special emphasis will be on bioplastics, biofibre, nanobiofibre, biocomposites and nanobiocomposites. Written communication and design skills will be developed through tutorials and assignments.

Exclusion: FOR423H1
Recommended Preparation: Basic knowledge of materials science.
Total AUs: 32.00

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

MAT294H1 - Calculus and Differential Equations

Credit Value: 0.50
Hours: 38.4L/25.6T

Partial differentiation, grad, div, curl, multiple integrals, line integrals, surface integrals, differential equations, first order differential equations, homogeneous linear differential equations, boundary conditions. Formulation of various problems relevant to materials and mining engineering - the concepts above are used.

Total AUs: 51.20

Mechanical and Industrial Engineering

MIE221H1 - Manufacturing Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Production Fundamentals: Metal casting; metal forming - rolling, forging, extrusion and drawing, and sheet-metal forming; plastic/ceramic/glass forming; metal removal - turning, drilling/ boring/reaming, milling, and grinding; non-traditional machining - ECM, EDM and laser cutting; welding; surface treatment; metrology. Environmental issues in manufacturing processes, recycling of materials. Automation Fundamentals: Automation in material processing and handling - NC, robotics and automatically-guided vehicles; flexible manufacturing - group technology, cellular manufacturing and FMS; and computer-aided design - geometric modelling, computer graphics, concurrent engineering and rapid prototyping.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 57.60

MIE243H1 - Mechanical Engineering Design

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Introduction to basic mechanical parts and mechanisms: gears, cams, bearings, linkages, actuators and motors, chain and belt drives, brakes and clutches, hydraulics and pneumatics. Tutorials on engineering drawing, sketching, and CAD/CAM in SolidWorks: views and drawing types, 2D sketching, 3D modeling and engineering drawing generation, modeling of assembly and motion analysis/animation. Conceptual design examples and mechanical engineering design process, including selection and applications of mechanisms. Dissection and reverse engineering of selected mechanical devices, mechanisms, and subsystems. Competitive group design project including technical report and 3D printing.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 64.00

MIE258H1 - Engineering Economics and Accounting

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering economic and accounting concepts needed in the design of engineering systems. Financial analysis topics include: financial statements, depreciation, income tax, and basic accounting techniques. Project analysis topics includes: time value of money, evaluation of cash flows, defining alternatives, analysis of independent projects, acceptance criteria, buy or lease, make or buy, replacement analysis, economic analysis in the public sector, project risk and uncertainty. Inflation concepts.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Exclusion: CHE249H1, CHE374H1, CME368H1, ECE472H1, MIE358H1
Total AUs: 44.80

MIE304H1 - Introduction to Quality Control

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Introduction to quality engineering. Quality standards and certification. TQM. Modeling processes with simulation. Making inferences about product quality from real or simulation output data. Introduction to statistical process control. Control charts for variables and attributes. Process capability analysis. Lot Acceptance Sampling.

Prerequisite: MIE231 or equivalent
Total AUs: 57.60

MIE311H1 - Thermal Energy Conversion

Credit Value: 0.50
Hours: 38.4L/38.4P

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework. Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Refrigeration, psychrometry and air conditioning. Fossil fuel combustion and advanced systems includes fuel cells.

Prerequisite: MIE210H1, MIE313H1
Total AUs: 57.60

MIE320H1 - Mechanics of Solids II

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Three-dimensional stress transformation, strain energy, energy methods, finite element method, asymmetric and curved beams, superposition of beam solutions, beams on elastic foundations, buckling, fracture mechanics, yield criteria, stress concentration, plane stress and strain.

Prerequisite: MIE222H1
Total AUs: 60.80

MIE342H1 - Circuits with Applications to Mechanical Engineering Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course presents analysis of complex circuits and application of circuit principles to design circuits for mechanical engineering systems. Discussions will centre around circuits and instrumentation. In-depth discussions will be given on a number of topics: (1) Mechatronics design applications of circuit principles; (2) Network theorems, node-voltage, mesh-current method, Thévenin equivalents; (3) Operational amplifier circuits; (4) 1st and 2nd order circuits; (5) Laplace transform, frequency response; (6) Passive and active filter design (low- and high-pass filters, bandpass and bandreject filters); (7) Interface/readout circuits for mechanical engineering systems, sensors, instrumentation; (8) Inductance, transformers, DC/AC machines; (9) Digital circuit and data sampling
introduction.

Prerequisite: MAT186H1 and MAT187H1
Recommended Preparation: ECE110H1 or ECE159H1
Total AUs: 54.40

MIE364H1 - Quality Control and Improvement

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

In manufacturing and service industries alike, quality is viewed as an important strategic tool for increasing competitiveness. Continuous quality improvement is a key factor leading to a company's success. With more emphasis on quality, the cost and the product cycle time are reduced and the communication between producer and customer is improved. The course focuses on the following topics: introduction to quality engineering, TQM, quality standards, supplier-producer relations and quality certification, costs of quality, statistical process control for long and short production runs, process capability analysis and acceptance sampling, quality certification, six sigma quality, quality improvement using designed experiments and an overview of the Taguchi Methods.

Prerequisite: MIE236H1 or equivalent
Total AUs: 57.60

Materials Science and Engineering

MSE120H1 - Materials Engineering, Processing and Application

Credit Value: 0.50
Hours: 38.4L/6.4T/12.8P

This course covers an introduction to the field of materials science and engineering following a design-led approach. Application areas such as stiffness-limited design, fracture-limited design, strength-limited design will be used to guide further investigations into elements of the processing-structure-properties-performance paradigm. Topics covered will include material property charts, computer-aided design and materials selection, crystallographic planes and directions, crystal structures, stiffness, strength, plasticity, yielding, ductility, fracture and fracture toughness, cyclic loading and fatigue, friction and wear, thermal properties of materials, electrical properties, optical properties, materials corrosion, and materials processing.

Total AUs: 48.00

MSE191H1 - Introduction to Materials Science and Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will introduce students to the community, upper-year experience, and core fields of Materials Science and Engineering. Seminar presenters will represent the major areas in Materials Science and Engineering and will also be drawn from an array of groups, including students, staff, faculty, and alumni. The format will vary and may include application examples, case studies, career opportunities, and research talks. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Department to enable them to make educated choices as they progress through the program. This course will be offered on a credit/no credit basis.

Total AUs: 12.80

MSE202H1 - Thermodynamics I

Credit Value: 0.50
Hours: 38.4L/25.6T

The three laws of thermodynamics, Heat capacity theory and Debye's law. Calculations of enthalpy, entropy, and free energy of pure materials and reactions. Reversible and irreversible processes. Gibbs free energy, chemical equilibria, and phase rule. Introduction of Ellingham, Pourbaix, and pre-dominance area diagrams. Treatment of ideal and non-ideal solutions with the introduction of the concept of activity and activity coefficient. Binary and ternary phase diagrams and their applications to materials processing and materials properties. Thermodynamics of electrochemical systems.

Total AUs: 51.20

MSE217H1 - Diffusion and Kinetics

Credit Value: 0.50
Hours: 38.4L/25.6T

Topics in the Diffusion part include: diffusion mechanisms, steady-state and non-steady-state diffusion, Fick's first and second laws, Kirkendall effect, short-circuit diffusions, diffusion in metallic, polymeric, ionic and semiconducting materials, Darken's first and second equations, marker's velocity, thin film diffusion. Topics in the Kinetics part include: experimental rate laws, reaction orders, determination of order of reaction (integral, differential, and half-life methods), Arrhenius equation, elucidation of mechanism, fluid-particle reactions, kinetic models (progressive-conversion, unreacted core, shrinking core model), reactor design (batch, plug flow, and mixed flow reactors).

Total AUs: 51.20

MSE218H1 - Phase Transformations

Credit Value: 0.50
Hours: 39L/13T/20P

A key part of MSE is focused on explaining how material systems transform from one condensed phase to another. These phase transformations are a critical aspect of understanding the behaviour of a material. MSE 218 builds on the thermodynamics and phase stability of MSE 202 and runs in parallel to the rates of transformation seen in MSE 217. In MSE 218 we will consider phase transformations in one component, two component, and multicomponent systems. We will look at both diffusional and diffusionless transformations, focusing on the nucleation and growth aspects of each case. Specific examples will include: solidification, precipitation, recrystallization, spinodal, massive, and order-disorder transformations. Both experimental and computational labs will be used to outline specific transformations in more depth.

Total AUs: 44.80

MSE219H1 - Structure and Characterization of Materials

Credit Value: 0.50
Hours: 39L/13T/39P

Introduction to two and three-dimensional crystallography and crystal structures of solids. Topics include: Pearson and Hermann-Mauguin symbols, reciprocal space, point group and space group symmetry analysis, stereographic projections. Introduction to tensor analysis of crystalline material properties, and symmetry breakdown by imperfections in crystals. Experimental techniques used to interpret structure and chemistry of solids and their defects will be covered theoretically and in the laboratory including: X-ray diffractometry, optical, electron and scanning probe microscopy, and surface/bulk spectroscopies based on optical, X-ray, electron and ion-beam analysis methods.

Total AUs: 64.00

MSE222H1 - Mechanics of Solid Materials

Credit Value: 0.50
Hours: 38.4L/19.2T/19.2P

Principles of stress and strains; Axial loading; Torsion; Shear forces and bending moments; Stresses in Beams; Plane stresses and strains; Pressure vessels; Deflection of beams; Introduction to Finite Element Analysis

Total AUs: 57.60

MSE235H1 - Materials Physics

Credit Value: 0.50
Hours: 3*12.8L/12.8T

Application of solid state physics to describe properties of materials. Thermal properties of solids: lattice vibrations (phonons), heat capacity, thermal conductivity. Electrical properties of metals: simple circuits, resistivity of metals (classical and quantum descriptions), Seebeck, Peltier, and Thomson effects. Electrical properties of semiconductors: band structure and occupancy, conductivity, Hall effect, simple devices. Electrical properties of insulators: polarization, capacitance, optical properties, ferroelectric and piezoelectric materials. Magnetic properties: diamagnetism and paramagnetism, ferromagnetic and ferrimagnetic materials, magnetic domains, B-H curves.

Total AUs: 44.80

MSE238H1 - Engineering Statistics and Numerical Methods

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

This course will teach engineering statistics and numerical methods with Python. Topics on statistics will include probability theory, hypothesis testing, discrete and continuous distribution, analysis of variance, sampling distributions, parameter estimation, regression analysis, statistical quality control and six-sigma. The topics on numerical methods will include curve fitting and interpolation, solving linear and nonlinear equations, numerical differentiation and integration, solution of ordinary and partial differential equations, initial and boundary value problems.

Total AUs: 64.00

MSE244H1 - Inorganic Materials Chemistry and Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

Basic materials processing flowsheet including priIntroduction to atomic and molecular structures, acid-base and redox reactions, transition metal complexes, and detailed chemical properties of the main group elements in the periodic table. Examples of industrial practice in metal processing industry and energy generation/storage technologies. Hands-on qualitative and quantitative analyses of inorganic compounds, by both classical "wet" volumetric and instrumental methods.mary processing and recycling of materials. Materials and energy balance of individual units and of overall process flowsheets. Use of computer software for flowsheet evaluation. Translating process flowsheets to resource and utility requirements, capital/operating cost, and environmental impact of processing operations. Basics of equipment sizing, operation scheduling, and plant layout.

Total AUs: 64.00

MSE245H1 - Organic Materials Chemistry and Properties

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

Introduction to organic chemistry and organic materials. Naming, bonding and shapes of organic molecules. Properties and reactions of organic compounds. Key mechanisms including electrophilic addition, nucleophilic aliphatic substitution, β-elimination reactions and electrophilic aromatic substitution. Syntheses of polymers (step-growth and radical chain growth polymerization) and processing methods. Structure and properties of polymeric materials (amorphous, crystalline, elastomeric). Thermo-transition properties of polymers. Life-cycle of polymers, mechanisms of degradation and strategies of polymer recycle. Hands-on organic syntheses and separation experiments.

Total AUs: 64.00

MSE250H1 - Materials Selection in Design I

Credit Value: 0.25
Hours: 25.6L/12.8T/25.6P

The basic principles underlying the selection and design of engineering materials for different applications are identified. The application of Cambridge Engineering Selection computer software during material selection. Selected case studies. (Half term course taught during last 6 weeks of term)

Total AUs: 44.80

MSE296H1 - Materials Paradigm at a Glance I

Credit Value: 0.15
Hours: 6.4L

Materials come in all sorts of forms and exhibit a wide range of behaviors, yet there is more in common to their explanation than there is difference. MSE296 & MSE297 will put the threads from the second year curriculum into a common informational framework more reflective of the emerging state-space based materials paradigm. This course will meet on a biweekly basis. Credit is obtained by participating in in-class exercises.

Total AUs: 6.40

MSE297H1 - Materials Paradigm at a Glance II

Credit Value: 0.15
Hours: 6.4L

Materials come in all sorts of forms and exhibit a wide range of behaviors, yet there is more in common to their explanation than there is difference. MSE296 & MSE297 will put the threads from the second year curriculum into a common informational framework more reflective of the emerging state-space based materials paradigm. This course will meet on a biweekly basis. Credit is obtained by participating in in-class exercises.

Total AUs: 6.40

MSE298H1 - Communications

Credit Value: 0.50
Hours: 12.8L/12.8T/6.4P

This full year laboratory, tutorial, and lecture course builds on the communication principles students learned in first year. Students will work in teams on open-ended design projects, and scaffolded assignments will provide students the opportunity to report on their projects in written reports, podium presentations, and poster presentations. The projects in this course are supported by laboratory exercises and tutorial activities designed to help students build engineering drawing skills with an emphasis on the SolidWorks package.

Total AUs: 22.40

MSE301H1 - Mineral Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Introduction to the theory and practice of mineral beneficiation. Topics covered include comminution, sizing, froth flotation, gravity separation, magnetic separation, electrostatic separation, dewatering and tailings management. The course also covers relevant aspects of sampling, particle size measurement, metallurgical accounting, material balances, surface chemistry and the movement of solid particles in liquid media. Open to 3rd and 4th year Minerals, Materials, and Chemical Engineering students, or with permission of the instructor.

Prerequisite: MIN225H1 or MSE244H1
Total AUs: 54.40

MSE302H1 - Thermodynamics II

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Introduction to statistical thermodynamics. The concept of chemical potential and its application in solution thermodynamics. Solution models. Equilibrium in multi-component, multi-phase systems. Thermodynamics of surfaces and interfaces. Applied thermodynamics with examples of industrial applications. Computational thermodynamics.

Total AUs: 57.60

MSE316H1 - Mechanical Behaviour of Materials

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

The mechanical behaviour of engineering materials including metals, alloys, ceramics and polymeric materials. The following topics will be discussed: macro- and micro-structural response of materials to external loads; load-displacement and stress-strain relationships, processes and mechanisms of elastic, visco-elastic, plastic and creep deformation, crystallographic aspects of plastic flow, effect of defects on mechanical behaviour, strain hardening theory, strengthening mechanisms and mechanical testing.

Total AUs: 57.60

MSE332H1 - Heat and Mass Transfer for Materials Processing

Credit Value: 0.50
Hours: 38.4L/25.6T

Fundamental concepts of heat and mass transfer as applied in materials engineering. Steady state and transient analysis in slabs, cylinders and spheres through solutions of problems in metallurgy and material processing. Similarity between heat and mass transfer. Concepts of momentum, mass and thermal boundary layers. Coupled problems.

Total AUs: 51.20

MSE335H1 - Materials Physics

Credit Value: 0.50
Hours: 39L/13T

Application of solid state physics to describe properties of materials. Thermal properties of solids: lattice vibrations (phonons), heat capacity, thermal conductivity. Electrical properties of metals: simple circuits, resistivity of metals (classical and quantum descriptions), Seebeck, Peltier, and Thomson effects. Electrical properties of semiconductors: band structure and occupancy, conductivity, Hall effect, simple devices. Electrical properties of insulators: polarization, capacitance, optical properties, ferroelectric and piezoelectric materials. Magnetic properties: diamagnetism and paramagnetism, ferromagnetic and ferrimagnetic materials, magnetic domains, B-H curves.

Total AUs: 44.80

MSE342H1 - Nanomaterials

Credit Value: 0.25
Hours: 26L/13T

An introduction to nanostructured materials. Topics include: the different classes of nanomaterials, synthesis and characterization methods, changes in physical properties on the nanometer scale, areas of application of nanostructured materials and materials issues in nanotechnology. (Quarter term course taught over the entire Fall term, worth .25 credits).

MSE343H1 - Biomaterials

Credit Value: 0.25
Hours: 26L/13P

Provides an overview of the field of biomaterials, introducing fundamental biological and materials design and selection concepts, and is open to CHE students. Key applications of materials for biomedical devices will be covered, along with an introduction to the expected biological responses. The concept of biocompatibility will be introduced along with the essential elements of biology related to an understanding of this criterion for biomaterial selection and implant design. In addition, structure-property relationships in both biological and bio-inspired materials will be highlighted.

Total AUs: 44.80

MSE351H1 - Design and Sim of Materials Processes

Credit Value: 0.50
Hours: 36L/12T/24P

An overview of computer modeling approaches to analyze various macro-scale phenomena involved in materials processing, product design, and manufacturing. These approaches will include weighted residual methods, finite element and finite difference methods, computational fluid dynamics, and multiphysics simulations. The students will apply these methods to study heat transfer, fluid flow, stress analysis, structural dynamics, and coupled behavior. Practical experience will be provided on commercial finite element (FE) and computer-aided design (CAD) packages such as ANSYS and SOLIDWORKS.

Total AUs: 57.60

MSE355H1 - Materials Production

Credit Value: 0.50
Hours: 38.4L/12.8T

Materials life cycle, primary and secondary resources, resource life and sustainability. Technologies and unit operations used in the production of light metals, non-ferrous and ferrous metals. Energy use and conservation in production of materials. Benefits and technologies of recycling. Treatment of waste streams for value recovery and safe disposal

Total AUs: 44.80

MSE390H1 - Communications II

Credit Value: 0.25
Hours: 12.8L/12.8T

The goals of Communication II are to i) gain in-depth knowledge of a specific area of work within a broader field of Materials Science and Engineering ii) read technical materials that will allow you to advance in the field iii) organize, write and present about the ideas of the field at a level of sophistication and clarity appropriate to university and iv) present clear, well-organized technical presentations.

Total AUs: 19.20

MSE398Y1 - Materials Manufacturing and Design

Credit Value: 1.00
Hours: 25.6L/51.2P

Bringing together concepts from across our entire curriculum, including Mechanical Behaviour of Materials, Phase Transformations, Heat and Mass Transport, and Thermodynamics, MSE398 explains the processing-microstructure-properties-performance paradigm underlying several manufacturing techniques. This full year course connects materials selection, CAD drawing (and simulation) and the basics of manufacturing methods for component and product design. The course culminates in a project in which students complete the design, prototyping, simulation, cost modelling and validation for product design of their own choosing.

Total AUs: 51.20

MSE401H1 - Materials Information in Design

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

This course presents approaches to composite and structural design, and optimization, for components and products. Tools for optimization, material property data analytics, and structural simulation will be used. We will apply advanced materials selection (and the CES materials database) to product and component design, and hybrid (composite) materials design. Composite mechanics theory and topology optimization will be developed for structural optimization. Finally, modern techniques including AI and machine learning will be presented for aspects of materials selection, composite design and structural optimization. Component design decisions will include both material properties and the capabilities of applicable fabrication processes, to identify the material and process which best satisfy the design requirements.

Total AUs: 44.80

MSE415H1 - Environmental Degradation of Materials

Credit Value: 0.50
Hours: 38.4L/25.6T

This course deals with four major areas: electrochemistry of low temperature aqueous solvents, the corrosion of materials, mechano-chemical effects in materials and corrosion prevention in design. Electrochemistry deals with thermodynamics of material-electrolyte systems involving ion-solvent, ion-ion interactions, activity coefficients, Nernst equation and Pourbaix diagrams, and rate theory through activation and concentration polarization. Corrosion of metallic, polymeric, ceramic, composite, electronic and biomaterials will be explored along with mechano-chemical effects of stress corrosion, hydrogen embrittlement and corrosion fatigue. Corrosion prevention in terms of case histories and the use of expert systems in materials selection.

Total AUs: 51.20

MSE419H1 - Fracture and Failure Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Fracture mechanisms and mechanics of solid materials. Topics include: nature of brittle and ductile fracture, macro-phenomena and micro-mechanisms of failure of various materials, mechanisms of fatigue; crack nucleation and propagation, Griffith theory, stress field at crack tips, stress intensity factor and fracture toughness, crack opening displacement, energy principle and the J-integral, fracture mechanics in fatigue, da/dN curves and their significance. Practical examples of fatigue analysis and fundamentals of non-destructive testing.

Total AUs: 44.80

MSE421H1 - Solid State Processing and Surface Treatment

Credit Value: 0.50
Hours: 38.4L/25.6T

The fundamentals and technologies of mechanical forming (rolling, forging, extrusion, drawing, sheet-metal forming), sintering and powder forming, thermo-mechanical processing and heat treatment are discussed. Various means to enhance surfaces for the purposes of i) improving corrosion and erosion properties, ii) change mechanical, chemical or electric properties, iii) produce a visually more appealing surface are also covered. Techniques include galvanizing, hot dipping, nitriding, vapour deposition, plasma spraying.

Total AUs: 51.20

MSE430H1 - Electronic Materials

Credit Value: 0.50
Hours: 26L/13T

Materials parameters and electronic properties of semiconductors are discussed as basic factors in the engineering of semiconductor devices. Materials parameters are related to preparation and processing methods, and thus to the electronic properties. The implications of materials parameters and properties on selected simple devices are discussed.

Total AUs: 32.00

MSE431H1 - Forensic Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The course provides participants with an understanding of scientific and engineering investigation methods and tools to assess potential sources, causes and solutions for prevention of failure due to natural accidents, fire, high and low speed impacts, design defects, improper selection of materials, manufacturing defects, improper service conditions, inadequate maintenance and human error. The fundamentals of accident reconstruction principles and procedures for origin and cause investigations are demonstrated through a wide range of real world case studies including: medical devices, sports equipment, electronic devices, vehicular collisions, structural collapse, corrosion failures, weld failures, fire investigations and patent infringements. Compliance with industry norms and standards, product liability, sources of liability, proving liability, defense against liability and other legal issues will be demonstrated with mock courtroom trial proceedings involving invited professionals to elucidate the role of an engineer as an expert witness in civil and criminal court proceedings.

Prerequisite: MSE101H1/APS104H1/MSE260H1 or MSE160H1
Total AUs: 44.80

MSE435H1 - Optical and Photonic Materials

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Optical and photonic materials play a central role in a variety of application fields including telecommunications, metrology, manufacturing, medical surgery, computing, spectroscopy, holography, chemical synthesis, and robotics - to name a few. The properties of light and its interaction with matter lie at the heart of this ever-expanding list of applications. The syllabus comprises the nature of light, wave motion, lasers, interference, coherence, fibre optics, diffraction, polarized light, photonic crystals, metamaterials, plasmonic materials, and practical design applications.

Total AUs: 64.00

MSE437H1 - Process Metallurgy of Iron and Steel

Credit Value: 0.50
Hours: 25.6L/12.8T

The production and refining of liquid iron in the iron blast furnace, the production and refining of liquid steel, secondary refining operations, continuous casting and thermomechanical processing (hot rolling). Specialty steels and newly emerging technologies (e.g. thin slab casting, direct ironmaking) are also discussed in terms of process/environment and productivity. Downstream topics will include cold rolling, batch and continuous annealing, and coating operations.

Total AUs: 32.00

MSE438H1 - Computational Materials Design

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Introduces computational design of materials at atomic scale by focusing on two of the most powerful techniques - density functional theory (DFT) and molecular dynamics (MD). At the heart of both these techniques lies atomistic understanding originating from quantum mechanics; thus the initial lectures will review basics of quantum mechanics to inspire the foundational principles of modern-day DFT approaches. Thereafter theoretical background of DFT and its implementation and application for materials design will be covered. Specific topics on

DFT will include Kohn-Sham equations, plane-wave basis sets, exchange and correlation, and nudged-elastic band calculations. Topics concerning MD will include foundational principles, Born-Oppenheimer hypothesis, time integration schemes such as velocity-verlet scheme, and interatomic potential functions. Finally, students will be exposed to the concepts and case-studies pertaining to multi-scale modeling. A particular emphasis of the course is providing hands-on training on open source software packages such as VESTA, Quantum-ESPRESSO, and LAMMPS.

Prerequisite: MSE335H1/PHY356H1/PHY452H1/ECE330H1
Total AUs: 44.80

MSE440H1 - Biomaterial Processing and Properties

Credit Value: 0.50
Hours: 39L/13T

Currently used biomaterials for formation of surgical implants and dental restorations include selected metals, polymers, ceramics, and composites. The selection and processing of these materials to satisfy biocompatibility and functional requirements for applications in selected areas will be presented. Materials used for forming scaffolds for tissue engineering, and strategies for repair, regeneration and augmentation of degenerated or traumatized tissues will be reviewed with a focus on biocompatibility issues and required functionality for the intended applications.

Prerequisite: MSE343H1
Total AUs: 44.80

MSE443H1 - Composite Materials Engineering

Credit Value: 0.50
Hours: 38.4L

This course is designed to provide an integrated approach to composite materials design, and provide a strong foundation for further studies and research on these materials. Topics include: structure, processing, and properties of composite materials; design of fillers reinforcements and matrices reinforcements, reinforcement forms, nanocomposites systems, manufacturing processes, testing and properties, micro and macromechanics modeling of composite systems; and new applications of composites in various sectors.

Exclusion: CHE461H1 and MSE330H1
Total AUs: 38.40

MSE450H1 - Plant and Process Design

Credit Value: 0.50
Hours: 25.6L/38.4T

Basic materials processing flowsheet including primary processing and recycling of materials. Materials and energy balance of individual units and of overall process flowsheets. Use of computer software for flowsheet evaluation. Translating process flowsheets to resource and utility requirements, capital/operating cost, and environmental impact of processing operations. Basics of equipment sizing, operation scheduling, and plant layout.

Total AUs: 44.80

MSE451H1 - Advanced Physical Properties of Structural Nanomaterials

Credit Value: 0.50
Hours: 39L/13T/39P

This course deals with the physical properties of bulk nanostructured materials. Included are mechanical properties (elastic behavior, tensile and compressive strength, creep, wear and fatigue properties) electrical properties (electrical transport phenomena, electrical resistivity) magnetic properties (paramagnetic, diamagnetic, soft and hard ferromagnetic, superparamagnetic and antiferromagnetic properties), thermodynamic properties (interfacial enthalpy, thermal stability, phase transformations, heat capacity). The considerable differences observed for nanocrystalline solids compared to conventional polycrystalline and amorphous solids will be discussed in terms of the microstructural differences for these materials.

Total AUs: 57.60

MSE455H1 - Process Simulation and Computer Design

Credit Value: 0.50
Hours: 38.4L/25.6T

Various production processes use simulation software to shorten the route from the initial design to finished product. Simulation software provides the designer and practicing engineer with a powerful tool in the tasks of improving and optimizing the industrial processes. Expensive trials can be avoided and the quality of the finished product secured from the beginning of production. First, this course will cover the basics of the process simulation used in industrial setting. Subsequently, the course will focus on industrial process simulation software used extensively in foundry industry worldwide. Essential elements of CAD/CAM techniques will be covered. Numerical simulation of the filling and solidification in castings will be presented. Calculation of foundry processes with multiple production cycles will be analyzed. Another course feature will be the graphical presentation of the results on the screen. Limited enrolment.

Total AUs: 51.20

MSE458H1 - Nanotechnology in Alternate Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

The unique surface properties and the ability to surface engineer nanocrystalline structures renders these materials to be ideal candidates for use in corrosion, catalysis and energy conversion devices. This course deals with the fabrication of materials suitable for use as protective coatings, and their specific exploitation in fields of hydrogen technologies (electrolysis, storage, and fuel cells) linked to renewables. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nanocrystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A major team design project along with demonstrative laboratory exercises constitutes a major portion of this course. Limited Enrolment.

Total AUs: 51.20

MSE459H1 - Synthesis of Nanostructured Materials

Credit Value: 0.50
Hours: 39L/26P

Various synthesis techniques to produce nanostructured materials will be introduced. These include methods involving the vapor phase (physical and chemical vapor deposition, organometallic chemical vapor deposition), the liquid phase (rapid solidification, spark erosion), the solid phase, (mechanical attrition, equal channel deformation) as well techniques producing these structures from solution (electrodeposition, electroless processing, precipitation). Secondary processing techniques to produce final products or devices will also be discussed.

Total AUs: 51.20

MSE461H1 - Engineered Ceramics

Credit Value: 0.50
Hours: 39L/24T

The unique combinations of physical, electrical, magnetic, and thermomechanical properties exhibited by advanced technical ceramics has led to a wide range of applications including automobile exhaust sensors and fuel cells, high speed cutting tool inserts and ball bearings, thermal barrier coatings for turbine engines, and surgical implants. This course examines the crystal and defect structures which determine the electrical and mass transport behaviours and the effects of microstructure on optical, magnetic, dielectric, and thermomechanical properties. The influence of these structure-property relations on the performance of ceramic materials in specific applications such as sensors, solid oxide fuel cells, magnets, and structural components is explored.

Total AUs: 51.20

MSE462H1 - Materials Physics II

Credit Value: 0.50
Hours: 25.6L/12.8T

Electron quantum wave theory of solid-state materials will be introduced. Quantum phenomena in various materials systems, in particular nano materials, will be discussed. Electronic properties of materials such as charge transport, dielectric properties, optical properties, magnetic properties, and thermal properties will be discussed using appropriate quantum theory. Materials systems to be studied may include metals, semiconductors, organics, polymers, and insulators.

Total AUs: 32.00

MSE478H1 - Materials Manufacturing and Design Laboratory II

Credit Value: 0.50
Hours: 12.8L/51.2P

This half year design course focuses on the simulation informed design and execution of a product and continues on the concepts learned in MSE398. Working in small groups, students will use the principles of materials selection and computer simulation to design and build a product of their own choosing. This design focused course will guide students through several iterations of their product design, each iteration further informed by computer simulation. Materials selection will include selection for mechanical design, process, and shape and will also be used to inform each iteration of the design process. Finally, computer simulation results will be experimentally validated in parts of, or the entire the final product. This course will involve significant time involved in hands-on manufacturing. The course is accepted as one of the Advanced Electives for the Advanced Manufacturing Minor.

Prerequisite: MSE398Y1
Total AUs: 38.40

MSE490H1 - Professional Ethics and Practice

Credit Value: 0.25
Hours: 25.6L

The various roles of a practicing engineer in industry and society will be presented through a series of seminars. The lecturers will include practicing engineers from local companies and consulting firms and representatives from professional and technical societies.

Total AUs: 25.60

MSE498Y1 - Capstone Project: Design of Materials Processes

Credit Value: 0.50
Hours: 12.8L/25.6T/12.8P

The students, working in small groups complete a project involving design of a materials processing plant, leading to a design report delivered at the conclusion of the course. The topics covered in the lectures and design process include basic materials processing flowsheet for primary processing and recycling of materials, materials and energy balance of individual units and of overall process flowsheets, use of computer software for flowsheet evaluation, translating process flowsheets to resource and utility requirements, energy analysis, capital/operating cost, basics of equipment sizing, operation scheduling, safety and HAZOP, plant layout, and design for sustainability.

Exclusion: CHM499Y1
Total AUs: 102.40

MSE550H1 - Advanced Physical Properties of Structural Nanomaterials

Credit Value: 0.50
Hours: 3*12.8L/12.8T/25.6P

This course deals with the physical properties of bulk nanostructured materials. Included are mechanical properties (elastic behavior, tensile and compressive strength, creep, wear and fatigue properties) electrical properties (electrical transport phenomena, electrical resistivity) magnetic properties (paramagnetic, diamagnetic, soft and hard ferromagnetic, superparamagnetic and antiferromagnetic properties), thermodynamic properties (interfacial enthalpy, thermal stability, phase transformations, heat capacity). The considerable differences observed for nanocrystalline solids compared to conventional polycrystalline and amorphous solids will be discussed in terms of the microstructural differences for these materials.

Total AUs: 57.60

MSE558H1 - Nanotechnology in Alternate Energy Systems

Credit Value: 0.50
Hours: 3*12.8L/1T/6.4P

The unique surface properties and the ability to surface engineer nanocrystalline structures renders these materials to be ideal candidates for use in corrosion, catalysis and energy conversion devices. This course deals with the fabrication of materials suitable for use as protective coatings, and their specific exploitation in fields of hydrogen technologies (electrolysis, storage, and fuel cells) linked to renewables. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nanocrystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A major team design project along with demonstrative laboratory exercises constitutes a major portion of this course. Limited Enrolment.

Total AUs: 42.10

Mechanical and Industrial Engineering

Industrial Engineering (AEINDBASC)

Academic Advisor
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Room MC109, Mechanical Engineering Building
416-978-6420
undergrad@mie.utoronto.ca

Industrial Engineering (IE) is a discipline that applies engineering principles to the design and operation of organizations. Industrial Engineering students learn to analyze, design, implement, control, evaluate and improve the performance of complex organizations, taking into consideration people, technology and information systems. Industrial engineers use operations research, information engineering and human factors tools and methods to improve and optimize systems operations and performance.

Industrial engineers share the common goal of increasing an organization's efficiency, profitability and safety in a variety of industries including health care, finance, retail, entertainment, government, information technology, transportation, energy, manufacturing and consulting. Unlike traditional disciplines in engineering and the mathematical sciences, IE addresses the role of the human decision-maker as a key contributor to the inherent complexity of systems and the primary benefactor of the analyses.

Industrial Engineering bears a close resemblance to management science, management engineering, operations research, operations management and systems engineering.

The objective of the Industrial Engineering program curriculum is to educate engineers who:

- Employ effective analysis and design tools.
- Integrate perspectives into a systems view of the organization.
- Understand both the theory and the practice of Industrial Engineering.

In the first two years of the curriculum, the emphasis is placed on fundamental principles of engineering and core industrial engineering concepts. Tools taught in second year include probability, psychology for engineers, fundamentals of object-oriented programming, engineering economics and accounting, operations research, differential equations, statistics, human-centered systems design and data modeling.

In third-year, students learn various perspectives on the operation of organizations, including productivity, information, ergonomics and economics. They also select technical electives allowing them to specialize in information engineering, operations research and human factors and investigate other IE areas such as business process engineering, design of information systems and data analytics. These same courses may be taken as fourth-year technical electives (schedule permitting). Therefore, students may use their fourth-year electives to pursue their specializations further in-depth or to investigate other IE areas.

In fourth-year, the central theme is the design and management of an organization as an integrated system. All students participate in an Integrated Systems Design course to design the business processes of an organization and a Capstone Design course that requires students to draw on knowledge from all years of the IE program to tackle a real-world project with an industry partner. There is also a research thesis option.

Job opportunities for IE graduates are diverse and offer challenging careers in a wide variety of industries, including consulting. Three prototypical jobs for new graduates include:

- Manage an organizational supply chain to ensure new products can be successfully introduced into global sales channels.
- Test the interaction features of a new software application.

- Identify the increased capacity requirements necessary to accommodate the expected surgical volume of hospitals.

Minors

The Cross-Disciplinary Programs Office (CDP) offers a variety of minors and certificate programs that complement the Industrial Engineering curriculum. Students interested in pursuing an Engineering minor and/or certificate are encouraged to consult with the CDP.

Graduate Studies in Industrial Engineering

The Department offers graduate studies and research opportunities in a wide range of fields within Industrial Engineering. These include human factors engineering, information engineering, management science, manufacturing, operations research, systems design and optimization, reliability and maintainability engineering. Subject areas include queuing theory, cognitive engineering, human-computer interaction and human factors in medicine. The programs available lead to MEng, MASc and PhD degrees. Evening courses are offered to accommodate participants who work full-time and are interested in pursuing M.Eng degrees. Additional information can be obtained from the Mechanical & Industrial Engineering Graduate Studies Office and www.mie.utoronto.ca/graduate.

Mechanical Engineering (AEMECBASC)

Academic Advisor
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The Mechanical Engineering profession faces unprecedented challenges and exciting opportunities in its efforts to serve the needs of society. The broad disciplinary base and design orientation of the field will continue to make the skills of the mechanical engineer crucial to the success of virtually all technical systems that involve energy, motion, materials, design, automation and manufacturing. The explosive growth in the availability of lower-cost, compact and high-speed computing hardware and software is already revolutionizing the analysis, design, manufacture and operation of many mechanical engineering systems. Mechanical engineering systems are part of automotive engineering, robotics, fuel utilization, nuclear and thermal power generation, materials behaviour in design applications, transportation, biomechanical engineering, environmental control and many others.

To prepare mechanical engineers for the challenges of such a broad discipline, the program is designed to:

- Provide fundamental knowledge of the various subdisciplines.
- Teach methodology and systems analysis techniques for integrating this knowledge into useful design concepts
- Make graduates fully conversant with modern facilities, such as CAD/CAM and microprocessor control, by which design concepts can be produced and competitively manufactured.

The knowledge component includes the key subdisciplines of mechanics, thermodynamics, fluid mechanics, control theory, dynamics, material science and design. All are based on adequate preparation in mathematics and in such fundamental subjects as physics and chemistry.

Integration of this knowledge is accomplished in third- and fourth-year courses. Students select many upper-year courses from a list of electives, permitting them to choose subjects compatible with their individual interests. Most technical elective courses are from one of five streams or subject areas: manufacturing, mechatronics, solid mechanics and machine design, energy and environment or bioengineering. Students are encouraged to select a sequence of courses from two of the five streams, acquiring a greater depth of knowledge in those areas. The fourth-year Capstone Design course encompasses all aspects of the program as students complete a two-term design project for an industrial partner or client. Students also have the option of doing a one- or two-term thesis in their fourth year of study, allowing independent study and research with faculty members.

With this diverse background, virtually all industries seek the services of the practicing mechanical engineer as an employee or a consultant. Mechanical engineers are involved in the primary power production industry where hydraulic, thermal and nuclear energy is converted to electricity; integrated manufacturing of automobiles and other equipment; aircraft and other transportation systems; heating and air conditioning industry; design and manufacture of electronic hardware; materials processing plants and many others industries.

For the modern mechanical engineer, the undergraduate program is only the first step in this educational process. An increasing number of graduates pursue advanced degrees in particular areas of specialization. Graduates entering the industry can continue their education by participating in the graduate program.

Graduate Program in Mechanical Engineering

The Department offers graduate study and research opportunities in a wide range of fields within Mechanical Engineering. These include applied mechanics, biomedical engineering, computer-aided engineering, energy studies, fluid mechanics and hydraulics, materials, manufacturing, robotics, automation and control, design, surface sciences, thermodynamics and heat transfer, plasma processing, vibration, computational fluid dynamics, microfluidics and micromechanics, environmental engineering, thermal spray coatings, finite element methods, internal combustion engines and spray-forming processes. The programs lead to MEng, MASc and PhD degrees. Evening courses are offered to accommodate participants who work full-time and are interested in pursuing an MEng. Additional information can be obtained from the Mechanical and Industrial Engineering Graduate Studies Office and www.mie.utoronto.ca/graduate.

Mechanical and Industrial Engineering Programs

INDUSTRIAL ENGINEERING (AEINDBASC)

FIRST YEAR INDUSTRIAL ENGINEERING

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
Core Required Courses					
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session – Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Core Required Courses					
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MIE100H1: Dynamics	S	3	-	2	0.50
MIE191H1: Seminar Course: Introduction to Mechanical and Industrial Engineering	S	1	-	-	0.15

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR INDUSTRIAL ENGINEERING

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
MIE236H1: Probability	F	3	-	2	0.50
MIE242H1: Psychology For Engineers	F	3	3	-	0.50
MIE250H1: Fundamentals of Object Oriented Programming	F	2	3	-	0.50
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50
MAT231H1: Modelling with Differential and Difference Equations	F	3	-	2	0.50
Winter Session – Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MIE237H1: Statistics	S	3	1	2	0.50
MIE240H1: Human Centred Systems Design	S	3	-	2	0.50
MIE253H1: Data Modelling	S	3	2	-	0.50
MIE262H1: Operations Research I: Deterministic OR	S	3	2	1	0.50
MIE263H1: Operations Research II: Stochastic OR	S	3	-	2	0.50

THIRD YEAR INDUSTRIAL ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
Core Required Courses					
MIE343H1: Industrial Ergonomics and the Workplace	F	3	3	-	0.50
MIE350H1: Design and Analysis of Information Systems	F	3	1	1	0.50
MIE360H1: Systems Modelling and Simulation	F	3	2	1	0.50
Technical Elective (Choose One):					
MIE344H1: Ergonomic Design of Information Systems	F	3	3	-	0.50
MIE354H1: Business Process Engineering	F	3	2	-	0.50
MIE365H1: Operations Research III: Advanced OR	F	3	2	1	0.50
MIE368H1: Analytics in Action	F	2	3	1	0.50
Complementary Studies Elective					
CS Elective	F				0.50
Winter Session - Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Core Required Courses					
MIE335H1: Algorithms & Numerical Methods	S	3	1	1	0.50
MIE363H1: Resource and Production Modelling	S	3	-	2	0.50
MIE364H1: Quality Control and Improvement	S	3	1	2	0.50
Technical Elective (Choose One):					
APS360H1: Applied Fundamentals of Machine Learning	S	3	-	1	0.50
MIE345H1: Case Studies in Human Factors and Ergonomics	S	3	-	2	0.50
MIE367H1: Cases in Operations Research	S	3	-	2	0.50
MIE369H1: Introduction to Artificial Intelligence	S	3	2	-	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
Complementary Studies Elective					
CS Elective	S				0.50

1. Practical Experience Requirement - As described in the beginning pages of this chapter, students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer periods).
2. At least two of the four (0.5 credit) Complementary Studies Electives to be taken between third and fourth year must be Humanities/Social Sciences courses (see the Complementary Studies section at the beginning of this chapter). Students are responsible for ensuring that each elective taken is approved. Please consult the electives list available on the Engineering Office of the Registrar's website.

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enrol and participate in the Professional Experience Year (PEY) co-op program. The PEY co-op program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating company. Details are described in the beginning of this chapter. For more information, consult the Professional Experience Year Office, 222 College Street, Suite 106 early in session 2F or 3F.

FOURTH YEAR INDUSTRIAL ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
Core Required Courses:					
MIE463H1: Integrated System Design	F	3	-	2	0.50
MIE490Y1: Capstone Design	Y	-	-	4	1.00
Technical Electives (Choose Two):					
APS502H1: Financial Engineering	F	-	-	3	0.50
CSC384H1: Introduction to Artificial Intelligence	F	3	-	-	0.50
MIE344H1: Ergonomic Design of Information Systems	F	3	3	-	0.50
MIE354H1: Business Process Engineering	F	3	2	-	0.50
MIE365H1: Operations Research III: Advanced OR	F	3	2	1	0.50
MIE368H1: Analytics in Action	F	2	3	1	0.50
MIE440H1: * Design of Innovative Products	F	2	2	1	0.50
MIE451H1: Decision Support Systems	F	3	1	1	0.50
MIE498H1: Research Thesis	F	-	-	4	0.50
MIE498Y1: Research Thesis	Y	-	-	4	1.00
MIE523H1: Engineering Psychology and Human Performance	F	3	3	-	0.50
MIE562H1: Scheduling	F	3	-	2	0.50
MIE566H1: Decision Making Under Uncertainty	F	3	-	2	0.50
Complementary Studies Elective					
CS Elective	F/Y				0.50

Winter Session - Year 4		Lect.	Lab.	Tut.	Wgt.
Core Required Courses:					
MIE459H1: Organization Design	S	4	-	-	0.50
MIE490Y1: Capstone Design	Y	-	-	4	1.00
Technical Electives (Choose Two):					
APS360H1: Applied Fundamentals of Machine Learning	S	3	-	1	0.50
APS511H1: Inventions and Patents for Engineers	S	3	-	-	0.50
MIE345H1: Case Studies in Human Factors and Ergonomics	S	3	-	2	0.50
MIE367H1: Cases in Operations Research	S	3	-	2	0.50
MIE369H1: Introduction to Artificial Intelligence	S	3	2	-	0.50
MIE424H1: Optimization in Machine Learning	S	3	1	-	0.50

Winter Session - Year 4		Lect.	Lab.	Tut.	Wgt.
MIE457H1: Knowledge Modelling and Management	S	3	1	1	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
MIE498H1: Research Thesis	S	-	-	4	0.50
MIE498Y1: Research Thesis	Y	-	-	4	1.00
MIE519H1: * Advanced Manufacturing Technologies	S	3	-	-	0.50
MIE542H1: Human Factors Integration	S	3	-	2	0.50
MIE561H1: Healthcare Systems	S	3	-	2	0.50
MIE567H1: Dynamic & Distributed Decision Making	S	3	-	2	0.50
Complementary Studies Elective					
CS Elective	S/Y				0.50

1. The Department is not able to schedule all fourth year courses without conflict. However, students are required to select courses that allow for a conflict-free timetable.
2. At least one technical elective in each of the 4F and 4W session must be chosen from the provided listings. Students who want to take a technical elective substitute are required to obtain formal Departmental approval from the Undergraduate Office.
3. Industrial Engineering students are required to complete a two-term Capstone Design project, MIE490Y1, supervised by a licensed member of the University of Toronto teaching staff.
4. At least two of the four (0.5 credit) Complementary Studies Electives to be taken between third and fourth year must be Humanities/Social Sciences courses (see the Complementary Studies section at the beginning of this chapter). Students are responsible for ensuring that each elective taken is approved. Please consult the electives list available on the Engineering Office of the Registrar's website.
5. Approval to register for the fourth-year thesis course (MIE498H1 or MIE498Y1) must be obtained from the Associate Chair - Undergraduate, and is normally restricted to students with an overall average of at least B in their second and third years. A summer thesis course is also available.

MINORS

The Cross Disciplinary Programs Office (CDP) offers a variety of minors and certificate programs that complement the Industrial Engineering curriculum. Students interested in pursuing an Engineering minor and/or certificate are encouraged to consult with the CDP.

MECHANICAL ENGINEERING (AEMECBASC)

FIRST YEAR MECHANICAL ENGINEERING

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
Core Required Courses					
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	1	1	0.50
CIV100H1: Mechanics	F	3	-	2	0.50
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session - Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Core Required Courses					
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
ECE110H1: Electrical Fundamentals	S	3	1	2	0.50

Winter Session - Year 1		Lect.	Lab.	Tut.	Wgt.
MAT187H1: Calculus II	S	3	-	1	0.50
MIE100H1: Dynamics	S	3	-	2	0.50
MIE191H1: Seminar Course: Introduction to Mechanical and Industrial Engineering	S	1	-	-	0.15

Approved Course Substitution

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR MECHANICAL ENGINEERING

Fall Session - Year 2		Lect.	Lab.	Tut.	Wgt.
Core Required Courses					
MIE230H1: Engineering Analysis	F	3	-	2	0.50
MIE231H1: Probability and Statistics with Engineering Applications	F	3	2	2	0.50
MIE243H1: Mechanical Engineering Design	F	3	2	2	0.50
MIE270H1: Materials Science	F	3	0.75	1.50	0.50
Complementary Studies Elective					
CS Elective	F/Y				0.50
Winter Session - Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Core Required Courses					
MAT234H1: Differential Equations	S	3	-	1.50	0.50
MIE210H1: Thermodynamics	S	3	1.50	0.50	0.50
MIE221H1: Manufacturing Engineering	S	3	2	1	0.50
MIE222H1: Mechanics of Solids I	S	3	1.50	1.50	0.50
Complementary Studies Elective					
CS Elective	S/Y				0.50

PROFESSIONAL EXPERIENCE YEAR

Students registered within this program, and all other undergraduate programs within the Faculty of Applied Science and Engineering, may elect to enrol and participate in the Professional Experience Year (PEY) co-op program. The PEY co-op program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating company. Details are described in the beginning of this chapter. For more information, consult the Professional Experience Year Office, 222 College Street, Suite 106 early in session 2F or 3F.

THIRD YEAR MECHANICAL ENGINEERING

Fall Session - Year 3		Lect.	Lab.	Tut.	Wgt.
Core Required Courses					
MIE301H1: Kinematics and Dynamics of Machines	F	3	3	2	0.50
MIE312H1: Fluid Mechanics I	F	3	1	1	0.50
MIE342H1: Circuits with Applications to Mechanical Engineering Systems	F	3	1.50	1	0.50
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50
Natural Science Elective (choose one):					
CHE353H1: Engineering Biology	F	2	-	2	0.50
CIV220H1: Urban Engineering Ecology	F	3	-	1	0.50

Fall Session - Year 3		Lect.	Lab.	Tut.	Wgt.
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
Winter Session - Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
Core Required Courses					
MIE315H1: Design for the Environment	S	3	-	1	0.50
MIE313H1: Heat and Mass Transfer	S	3	1.50	2	0.50
MIE334H1: Numerical Methods I	S	3	-	1.50	0.50
Stream Options (Choose two streams):					
Manufacturing					
MIE304H1: Introduction to Quality Control	S	3	1	2	0.50
Mechatronics					
MIE346H1: Analog and Digital Electronics for Mechatronics	S	3	1.50	1	0.50
Solid Mechanics & Design					
MIE320H1: Mechanics of Solids II	S	3	1.50	2	0.50
Energy and Environment					
MIE311H1: Thermal Energy Conversion	S	3	3	-	0.50
Bioengineering					
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50

1. In 4F, students will be required to take one additional course from each of the same two streams followed in third year.
2. The Department is not able to schedule all third year stream courses without conflict. However, students are required to select courses that allow for a conflict-free timetable.
3. Students may choose an alternative Natural Science course to the three listed. A list of approved alternative Natural Science courses offered by the Faculty of Arts & Science is available on the Faculty of Engineering's Registrar's Office website.

FOURTH YEAR MECHANICAL ENGINEERING

Fall Session - Year 4		Lect.	Lab.	Tut.	Wgt.
Core Required Course:					
MIE491Y1: Capstone Design	Y	-	-	4	1.00
Stream Courses (two of):					
Manufacturing					
MIE422H1: Automated Manufacturing	F	2	3	-	0.50
Mechatronics					
MIE404H1: Control Systems I	F	3	3	2	0.50
Solid Mechanics & Design					
MIE442H1: Machine Design	F	3	1.50	3	0.50
Energy & Environment					
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
Bioengineering					
MIE520H1: Biotransport Phenomena	F	3	-	1	0.50
Technical Electives (one of):					
AER307H1: Aerodynamics	F	3	-	1	0.50
AER525H1: Robotics	F	3	1.50	1	0.50
ECE344H1: Operating Systems	F	3	3	-	0.50
MIE343H1: Industrial Ergonomics and the Workplace	F	3	3	-	0.50
MIE360H1: Systems Modelling and Simulation	F	3	2	1	0.50
MIE407H1: Nuclear Reactor Theory and Design	F	3	-	2	0.50
MIE414H1: * Applied Fluid Mechanics	F	3	3	1	0.50

Fall Session - Year 4		Lect.	Lab.	Tut.	Wgt.
MIE440H1: * Design of Innovative Products	F	2	2	1	0.50
MIE444H1: * Mechatronics Principles	F	2	3	-	0.50
MIE498H1: Research Thesis	F	-	-	4	0.50
MIE498Y1: Research Thesis	Y	-	-	4	1.00
MIE508H1	F	3	-	1	0.50
MIE510H1: Finite Element Analysis in Engineering Design	F	2	-	1	0.50
MIE516H1: Combustion and Fuels	F	3	-	1	0.50
MIE523H1: Engineering Psychology and Human Performance	F	3	3	-	0.50
MIE563H1: Engineering Analysis II	F	3	-	2	0.50
MSE401H1: Materials Information in Design	F	2	2	1	0.50
Complementary Studies Elective (one):					
CS Elective	F				0.50

Winter Session - Year 4		Lect.	Lab.	Tut.	Wgt.
Core Required Course:					
MIE491Y1: Capstone Design	Y	-	-	4	1.00
Technical Electives (three of):					
BME520H1: Imaging Case Studies in Clinical Engineering	S	2	2	1	0.50
BME595H1: Medical Imaging	S	2	3	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
ECE344H1: Operating Systems	S	3	3	-	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
MIE402H1: Vibrations	S	3	1	2	0.50
MIE408H1: * Thermal and Machine Design of Nuclear Power Reactors	S	3	-	2	0.50
MIE433H1: Waves and Their Applications in Non-Destructive Testing and Imaging	S	3	-	-	0.50
MIE438H1: Microprocessors and Embedded Microcontrollers	S	2	3	-	0.50
MIE439H1: Biomechanics I	S	3	2	-	0.50
MIE441H1: * Design Optimization	S	3	2	-	0.50
MIE443H1: * Mechatronics Systems: Design and Integration	S	2	5	-	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
MIE498H1: Research Thesis	S	-	-	4	0.50
MIE498Y1: Research Thesis	Y	-	-	4	1.00
MIE504H1: Applied Computational Fluid Dynamics	S	3	-	-	0.50
MIE505H1: Micro/Nano Robotics	S	3	3	-	0.50
MIE506H1: * MEMS Design and Microfabrication	S	3	1.50	1	0.50
MIE507H1: Heating, Ventilating, and Air Conditioning (HVAC) Fundamentals	S	3	-	2	0.50
MIE517H1: Fuel Cell Systems	S	3	-	1	0.50
MIE519H1: * Advanced Manufacturing Technologies	S	3	-	-	0.50
MIE540H1: * Product Design	S	3	-	1	0.50
MIE550H1: Advanced Momentum, Heat and Mass Transfer	S	3	-	-	0.50
MSE443H1: Composite Materials Engineering	S	3	-	-	0.50
MIE507H1: Heating, Ventilating, and Air Conditioning (HVAC) Fundamentals	S	3	-	2	0.50
Complementary Studies Elective (one):					
CS Elective	S				0.50

1. In 4F, students must take one required course (indicated above) from each of the same two streams followed in 3W.
2. Students are required to include at least one of the engineering design courses marked with an asterisk (*) during fourth year. It may be taken in either 4F or 4W.
3. In 4F, students may select an additional course from the Stream Courses list (above) to substitute for the technical elective.
4. Students may take only one of MIE422H1 (Automated Manufacturing) or AER525H1 (Robotics). AER525H1 (Robotics) has limited enrolment.
5. The Department is not able to schedule all fourth year courses without conflict. However, students are required to select courses that allow for a conflict-free timetable.
6. Students are permitted to take at most two technical elective substitutes in their fourth year, but are required to obtain formal Departmental approval from the Undergraduate Office.
7. At least two of the four half credit Complementary Studies Electives to be taken between second and fourth year must he Humanities/Social Sciences courses (see the Complementary Studies section at the beginning of this chapter). An equivalent full credit course is also acceptable. Students are responsible for ensuring that each elective taken is approved. Please consult the electives list available on the Faculty of Engineering's Registrar's Office website.
8. Approval to register for the fourth-year thesis course (MIE498H1 or MIE498Y1) must be obtained from the Associate Chair - Undergraduate, and is normally restricted to students with an overall average of at least B in their second and third years.

Mechanical and Industrial Engineering Courses

Aerospace Science and Engineering

AER307H1 - Aerodynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

Review of fundamentals of fluid dynamics, potential-flow, Euler, and Navier-Stokes equations; incompressible flow over airfoils, incompressible flow over finite wings; compressibility effects; subsonic compressible flow over airfoils; supersonic flow; viscous flow; laminar layers and turbulent boundary layers and unsteady aerodynamics. Textbook: Anderson, J.D., Fundamentals of Aerodynamics, 3rd Edition, McGraw Hill, 2001.

Prerequisite: AER210H1 or MIE312H1
Total AUs: 44.80

AER525H1 - Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course addresses fundamentals of analytical robotics as well as design and control of industrial robots and their instrumentation. Topics include forward, inverse, and differential kinematics, screw representation, statics, inverse and forward dynamics, motion and force control of robot manipulators, actuation schemes, task-based and workspace design, mobile manipulation, and sensors and instrumentation in robotic systems. A series of experiments in the Robotics Laboratory will illustrate the course subjects.

Prerequisite: AER301H1 and AER372H1
Exclusion: ECE470H1
Total AUs: 54.40

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS106H1 - Fundamentals of Computer Programming

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the Python programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

APS360H1 - Applied Fundamentals of Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T

A basic introduction to the history, technology, programming and applications of the fast evolving field of machine learning. Topics to be covered may include neural networks, autoencoders/decoders, recurrent neural networks, natural language processing, and generative adversarial networks. Special attention will be paid to fairness and ethics issues surrounding machine learning. An applied approach will be taken, where students get hands-on exposure to the covered techniques through the use of state-of-the-art machine learning software frameworks.

Prerequisite:
APS105H1/APS106H1/ESC180H1/CSC180H1; APS163/MAT187H1/ESC195H1; MAT185H1/MAT188H1
Recommended Preparation:
CHE223H1/CME263H1/ECE302H1/MIE231H1/MIE236H1/MSE238H1/STA286H1/ECE286H1
Total AUs: 44.80

APS490Y1 - Multi-Disciplinary Capstone Design

Credit Value: 1.00
Hours: 38.4T

An experience in multi-disciplinary engineering practice through a significant, open-ended, client-driven design project in which student teams address stakeholder needs through the use of a creative and iterative design process.

Prerequisite: Permission of student's home department
Exclusion:

CHE430Y1/CIV498H1/MIE490Y1/MIE491Y1/ECE496Y1/ESC470H1/ESC471H1/ESC472H1/MSE498Y1
Total AUs: 102.92

APS502H1 - Financial Engineering

Credit Value: 0.50
Hours: 38.4L

This course will focus on capital budgeting, financial optimization, and project evaluation models and their solution techniques. In particular, linear, non-linear, and integer programming models and their solutions techniques will be studied. The course will give engineering students a background in modern capital budgeting and financial techniques that are relevant in practival engineering and commercial settings.

Prerequisite: MAT186H1, MAT187H1, MAT188H1, MIE236H1, MIE237H1, or equivalent.
Exclusion: MIE375H1
Total AUs: 19.20

APS511H1 - Inventions and Patents for Engineers

Credit Value: 0.50
Hours: 38.4L

Teaches the process of preparing a patent application for an invention for engineers and scientists. Teaches methods to take an invention from conception to a level that a patent application can be filed on it. Describes how to write an invention disclosure. Describes how to prepare the background section, brief listing of figures, detailed description of the invention, independent and dependent claims, abstract, and artwork. Teaches use of patent search engines.

Total AUs: 38.40

Biomaterials and Biomedical Engineering

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

BME520H1 - Imaging Case Studies in Clinical Engineering

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

An introduction to current practices in modern radiology - the detection and assessment of various human diseases using specialized imaging tools (e.g., MRI, CT, ultrasound, and nuclear imaging) from the perspective of the end-user, the clinician. Course content will include lectures delivered by radiologists describing normal anatomy and physiology as well as tissue pathophysiology (i.e., disease). Visualization and characterization using medical imaging will be described, with core lecture material complemented by industry representative guest lectures where challenges and opportunities in the development of new medical imaging technologies for niche applications will be discussed.

Note: BME520H1 will not be offered for the 2018-19 academic year.

Prerequisite: BME595H1
Total AUs: 44.80

BME595H1 - Medical Imaging

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

An introductory course to medical imaging and is designed as a final year course for engineers. The main clinical imaging modalities are covered: magnetic resonance imaging, ultrasound imaging, x-ray and computed tomography, nuclear medicine, and clinical optical imaging. Emphasis is placed on the underlying physical and mathematical concepts behind each modality, and applications are discussed in the context of how different modalities complement one another in the clinical setting. Early year engineering concepts are extensively used, including: basic electromagnetics theory, fields and waves, signals and systems, digital signal processing, differential equations and calculus, and probability and random processes. The laboratories involve image reconstruction and analysis for the various imaging modalities and a live animal imaging session.

Total AUs: 51.20

Chemical Engineering and Applied Chemistry

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

CHE475H1 - Biocomposites: Mechanics and Bioinspiration

Credit Value: 0.50
Hours: 38.4L/12.8T

An overview on structure, processing and application of natural and biological materials, biomaterials for biomedical applications, and fibre-reinforced eco-composites based on renewable resources will be provided. Fundamental principles related to linear elasticity, linear viscoelasticity, dynamic mechanical response, composite reinforcement mechanics, and time-temperature correspondence will be introduced. Novel concepts in comparative biomechanics, biomimetic and bio-inspired material design, and materials' ecological and environmental impact will be discussed. In addition, key material processing methods and testing and characterization techniques will be presented. Structure-property relationships for materials broadly ranging from natural materials, including wood, bone, cell, and soft tissue, to synthetic composite materials for industrial and biomedical applications will be covered.

Total AUs: 44.80

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

CIV220H1 - Urban Engineering Ecology

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor Basic concepts of ecology within the context of urban environments. Response of organisms, populations, dynamic predator-prey and competition processes, and ecosystems to human activities. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Biogeochemical cycles, habitat fragmentation and bioaccumulation. Introduction to industrial ecology and life cycle assessment principles. Urban metabolism and material flow analysis of cities. Response of receiving waters to pollution and introduction to waste water treatment. Emphasis is on identifying the environment/engineering interface and minimizing environmental impacts.

Prerequisite: CHE112H1
Total AUs: 44.80

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

Computer Science

CSC384H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 24L/12T

Theories and algorithms that capture (or approximate) some of the core elements of computational intelligence. Topics include: search; logical representations and reasoning, classical automated planning, representing and reasoning with uncertainty, learning, decision making (planning) under uncertainty. Assignments provide practical experience, in both theory and programming, of the core topics.

Prerequisite: (CSC263H1/ CSC265H1/ CSC263H5/ CSCC63H3/ ECE345H1/ ECE358H1/ MIE335H1, STA237H1/ STA247H1/ STA255H1/ STA257H1/ STA237H1/ STAB57H3/ STAB52H3/ ECE302H1/ STA286H1/ CHE223H1/ CME263H1/ MIE231H1/ MIE236H1/ MSE238H1/ ECE286H1)
Exclusion: NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Recommended Preparation: CSC324H1
Total AUs: 32.00

Electrical and Computer Engineering

ECE110H1 - Electrical Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An overview of the physics of electricity and magnetism: Coulomb's law, Gauss' law, Ampere's law, Faraday's law. Physics of capacitors, resistors and inductors. An introduction to circuit analysis: resistive circuits, nodal and mesh analysis, 1st order RC and RL transient response and sinusoidal steady-state analysis.

Total AUs: 57.60

ECE344H1 - Operating Systems

Credit Value: 0.50
Hours: 38.4L/38.4P

Operating system structures, concurrency, synchronization, deadlock, CPU scheduling, memory management, file systems. The laboratory exercises will require implementation of part of an operating system.

Prerequisite: ECE244H1 and ECE243H1
Exclusion: ECE353H1
Total AUs: 53.40

Forestry

FOR424H1 - Innovation and Manufacturing of Sustainable Materials

Credit Value: 0.50
Hours: 25.6L/12.8T

Sustainable materials are a mandate for sustainable societies. This course will explore the manufacturing, engineering principles and design fundamentals for creating sustainable materials from renewable resources. Special emphasis will be on bioplastics, biofibre, nanobiofibre, biocomposites and nanobiocomposites. Written communication and design skills will be developed through tutorials and assignments.

Exclusion: FOR423H1
Recommended Preparation: Basic knowledge of materials science.
Total AUs: 32.00

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

MAT231H1 - Modelling with Differential and Difference Equations

Credit Value: 0.50
Hours: 38.4L/25.6T

Ordinary differential equations. Equations of first order and first degree. Linear equations of order n. Equations of second order. Systems of simultaneous equations. Difference equations. Linear control. Forecasting. Business dynamics. Throughout the course: formulating and analysing differential or difference equation models for real-world problems.

Total AUs: 51.20

MAT234H1 - Differential Equations

Credit Value: 0.50
Hours: 38.4L/19.2T

Ordinary differential equations. Classification. Equations of first order and first degree. Linear equations of order n. Equations of second order. Bessel's equation. Legendre's equation. Series solutions. Systems of simultaneous equations. Partial differential equations. Classification of types. The diffusion equation. Laplace's equation. The wave equation. Solution by separation of variables.

Total AUs: 48.00

Mechanical and Industrial Engineering

MIE100H1 - Dynamics

Credit Value: 0.50
Hours: 38.4L/25.6T

This course on Newtonian mechanics considers the interactions which influence 2-D, curvilinear motion. These interactions are described in terms of the concepts of force, work, momentum and energy. Initially the focus is on the kinematics and kinetics of particles. Then, the kinematics and kinetics of systems of particles and solid bodies are examined. Finally, simple harmonic motion is discussed. The occurrence of dynamic motion in natural systems, such as planetary motion, is emphasized. Applications to engineered systems are also introduced.

Exclusion: APS161H1
Total AUs: 51.20

MIE191H1 - Seminar Course: Introduction to Mechanical and Industrial Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will preview the core fields in Mechanical and Industrial Engineering. Each seminar will be given by a professional in one of the major areas in MIE. The format will vary and may include application examples, challenges, case studies, career opportunities, etc. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Department to enable them to make educated choices for second year. This course will be offered on a credit/no credit basis. Students who receive no credit for this course must re-take it in their 2S session.

Students who have not received credit for this course at the end of their 2S session will not be permitted to register in session 3F.

Total AUs: 12.80

MIE210H1 - Thermodynamics

Credit Value: 0.50
Hours: 38.4L/6.4T/19.2P

This is a basic course in engineering thermodynamics. Topics covered include: properties and behaviour of pure substances; equation of states for ideal and real gases; compressibility factor; first and second laws of thermodynamics; control mass and control volume analyses; applications of first and second laws of thermodynamics to closed systems, open systems and simple thermal cycles.

Prerequisite: MAT186H1
Total AUs: 51.20

MIE221H1 - Manufacturing Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Production Fundamentals: Metal casting; metal forming - rolling, forging, extrusion and drawing, and sheet-metal forming; plastic/ceramic/glass forming; metal removal - turning, drilling/ boring/reaming, milling, and grinding; non-traditional machining - ECM, EDM and laser cutting; welding; surface treatment; metrology. Environmental issues in manufacturing processes, recycling of materials. Automation Fundamentals: Automation in material processing and handling - NC, robotics and automatically-guided vehicles; flexible manufacturing - group technology, cellular manufacturing and FMS; and computer-aided design - geometric modelling, computer graphics, concurrent engineering and rapid prototyping.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 57.60

MIE222H1 - Mechanics of Solids I

Credit Value: 0.50
Hours: 38.4L/19.2T/19.2P

Design of mechanical joints. Elasto-plastic torsion of circular sections. Elasto-plastic bending of beams. Residual stresses, shearing stresses in beams, analysis of plane stress and plant strain problems. Pressure vessels, design of members of strength criteria, deflection of beams. Statistically indeterminate problems.

Total AUs: 57.60

MIE230H1 - Engineering Analysis

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to complex analysis. Multivariate integration with application to calculation of volumes, centroids and moments. Vector calculus. Divergence, curl and gradient operators. Green's theorem. Gauss' theorem. Stokes' theorem. Integral transforms. Laplace transforms and Fourier series, integral and transform.

Prerequisite: MAT186H1, MAT187H1
Total AUs: 51.20

MIE231H1 - Probability and Statistics with Engineering Applications

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Use of data in engineering decision processes. Elements of probability theory. Discrete and continuous random variables. Standard distributions: binomial, Poisson, hypergeometric, exponential, normal etc. Expectation and variance. Random sampling and parameter estimation. Confidence intervals. Hypothesis testing. Goodness-of-fit tests. Regression and correlation. Statistical Process Control and quality assurance. Engineering applications in manufacturing, instrumentation and process control.

Total AUs: 64.00

MIE236H1 - Probability

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to probability (the role of probability, exploratory data analysis and basic graphical methods). Sample space and events, Venn diagram. Definitions of probability. Axiomatic definition and basic rules. Conditional probability and Bayes' rule. Concept of random variables. Discrete, continuous, and joint distributions. Probability mass functions, density function, cumulative distribution function. Expectation, variance, and covariance. Important discrete and continuous distributions. Multivariate normal distribution. Functions of random variables. Moment Generating functions. Central limit theorem, laws of large numbers, Markov and Chebyshev's inequalities, types of convergence. Fundamental sampling distributions, Chi-square, t, and F distributions. One sample estimation and hypothesis testing.

Total AUs: 51.20

MIE237H1 - Statistics

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Two sample estimation and hypothesis testing. Least squares estimation. Simple linear regression and correlation. Multiple linear regression. Linear models. Model building and model assessment. Design and analysis of single and multi factor experiments. Analysis of variance. Randomization and blocking. Fixed and random effects models. Multiple comparisons. Sample size calculations.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 57.60

MIE240H1 - Human Centred Systems Design

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to principles, methods, and tools for the analysis, design and evaluation of human-centred systems. Consideration of impacts of human physical, physiological, perceptual, and cognitive factors on the design and use of engineered systems. Basic concepts of anthropometrics, work-related hazards, shiftwork, workload, human error and reliability, and human factors standards. The human-centred systems design process, including task analysis, user requirements generation, prototyping, and usability evaluation. Design of work/rest schedules, procedures, displays and controls, and training systems; design for error prevention and human-computer interaction; design for aging populations.

Prerequisite: MIE242H1 recommended
Total AUs: 51.20

MIE242H1 - Psychology For Engineers

Credit Value: 0.50
Hours: 38.4L/38.4P

Introduction to neuroanatomy and processes that are core to perception, cognition, language, decision making, and action. Use of experiments to test hypotheses concerning brain activities and computations. Conducting and reporting experimental research, use of elementary statistics, and satisfaction of research ethics requirements.

Total AUs: 57.60

MIE243H1 - Mechanical Engineering Design

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Introduction to basic mechanical parts and mechanisms: gears, cams, bearings, linkages, actuators and motors, chain and belt drives, brakes and clutches, hydraulics and pneumatics. Tutorials on engineering drawing, sketching, and CAD/CAM in SolidWorks: views and drawing types, 2D sketching, 3D modeling and engineering drawing generation, modeling of assembly and motion analysis/animation. Conceptual design examples and mechanical engineering design process, including selection and applications of mechanisms. Dissection and reverse engineering of selected mechanical devices, mechanisms, and subsystems. Competitive group design project including technical report and 3D printing.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 64.00

MIE250H1 - Fundamentals of Object Oriented Programming

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

Introduction to object-oriented programming using the Java programming language with heavy emphasis on practical application; variable types; console and file input/output; arithmetic; logical expressions; control structures; arrays; modularity; functions; classes and objects; access modifiers; inheritance; polymorphism; fundamental data structures; design and implementation of programs relevant to industrial engineering needs according to strict specifications.

Prerequisite: APS105H1/APS106H1 or equivalent
Total AUs: 44.80

MIE253H1 - Data Modelling

Credit Value: 0.50
Hours: 38.4L/25.6P

This course provides an understanding of the principles and techniques of information modelling and data management, covering both relational theory and SQL database systems (DBMS), as well as entity-relation conceptual modelling. The course also familiarizes the student with analytical applications (OLAP) and provides an introduction to XML data modelling. The laboratory focuses on database application development using SQL DBMS, OLAP queries and entity-relation data modelling.

Prerequisite: MIE250H1
Total AUs: 51.20

MIE258H1 - Engineering Economics and Accounting

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering economic and accounting concepts needed in the design of engineering systems. Financial analysis topics include: financial statements, depreciation, income tax, and basic accounting techniques. Project analysis topics includes: time value of money, evaluation of cash flows, defining alternatives, analysis of independent projects, acceptance criteria, buy or lease, make or buy, replacement analysis, economic analysis in the public sector, project risk and uncertainty. Inflation concepts.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Exclusion: CHE249H1, CHE374H1, CME368H1, ECE472H1, MIE358H1
Total AUs: 44.80

MIE262H1 - Operations Research I: Deterministic OR

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Introduction to deterministic operations research. Formulations of mathematical models to improve decision making; linear and integer programming; the simplex method; the revised simplex method; branch-and-bound methods; sensitivity analysis; duality; network models; network simplex method; Dijkstra's algorithm; basic graph theory; and deterministic dynamic programming.

Prerequisite: MAT186H1, MAT188H1
Total AUs: 57.60

MIE263H1 - Operations Research II: Stochastic OR

Credit Value: 0.50
Hours: 38.4L/25.6T

Modeling and analysis of systems subject to uncertainty using probabilistic methods. Introduction to decision analysis. Derivation and application of Bernoulli and Poisson processes, Markov chains, and queuing models. Stochastic optimization and extensions. Applications to engineering, games of chance, health care, and management.

Prerequisite: MIE231H1 or MIE236H1
Total AUs: 51.20

MIE270H1 - Materials Science

Credit Value: 0.50
Hours: 38.4L/19.2T/9.6P

Corrosion and degradation of materials; Phase transformation and strengthening mechanisms; Mechanical failure, fatigue, creep, impact; Electrical, thermal, magnetic, optical properties of materials; Composite materials.

Prerequisite: APS110H1/APS164H1/MSE101H1
Total AUs: 52.80

MIE297H1 - Foundations of Design Portfolio

Credit Value: 0.00

Students will assemble a short design portfolio with items drawn from engineering courses and extra-curricular experience. The portfolio will demonstrate an understanding and application of basic principles of engineering design through a showcase of the student's best work. The portfolio will further demonstrate competence in written and oral communication through a brief summary of each item and an introduction to the portfolio. Students whose communication work is not up to standard will be provided with opportunities for remediation. The course will be offered on a credit/no credit basis; students who receive no credit must retake the course in year 3.

Total AUs: 0.00

MIE301H1 - Kinematics and Dynamics of Machines

Credit Value: 0.50
Hours: 38.4L/25.6T/38.4P

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented methods, gears, geartrains, cams, flywheels, mechanism dynamics.

Instruction and assessment of engineering communication that will form part of an ongoing design portfolio.

Prerequisite: MIE100H1
Total AUs: 70.40

MIE304H1 - Introduction to Quality Control

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Introduction to quality engineering. Quality standards and certification. TQM. Modeling processes with simulation. Making inferences about product quality from real or simulation output data. Introduction to statistical process control. Control charts for variables and attributes. Process capability analysis. Lot Acceptance Sampling.

Prerequisite: MIE231 or equivalent
Total AUs: 57.60

MIE311H1 - Thermal Energy Conversion

Credit Value: 0.50
Hours: 38.4L/38.4P

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework. Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Refrigeration, psychrometry and air conditioning. Fossil fuel combustion and advanced systems includes fuel cells.

Prerequisite: MIE210H1, MIE313H1
Total AUs: 57.60

MIE312H1 - Fluid Mechanics I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Fluid statics, pressure measurement, forces on surfaces. Kinematics of flow, velocity field, streamlines. Conservation of mass. Fluid dynamics, momentum analysis, Euler and Bernoulli equations. Energy and head lines. Laminar flow. Flow at high Reynolds numbers, turbulence, the Moody diagram. External flows. Boundary layers. Lift and drag. Flow separation.

Prerequisite: MIE100H1, MAT234H1, MIE210H1
Total AUs: 51.20

MIE313H1 - Heat and Mass Transfer

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Exact and numerical analysis of steady and transient conduction in solids. Solutions of one-dimensional and multidimensional systems. Principles of convection and solutions under laminar and turbulent flow over flat plates and inside and over pipes. Free convection. Thermal radiation between multiple black and grey surfaces. Analysis of open-ended design problems for improving thermal transport in commercial products.

Prerequisite: MAT234H1, MIE210H1, MIE230H1, MIE312H1 or equivalent
Total AUs: 60.80

MIE315H1 - Design for the Environment

Credit Value: 0.50
Hours: 38.4L/12.8T

Life Cycle Assessment for the measurement of environmental impacts of existing products and processes. Design for Environment principles for the reduction of environmental impacts in new product and process designs. Functional, economic, and societal analysis taught for use in a major team-written project to compare and contrast two product or process alternatives for a client.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 44.80

MIE320H1 - Mechanics of Solids II

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Three-dimensional stress transformation, strain energy, energy methods, finite element method, asymmetric and curved beams, superposition of beam solutions, beams on elastic foundations, buckling, fracture mechanics, yield criteria, stress concentration, plane stress and strain.

Prerequisite: MIE222H1
Total AUs: 60.80

MIE334H1 - Numerical Methods I

Credit Value: 0.50
Hours: 38.4L/19.2T

This introductory course to numerical methods includes the following topics: polynomial interpolation, numerical integration, solution of linear systems of equations, least squares fitting, solution of nonlinear equations, numerical differentiation, solution of ordinary differential equations, and solution of partial differential equations. Tutorial assignments using MATLAB will focus on engineering applications relevant to the background of students taking the course.

Total AUs: 48.00

MIE335H1 - Algorithms & Numerical Methods

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Algorithmic analysis, big-O asymptotic analysis; numerical linear algebra, solution techniques for linear and non-linear systems of equations; matrix factorization, LU and Cholesky factorization, factorization in the revised simplex method; Newton's method, Gale-Shapley method, greedy methods for combinatorial optimization, branch-and-bound search methods; graph theory and graph theoretic algorithms; design and implementation of algorithms to optimize mathematical models.

Prerequisite: MIE262H1
Total AUs: 51.20

MIE341H1 - Mechanical Engineering Design

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

Technical drawing including sketching. Computer-aided drafting and design analysis Mechanical components - nomenclature, function and selection. Mechanical dissection of selected mechanical devices. Group competitive conceptual design projects including technical reports, oral presentations and display posters.

Total AUs: 64.00

MIE342H1 - Circuits with Applications to Mechanical Engineering Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course presents analysis of complex circuits and application of circuit principles to design circuits for mechanical engineering systems. Discussions will centre around circuits and instrumentation. In-depth discussions will be given on a number of topics: (1) Mechatronics design applications of circuit principles; (2) Network theorems, node-voltage, mesh-current method, Thévenin equivalents; (3) Operational amplifier circuits; (4) 1st and 2nd order circuits; (5) Laplace transform, frequency response; (6) Passive and active filter design (low- and high-pass filters, bandpass and bandreject filters); (7) Interface/readout circuits for mechanical engineering systems, sensors, instrumentation; (8) Inductance, transformers, DC/AC machines; (9) Digital circuit and data sampling
introduction.

Prerequisite: MAT186H1 and MAT187H1
Recommended Preparation: ECE110H1 or ECE159H1
Total AUs: 54.40

MIE343H1 - Industrial Ergonomics and the Workplace

Credit Value: 0.50
Hours: 38.4L/38.4P

The Biology of Work: anatomical and physiological factors underlying the design of equipment and work places. Biomechanical factors governing physical workload and motor performance. Circadian rhythms and shift work. Measurement and specification of heat, light, and sound with respect to design of the work environment.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 57.60

MIE344H1 - Ergonomic Design of Information Systems

Credit Value: 0.50
Hours: 38.4L/38.4P

The goal of this course is to provide an understanding of how humans and machines can be integrated with information systems. The focus will be on the design of human-machine interfaces, and on the analysis of the impact of computers on people. The course will also include coverage of usability engineering and rapid prototyping design, analysis of user mental models and their compatibility with design models, and quantitative modelling of human-computer interaction.

Prerequisite: MIE240H1 or permission of the instructor
Total AUs: 57.60

MIE345H1 - Case Studies in Human Factors and Ergonomics

Credit Value: 0.50
Hours: 38.4L/25.6T

A detailed analysis will be made of several cases in which human factors methods have been applied to improve the efficiency with which human-machine systems operate. Examples will be chosen both from the area of basic ergonomics and from high technology. Emphasis will be placed on the practical use of material learned in earlier human factors courses.

Prerequisite: MIE240H1
Total AUs: 51.20

MIE346H1 - Analog and Digital Electronics for Mechatronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

A study of the fundamental behaviour of the major semiconductor devices (diodes, bipolar junction transistors and field effect transistors). Development of analysis and design methods for basic analog and digital electronic circuits and devices using analytical, computer and laboratory tools. Application of electronic circuits to instrumentation and mechatronic systems.

Prerequisite: MIE230H1, MAT234H1, MIE342H1
Total AUs: 54.40

MIE350H1 - Design and Analysis of Information Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Provides students with an understanding of the mothods of information system analysis and design. These include methods for determining and documenting an organization's structure (FDD), activities, behaviours and information flows (DFDs, decision tables and trees, network diagrams, etc); model acquisition (data repositories), verification and validation. Methods such as SADT, RAD and prototyping will be covered. Students will acquire a working knowledge of various frameworks for analysis (e.g., information technology categories, system and application classifications, decision types, data vs information). Throughout the course, emphasis is placed on the importance of systems thinking and organizational culture in the analysis and design process. In the laboratory, students will use a CASE-based computer program (Visible Analyst) for the analysis and design of information systems for selected organizations. Students will be asked to work in teams to create a web-based information site and to document and present their development progress through the use of a structured project log.

Prerequisite: MIE253H1
Total AUs: 51.20

MIE354H1 - Business Process Engineering

Credit Value: 0.50
Hours: 38.4L/25.6P

This course focuses on understanding multiple perspectives for grouping, assessing, designing and implementing appropriately integrated and distributed information systems to support enterprise objectives. The emphasis is on understanding how Business Process Management techniques and tools can contribute to align an organization's business and information technology perspectives, as well as the characteristics of application and system types and the implications for their design, operation and support of information needs, including those associated with different platforms and technology infrastructure e.g., legacy systems, client/server, the Internet and World Wide Web including the emergence of a web-service-based service oriented architecture. Students will work in the laboratory to develop business processes that can be specified and executed by information systems supporting BPEL, a widely supported standard for describing web-service-based business process.

Prerequisite: MIE253H1 or permission of the instructor
Total AUs: 51.20

MIE360H1 - Systems Modelling and Simulation

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Principles for developing, testing and using discrete event simulation models for system performance improvement. Simulation languages, generating random variables, verifying and validating simulation models. Statistical methods for analyzing simulation model outputs, and comparing alternative system designs. Fitting input distributions, including goodness of fit tests. Role of optimization in simulation studies.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 57.60

MIE363H1 - Resource and Production Modelling

Credit Value: 0.50
Hours: 38.4L/25.6T

This course focuses on features of production/service systems and methods of modelling their operation; the material flow, information flow and control systems. Topics include demand forecasting, inventory management, supply chain management, capacity planning, and lot size planning. Emphasis will be placed on the modelling aspects of operations management, as well as the application of analytical methods in the design of production/service systems. Students will be asked to address open-ended design problems in various activities of the course.

Prerequisite: MIE231H1/MIE236H1, MIE262H1 or equivalent
Total AUs: 51.20

MIE364H1 - Quality Control and Improvement

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

In manufacturing and service industries alike, quality is viewed as an important strategic tool for increasing competitiveness. Continuous quality improvement is a key factor leading to a company's success. With more emphasis on quality, the cost and the product cycle time are reduced and the communication between producer and customer is improved. The course focuses on the following topics: introduction to quality engineering, TQM, quality standards, supplier-producer relations and quality certification, costs of quality, statistical process control for long and short production runs, process capability analysis and acceptance sampling, quality certification, six sigma quality, quality improvement using designed experiments and an overview of the Taguchi Methods.

Prerequisite: MIE236H1 or equivalent
Total AUs: 57.60

MIE365H1 - Operations Research III: Advanced OR

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Design of operations research models to solve a variety of open-ended problems. Linear programming extensions are presented: goal programming, column generation, Dantzig-Wolfe decomposition, and interior point solution methods. Non-linear programming solution methods are developed: optimality conditions, quadratic programming and bi-level programming. Solutions to advanced stochastic models: stochastic programming, 2-person and n-person game theory, and Markov Decision Processes.

Prerequisite: MIE262H1, MIE263H1
Total AUs: 57.60

MIE367H1 - Cases in Operations Research

Credit Value: 0.50
Hours: 38.4L/25.6T

This course focuses on the integration of the results from earlier operations research courses and an assessment of the different methods with regard to typical applications. The course is taught using the case method. Students are expected to analyze cases based on real applications on their own, in small groups and during lecture sessions, and solve them using commercial software packages.

Prerequisite: MIE263H1
Total AUs: 51.20

MIE368H1 - Analytics in Action

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

This course showcases the impact of analytics focusing on real world examples and case studies. Particular focus on decision analytics, where data and models are combined to ultimately improve decision-making. Methods include: linear and logistic regression, classification and regression trees, clustering, linear and integer optimization. Application areas include: healthcare, business, sports, manufacturing, finance, transportation, public sector.

Prerequisite: MIE237H1/ECE286H1, MIE262H1/MIE376H1, MIE263H1/STA347H1, or permission of the instructor
Total AUs: 51.20

MIE369H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 38.4L/25.6P

Introduction to Artificial Intelligence. Search. Constraint Satisfaction. Propositional and First-order Logic Knowledge Representation. Representing Uncertainty (Bayesian networks). Rationality and (Sequential) Decision Making under Uncertainty. Reinforcement Learning. Weak and Strong AI, AI as Engineering, Ethics and Safety in AI.

Prerequisite: MIE250H1/ECE244H1/ECE345H1/CSC263H1/CSC265H1, MIE236H1/ECE286H1/ECE302H1
Exclusion: ROB311H1, CSC384H1
Total AUs: 52.20

MIE397Y1 - Design Portfolio

Credit Value: 0.00

Students will assemble a comprehensive design portfolio with items drawn from engineering courses and extra-curricular experience. The portfolio will articulate and demonstrate an understanding and application of basic and advanced principles of engineering design through a showcase of the student's best work. The portfolio shall also anticipate continued development of design skills through the capstone design courses and reflect on the transition to a career in engineering. The portfolio will demonstrate competence in written and oral communication through a brief summary of each item and an introduction to the portfolio. Students whose communication work is not up to standard will be provided with opportunities for remediation. The course will be offered on a credit/no credit basis; students who receive no credit must retake the course in year 4.

Total AUs: 0.00

MIE402H1 - Vibrations

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Fundamental concepts of vibration of mechanical systems. Free vibration single degree of freedom systems. Various types of damping. Forced vibrations. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Vibration isolation. Modal analysis. Lagrange equations and Hamilton's principle. Vibration of continuous systems. Special topics.

Prerequisite: MAT186H1, MAT187H1, MAT188H1, MIE100H1, MIE222H1
Total AUs: 57.60

MIE404H1 - Control Systems I

Credit Value: 0.50
Hours: 38.4L/25.6T/38.4P

Analysis of stability, transient and steady state characteristics of dynamic systems. Characteristics of linear feedback systems. Design of control laws using the root locus method, frequency response methods and state space methods. Digital control systems. Application examples.

Prerequisite: MIE346H1
Total AUs: 70.40

MIE407H1 - Nuclear Reactor Theory and Design

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the neutronic design and analysis of nuclear fission reactors with a focus on Generation IV nuclear systems. Topics include radioactivity, neutron interactions with matter, neutron diffusion and moderation, the fission chain reaction, the critical reactor equation, reactivity effects and reactor kinetics. Multigroup neutron diffusion calculations are demonstrated using fast-spectrum reactor designs.

Prerequisite: MIE230H1 or equivalent
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE408H1 - * Thermal and Machine Design of Nuclear Power Reactors

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.

Prerequisite: MIE407H1/MIE222H1, MIE312H1, MIE313H1 or equivalents
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE414H1 - * Applied Fluid Mechanics

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

This course builds upon the material introduced in Fluid Mechanics I and connects it to a wide range of modern technical applications of fluid flow. Applications include the design of pipe and microfluidic networks, transient flow phenomena, compressible flow and shocks, characteristics of pumps, open channel flow and an overview of flow measurement techniques. Lectures are complemented by laboratory experiments on topics such as centrifugal pumps, flow transients and fluid flow in microfluidic chips.

Prerequisite: MIE312H1
Total AUs: 64.00

MIE422H1 - Automated Manufacturing

Credit Value: 0.50
Hours: 25.6L/38.4P

Introduction to Computer Integrated Manufactuing. Definitions, terminology. Organization of manufacturing systems. Introduction to NC machines. Introduction to robotics. Types of robot motion. Robot kinematics. Jacobians, singularities. Robot motion trajectories. Interpolation, spline fits. Robot joint control. Flexible manufacturing systems, justification. Robot cell design. Group technology. Design of group technology cell. Programmable logic controllers. Limited enrolment.

Prerequisite: MIE221H1 or equivalent
Total AUs: 44.80

MIE424H1 - Optimization in Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

1. To enable deeper understanding and more flexible use of standard machine learning methods, through development of machine learning from an Optimization perspective.

2. To enable students to apply these machine learning methods to problems in finance and marketing, such as stock return forecasting, credit risk scoring, portfolio management, fraud detection and customer segmentation.

Prerequisite:
MIE365H1/MIE376H1/ECE367H1/ROB310H1, or equivalent
Total AUs: 51.20

MIE433H1 - Waves and Their Applications in Non-Destructive Testing and Imaging

Credit Value: 0.50
Hours: 38.4L

The course is designed for students who are interested in more advanced studies of applying wave principles to engineering applications in the field of non-destructive testing (NDT) and imaging (NDI). Topics will cover: Review of principles and characteristics of sound and ultrasonic waves; thermal waves; optical (light) waves; photons: light waves behaving as particles; black body radiation, continuous wave and pulsed lasers. The course will focus on NDT and NDI applications in component inspection and medical diagnostics using ultrasonics, laser photothermal radiometry, thermography and dynamic infrared imaging.

Total AUs: 38.40

MIE438H1 - Microprocessors and Embedded Microcontrollers

Credit Value: 0.50
Hours: 25.6L/38.4P

Review (number systems, CPU architecture, instruction sets and subroutines); Interfacing Memory; Interfacing Techniques; Transistors and TTL/CMOS Logic; Mechanical Switches & LED Displays; Interfacing Analog, A/D & D/A Conversions; Stepper Motors & DC Motors; RISC Technology and Embedded Processors; DAS Systems; Embedded Microcontroller System Design; CPU-based Control.

Exclusion: ECE243H1, ECE352H1
Total AUs: 44.80

MIE439H1 - Biomechanics I

Credit Value: 0.50
Hours: 38.4L/25.6P

Introduction to the application of the principles of mechanical engineering - principally solid mechanics, fluid mechanics, and dynamics - to living systems. Topics include cellular mechanics, blood rheology, circulatory mechanics, respiratory mechanics, skeletal mechanics, and locomotion. Applications of these topics to biomimetic and biomechanical design are emphasized through a major, integrative group project.

Total AUs: 51.20

MIE440H1 - * Design of Innovative Products

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Recently developed methods applied at different stages of the design process include: Identification of unmet/underserved user needs through a modified definition of lead users (those who experience needs in advance of the mainstream population) including identifying/studying lead users, identifying which lead-user needs are relevant to the general population; Roles of function and affordance in successful products; Obstacles of fixation and cognitive bias to creativity; Concept generation methods including TRIZ/TIPS (Theory of Inventive Problem Solving, use of unrelated stimuli and analogy (e.g., from biology); Configuration design methods including design for transformation, design for assembly and end-of-life, e.g., reuse, repair and recycling. Hands-on experience of these topics in lectures, tutorials, and labs support successful application of the methods for the course project, as well as future design activities.

Total AUs: 44.80

MIE441H1 - * Design Optimization

Credit Value: 0.50
Hours: 38.4L/25.6P

Problem definition and formulation for optimization, optimization models, and selected algorithms in optimization. Design for Tolerancing, Design for Manufcaturing, and Design for Assembly. State of the are Computer Aided Design packages are introduced with case studies. Emphasis is placed on gaining practical skills by solving realistic design problems.

Prerequisite: MIE341H1, MIE222H1 or equivalents
Total AUs: 51.20

MIE442H1 - Machine Design

Credit Value: 0.50
Hours: 38.4L/38.4T/19.2P

Introduction to the fundamental elements of mechanical design including the selection of engineering materials, load determination and failure analysis under static, impact, vibration and cyclic loads. Surface failure and fatigue under contact loads, lubrication and wear. Consideration is given to the characteristics and selection of machine elements such as bearings, shafts, power screws and couplings.

Prerequisite: MIE320H1
Total AUs: 67.20

MIE443H1 - * Mechatronics Systems: Design and Integration

Credit Value: 0.50
Hours: 25.6L/64P

The course aims to raise practical design awareness, provide pertinent project engineering methodology, and generate a know-how core in integration of complex automation. This course has mainly practical content, and is integral and useful in the training and education of those students who plan to be employed in areas related to intelligent automation, as well as to the breadth of knowledge of all others. Although emphasis will be on robotic-based automation (mechatronics), the learning will be useful in all domains of system integration. This course will introduce students to the basics of integration, methodology of design, tools, and team project work. The course will be monitored based on projects from a selected list of topics. The lectures will be in format of tutorials as preparation and discussions on project related issues. A main goal is to bring the methods, means and spirit of the industrial design world to the class room. Emphasis will be on understanding the elements of integration, methodology and approaches, and will involve numerous case studies. Specifically the course will provide a practical step-by-step approach to integration: specifications, conceptual design, analysis, modeling, synthesis, simulation and bread-boarding, prototyping, integration, verification, installation and testing. Issues of project management, market, and economics will be addressed as well. Limited Enrolment.

Prerequisite: MIE346H1
Total AUs: 57.60

MIE444H1 - * Mechatronics Principles

Credit Value: 0.50
Hours: 25.6L/38.4P

This course provides students with the tools to design, model, analyze and control mechatronic systems (e.g. smart systems comprising electronic, mechanical, fluid and thermal components). This is done through the synergic combination of tools from mechanical and electrical engineering, computer science and information technology to design systems with built-in intelligence. The class provides techniques for the modeling of various system components into a unified approach and tools for the simulation of the performance of these systems. The class also presents the procedures and an analysis of the various components needed to design and control a mechatronic system including sensing, actuating, and I/O interfacing components.

Prerequisite: MIE342H1, MIE346H1
Total AUs: 44.80

MIE448H1 - Engineering Psychology and Human Performance

Credit Value: 0.50
Hours: 38.4L/38.4P

An examination of the relation between behavioural science and the design of human-machine systems, with special attention to advanced control room design. Human limitations on perception, attention, memory and decision making, and the design of displays and intelligent machines to supplement them. The human operator in process control and the supervisory control of automated and robotic systems. Laboratory exercises to introduce techniques of evaluating human performance.

Prerequisite: MIE231H1/MIE236H1/STA286H1 or equivalent required; MIE237H1 or equivalent recommended
Total AUs: 57.60

MIE451H1 - Decision Support Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Provides students with an understanding of the role of a decision support system in an organization, its components, and the theories and techniques used to construct them. Focuses on information analysis to support organizational decision-making needs and covers topics including information retrieval, descriptive and predictive modeling using machine learning and data mining, recommendation systems, and effective visualization and communication of analytical results.

Prerequisite: MIE253H1, MIE350H1
Total AUs: 51.20

MIE457H1 - Knowledge Modelling and Management

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course explores both the modelling of knowledge and its management within and among organizations. Knowledge modelling will focus on knowledge types and their semantic representation. It will review emerging representations for knowledge on the World Wide Web (e.g., schemas, RDF). Knowledge management will explore the acquisition, indexing, distribution and evolution of knowledge within and among organizations. Emerging Knowledge Management System software will be used in the laboratory.

Prerequisite: MIE253H1, MIE350H1
Total AUs: 51.20

MIE459H1 - Organization Design

Credit Value: 0.50
Hours: 51.2L

Study of work systems design in new and existing organizations. Consideration will be given to sociotechnical systems design methodology, division of labour, change management, teams, incentives, project management, safety culture, automation, equity and union-management relations.

Prerequisite: APS111H1/APS112H1/ESC102H1, MIE258H1 or an equivalent engineering economics course
Total AUs: 51.20

MIE463H1 - Integrated System Design

Credit Value: 0.50
Hours: 38.4L/25.6T

Integrated System Design is a capstone course that integrates the various perspectives of an integrated system taught in third year, including: Optimization, Quality, Management, Information, and Economics. The course approaches systems design from a Business Process perspective. Beginning with the Business Processes, it explores the concept of Business Process Re-engineering. It extends the concept of business processes to incorporate perspectives such as cost, quality, time, behaviour, etc. The second part of the course focuses on business process design tools. Namely, software tools to both design, simulate and analyse business processes. The third part of the course explores the application of process design to various domains. Guest speakers are used to provide domain background.

Prerequisite: Fourth-year, Industrial Engineering standing
Total AUs: 51.20

MIE464H1 - * Smart Materials and Structures

Credit Value: 0.50
Hours: 38.4L/25.6P

Smart materials are characterized by new and unique properties that can be altered in response to environmental stimuli. They can be used in a wide range of applications since they can exceed the current abilities of traditional materials especially in environments where conditions are constantly changing. This course is designed to provide an integrated introduction to smart materials and structures, and provide a strong foundation for further studies and research on these materials. Topics include: structure, processing, and properties of smart materials; dependence of properties on structure; processing and design; mechanical, thermal, electrical, magnetic and optical smart materials systems such as shape memory materials, electrostrictive materials, magnetostrictive materials, active polymers; design, modeling and optimization of smart materials systems using CAD and FEA software packages.

Prerequisite: MSE101H1, MSE270H1/MSE235H1, MIE222H1/MSE316H1
Total AUs: 51.20

MIE465H1 - Analytics in Action

Credit Value: 0.50
Hours: 38.4L/25.6P

This course showcases the impact of analytics focusing on real world examples and case studies. Particular focus on decision analytics, where data and models are combined to ultimately improve decision-making. Methods include: linear and logistic regression, classification and regression trees, clustering, linear and integer optimization. Application areas include: healthcare, business, sports, manufacturing, finance, transportation, public sector.

Total AUs: 51.20

MIE468H1 - Facility Planning

Credit Value: 0.50
Hours: 38.4L/25.6T

Fundamentals of developing efficient layouts of production/ service systems and determining optimal locations of facilities in a network. Activity relationships, manufacturing flow patterns, layout procedure types (construction and improvement algorithms), manual and computerized layout techniques, single and multiple facility location, and supply chain (location) network-distribution design.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE262H1
Total AUs: 51.20

MIE469H1 - Reliability and Maintainability Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the life-cycle costing concept for equipment acquisition, operation, and replacement decision-making. Designing for reliability and determination of optimal maintenance and replacement policies for both capital equipment and components. Topics include: identification of an items failure distribution and reliability function, reliability of series, parallel, and redundant systems design configurations, time-to-repair and maintainability function, age and block replacement policies for components, the economic life model for capital equipment, provisioning of spare parts.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE258H1
Total AUs: 51.20

MIE490Y1 - Capstone Design

Credit Value: 1.00
Hours: 51.2T

An experience in engineering practice through a significant design project whereby student teams meet specific client needs through a creative, iterative, and open-ended design process. The project must include:
• The application of disciplinary knowledge and skills to conduct engineering analysis and design,
• The demonstration of engineering judgment in integrating economic, health, safety, environmental, social or other pertinent interdisciplinary factors,
• Elements of teamwork, project management and client interaction, and
• A demonstration of proof of the design concept.

Exclusion: APS490Y1
Total AUs: 102.92

MIE491Y1 - Capstone Design

Credit Value: 1.00
Hours: 51.2T

An experience in engineering practice through a significant design project whereby students teams meet specific client needs or the requirements of a recognized design competition through a creative, iterative, and open-ended design process. The project must include:

The application of disciplinary knowledge and skills to conduct engineering analysis and design, The demonstration of engineering judgement in integrating economic, health, safety, environmental, social or other pertinent interdisciplinary factors,

Elements of teamwork, project management and client interaction, and

A demonstration of proof of the design concept.

Exclusion: APS490Y1
Total AUs: 104.60

MIE498H1 - Research Thesis

Credit Value: 0.50
Hours: 51.2T

An opportunity to conduct independent research under the supervision of a faculty member in MIE. Admission to the course requires the approval of a project proposal by the Undergraduate office. The proposal must: 1) Explain how the research project builds upon one or more aspects of engineering science introduced in the student's academic program, 2) provide an estimate of a level of effort not less than 130 productive hours of work per term, 3) specify a deliverable in each term to be submitted by the last day of lectures, 4) be signed by the supervisor, and 5) be received by the Undergraduate Office one week prior to the last add day.

Note: Approval to register for the fourth-year thesis course must be obtained from the Associate Chair - Undergraduate and is normally restricted to students with an overall average of at least B in their second and third years.

Prerequisite: Approval to register for the fourth-year thesis course must be obtained from the Associate Chair – Undergraduate and is normally restricted to students with an overall average of at least B in their second and third years.
Exclusion: MIE498Y1
Total AUs: 51.46

MIE498Y1 - Research Thesis

Credit Value: 1.00
Hours: 51.2T

An opportunity to conduct independent research under the supervision of a faculty member in MIE. Admission to the course requires the approval of a project proposal by the Undergraduate office. The proposal must: 1) Explain how the research project builds upon one or more aspects of engineering science introduced in the student's academic program, 2) provide an estimate of a level of effort not less than 130 productive hours of work per term, 3) specify a deliverable in each term to be submitted by the last day of lectures, 4) be signed by the supervisor, and 5) be received by the Undergraduate Office one week prior to the last add day.

Note: Approval to register for the fourth-year thesis course must be obtained from the Associate Chair - Undergraduate and is normally restricted to students with an overall average of at least B in their second and third years.

Prerequisite: Approval to register for the fourth-year thesis course must be obtained from the Associate Chair – Undergraduate and is normally restricted to students with an overall average of at least B in their second and third years.
Exclusion: MIE498H1
Total AUs: 102.92

MIE504H1 - Applied Computational Fluid Dynamics

Credit Value: 0.50
Hours: 64L

The course is designed for Students with no or little Computational Fluid Dynamics (CFD) knowledge who want to learn CFD application to solve engineering problems. The course will provide a general perspective to the CFD and its application to fluid flow and heat transfer and it will teach the use of some of the popular CFD packages and provides them with the necessary tool to use CFD in specific applications. Students will also learn basics of CFD and will use that basic knowledge to learn Fluent Ansys CFD software. Most CFD packages have a variety of modules to deal with a specific type of flow. Students will be introduced to different modules and their specific applications. They will then be able to utilize the CFD package to simulate any particular problem. Ansys software will be the commercial package that will be used in this course. Ansys Fluent is the most common commercial CFD code available and most of the engineering companies use this code for their research & development and product analysis.

Prerequisite: MIE230H1, MAT234H1, MIE334H1
Total AUs: 64.00

MIE505H1 - Micro/Nano Robotics

Credit Value: 0.50
Hours: 38.4L/38.4P

This course will cover the design, modeling, fabrication, and control of miniature robot and micro/nano-manipulation systems for graduate and upper level undergraduate students. Micro and Nano robotics is an interdisciplinary field which draws on aspects of microfabrication, robotics, medicine and materials science.

In addition to basic background material, the course includes case studies of current micro/nano-systems, challenges and future trends, and potential applications. The course will focus on a team design project involving novel theoretical and/or experimental concepts for micro/nano-robotic systems with a team of students. Throughout the course, discussions and lab tours will be organized on selected topics.

Total AUs: 57.60

MIE506H1 - * MEMS Design and Microfabrication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course will present the fundamental basis of microelectromechanical systems (MEMS). Topics will include: micromachining/microfabrication techniques, micro sensing and actuation principles and design, MEMS modeling and simulation, and device characterization and packaging. Students will be required to complete a MEMS design term project, including design modeling, simulation, microfabrication process design, and photolithographic mask layout.

Prerequisite: MIE222H1, MIE342H1
Total AUs: 54.40

MIE507H1 - Heating, Ventilating, and Air Conditioning (HVAC) Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to the fundamentals of HVAC system operation and the relationship between these systems, building occupants and the building envelope. Fundamentals of psychrometrics, heat transfer and refrigeration; determination of heating and cooling loads driven by occupant requirements and the building envelope; heating and cooling equipment types and HVAC system configurations; controls and maintenance issues that influence performance; evaluation of various HVAC systems with respect to energy and indoor environmental quality performance.

Total AUs: 51.20

MIE510H1 - Finite Element Analysis in Engineering Design

Credit Value: 0.50
Hours: 25.6L/25.6P

This course will not be offered in the 2021-22 academic year.

Finite Element Method (FEM) is a very powerful numerical tool that has a wide range of applications in a multitude of engineering disciplines; such as mechanical, aerospace, automotive, locomotive, nuclear, geotechnical, bioengineering, metallurgical and chemical engineering. Typical applications include: design optimisation, steady and transient thermal analysis/stress analysis, wave propagation, natural frequencies, mode shapes, crashworthiness analysis, nuclear reactor containment, dynamic analysis of motors, manufacturing process simulation, failure analysis, to name a few.The focus of this course is to provide seniors and graduate students with a fundamental understanding of the principles upon which FEM is based, how to correctly apply it to real engineering problems using a commercial code. Specifically, participants will learn the principles governing model generation, discretization of a continuum, element selection, applying the loads and the constraints to real world problems. Participants will also learn how to scrutinize their model predictions, and avoid the pitfalls of this essential design tool.

Total AUs: 44.80

MIE515H1 - Alternative Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers the basic principles, current technologies and applications of selected alternative energy systems. Specific topics include solar thermal systems, solar photovoltaic systems, wind, wave, and tidal energy, energy storage, and grid connections issues. Limited enrolment.

Prerequisite: MIE210H1,MIE312H1 and MIE313H1 (or equivalent courses).
Total AUs: 44.80

MIE516H1 - Combustion and Fuels

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to combustion theory. Chemical equilibrium and the products of combustion. Combustion kinetics and types of combustion. Pollutant formation. Design of combustion systems for gaseous, liquid and solid fuels. The use of alternative fuels (hydrogen, biofuels, etc.) and their effect on combustion systems.

Total AUs: 44.80

MIE517H1 - Fuel Cell Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation, including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

Total AUs: 44.80

MIE519H1 - * Advanced Manufacturing Technologies

Credit Value: 0.50
Hours: 38.4L

This course is designed to provide an integrated multidisciplinary approach to Advanced Manufacturing Engineering, and provide a strong foundation including fundamentals and applications of advanced manufacturing AM. Topics include: additive manufacturing, 3D printing, micro and nanomanufacturing, intelligent manufacturing, Advanced Materials, lean manufacturing, AM in machine design and product development, process control technologies. New applications of AM in sectors such as automotive, aerospace, biomedical, electronic, food processing.

Total AUs: 38.40

MIE520H1 - Biotransport Phenomena

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of conservation relations and momentum balances, dimensional analysis and scaling, mass transfer, heat transfer, and fluid flow to biological systems, including: transport in the circulation, transport in porous media and tissues, transvascular transport, transport of gases between blood and tissues, and transport in organs and organisms.

Prerequisite: MIE312H1 /AER210H1 /equivalent
Total AUs: 44.80

MIE523H1 - Engineering Psychology and Human Performance

Credit Value: 0.50
Hours: 38.4L/38.4P

An examination of the relation between behavioural science and the design of human-machine systems, with special attention to advanced control room design. Human limitations on perception, attention, memory and decision making, and the design of displays and intelligent machines to supplement them. The human operator in process control and the supervisory control of automated and robotic systems. Laboratory exercises to introduce techniques of evaluating human performance.

Prerequisite: MIE231H1/MIE236H1/ECE286H1 or equivalent required; MIE237H1 or equivalent recommended
Total AUs: 57.60

MIE540H1 - * Product Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course takes a 360° perspective on product design: beginning at the market need, evolving this need into a concept, and optimizing the concept. Students will gain an understanding of the steps involved and the tools utilized in developing new products. The course will integrate both business and engineering concepts seamlessly through examples, case studies and a final project. Some of the business concepts covered include: identifying customer needs, project management and the economics of product design. The engineering design tools include: developing product specifications, concept generation, concept selection, Product Functional Decomposition diagrams, orthogonal arrays, full and fractional factorials, noises, interactions, tolerance analysis and latitude studies. Specific emphasis will be placed on robust and tunable technology for product optimization.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE243H1 or instructor's permission
Total AUs: 44.80

MIE542H1 - Human Factors Integration

Credit Value: 0.50
Hours: 38.4L/25.6T

The integration of human factors into engineering projects. Human factors integration (HFI) process and systems constraints, HFI tools, and HFI best practices. Modelling, economics, and communication of HFI problems. Examples of HFI drawn from energy, healthcare, military, and software systems. Application of HFI theory and methods to a capstone design project, including HFI problem specification, concept generation, and selection through an iterative and open-ended design process.

Prerequisite: MIE240H1/MIE1411H1 or equivalent or permission from the instructor.
Total AUs: 51.20

MIE550H1 - Advanced Momentum, Heat and Mass Transfer

Credit Value: 0.50
Hours: 38.4L

This course observes: conservation of mass, momentum, energy and species; diffusive momentum, heat and mass transfer; dimensionless equations and numbers; laminar boundary layers; drag, heat transfer and mass transfer coefficients; transport analogies; simultaneous heat and mass transfer; as well as evaporative cooling, droplet evaporation and diffusion flames.

Prerequisite: MIE313H1
Total AUs: 38.40

MIE561H1 - Healthcare Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

MIE 561 is a "cap-stone" course. Its purpose is to give students an opportunity to integrate the Industrial Engineering tools learned in previous courses by applying them to real world problems. While the specific focus of the case studies used to illustrate the application of Industrial Engineering will be the Canadian health care system, the approach to problem solving adopted in this course will be applicable to any setting. This course will provide a framework for identifying and resolving problems in a complex, unstructured decision-making environment. It will give students the opportunity to apply a problem identification framework through real world case studies. The case studies will involve people from the health care industry bringing current practical problems to the class. Students work in small groups preparing a feasibility study discussing potential approaches. Although the course is directed at Industrial Engineering fourth year and graduate students, it does not assume specific previous knowledge, and the course is open to students in other disciplines.

Total AUs: 51.20

MIE562H1 - Scheduling

Credit Value: 0.50
Hours: 38.4L/25.6T

This course takes a practical approach to scheduling problems and solution techniques, motivating the different mathematical definitions of scheduling with real world scheduling systems and problems. Topics covered include: job shop scheduling, timetabling, project scheduling, and the variety of solution approaches including constraint programming, local search, heuristics, and dispatch rules. Also covered will be information engineering aspects of building scheduling systems for real world problems.

Prerequisite: MIE262H1
Total AUs: 51.20

MIE563H1 - Engineering Analysis II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course explores exact solution techniques for common engineering Partial Differential Equations (PDEs), such as separation of variables, superposition, eigenfunctions, orthogonal functions, complex functions. Other topics include: derivation of common engineering PDEs, introduction to methods of weighted residuals for deriving finite element formulations and limitations of exact solutions relative to approximate solutions.

Prerequisite: MIE230H1, MAT234H1, MIE334H1
Total AUs: 51.20

MIE566H1 - Decision Making Under Uncertainty

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

The purpose of this course is to provide a working knowledge of methods of analysis of problem and of decision making in the face of uncertainty. Topics include decision trees, subjective probability assessment, multi-attribute utility approaches, goal programming, Analytic Hierarchy Process and the psychology of decision making.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 64.00

MIE567H1 - Dynamic & Distributed Decision Making

Credit Value: 0.50
Hours: 38.4L/25.6T

Fundamental concepts and mathematical frameworks for scientific sequential decision making in the presence of uncertainty. Utility theory, uncertainty modeling, theory of games, dynamic programming, and multi-agent system. Discussion of how the decision theories can be applied to design algorithms and processes for real-world cases.

Total AUs: 51.20

Materials Science and Engineering

MSE270H1 - Materials Science

Credit Value: 0.50
Hours: 38.4L/19.2T/9.6P

Electrical, thermal, magnetic, optical properties of materials; Corrosion and degradation of materials; Phase transformation and strengthening mechanisms; Failure analysis and testing; Fatigue, creep, impact; Composite materials, special purpose materials.

Prerequisite: MSE101H1
Total AUs: 52.80

MSE401H1 - Materials Information in Design

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

This course presents approaches to composite and structural design, and optimization, for components and products. Tools for optimization, material property data analytics, and structural simulation will be used. We will apply advanced materials selection (and the CES materials database) to product and component design, and hybrid (composite) materials design. Composite mechanics theory and topology optimization will be developed for structural optimization. Finally, modern techniques including AI and machine learning will be presented for aspects of materials selection, composite design and structural optimization. Component design decisions will include both material properties and the capabilities of applicable fabrication processes, to identify the material and process which best satisfy the design requirements.

Total AUs: 44.80

MSE443H1 - Composite Materials Engineering

Credit Value: 0.50
Hours: 38.4L

This course is designed to provide an integrated approach to composite materials design, and provide a strong foundation for further studies and research on these materials. Topics include: structure, processing, and properties of composite materials; design of fillers reinforcements and matrices reinforcements, reinforcement forms, nanocomposites systems, manufacturing processes, testing and properties, micro and macromechanics modeling of composite systems; and new applications of composites in various sectors.

Exclusion: CHE461H1 and MSE330H1
Total AUs: 38.40

Mineral Engineering

Lassonde Mineral Engineering Program (AELMEBASC)

Academic Advisor
Shayni Curtis-Clarke
Room GB116, Galbraith Building
416-978-5905
shayni@ecf.utoronto.ca

The first year of the four-year curriculum is similar to that of other engineering programs at the University. All subsequent years are unique to the Lassonde Mineral Engineering Program, with transfer into year two of Mineral Engineering being permitted from both the General Engineering (TrackOne) first year and other engineering programs. Year two curriculum concentrates on minerals engineering fundamentals, and years three and four comprise a minerals engineering core supplemented by technical electives. A wide range of technical electives are available, thereby allowing students to specialise should they so wish in one particular branch of minerals engineering. Students also study humanities and complementary studies electives in the final two years.

Practical aspects of the program are presented through laboratory sessions and students attend one survey and one geology field camp, each of which is two weeks in duration. Students are encouraged to obtain industrial experience during the summer breaks. They also have the opportunity to participate in the Professional Experience Year Co-op Program between years three and four.

Attractive entrance and in-course scholarships and bursaries are available, including the prestigious, competitively awarded Lassonde Scholarships.Mineral engineering encompasses those activities necessary to extract and process natural mineral resources. The Lassonde Mineral Engineering Program is comprehensive, covering topics from the entire scope of minerals engineering: from geology and mineral exploration, through analysis and design of surface and underground excavations, mechanical and explosive excavation of geological materials, planning and management of mines and quarries, processing of metallic, non-metallic and industrial minerals, safety and environmental protection and on to financial aspects of minerals operations. This wide range of topics means that the program is truly interdisciplinary, using concepts and techniques from mathematics, physics, chemistry, geology and economics; in the setting of the University of Toronto it is thus both interdepartmental and interfaculty, with the Departments of Civil Engineering, Geology and Materials Science and Engineering contributing to the program. As Toronto is a world centre for mining and mining finance, the program is able to maintain close links with the minerals industry and thus invites recognised experts from various branches of the industry to deliver state-of-the-art treatment of specialised topics within the curriculum.

Graduates obtain a comprehensive training in minerals engineering and are well prepared for future challenges in the planning and financing of mineral and related engineering projects as well as for graduate study in mining, geological, or civil engineering. The program is accredited with the Canadian Engineering Accreditation Board.

Personal Protective Equipment

There will be many occasions when students are required to use Personal Protective Equipment (PPE), including safety footwear bearing the CSA Green Patch, hard hats, protective eyewear with side shields, tear away safety vests and ear protection. Students are required to purchase their own PPE. All field trips, laboratories and other events require advance briefing on the nature of potential hazards and students are required to attend these briefings and to follow the provided instructions.

Practical Experience Requirement (PER)

Students are required to have completed a total of 600 hours of acceptable practical experience before graduation (normally during their summer vacation periods). Satisfactory completion of **CME358H1:** Survey Camp (Civil & Mineral Practicals) and **MIN400H1:** Geology Camp will contribute 200 hours towards this requirement. Satisfactory completion of PEY Co-op will also completely fulfil the Practical Experience Requirement.

Professional Experience Year Co-op Program (PEY Co-op)

Students registered within this program and all other undergraduate programs within the Faculty of Applied Science & Engineering, may elect to enrol and participate in PEY Co-op. The program requires that qualified students undertake a paid, full-time 12-16 month continuous work period with a cooperating company. Detailed information is available through the Engineering Career Centre.

Summer Field Camp

An August Field Camp must be completed by all Lassonde Mineral Engineering students in the summer before fourth year. Results of the course are used to compute the fourth-year Fall Term average. An extra fee is charged to cover part of the cost of transportation, food and accommodation.

Minors & Certificate Programs

A number of engineering minors and certificate programs are available and generally require the student to successfully complete a carefully selected slate of electives in their fourth year. Late in the Winter Term of third year, students use an online pre-registration tool to indicate their preferred fourth-year electives. Students should review the various minor and certificate program requirements and attend the Department's information sessions during third year to ensure that the appropriate electives are taken in fourth year. Students should note that they can also complete the requirements of a minor or certificate program even after they have graduated, as long as the additional requirements are met within nine years of their initial registration in the BASc program. If completed after graduation, additional fees will be assessed and a transcript will be issued with the amended courses and indication of completed minor or certificate program requirements.

Jeffrey Skoll BASc / MBA Program

The Jeffrey Skoll Combined BASc / MBA Program allows qualified and selected students in the Faculty of Applied Science & Engineering to complete both a BASc and an MBA in a reduced time. Students will be admitted to the program prior to entering their fourth year of studies in the BASc program. Interested students should contact the Rotman School of Management.

Graduate Training in Mineral Engineering

Students with the necessary qualifications (generally, at least a B+ average in the final year of the undergraduate program) who wish to proceed to graduate studies may do so through the Lassonde Institute, an interdisciplinary research institute for engineering geoscience. The Department of Civil Engineering, Department of Mechanical Engineering, Department of Materials Science & Engineering, Department of Geology and Collaborative Program in Geophysics are all collaborators in the Lassonde Institute.

U of T Engineering offers programs that lead to MASc, MEng and PhD degrees. Other departments offer MSc and PhD degree programs. Additional information may be found at www.lassondeinstitute.utoronto.ca or on the websites of the collaborating departments.

LASSONDE MINERAL ENGINEERING PROGRAM (AELMEBASC)

FIRST YEAR MINERAL ENGINEERING

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
APS100H1: Orientation to Engineering	F	1	-	1	0.25
APS110H1: Engineering Chemistry and Materials Science	F	3	1	1	0.50
APS111H1: Engineering Strategies & Practice I	F	3	-	2	0.50
CIV100H1: Mechanics	F	3	-	2	0.50

Fall Session – Year 1		Lect.	Lab.	Tut.	Wgt.
MAT186H1: Calculus I	F	3	-	1	0.50
MAT188H1: Linear Algebra	F	3	1	1	0.50
Winter Session – Year 1		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS106H1: Fundamentals of Computer Programming	S	3	2	1	0.50
APS112H1: Engineering Strategies & Practice II	S	2	2	-	0.50
CHE112H1: Physical Chemistry	S	3	1	1	0.50
MIN120H1: Insight into Mineral Engineering	S	3	2	1	0.50
MAT187H1: Calculus II	S	3	-	1	0.50
MIN120H1: Insight into Mineral Engineering	S				
MIN191H1: Introduction to Mineral Engineering	S	1	-	-	0.15

Approved Course Substitutions

1. Students are able to substitute MAT186H1 with the online calculus course APS162H1.
2. Students are able to substitute MAT187H1 with the online calculus course APS163H1.
3. Students are able to substitute APS110H1 with the online course APS164H1.
4. Students are able to substitute CIV100H1 with the online course APS160H1.

SECOND YEAR MINERAL ENGINEERING

Fall Session – Year 2		Lect.	Lab.	Tut.	Wgt.
CME210H1: Solid Mechanics I	F	3	1.50	1.50	0.50
CME261H1: Engineering Mathematics I	F	3	1	1	0.50
CME270H1: Fluid Mechanics I	F	3	1.50	1	0.50
ESS262H1: Earth Systems Processes	F	2	3	-	0.50
MSE202H1: Thermodynamics I	F	3	-	2	0.50
Winter Session – Year 2		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
CME259H1: Technology in Society and the Biosphere I	S	3	-	1	0.50
CME262H1: Engineering Mathematics II	S	3	-	2	0.50
CME263H1: Probability Theory for Civil and Mineral Engineers	S	3	-	2	0.50
ESS224H1: Introduction to Mineralogy and Petrology	S	2	3	-	0.50
MIN250H1: Surface Mining	S	3	-	1	0.50
CS/HSS Elective	S				0.50

* In order to graduate, students must obtain credits in the equivalent of at least four half-year Complementary Studies/Humanities and Social Sciences (CS/HSS) Electives. Of these Electives, the equivalent of at least two half-year credits must be Humanities and Social Sciences. Refer to the Faculty of Engineering's Registrar's Office website for a list of pre-approved CS/HSS Electives.

THIRD YEAR MINERAL ENGINEERING

Fall Session – Year 3		Lect.	Lab.	Tut.	Wgt.
CME321H1: Geotechnical Engineering I	F	3	1	1	0.50
CME358H1: Survey CAMP (Civil and Mineral Practicals)	F	-	-	-	0.50
CME368H1: Engineering Economics and Decision Making	F	3	-	1	0.50
ESS241H1	F	2	3	-	0.50
MIN329H1: Engineering Rock Mechanics	F	3	1	1	0.50
MSE202H1: Thermodynamics I	F	3	-	2	0.50
Winter Session – Year 3		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MIN301H1: Mineral Reserve and Mineral Resource Estimation	S	3	-	1	0.50

Winter Session – Year 3		Lect.	Lab.	Tut.	Wgt.
MIN320H1: Explosives and Fragmentation in Mining	S	3	-	1	0.50
MIN351H1: Underground Mining	S	3	-	1	0.50
MIN330H1: Mining Environmental Management	S	3	-	1	0.50
MSE301H1: Mineral Processing	S	3	1.50	1	0.50
CS/HSS Elective	S				0.50

* CME358H1 – Survey CAMP (Civil and Mineral Practicals) is a two-week field-based course taken in the month prior to starting Third Year. The results of this course are used in computing the student's Third Year Fall Session Average. An extra fee is charged to cover part of the costs of food and accommodation.

*In order to graduate, students must obtain credits in the equivalent of at least four half-year Complementary Studies/Humanities and Social Sciences (CS/HSS) Electives. Of these Electives, the equivalent of at least two half-year credits must be Humanities and Social Sciences. Refer to the Registrar's Office website for a list of pre-approved CS/HSS Electives.

Note: Technical Electives outside of the group of courses listed below must be approved in advance. Students wishing to take elective courses from other departments need to ensure that they have the appropriate background and prerequisites. Students with an overall average of 75% or greater in their third year may take up to two graduate level (1000-series) courses, depending upon availability. In all cases the interested student should consult with the Department's Office of Student Services (GB116) to obtain further information and the appropriate permission.

FOURTH YEAR MINERAL ENGINEERING

Fall Session – Year 4		Lect.	Lab.	Tut.	Wgt.
MIN466H1: Mineral Project Design I	F	2	2	1	0.50
MIN450H1: Mineral Economics	F	3	-	1	0.50
MIN565H1: Design and Support of Underground Mine Excavations	F	3	-	1	0.50
CS/HSS Elective	F				0.50
Field Camp					
MIN400H1: Geology Field Camp for Engineers	F	-	-	-	0.50
Choose two of the following Technical Electives:					
CHE565H1: Aqueous Process Engineering	F	3	-	1	0.50
CIV420H1: Construction Engineering	F	3	-	2	
CIV549H1: Groundwater Flow and Contamination	F	3	-	1	0.50
CME525H1: Tunneling and Urban Excavation	F	3	-	1	0.50
ESS452H1: Geophysical Imaging with Non-seismic Methods	F	2	-	-	0.50
JGA305H1: Environmental and Archaeological Geophysics	F	2	1	-	0.50
MIN511H1: Integrated Mine Waste Engineering	F	3	-	1	0.50
CME499H1: Individual Project	F	-	-	3	0.50
CME499Y1: Individual Project	Y	-	-	3	1.00
Winter Session – Year 4		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
MIN467H1: Mineral Project Design II	S	1	4	1	0.50
MIN470H1: Ventilation and Occupational Health	S	3	-	1	0.50
CS/HSS Elective	S				0.50
CS/HSS Elective	S				0.50
Choose one of the following Technical Electives:					
APS502H1: Financial Engineering	S	3	-	-	0.50

Winter Session – Year 4		Lect.	Lab.	Tut.	Wgt.
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
CIV324H1: Geotechnical Engineering II	S	3	1	1	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
CIV523H1: Geotechnical Design	S	3	-	1	0.50
CIV580H1: Engineering and Management of Large Projects	S	3	-	-	0.50
CME499H1: Individual Project	S	-	-	3	0.50
CME499Y1: Individual Project	Y	-	-	3	1.00
CME500H1: Fundamentals of Acid Rock Drainage	S	3	2	1	0.50
ESS331H1: Sedimentation and Stratigraphy	S	2	3	-	0.50
ESS423H1: Mineral Deposits	S	2	3	-	0.50

* MIN400H1 – Geology Camp is taken in the week prior to fall term of fourth year. The results of this are used in computing the student's fourth year fall session average. An extra fee is charged to cover cost of room, board and travel.

*Students must choose 3 half credits of Technical Elective from the lists provided below each term. 2 credits are taken in the fall semester, 1 credit is taken in the winter semester.

*In order to graduate, students must obtain credits in the equivalent of at least four half-year Complementary Studies/Humanities and Social Sciences (CS/HSS) Electives. Of these Electives, the equivalent of at least two half-year credits must be Humanities and Social Sciences. Refer to the Faculty of Engineering's Registrar's Office website for a list of pre-approved CS/HSS Electives".

Mineral Engineering Courses

Applied Science and Engineering (Interdepartmental)

APS100H1 - Orientation to Engineering

Credit Value: 0.25
Hours: 12.8L/12.8T

This course is designed to help students transition into first-year engineering studies and to develop and apply a greater understanding of the academic learning environment, the field of engineering, and how the fundamental mathematics and sciences are used in an engineering context. Topics covered include: study skills, time management, problem solving, successful teamwork, effective communications, exam preparation, stress management and wellness, undergraduate research, extra- and co-curricular involvement, engineering disciplines and career opportunities, and applications of math and science in engineering.

Total AUs: 19.20

APS106H1 - Fundamentals of Computer Programming

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the Python programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

Total AUs: 57.60

APS110H1 - Engineering Chemistry and Materials Science

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course is structured around the principle of the structure-property relationship. This relationship refers to an understanding of the microstructure of a solid, that is, the nature of the bonds between atoms and the spatial arrangement of atoms, which permits the explanation of observed behaviour. Observed materials behaviour includes mechanical, electrical, magnetic, optical, and corrosive behaviour. Topics covered in this course include: structure of the atom, models of the atom, electronic configuration, the electromagnetic spectrum, band theory, atomic bonding, optical transparency of solids, magnetic properties, molecular bonding, hybridized orbitals, crystal systems, lattices and structures, crystallographic notation, imperfections in solids, reaction rates, activation energy, solid-state diffusion, materials thermodynamics, free energy, and phase equilibrium.

Total AUs: 51.20

APS111H1 - Engineering Strategies & Practice I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports.

Total AUs: 51.20

APS112H1 - Engineering Strategies & Practice II

Credit Value: 0.50
Hours: 25.6L/25.6P

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

Total AUs: 38.40

APS502H1 - Financial Engineering

Credit Value: 0.50
Hours: 38.4L

This course will focus on capital budgeting, financial optimization, and project evaluation models and their solution techniques. In particular, linear, non-linear, and integer programming models and their solutions techniques will be studied. The course will give engineering students a background in modern capital budgeting and financial techniques that are relevant in practival engineering and commercial settings.

Prerequisite: MAT186H1, MAT187H1, MAT188H1, MIE236H1, MIE237H1, or equivalent.
Exclusion: MIE375H1
Total AUs: 19.20

Chemical Engineering and Applied Chemistry

CHE112H1 - Physical Chemistry

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

A course in physical chemistry. Topics discussed include systems and their states, stoichiometry, the properties of gases, the laws of chemical thermodynamics (calculations involving internal energy, enthalpy, free energy, and entropy), phase equilibrium, chemical equilibrium, ionic equilibrium, acids and bases, solutions, colligative properties, electrochemistry, and corrosion.

Total AUs: 51.20

CHE565H1 - Aqueous Process Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2) treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

Total AUs: 44.80

Civil Engineering

CIV100H1 - Mechanics

Credit Value: 0.50
Hours: 38.4L/25.6T

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

Exclusion: APS160H1
Total AUs: 51.20

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

CIV324H1 - Geotechnical Engineering II

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Building on CME321, more complex aspects of geotechnical analysis and design are considered. Topics include: mineralogy; soil identification and classification; laboratory- and field-based soil index tests; correlations of index test results to engineering properties; vertical stress distribution; soil-foundation interaction; volume change and consolidation of clay and settlement. Shear strength of soil and slope stability analysis are also discussed. Laboratories are held for soil identification and classification, and confined triaxial compression tests of clay and sand.

Prerequisite: CME321H1
Total AUs: 51.20

CIV420H1 - Construction Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

This course considers the engineering aspects of construction including earthmoving, equipment productivity, fleet balancing, formwork design, shoring, hoisting, aggregate production, equipment operating costs, and modular construction. Several construction projects will be reviewed to demonstrate methods and processes. Students will be expected to visit construction sites, so safety boots and hard hats are required.

Total AUs: 51.20

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

CIV523H1 - Geotechnical Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is built around a transportation project that contains all the essential geotechnical investigation and design elements and illustrates how they all come together on a project. The students will be taken through the entire design process from project initiation to construction. In essence, the project will include a bridge over a river with some property constraints requiring the use of a retaining wall as well as deep and shallow foundations and some groundwater control. The highway will require a soil cut. One section crosses a low-lying swampy area that will require embankment construction over deep soft soils. A short tunnel section is planned beneath a railway that cannot be taken out of service. A pavement design will be required along the entire route as well as materials testing and construction monitoring.

Prerequisite: CME321H1; equivalent or permission of instructor
Total AUs: 44.80

CIV549H1 - Groundwater Flow and Contamination

Credit Value: 0.50
Hours: 38.4L/12.8T

Mechanics of saturated and unsaturated fluid flow in porous media. Confined and unconfined flow. Flow to wells. Analytical and numerical solutions of groundwater flow equations. Non-reactive and reactive contaminant transport on groundwater systems. Analytical and numerical solutions of contaminant transport equations. Flow and solute transport in fractured porous media. Assessment of environmental impacts of waste disposal operations. Remediation of contaminated groundwater.

Prerequisite: CME270H1, CIV250H1 or equivalent
Total AUs: 44.80

CIV580H1 - Engineering and Management of Large Projects

Credit Value: 0.50
Hours: 38.4L

This technical elective course will investigate the role of stakeholders in major civil engineering projects; the complexities of managing project stages, multiple stakeholders, and technical challenges, and, social and environmental factors.

Each week includes a different speaker who can address issues related to technical, social, and environmental challenges in the project and how they were overcome.

Total AUs: 38.40

Civil and Mineral Engineering

CME210H1 - Solid Mechanics I

Credit Value: 0.50
Hours: 38.4L/19.2T/19.2P

An introduction to the mechanics of deformable bodies. General biaxial and triaxial stress conditions in continua are studied, as are elastic stress, strain and deformation relations for members subjected to axial load, bending and shear. Properties of plane sections, moment-area theorems for calculating deflection, and Mohr's circle representation of stress and of moment of inertia are examined, followed by a look at stability.

Prerequisite: CIV100H1, MAT186H1, MAT187H1
Exclusion: CIV210H1
Total AUs: 57.60

CME259H1 - Technology in Society and the Biosphere I

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science Elective
This course teaches future engineers to look beyond their specialized domains of expertise in order to understand how technology functions within human life, society and the biosphere. By providing this context for design and decision-making, students will be enabled to do more than achieve the desired results by also preventing or significantly reducing undesired consequences. A more preventively-oriented mode of practicing engineering will be developed in four areas of application: materials and production, energy, work and cities. The emphasis within these topics will reflect the interests of the class.

Exclusion: ESC203H1
Total AUs: 44.80

CME261H1 - Engineering Mathematics I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course deals with both numerical methods for engineering analysis (solution of linear and non-linear equations, interpolation, numerical integration) and advanced topics in analytical calculus (multiple integrals and vector analysis). Within the numerical methods portion of the course emphasis is placed on problem formulation, solution algorithm design and programming applications. Within the analytical calculus portion emphasis is placed on the mathematical foundations of engineering practice and the interrelationship between analytical and numerical solution methods.

Prerequisite: MAT188H1, MAT187H1
Total AUs: 51.20

CME262H1 - Engineering Mathematics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course continues the study of numerical and analytical methods for civil engineering analysis. Analytical and numerical methods for solving ordinary differential equations are treated in some detail, followed by numerical solution methods for partial differential equations. The final major topic of the course deals with an introduction to optimization. Emphasis is placed throughout the course on problem formulation, solution algorithm design and programming applications.

Prerequisite: CME261H1
Exclusion: CME362H1
Total AUs: 51.20

CME263H1 - Probability Theory for Civil and Mineral Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

Probability theory as the study of random phenomena in Civil and Mineral Engineering systems, including the definition of probability, conditional probability, Bayes' theorem in discrete and continuous sample spaces. Common single and multivariate distributions. Mathematical expectation including mean and variance. Independence. An introduction to realizations of probability models and parameter estimation.

Total AUs: 51.20

CME270H1 - Fluid Mechanics I

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Fluid and flow characteristics, applications, dimensions and units. Fluid statics. One-dimensional flow including conservation of mass, energy and momentum. Introduction to dimensional analysis and similitude, laminar and turbulent flow, boundary layer concept, and flow about immersed objects. Calculation of flow in closed conduits and open channels.

Total AUs: 54.40

CME321H1 - Geotechnical Engineering I

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

An introduction to elements of geotechnical analysis and design. Basic site investigation techniques and quantitative descriptions of soil properties and behaviour. Permeability, seepage analysis, and internal stability of granular soil; granular filter design for internal hydraulic stability. Compaction of granular soil; engineered fills for earth dams, road bases, and backfills. Soil shear strength at constant volume; ultimate limit state design of retaining walls, shallow footings, natural slopes and constructed embankments. Groundwater flow analysis and slope stability analysis using commercial software. Physical laboratories for basic soil identification, model groundwater flow analysis, direct shear strength tests, and reinforced earth models.

Prerequisite: CME270H1, CME210H1
Total AUs: 51.20

CME358H1 - Survey CAMP (Civil and Mineral Practicals)

Credit Value: 0.50
Hours: 12.8T

This two-week August field camp provides students with the opportunity to further their understanding of the vital interactions between the natural and the built environments. Through fieldwork, students gain hands-on experience in the use of various field instruments used by Civil and Mineral Engineers. The essentials of land surveying and the use of surveying instruments including Global Positioning Systems are taught as students carry out a series of field exercises that include route surveys, topographic surveys and construction surveys. Survey calculations, sources of error, corrections and adjustments are also introduced. In order to better understand our impact on the natural environment, students also perform several additional exercises. These may include the measurement of river flows, remote sensing of soil and rock, remediation of a borrow pit, and the evaluation of the renewable energy potential of the wind and solar radiation. Note: This course requires payment of an extra fee for room and board.

Total AUs: 5.28

CME368H1 - Engineering Economics and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

The incorporation of economic and non-monetary considerations for making decision about public and private sector engineering systems in urban and other contexts. Topics include rational decision making; cost concepts; time value of money and engineering economics; microeconomic concepts; treatment of risk and uncertainty; and public project evaluation techniques incorporating social and environmental impacts including benefit cost analysis and multi-objective analysis.

Total AUs: 44.80

CME499H1 - Individual Project

Credit Value: 0.50
Hours: 38.4T

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project and MIN466 Mineral Project Design experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken only once, either in the Fall (F) or Winter (S) Session (0.5 weight), or as a full year (Y) course (1.0 weight).

Total AUs: 19.20

CME499Y1 - Individual Project

Credit Value: 1.00
Hours: 38.4T

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken in either the Fall (F) or Winter (S) Session, but not both (i.e., the Individual Project carries a maximum weight of 0.5; it cannot be made into a full year course)

Total AUs: 19.20

CME500H1 - Fundamentals of Acid Rock Drainage

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Geochemistry of acid rock / acid mine drainage (ARD/AMD) which covers the role of bacteria in generating this global mining pollution issue and how mines currently treat and attempt to prevent it. An introduction to the underlying chemical reactions involved, the role of microbes in these processes and the mitigation and treatment strategies currently available.

* Course offering pending Faculty Council approval for 2018-19 academic year.

Prerequisite: APS110H1/CHE112H1 or equivalent
Total AUs: 57.60

CME525H1 - Tunneling and Urban Excavation

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces fundamental concepts of underground tunneling and its impact on surrounding urban environment. Topics: role of geology on the choice of tunneling methodology; classical and mechanized tunneling excavation methods; interaction between tunnel and surrounding structures; tunnel support methodologies; innovation and current research in tunneling and underground construction.

Total AUs: 44.80

Mathematics

MAT186H1 - Calculus I

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: limits and continuity; differentiation; applications of the derivative - related rates problems, curve sketching, optimization problems, L'Hopital's rule; definite and indefinite integrals; the Fundamental Theorem of Calculus; applications of integration in geometry, mechanics and other engineering problems.

Exclusion: APS162H1
Total AUs: 44.80

MAT187H1 - Calculus II

Credit Value: 0.50
Hours: 38.4L/12.8T

Topics include: techniques of integration, an introduction to mathematical modeling with differential equations, infinite sequences and series, Taylor series, parametric and polar curves, vector-valued functions, partial differentiation, and application to mechanics and other engineering problems.

Prerequisite: APS162H1/MAT186H1
Exclusion: APS163H1/MAT197H1
Total AUs: 44.80

MAT188H1 - Linear Algebra

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course covers systems of linear equations and Gaussian elimination, applications; vectors in Rn, independent sets and spanning sets; linear transformations, matrices, inverses; subspaces in Rn, basis and dimension; determinants; eigenvalues and diagonalization; systems of differential equations; dot products and orthogonal sets in Rn; projections and the Gram-Schmidt process; diagonalizing symmetric matrices; least squares approximation. Includes an introduction to numeric computation in a weekly laboratory.

Total AUs: 51.20

Mineral Engineering

MIN120H1 - Insight into Mineral Engineering

Hours: 38.4L/12.8T/25.6P

A comprehensive introduction into the global minerals industry using international regulatory requirements as a thematic structure. Engineering applications together with current and emerging issues are emphasized throughout. Principal topics include: mineral resources in the economy; land and mineral ownership; legal and environmental issues; mineral exploration; surface and sub-surface mine development and management; fundamentals of mineral processing; mineral industry finance. Graphics communication skills are developed in the associated laboratory sessions, and a visit to an operating mine is used to place the course material in context.

Total AUs: 57.60

MIN191H1 - Introduction to Mineral Engineering

Credit Value: 0.15
Hours: 12.8L

This is a seminar series that will introduce students to the community, upper-year experience, and core fields of Mineral Engineering. Seminar presenters will represent the major areas in Mineral Engineering and will also be drawn from an array of groups, including students, staff, faculty, and alumni. The format will vary and may include application examples, case studies, career opportunities, and research talks. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Department to enable them to make educated choices as they progress through the program. This course will be offered on a credit/no credit basis.

Total AUs: 12.80

MIN250H1 - Surface Mining

Credit Value: 0.50
Hours: 38.4L/12.8T

Operational aspects of open pit mine design and mine planning. Topics will include: open pit design and pit optimization; long term and short term planning considerations; materials handling; equipment selection and optimization; industrial minerals production; mine safety and mine regulations; mining and the environment; mine personnel organization; ethics and professional issues. Pit dewatering, the location and stability of waste dumps and an examination of equipment cost and production statistics are also included.

Total AUs: 44.80

MIN301H1 - Mineral Reserve and Mineral Resource Estimation

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to Mineral Resource and Mineral Reserve Estimation is an advanced level course that focuses on the stages of a mineral resource and mineral reserve estimation program from assembling the database through to reporting under industry guidelines. Major course topics include: statistical analysis of sampling data, geologic interpretation and deposit models; mineral resources estimation approaches and methods, mineral reserve estimation, classification of resources and reserves, and reporting under regulatory standards and industry guidelines for professional practice.

Total AUs: 44.80

MIN320H1 - Explosives and Fragmentation in Mining

Credit Value: 0.50
Hours: 38.4L/12.8T

Efficient drilling and blasting is important to successful mining in rock formations. This course studies the planning, design, and economics of rock blasting for a full range of surface and underground, mining and construction projects. Emphasis will be on optimization of fragmentation using blast geometry and those variables available to the field engineer. This course covers the selection of modern industrial explosives, their history, physical properties, and safe handling, including an introduction to the theory of detonation, and rock response. Safety procedures in storage and transportation will be studied along with the monitoring and control of blast side effects. A field trip is associated with this course.

Total AUs: 44.80

MIN329H1 - Engineering Rock Mechanics

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course introduces students to the fundamental concepts of rock mechanics and their application to rock engineering. The following rock mechanics topics are covered: stress and strain; in situ stress; intact rock strength; discontinuity geometry, strength and stiffness; rock mass behavious; anisotropy, heterogeneity and the size effect; rock mass classifcation schemes. Rock engineering topics include: rock excavation; rock stabilisation; instability mechanisms in foundationas and slopes; rock slope design methods; underground openings in discontinuous and continuous rocks; rock-support interaction; synopsis of numerical methods. Associated laboratory sessions involve stress measurement, core logging, compressive strength determination and index testing.

Exclusion: CIV529H1
Total AUs: 64.00

MIN330H1 - Mining Environmental Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

Total AUs: 44.80

MIN351H1 - Underground Mining

Credit Value: 0.50
Hours: 38.4L/12.8T

Operational aspects of underground mine design and mine planning. Topics will include: underground mining methods for hard and soft rock; shaft sinking, hoisting and materials handling; equipment selection and optimization; mine safety and mine regulations; mine personnel organization; ethics and professional issues. Development and production costs associated with mining are an inherent aspect of this course.

Exclusion: MIN350H1
Total AUs: 44.80

MIN400H1 - Geology Field Camp for Engineers

Credit Value: 0.50

At Geology Field Camp, students will learn to incorporate geological observations into their engineering data sets. The course will focus on the recognition of rock types in the field, mapping of geological structures related to mineralization of potential economic importance, and field measurement techniques for obtaining rock engineering data. Students will learn how to make geological observations that are of critical importance to their success as mineral engineers, and to foster a sense of excitement and curiosity about the rocks that form the physical environment within which they will work as professionals. The course will be taught in the Sudbury region where there are several operating mines, numerous excellent field exposures of rocks related to the formation of the impact-related Sudbury structure, inexpensive accommodations, as well as unrelated older rock sequences typical of Archean greenstone belts where much of Canada's mineral exploration takes place. Students attend the two week Geology Field Camp prior to the start of Fourth Year Fall Session.

Prerequisite: GLG207H1, GLG345H1, MIN429H1
Total AUs: 49.61

MIN450H1 - Mineral Economics

Credit Value: 0.50
Hours: 38.4L/12.8T

Course covers the evaluation of mineral projects, mining operations, and mining companies. Topics will include: discounted cash flow techniques including net present value (NPV), internal rate of return (IRR), net asset value (NAV); feasibility studies and due diligence reports; reserves and resources, data sources; metal prices and markets; cash flow modeling including revenue calculations, capital and operating costs, taxes, depreciation, inflation; risk and risk assessment, discount rates, red flags, checklists; financing. Guest lectures will provide industry insights into financing, fund raising, consulting, project control, and evaluation. There are two assignments: review of an annual report; due diligence report and net asset value calculation.

Prerequisite: CIV368H1/CME368H1
Total AUs: 44.80

MIN466H1 - Mineral Project Design I

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Mineral Project Design is a two-part capstone course that draws on all course materials developed in the first three years of the Mineral Engineering Curriculum. The course will culminate in the design of a mining or civil rock engineering project. In the first half of the course (F) students perform individual detailed case history analyses. Additional instruction in technical aspects of communication is provided during both semesters (preparing and writing technical reports, industry research and analysis, presentation skills, as well as other technical elements as required). These skills will form a foundation for students to use in industry. Critical non-technical aspects of rock engineering projects will also be examined, and guest speakers will present on specialized topics such as: cultural and social effects of rock engineering projects on communities and the environment; economic planning and impact; ethical considerations; aboriginal land claims, etc.. The social license to operate will be emphasized. Students will receive a final grade at the end of each term course, but both courses must be taken in sequence. (MIN 467H1 S cannot be taken without successful completion of MIN 466H1 F)

Prerequisite: MIN429H1, MIN350H1
Total AUs: 49.61

MIN467H1 - Mineral Project Design II

Credit Value: 0.50
Hours: 12.8L/12.8T/51.2P

Mineral Project Design is a two-part capstone course that draws on all course materials developed in the first three years of the Mineral Engineering Curriculum. Part II (S) focuses on the design of a mining or civil rock engineering project. Students will be grouped into teams and provided with one or more data sets and a design problem to solve. The end product is a major engineering design report and oral presentation (including several interim reports and presentations). Technical aspects will serve to examine a "cradle to grave" view of a project, from initial planning through to final closure and site remediation. The course will include an intensive two-day Professional Supervisors Short Course. Topics include: Discovering a commonality among supervisors and their key role in maintaining standards. The importance of sharing information and expectations about costs, production goals and business objectives are explored in the context of motivation. The necessity of successful communication skills and techniques are discussed and demonstrated to achieve behaviours on the job, producing consistent results. A reliable methodology for handling difficult situations is provided. The fundamental rationale for safety and loss control is presented as well as a relevant perspective on management structure. A workable code of conduct that is a guide to professional behaviour is developed. Students will receive a final grade at the end of each term course, but both courses must be taken in sequence (MIN 467H1 S cannot be taken without successful completion of MIN 466H1 F)

Prerequisite: MIN466H1
Total AUs: 49.61

MIN470H1 - Ventilation and Occupational Health

Credit Value: 0.50
Hours: 38.4L/12.8T

Hydraulics of air flow through underground openings is studied leading to mine ventilation design calculations and ventilation network analysis. Related topics discussed in the course include: statutory regulations and engineering design criteria; application and selection of ventilation fans; auxiliary fan design; air conditioning (heating and cooling); dust and fume control; ventilation economics. Health hazards related to mine gasses, dust and radiation along with relevant statutory requirements are reviewed. Air quality and quantity measurement and survey techniques are presented.

Prerequisite: CIV270H1/CME270H1
Total AUs: 44.80

MIN511H1 - Integrated Mine Waste Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The engineering design of conventional mine waste management systems, including tailings ponds, rock dumps, and underground mine backfill systems, is considered first. Emerging trends in integrated mine waste management systems, including paste stacking and "paste rock" on surface, and cemented paste backfill forunderground mining will then be covered. Engineering case studies will be used throughout, and each case study will be evaluated in terms of how the mine waste systems used contribute to the economic and environmental sustainability of the mining operation.

Prerequisite: CME321H1
Total AUs: 44.80

MIN565H1 - Design and Support of Underground Mine Excavations

Credit Value: 0.50
Hours: 38.4L/12.8T

Geomechanical issues concerning the design of underground openings in hard rock are covered in the course: ground support [i.e. rock mass reinforcement] design, the dimensioning and sequencing of underground excavations and rock pillar design in hard rock applications. A review of modern concepts concerning rock and rock mass failure modes with application to support design is given. Both static and dynamic [rockburst] support design issues are addresses. Lastly instrumentation and monitoring techniques and backfill design and behaviour are also covered. Design issues are illustrated through the use of numerous field case studies .

Prerequisite: MIN429H1/CIV529H1
Total AUs: 44.80

Materials Science and Engineering

MSE202H1 - Thermodynamics I

Credit Value: 0.50
Hours: 38.4L/25.6T

The three laws of thermodynamics, Heat capacity theory and Debye's law. Calculations of enthalpy, entropy, and free energy of pure materials and reactions. Reversible and irreversible processes. Gibbs free energy, chemical equilibria, and phase rule. Introduction of Ellingham, Pourbaix, and pre-dominance area diagrams. Treatment of ideal and non-ideal solutions with the introduction of the concept of activity and activity coefficient. Binary and ternary phase diagrams and their applications to materials processing and materials properties. Thermodynamics of electrochemical systems.

Total AUs: 51.20

MSE301H1 - Mineral Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Introduction to the theory and practice of mineral beneficiation. Topics covered include comminution, sizing, froth flotation, gravity separation, magnetic separation, electrostatic separation, dewatering and tailings management. The course also covers relevant aspects of sampling, particle size measurement, metallurgical accounting, material balances, surface chemistry and the movement of solid particles in liquid media. Open to 3rd and 4th year Minerals, Materials, and Chemical Engineering students, or with permission of the instructor.

Prerequisite: MIN225H1 or MSE244H1
Total AUs: 54.40

Engineering Minors

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Engineering Minors

Students wishing to pursue an Engineering minor must take a minimum of six courses.

Completion of an Engineering Minor is subject to the following constraints:

1. Students must ensure they meet the requirements of their chosen engineering-degree program or Major therein;
2. Of the 6 (half year) courses required for the minor, one (half year) course can also be a core course in a student's Program or Major, if applicable;
3. No course that is counted for degree credit can be counted towards more than one minor or certificate;
4. In some minor programs where indicated, either a Thesis or Design course can count for up to two (half year) electives towards the elective requirements IF the Thesis or Design course is strongly related to the subject area of the minor. This requires approval of the Director of the Minor;
5. Availability of the courses to complete an engineering minor (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable;
6. Students must secure approval from their home department before selecting any elective outside their home department.

MINOR IN ADVANCED MANUFACTURING (AEMINADVM)

Manufacturing is the most intensive research and development economic sector in Canada, accounting for 75 per cent of all private sector research expenditures. The courses in this minor draw on an array of engineering skills, leadership and multi-disciplinary knowledge, all of which can be leveraged in a wide range of sectors, including biomedical, automotive, aviation, aerospace, energy and others. The minor provides a strong foundation in advanced manufacturing which can lead to a career in industry or graduate degrees.

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

1. Choose one (1) of the following foundational courses:
    a. CHE324H1: Process Design
    b. MIE221H1: Manufacturing Engineering
    c. MIE304H1: Introduction to Quality Control
    d. MIE364H1: Methods of Quality Control and Improvement
    e. MSE351H1: Design and Simulation of Materials Processes

2. MIE519H1: Advanced Manufacturing Technologies
3. Choose one of the following business management/leadership courses:
    a. TEP343H1: Engineering Leadership
    b. TEP442H1: Cognitive and Psychological Foundations of Effective Leadership
    c. CHE488H1/ CIV488H1/ ECE488H1/ MSE488H1/ MIE488H1: Entrepreneurship and Business for Engineers
    d. JRE420H1: People Management and Organizational Behaviour
4. Three (3) other electives from the list of designated courses below or departmental thesis and design courses subject to the following constraints:
    a. Of the 6 half year courses required for the minor, only one half year course can be a core course in the student's degree program, including courses listed in requirement #1.
    b. Of the 3 elective courses, at least 2 must be from the Advanced category.
    c. Either a Thesis or Design course can count for up to two half year Advanced elective courses towards the 4 elective courses IF the Thesis or Design course is strongly related to advanced manufacturing. This requires approval by the Advanced Manufacturing Minor Director.
    d. Some Departments may require students select their electives from a pre-approved subset. Please contact your Departmental Advisor for details.

Introductory Courses		Lect.	Lab.	Tut.	Wgt.
CHE441H1: Engineering Materials	F	3	-	1	0.50
MIE304H1: Introduction to Quality Control	S	3	1	2	0.50
MIE342H1: Circuits with Applications to Mechanical Engineering Systems	F	3	1.50	1	0.50
MIE354H1: Business Process Engineering	F	3	2	-	0.50

Advanced Courses		Lect.	Lab.	Tut.	Wgt.
AER525H1: Robotics	F	3	1.50	1	0.50
CHE462H1: Food Engineering	S	3	-	1	0.50
CHE562H1: Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering	F	3	-	-	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CHE561H1: Risk Based Safety Management	S	3	-	1	0.50
ECE442H1	F	3	2	1	0.50
ECE470H1: Robot Modeling and Control	F/S	3	1.50	1	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
MIE368H1: Analytics in Action	F	3	2	-	0.50
MIE422H1: Automated Manufacturing	F	2	3	-	0.50
MIE440H1: * Design of Innovative Products	F	2	2	1	0.50
MIE441H1: * Design Optimization	S	3	2	-	0.50
MIE443H1: * Mechatronics Systems: Design and Integration	S	2	5	-	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
MIE51H1					0.50
MIE540H1: * Product Design					0.50
MIE562H1: Scheduling	F	3	-	2	0.50
MIE566H1: Decision Making Under Uncertainty	F	3	-	2	0.50
MSE419H1: Fracture and Failure Analysis	F	3	-	1	0.50
MSE421H1: Solid State Processing and Surface Treatment	S	3	-	2	0.50
MSE431H1: Forensic Engineering	S	3	-	1	0.50
MSE432H1	S	3	-	-	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50

Advanced Courses		Lect.	Lab.	Tut.	Wgt.
MSE455H1: Process Simulation and Computer Design	S	3	-	2	0.50
MSE461H1: Engineered Ceramics	F	3	-	2	0.50
MSE478H1: Materials Manufacturing and Design Laboratory II	S	-	-	-	0.50
Thesis or Design Project courses with approval of the Director of the Minor					

MINOR IN ARTIFICIAL INTELLIGENCE ENGINEERING (AEMINAIEN)

Artificial intelligence (AI) and Machine learning (ML) have exploded in importance in recent years and garnered attention in a wide variety of application areas, including computer vision (e.g., image recognition), game playing (e.g., AlphaGo), autonomous driving, speech recognition, customer preference elicitation, bioinformatics (e.g., gene analysis) and others. While the topics may appear primarily to reside in the disciplines of computer engineering and computer science, the topics of AI and ML now apply to all disciplines of engineering, such as projection of future road-traffic patterns, applications in industrial automation and robotic control, or the use of AI/ML drug discovery, to name just a few examples.

All U of T Engineering undergraduates (except students in the Engineering Science Machine Learning Major) are eligible to participate in this minor. Note that Engineering Science students in the Robotics Major will have to take additional courses due to the number of core courses that overlap with their degree program.

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

Required Courses

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
Required:					
APS360H1: Applied Fundamentals of Machine Learning	S	3	-	1	0.5
One of:					
ECE345H1: Algorithms and Data Structures	F/S	3	-	2	0.5
ECE358H1: Foundations of Computing	F	3	-	1	0.5
CSC263H1: Data Structures and Analysis	F/S	2	-	1	0.5
MIE335H1: Algorithms & Numerical Methods	S	3	1	1	0.5
One of:					
ROB311H1: Artificial Intelligence	S	3	-	1	0.5
CSC384H1: Introduction to Artificial Intelligence	F/S/Y	2	-	1	0.5
MIE369H1: Introduction to Artificial Intelligence	S	3	-	2	0.5
One of:					
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.5
CSC311H1: Introduction to Machine Learning	F/S	2	-	1	0.5
ROB313H1: Introduction to Learning from Data	S	3	-	2	0.5
MIE424H1: Optimization in Machine Learning	S	3	1	-	0.5
One or two of:		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ECE368H1: Probabilistic Reasoning	S	3	-	1	0.5
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.5
CSC401H1: Natural Language Computing	F/S/Y	2	-	1	0.5

Fall Session - Year 1		Lect.	Lab.	Tut.	Wgt.
CSC420H1: Introduction to Image Understanding	F	3	-	-	0.5
CSC413H1: Neural Networks and Deep Learning	S	2	-	1	0.5
CSC485H1: Computational Linguistics	F/S	3	-	-	0.5
CSC486H1: Knowledge Representation and Reasoning	F/S/Y	2	-	1	0.5
HPS345H1: Quantifying the World & Epistemic Implications of AI	F/S/Y	2	-	-	0.5
HPS346H1: Modifying and Optimizing Life: AI, Biology & Engineering	F/S/Y	2	-	1	0.5
MIE368H1: Analytics in Action	F	2	3	1	0.5
MIE451H1: Decision Support Systems	F	3	1	1	0.5
MIE457H1: Knowledge Modelling and Management	S	3	1	1	0.5
MIE562H1: Scheduling	S	3	-	2	0.5
MIE566H1: Decision Making Under Uncertainty	F	3	-	2	0.5
ROB501H1: Computer Vision for Robotics	F	3	-	1	0.5
AI/ML-related capstone or thesis with Director's approval	F/S/Y				0

As needed to bring credit weight to 3.0:		Lect.	Lab.	Tut.	Wgt.
AER336H1: Scientific Computing	S	3	-	1	0.5
BME595H1: Medical Imaging	F	2	3	1	0.5
CHE322H1: Process Control					
CSC343H1: Introduction to Databases	F/S	2	-	1	0.5
CSC412H1: Probabilistic Learning and Reasoning	F/S	3	-	-	0.5
ECE444H1: Software Engineering	F	3	1.5	1	0.5
ECE344H1: Operating Systems	F/S	3	3	-	0.5
ECE353H1: Systems Software		3	3	-	0.5
ECE356H1: Introduction to Control Theory	S	3	1.5	1	0.5
ECE367H1: Matrix Algebra and Optimization	F	3	-	2	0.5
ECE411H1: Real-Time Computer Control	S	3	1.5	1	0.5
ECE419H1: Distributed Systems	S	3	1.5	1	0.5
ECE431H1: Digital Signal Processing	F	3	1.5	1	0.5
ECE454H1: Computer Systems Programming	F	3	3	-	0.5
ECE470H1: Robot Modeling and Control	F/S	3	1.5	1	0.5
ECE516H1: Intelligent Image Processing					
ECE532H1: Digital Systems Design	S	3	3	-	0.5
ECE557H1: Linear Control Theory	F	3	1.5	1	0.5
ECE568H1: Computer Security	F/S	3	3	-	0.5
MAT336H1: Elements of Analysis	F/S	2	-	1	0.5
MAT389H1: Complex Analysis	F	3	-	1	0.5
STA302H1: Methods of Data Analysis I	F/S	-	-	-	0
STA410H1: Statistical Computation	F	-	-	-	0

NOTE:

1. Robotics Major students in Engineering Science will only be able to access the Minor with the permission of the Cross-Disciplinary Programs Office. The permission will be based on the selection of a suitable set of alternative courses.
2. ROB313H1 and ROB501H1 may be only used towards the Minor by Engineering Science students.
3. Either a thesis or design course may count for up to two electives IF the thesis or design course is strongly related to artificial intelligence. This requires approval by the Director of the Minor.

MINOR IN BIOENGINEERING (AEMINBIO)

The Undergraduate Bioengineering Minor is a collaborative effort across the Faculty of Applied Science and Engineering and is open to Engineering students interested in learning more about biology and its application to engineering. Our definition of bioengineering is broad, reaching to all areas at the interface of engineering and biology. This includes bioprocess engineering, environmental microbiology, biomaterials, tissue engineering, bioelectricity, biomedical imaging, biomechanical engineering, nanotechnology related to medicine and the environment, and engineering design for human interfaces. All undergraduate Engineering students except students in the Engineering Science Biomedical Systems Engineering Major are eligible to participate in this minor course of study.

Requirements for the Minor in Bioengineering

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

1. CHE353H1 OR BME205H1**
2. One of:
   i. CHE354H1 OR BME395H1**
   ii. BME331H1 OR BME350H1**
3. Four (4) other electives from the list of Bioengineering designated courses or departmental thesis and design courses subject to the following constraints:
   i. Of the 6 (half year) bioengineering courses required, one (half year) course can also be a core course in a student's Program, if applicable.
   ii. Of the 4 elective courses, at least 2 must be from the Advanced category.
   iii. Either a Thesis or Design course can count for up to two (half year) electives towards the 6 required courses IF the Thesis or Design course is strongly related to bioengineering. This requires approval by the Bioengineering Minor Director.
   iv. Some Departments may require students to select their electives from a pre-approved subset. Please contact your Departmental Advisor for details.
   v. Arts and Science Courses listed below may be considered eligible electives for students taking the Bioengineering Minor, subject to the student meeting any prerequisite requirements. Students must also seek the approval of their home program to ensure that they meet their degree requirements. In situations where these courses don't meet those of their home program, students can elect to take these as extra courses.

**Denotes courses available to Engineering Science students only

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
BME350H1: Biomedical Systems Engineering I: Organ Systems	F	3	1	2	0.50
CHE353H1: Engineering Biology	F	2	-	2	0.50
Introductory Courses					
BME330H1: Patents in Biology and Medical Devices	S	3	-	-	0.50
BME440H1: Biomedical Engineering Technology and Investigation	F	2	4	-	0.50
CIV342H1: Water and Wastewater Treatment Processes	F	3	1	1	0.50

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
FOR308H1: Discovering Wood and its Role in Societal Development	F	3	-	1	0.50
HMB265H1	F	2	-	1	0.50
MIE242H1: Psychology For Engineers	F	3	3	-	0.50
MIE343H1: Industrial Ergonomics and the Workplace	F	3	3	-	0.50
MSE343H1: Biomaterials	F	3	-	1	0.50
Advanced Courses					
BCH441H1: Bioinfomatics	F	2	-	1	0.50
BME395H1: Biomedical Systems Engineering II: Cells and Tissues	F	2	1	2	0.50
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
BME455H1: Cellular and Molecular Bioengineering II	F	3	1.50	1	0.50
CHE450H1: Bioprocess Technology and Design	F	3	0.66	1	0.50
CIV541H1: Environmental Biotechnology	F	3	-	-	0.50
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
FOR421H1: Green Urban Infrastructure: Sustainable City Forests	F	2	-	-	0.50
IMM250H1: The Immune System & Infectious Disease	F	-	-	-	0.50
MGY377H1: Microbiology I: Bacteria	F	3	-	-	0.50
MIE458H1: Biofluid Mechanics	F	3	-	1	0.50
MIE520H1: Biotransport Phenomena	F	3	-	1	0.50
MIE523H1: Engineering Psychology and Human Performance	F	3	3	-	0.50
MSE440H1: BIomaterial Processing and Properties	F	3	-	1	0.50
PSL300H1: Pharmacodynamic Principles	F	3	-	1	0.50

Courses Offered in the Winter		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
BME205H1: Fundamentals of Biomedical Engineering	S	2	1.50	1	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50
Introductory Courses					
HMB201H1: Introduction to Fundamental Genetics and its Applications	S	2	-	1	0.50
HPS319H1: History of Medicine II	S	-	-	-	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50
MIE439H1: Biomechanics I	S	3	2	-	0.50
PCL201H1: Introduction to Pharmacology and Pharmacokinetic Principles	S	3	-	1	0.50
PHL281H1 (formerly PHL281Y1): Bioethics	S	-	-	-	0.50
Advanced Courses					
BCB420H1: Computational Systems Biology	S	2	-	2	0.50
BME430H1	S	3	2	-	0.50
BME435H1: Biostatistics	S	3	-	1	0.50
BME595H1: Medical Imaging	S	2	3	1	0.50
CHE354H1: Cellular and Molecular Biology	S	3	1	2	0.50
CHE416H1: Chemical Engineering in Human Health	S	3	-	-	0.50
CHE462H1: Food Engineering	S	3	-	1	0.50
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50

Courses Offered in the Winter		Lect.	Lab.	Tut.	Wgt.
CHE564H1: Pulp and Paper Processes	S	3	-	1	0.50
CHM446H1: Organic Materials Chemistry	S	2	-	-	0.50
ECE448H1: Biocomputation	S	3	-	2	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50
IMM250H1: The Immune System & Infectious Disease	S	-	-	-	0.50
MIE561H1: Healthcare Systems	S	3	-	2	0.50

Notes

1. For those Engineering Science students who transferred into another program, BME205H1 can replace CHE353H1 and is an eligible prerequisite for CHE354H1 and BME331H1.
2. If a student takes both CHE354H1 and BME331H1, one of these courses can be counted as one of the four electives.
3. BME440H1 and BME455H1 are open to all students in the Faculty of Applied Science and Engineering, except those in Engineering Science, so long as the pre-requisites for each have been met.
4. BME205H1, BME350H1, BME395H1 and MSE352H1 are only open to Engineering Science Students.

MINOR IN BIOMEDICAL ENGINEERING (AEMINBME)

This highly focused minor examines engineering's intersection with medical research and biomedical technology. Courses provide training in physiological control systems, bioinstrumentation, biomechanics and a choice of lab or design experience. All Engineering undergraduates starting from Year 1 through to degree completion are eligible to pursue the Biomedical Engineering Minor, with the exception of students in the Engineering Science Biomedical Systems Engineering Major.

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

1. CHE353H1 - Engineering Biology
2. BME331H1 - Physiological Control Systems
3. BME440H1 - Biomedical Engineering Technology and Investigation
4. One (1) of the following:
   i. MIE439H1 - Biomechanics
   ii. BME430H1 - Human Whole Body Biomechanics
5. One (1) of the following fourth year courses:
   i. BME499Y1 - Applied Research in Biomedical Engineering
   ii. BME498Y1 - Biomedical Engineering Capstone Design

Notes:

- Entry into BME498Y1 or BME499Y1 requires permission from the IBBME Undergraduate and Graduate Office. Students should make this request when completing pre-registration, and no later than June 16.
- A Biomedical Engineering Minor student may take both courses (BME499Y1, BME498Y1) but only one may count towards the minor.
- A Biomedical Engineering Minor student may take both courses (BME430H1, MIE439H1) but only one may count towards the minor.
- For those Engineering Science students who transferred into another program, BME205H1 can replace CHE353H1 and is an eligible pre-requisite for BME331H1.

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
Courses to be taken in Year Three					

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
CHE353H1: Engineering Biology	F	2	-	2	0.50
Courses to be taken in Year Four					
BME440H1: Biomedical Engineering Technology and Investigation	F	2	4	-	0.50
One (1) of the following:					
BME498Y1: Biomedical Engineering Capstone Design	Y	2	3	-	1.00
BME499Y1: Applied Research in Biomedical Engineering	Y	1	7	-	1.00

Courses Offered in the Winter		Lect.	Lab.	Tut.	Wgt.
Courses to be taken in Year Three					
BME331H1: Physiological Control Systems	S	3	1	1	0.50
Courses to be taken in Year Four					
One (1) of the following:					
MIE439H1: Biomechanics I	S	3	2	-	0.50
BME430H1	S	3	2	-	0.50
One (1) of the following:					
BME498Y1: Biomedical Engineering Capstone Design	Y	2	3	-	1.00
BME499Y1: Applied Research in Biomedical Engineering	Y	1	7	-	1.00

Notes:

The above is a recommendation of the scheduling of minor courses but may not fit into each departments academic scheduling for a student's major. It is recommended that students wishing to complete the Biomedical Engineering Minor visit the IBBME Undergraduate and Graduate Programs Office (MB 332, undergrad.bme@utoronto.ca) for assistance or speak with their program advisor.

*Students from the department of Material Science Engineering cannot take both BME498Y1 and BME499Y1.

MINOR IN ENGINEERING BUSINESS (AEMINBUS)

This minor is for students interested in learning more about the business dimension of engineering, from finance and economics to management and leadership. Courses reach to areas of wealth production and creation, accounting, research and development, management, economics and entrepreneurship, all within a global context.

Students in the Engineering Science Mathematics, Statistics and Finance Major are not eligible to take this minor.

Course Requirements for the Minor in Engineering Business

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

1. Required Departmental Engineering Economics Course: CHE249H1, CHE374H1, CME368H1, ECE472H1, MIE258H1
2. JRE300H1 - CS Elective
3. JRE410H1 - CS Elective
4. JRE420H1 - HSS Elective
    1. Note - changed from CS as of Winter 2019, retroactive to Fall 2014

5. Two (2) Course Electives from the list of Engineering Business designated courses. A Departmental Thesis course may be counted as 1 elective (if an H course) or 2 electives (if a Y course) if strongly related to Engineering Business. This requires approval of the Director of the Minor.

Courses offered in the Fall		Lect.	Lab.	Tut.	Wgt.
Engineering Economics Course (one of:)					
CHE249H1: Engineering Economic Analysis	F	3	-	1	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CME368H1: Engineering Economics and Decision Making	F	3	-	1	0.50
ECE472H1: Engineering Economic Analysis & Entrepreneurship	F	3	-	2	0.50
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50
Required Courses					
JRE300H1: Fundamentals of Accounting and Finance	F/S	3	-	1	0.50
JRE410H1: Markets and Competitive Strategy	F/S	2	2	-	0.50
JRE420H1: People Management and Organizational Behaviour	F/S	3	-	1	0.50
Elective Courses					
APS500H1: Negotiations in an Engineering Context	F	3	-	-	0.50
APS502H1: Financial Engineering	F	-	-	3	0.50
ECE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50
ECO101H1	F	-	-	-	0.50
FOR308H1: Discovering Wood and its Role in Societal Development	F	3	-	1	0.50
MIE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50
MSE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50
MIE354H1: Business Process Engineering	F	3	2	-	0.50
PHL295H1	F	-	-	-	0.50
TEP234H1: Entrepreneurship and Small Business	F	4	-	1	0.50
TEP343H1: Engineering Leadership	F	1	2	-	0.50
TEP444H1: Positive Psychology for Engineers	F	3	-	-	0.50
TEP445H1: The Power of Story: Discovering Your Leadership Narrative	F	2	-	1	0.50
APS510H1: Innovative Technologies and Organizations in Global Energy Systems	F	3	-	1	0.50

Courses offered in the Winter		Lect.	Lab.	Tut.	Wgt.
Engineering Economics Course					
ECE472H1: Engineering Economic Analysis & Entrepreneurship	S	3	-	2	0.50
Required Courses					
JRE300H1: Fundamentals of Accounting and Finance	F/S	3	-	1	0.50
JRE410H1: Markets and Competitive Strategy	F/S	2	2	-	0.50
JRE420H1: People Management and Organizational Behaviour	F/S	3	-	1	0.50
Elective Courses					
APS511H1: Inventions and Patents for Engineers	S	3	-	-	0.50
CHE488H1: Entrepreneurship and Business for Engineers	S	3	-	2	0.50
CIV488H1: Entrepreneurship and Business for Engineers	S	3	-	2	0.50
ECO102H1	S	-	-	-	0.50
GGR251H1: Geography of Information	S	-	-	-	0.50
GGR252H1: Marketing Geography	S	2	-	1	0.50

Courses offered in the Winter		Lect.	Lab.	Tut.	Wgt.
HPS283H1: The Engineer in History	S	2	-	1	0.50
MIE540H1: * Product Design	S	3	-	1	0.50
TEP343H1: Engineering Leadership	S	1	2	-	0.50
TEP432H1: Entrepreneurship and Business Management	S	4	-	1	0.50
APS420H1: Technology, Engineering and Global Development	S	3	-	-	0.50
TEP442H1: Cognitive and Psychological Foundations of Effective Leadership	S	3	-	-	0.50
TEP447H1: The Art of Ethical & Equitable Decision Making in Engineering	S	3	-	-	0.50

MINOR IN ENGINEERING MUSIC PERFORMANCE (AEMINMUSP)

The Engineering Performance Minor was designed for Engineering undergraduates interested in exploring creativity in performance with music technology. This minor is open to any student completing an undergraduate degree in the Faculty of Applied Science and Engineering.

Through our partnership with the Faculty of Music, we are able to provide access to a performance-based program, including courses normally only open to their students.

Due to the nature of these courses and the requirements set by the CEAB, there are courses within this minor that are only eligible for Free Elective (FE) or Extra course status (EXT). Thus students wishing to pursue this minor must be prepared to be taking on course work above and beyond their degree requirements. ECE446 and Technical courses from the Faculty of Music may be requested as Technical Elective Substitutions (TES) for a student's degree program, subject to the approval of the student's home department.

Note: Enrollment in the core course for the Minor, PMU299Y1 Y, will be based on a placement test, and may be competitive if demand exceeds the maximum number of placements. Minimum playing level required is RCM Gr. 8, plus background in theory and rudiments (Rudiments II or equivalent).

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

1. PMU299Y1 - Applied Performance
2. TMU130H1 - Music Theory 1
3. ECE446H1- Sensory Communication
4. Two other electives (1.0 FCE) from the list of designated courses or departmental thesis and design courses subject to the following constraints:
   a. At least one elective (0.5 FCE) must come from the Technical (T) category
   b. Either a Thesis or Design course can count for up to two (half year) courses towards the 2 elective courses IF the Thesis or Design course is strongly related to music. This requires approval by the Minor Director.
   c. Courses listed below may be considered eligible electives for students taking the Music Minor, subject to the student meeting any prerequisite requirements. Students must also seek the approval of their home program to ensure that they meet their degree requirements. In situations where these courses don't meet those of their home program, students can elect to take these as extra courses.

Core Courses		Lec.	Lab.	Tut.	Wgt.
ECE446H1: Sensory Communication	F	3	1.50	1.	0.50
PMU299Y1: Applied Performance	Y	1	-	-	1.00
TMU130H1: Music Theory 1	F	3	-	-	0.50
One (1) Technical Elective					
TMU111H1: Introduction to Computer Applications in Music	F/S	-	-	-	0.50

TMU313H1: Introduction to Music Recording	F/S	-	-	-	0.50
TMU319H1: Electroacoustic Music I	F/S	-	-	-	0.50
TMU320H1: Electroacoustic Music II	F/S	-	-	-	0.50
TMU330H1: Live Coding: Digital Audio in Real Time	F/S	-	-	-	0.50
TMU406H1: Max/MSP	F/S	-	-	-	0.50
Music Related Thesis or Capstone	F/S	-	-	-	0.50
Music Related Thesis or Capstone	Y	-	-	-	1.00

Elective Courses		Lec.	Lab.	Tut.	Wgt.
HMU111H1: Introduction to Music and Society	F/S	-	-	-	0.5
MUS110H1: Introduction to Music History and Culture	F/S	-	-	-	0.5
MUS111H1: Historical Survey of Western Music	F/S	-	-	-	0.5
MUS200H1: Music of the World's Peoples	F/S	-	-	-	0.5
MUS204H1: The Age of Bach and Handel	F/S	-	-	-	0.5
MUS209H1: Performing Arts of South Asia	F/S	-	-	-	0.5
MUS211H1: The World of Popular Music	F/S	-	-	-	0.5
MUS212H1: Music, Sound & Power in the Middle East	F/S	-	-	-	0.5
MUS240H1: Heavy Music	F/S	-	-	-	0.5
MUS302H1: Symphony	F/S	-	-	-	0.5
MUS306H1: Popular Music in North America	F/S	-	-	-	0.5
MUS308H1: Handel	F/S	-	-	-	0.5
MUS335H1: A Social History of the Piano	F/S	-	-	-	0.5
TMU131H1: Music Theory 2	F/S	-	-	-	0.5

Note: Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.

Note for Electives: The Faculty of Music updates the list of MUS courses offered each year. A final list of MUS electives eligible for the academic year will be posted on the Minors web site in May.

MINOR IN ENVIRONMENTAL ENGINEERING (AEMINENV)

Environmental Engineering Minor (U of T Sustainability Scholar)

Students interested in learning more about ecology, sustainable design, risk assessment and environmental impact may be interested in this minor. Our definition of environmental engineering is broad, reaching to all areas at the interface of engineering and the environment. This includes ecology and ecological impacts, waste management, water and wastewater treatment, environmental microbiology, water resources engineering, hydrology, preventive engineering, life cycle analysis, design for the environment, and extends to the social and environmental impacts of technology.

Students who complete the requirements of the Environmental Engineering Minor are considered University of Toronto Sustainability Scholars.

All undergraduate Engineering students are eligible to participate in this minor course of study.

Course Requirements for the Minor in Environmental Engineering

The requirements for an Environmental Engineering Minor in the Faculty of Applied Science and Engineering are the successful completion of the following courses.

1. One (1) courses from the following:
    1. CME259H1
    2. ESC203H1
    3. ENV221H1
    4. GGR223H1
2. One (1) courses from the following:
    1. CIV220H1
    2. CIV440H1
    3. CHE460H1
    4. CHE467H1
3. Four (4) other electives from the list of Environmental Engineering designated courses or departmental thesis and design courses subject to the following constraints:
1. Of the 6 half year environmental engineering courses required, one half year course can also be a core course in a student's Program, if applicable.
    2. Of the 4 elective courses, at least 2 must be from the Advanced category.
    3. Either a Thesis or Design course can count for up to 2 half year electives towards the 6 required courses if the Thesis or Design course is strongly related to environmental engineering. This requires approval by the Environmental Engineering Minor Director.
    4. Some Departments may require students to select their electives from a pre-approved subset. Please contact your Departmental Advisor for details.
    5. Faculty of Arts and Science courses listed below may be considered eligible electives for students taking the Environmental Engineering Minor, subject to the student meeting any prerequisite requirements. Students must also seek the approval of their home program to ensure that they meet their degree requirements. In situations where these courses don't meet those of their home program, students can elect to take these as extra courses.

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
CHE467H1: Environmental Engineering	F	3	-	1	0.50
CIV220H1: Urban Engineering Ecology	F	3	-	1	0.50
CME259H1: Technology in Society and the Biosphere I	F	3	-	1	0.50
ENV221H1	F	-	-	-	0.50
ESC203H1: Engineering and Society	F	2	-	2	0.50
Introductory Courses					
CHM210H1	F	2	-	1	0.50
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
CIV375H1: Building Science	F	3	0.33	2	0.50
ENV234H1	F	-	-	-	0.50
ENV350H1	F	-	-	-	0.50
FOR308H1: Discovering Wood and its Role in Societal Development	F	3	-	1	0.50
GGR314H1	S	-	-	-	0.50
Advanced Courses					
CHE565H1: Aqueous Process Engineering	F	3	-	1	0.50
CIV531H1: Transport Planning	F	3	-	1	0.50
CIV536H1: Urban Activity, Air Pollution, and Health	F	3	-	-	0.50
CIV541H1: Environmental Biotechnology	F	3	-	-	0.50
CIV549H1: Groundwater Flow and Contamination	F	3	-	1	0.50
CIV550H1: Water Resources Engineering	F	3	-	2	0.50

Courses Offered in the Fall		Lect.	Lab.	Tut.	Wgt.
CIV575H1: Studies in Building Science	F	3	-	2	0.50
CIV578H1: Design of Building Enclosures	F	3	-	2	0.50
FOR421H1: Green Urban Infrastructure: Sustainable City Forests	F	2	-	-	0.50
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
MIN511H1: Integrated Mine Waste Engineering	F	3	-	1	0.50
MSE415H1: Environmental Degradation of Materials	F	3	-	1	0.50

Courses Offered in the Winter		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
CHE460H1: Environmental Pathways and Impact Assessment	S	3	-	2	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
GGR223H1 (formerly GGR222H1): Environment, Society, and Resources	S	2	-	1	0.50
Introductory Courses					
CHE230H1: Environmental Chemistry	S	3	-	2	0.50
CHM310H1	S	2	-	-	0.50
CIV250H1: Hydraulics and Hydrology	S	3	1.50	1	0.50
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
ENV222H1	S	-	-	-	0.50
MIE315H1: Design for the Environment	S	3	-	1	0.50
Advanced Courses					
APS530H1: Appropriate Technology & Design for Global Development	S	3	-	-	0.50
CHE471H1: Modelling in Biological and Chemical Systems	S	3	-	1	0.50
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CHE564H1: Pulp and Paper Processes	S	3	-	1	0.50
CHM410H1	S	2	4	-	0.50
CHM415H1	S	2	-	-	0.50
CIV576H1: Sustainable Buildings	S	3	-	0	0.50
CIV577H1: Infrastructure for Sustainable Cities	S	3	-	1	0.50
CME500H1: Fundamentals of Acid Rock Drainage	S	3	2	1	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
MIN330H1: Mining Environmental Management	S	3	-	1	0.50
APS420H1: Technology, Engineering and Global Development	S	3	-	-	0.50

MINOR IN NANOENGINEERING (AEMINNANO)

Course Requirements for the Minor in Nanoengineering

Nanoengineering, and its underlying science and engineering skills, has now become embedded in academic and industrial sectors spanning the electronics industry, communications, sustainable and legacy energy, medical diagnostics and devices, micro electrical mechanical systems, and new materials for the automotive, aviation, and manufacturing sectors. The minor provides students with an understanding of both the structure and the application of nanomaterials and includes a range of electives connected to their core programs.

The requirements for the Minor in Nanoengineering in the Faculty of Applied Science and Engineering are the successful completion of 3.0 FCE as outlined below:

1. MSE219H1 – Structure and Characterization of Materials
2. Thesis or Capstone Design course strongly related to nanoengineering. This requires approval by the Director of the Nanoengineering Minor. Thesis and capstone courses are not subject to the core course limit.
3. Three (or four) other courses from the list of electives below. If the thesis or capstone project is only 0.5 FCE weight, students will require four electives.
    a. a. Of the courses required, one course (0.5 FCE) can also be a core course in a student's Program, if applicable. Thesis and capstone are exempt from this limit.
    b. Of the 3 elective courses, at least 2 must be from the Advanced category.
    c. Some Departments may require students select their electives from a preapproved subset. Please contact your Departmental Advisor for details.
    d. Arts and Science Courses listed below may be considered eligible electives for students taking the Nanoengineering Minor, subject to the student meeting any prerequisite requirements. Students must also seek the approval of their home program to ensure that they meet their degree requirements. In situations where these courses don't meet those of their home program, students can elect to take these as extra courses.

Introductory Courses

Fall Session		Lect.	Lab.	Tut.	Wgt.
ECE335H1: Introduction to Electronic Devices	F	3	-	2	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME346H1: Biomedical Engineering and Omics Technologies	S	2	4	-	0.50
ECE330H1: Quantum and Semiconductor Physics	S	3	-	2	0.50
ECE350H1: Semiconductor Electronic Devices	S	3	1.50	1	0.50
PHY358H1	S	2	-	1	0.50

Advanced Courses

Fall Session		Lect.	Lab.	Tut.	Wgt.
CHE562H1: Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering	F	3	-	-	0.50
CHM338H1	F	-	-	-	0.50
ECE427H1: Photonic Devices	F	3	-	2	0.50
MSE430H1: Electronic Materials	F	2	-	1	0.50
MSE438H1: Computational Materials Design	F	3	1	-	0.50
MSE459H1: Synthesis of Nanostructured Materials	F	3	2	-	0.50
PHY427H1: Advanced Physics Laboratory	F	-	6	-	0.50
PHY456H1	F	2	-	1	0.50
PHY485H1	F	2	-	-	0.50
PHY487H1	F	2	-	-	0.50
Winter Session		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
BME440H1: Biomedical Engineering Technology and Investigation	S	2	4	- 0.50	
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
CHM325H1	S	2	-	-	0.50
CHM328H1	S	-	-	-	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
MSE443H1: Composite Materials Engineering	S	3	-	-	0.50
MSE462H1: Materials Physics II	S	2	-	1	0.50

Winter Session		Lect.	Lab.	Tut.	Wgt.
MSE451H1: Advanced Physical Properties of Structural Nanomaterials	S	3	2	1	0.50
MSE458H1: Nanotechnology in Alternate Energy Systems	S	3	-	2	0.50
MIE506H1: * MEMS Design and Microfabrication	S	3	1.50	1	0.50
MIE517H1: Fuel Cell Systems	S	3	-	1	0.50
PHY427H1: Advanced Physics Laboratory	S	-	6	-	0.50
PHY450H1	S	2	-	1	0.50
PHY452H1	S	2	-	-	0.50

MINOR IN ROBOTICS AND MECHATRONICS (AEMINRAM)

The Minor in Robotics and Mechatronics is a collaborative effort among The Edward S. Rogers Sr. Department of Electrical and Computer Engineering, Department of Mechanical and Industrial Engineering, the Institute for Aerospace Studies, and the Institute of Biomaterials and Biomedical Engineering. The minor in robotics and mechatronics exposes students to the fundamental paradigms, the enabling technologies, the design, and the applications of robotics and mechatronics. The program is intended to give a comprehensive view to these fields by drawing together relevant courses from all of the engineering departments. The emphasis is on giving the student a systems view rather than a narrowly focused study of one area. Courses examine the areas of sensing and actuation, control and signal processing, computer vision, intelligent algorithms, computation, and system integration. The minor prepares students for careers in industries that have a growing investment in automation, autonomy, and intelligent systems. It is open to all students in the Faculty of Applied Science and Engineering except those in the Engineering Science Robotics Major.

Requirements for the Minor in Robotics and Mechatronics

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

1. One of:
   i. CHE322H1
   ii. ECE311H1
   iii. ECE356H1
   iv. MIE404H1
   v. AER372H1
   vi. BME344H1
2. One of:
   i. AER525H1
   ii. ECE470H1
   iii. MIE422H1
   iv. MIE443H1
   v. MIE444H1
3. Four (4) other electives from the list of robotics and mechatronics-designated courses or a departmental thesis or design course subject to the following constraints:

i. Of the 6 half year courses required, one (half year) course can also be a core course in a student's Program, if applicable.
   ii. Of the four elective courses, at least two must be from the Advanced category.
   iii. A thesis or capstone design course can count for up to two electives (2 HCEs) toward the four elective courses if the thesis is strongly related to robotics or mechatronics. This requires approval by the Director of the Minor.
   iv. Of the six Minor courses required, not all can have the same course prefix.

Introductory Courses					
Fall Courses		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER301H1: Dynamics	F	3	-	1	0.50

Introductory Courses					
Fall Courses		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS360H1: Applied Fundamentals of Machine Learning	F	3	-	1	0.50
BME350H1: Biomedical Systems Engineering I: Organ Systems	F	3	1	2	0.50
ECE316H1: Communication Systems	F	3	1.50	1	0.50
ECE345H1: Algorithms and Data Structures	F	3	-	2	0.50
MIE243H1: Mechanical Engineering Design	F	3	2	2	0.50
MIE301H1: Kinematics and Dynamics of Machines	F	3	3	2	0.50
ROB310H1: Mathematics for Robotics	F	3	-	1	0.50
Winter Courses		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
APS360H1: Applied Fundamentals of Machine Learning	S	3	-	1	0.50
ECE316H1: Communication Systems	S	3	1.50	1	0.50
ECE345H1: Algorithms and Data Structures	S	3	-	2	0.50
ECE353H1: Systems Software	S	3	3	-	0.50
ECE358H1: Foundations of Computing	S	3	-	1	0.50
ECE363H1: Communication Systems	S	3	1.50	1	0.50
BME331H1: Physiological Control Systems	S	3	1	1	0.50
MIE346H1: Analog and Digital Electronics for Mechatronics	S	3	1.50	1	0.50
ROB311H1: Artificial Intelligence	S	3	-	1	0.50
ROB313H1: Introduction to Learning from Data	S	3	-	2	0.50

Advanced Courses					
Fall Courses		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
AER407H1: Space Systems Design	F	-	3	-	0.50
CSC384H1: Introduction to Artificial Intelligence	F	2	-	1	0.50
CSC311H1	F	2	-	1	0.50
ECE410H1: Linear Control Systems	F	3	1.50	1	0.50
ECE431H1: Digital Signal Processing	F	3	1.50	1	0.50
BME445H1: Neural Bioelectricity	F	3	1.50	1	0.50
ECE557H1: Linear Control Theory	F	3	1.50	1	0.50
MIE442H1: Machine Design	F	3	1.50	3	0.50
* MIE444H1: * Mechatronics Principles	F	2	3	-	0.50
Winter Courses		**Lect.**	**Lab.**	**Tut.**	**Wgt.**
ROB521H1: Mobile Robotics and Perception	S	3	1.50	1	0.50
CHE507H1: Data-based Modelling for Prediction and Control	S	3	-	1	0.50
CSC384H1: Introduction to Artificial Intelligence	S	2	-	1	0.50
CSC428H1	S	2	-	1	0.50
ECE411H1: Real-Time Computer Control	S	3	1.50	1	0.50
ECE516H1: Intelligent Image Processing	S	3	3	-	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
ECE532H1: Digital Systems Design	S	3	3	-	0.50
MAT363H1	S	3	-	-	0.50
MIE438H1: Microprocessors and Embedded Microcontrollers	S	2	3	-	0.50
* MIE443H1: * Mechatronics Systems: Design and Integration	S	2	5	-	0.50
MIE505H1: Micro/Nano Robotics	S	3	3	-	0.50
* MIE506H1: * MEMS Design and Microfabrication	S	3	1.50	1	0.50

NOTES:

- Computer Science courses may have limited enrollment.
- Courses requiring special approval must be approved by the undergraduate Associate Chair of the student's home department.
- Enrolment in ROB311H1 and ROB313H1 limited to Engineering Science students

MINOR IN SUSTAINABLE ENERGY (AEMINENR)

Sustainable Energy Minor (U of T Sustainability Scholar)

This minor is for students interested in learning more about energy, its sustainable use, energy demand management, and the public policy context in which energy use and production is regulated.

Our courses reach all areas of energy use, production, distribution, transmission, storage, and development. This includes energy use and production for transportation, for space cooling and heating demands, and electrical production (from both alternative and conventional sources), energy distribution and storage, and extends to energy conservation, price, greenhouse gas production and control, and aspects of public policy.

Students who complete the requirements of the Sustainable Energy Minor are considered University of Toronto Sustainability Scholars.

Students in the Engineering Science Energy System Major are not allowed to take this minor.

Course Requirements for the Minor in Sustainable Energy

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

1. CIV300H1
2. One of:
   i. APS305H1
   ii. ENV350H1
3. Four (4) other electives from the list of Sustainable Energy designated courses or departmental thesis and design courses subject to the following constraints:

i. Of the 6 half year sustainable energy courses required, one half year course can also be a core course in a student's Program, if applicable.
   ii. Of the 4 elective courses, at least 2 must be from the Advanced category.
   iii. Either a Thesis or Design course can count for up to 2 half year electives towards the 6 required courses if the Thesis or Design course is strongly related to sustainable energy. This requires approval by the Sustainable Energy Minor Director.
   iv. Some Departments may require students to select their electives from a pre-approved subset. Please contact your Departmental Advisor for details.
   v. Faculty of Arts and Science courses listed below may be considered eligible electives for students taking the Sustainable Energy Minor, subject to the student meeting any prerequisite requirements. Students must also seek the approval of their home program to ensure that they meet their degree requirements. In situations where these courses don't meet those of their home program, students can elect to take these as extra courses.

Courses offered in the Fall		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
CIV300H1: Terrestrial Energy Systems	F	3	-	2	0.50
ENV350H1	F	-	-	-	0.50
Introductory Courses					
CME259H1: Technology in Society and the Biosphere I	F	3	-	1	0.50
CHE260H1: Thermodynamics and Heat Transfer	F	3	0.50	1	0.50
CHE323H1: Engineering Thermodynamics	F	3	-	2	0.50

Courses offered in the Fall		Lect.	Lab.	Tut.	Wgt.
CHE467H1: Environmental Engineering	F	3	-	1	0.50
CIV375H1: Building Science	F	3	0.33	2	0.50
ECE313H1: Energy Systems and Distributed Generation	F	3	1.50	1	0.50
ECE314H1: Fundamentals of Electrical Energy Systems	F	3	1.50	1	0.50
ECE349H1: Introduction to Energy Systems	F	3	1.50	1	0.50
GGR347H1 (formerly JGE347H1)	F	2	-	1	0.50
Advanced Courses					
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
CHE451H1: Petroleum Processing	F	3	-	-	0.50
CHE566H1: Elements of Nuclear Engineering	F	3	-	2	0.50
CIV531H1: Transport Planning	F	3	-	1	0.50
ECE520H1: Power Electronics	F	3	1.5	1	0.50
MIE407H1: Nuclear Reactor Theory and Design	F	3	-	2	0.50
MIE515H1: Alternative Energy Systems	F	3	-	1	0.50
MIE516H1: Combustion and Fuels	F	3	-	1	0.50
APS510H1: Innovative Technologies and Organizations in Global Energy Systems	F	3	-	1	0.50

Courses Offered in the Winter		Lect.	Lab.	Tut.	Wgt.
Core Requirement Courses					
CIV300H1: Terrestrial Energy Systems	S	3	-	2	0.50
APS305H1: Energy Policy	S	3	-	1	0.50
Introductory Courses					
CHE460H1: Environmental Pathways and Impact Assessment	S	3	-	2	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
FOR310H1	S	2	-	1	0.50
GGR348H1 (formerly JGE348H1)	S	2	-	1	0.50
MIE311H1: Thermal Energy Conversion	S	3	3	-	0.50
MIE313H1: Heat and Mass Transfer	S	3	1.50	2	0.50
MSE355H1: Materials Production	S	3	-	1	0.50
JPE395H1 (formerly PHY395H1)	S	-	-	-	0.50
Advanced Courses					
APS530H1: Appropriate Technology & Design for Global Development	S	3	-	-	0.50
CHE469H1: Fuel Cells and Electrochemical Conversion Devices	S	3	-	1	0.50
CHE568H1: Nuclear Engineering	S	3	-	1	0.50
CIV576H1: Sustainable Buildings	S	3	-	0	0.50
CIV577H1: Infrastructure for Sustainable Cities	S	3	-	1	0.50
ECE463H1: Electric Drives	S	3	1.50	1	0.50
ECE526H1: Power System Protection and Automation	S	-	-	-	0.50
FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50
MIE408H1: * Thermal and Machine Design of Nuclear Power Reactors	S	3	-	2	0.50
MIE507H1: Heating, Ventilating, and Air Conditioning (HVAC) Fundamentals	S	3	-	2	0.50
MIE517H1: Fuel Cell Systems	S	3	-	1	0.50
MSE458H1: Nanotechnology in Alternate Energy Systems	S	3	-	2	0.50

Self-Initiated Minors

Students may be eligible to receive acknowledgement of an Arts and Science minor upon completion of its associated course requirements within specific disciplines (political science, cinema studies etc.). Information regarding minor requirements for each discipline may be found in the Arts and Science Calendar. A student must complete all requirements within nine calendar years of first registration, exclusive of mandatory absences from their program.

Students are advised that pursuing a self-initiated minor may extend their studies by a term or year in order to complete all program requirements.

Students must obtain documentation from the relevant department within the Faculty of Arts & Science so as to provide the Faculty with evidence that all requirements will have been completed. Successful completion will result in the annotation of the students' transcripts as to the completion of the minor.

Students may use any of their HSS elective credits, any of their CS elective credits, any Free Electives credits and/or any two other courses (two half-course equivalents) towards their Arts & Science Minor. All other courses taken for the Minor designation must be taken as "Extra" courses.

Students who have IB, AP, GCE, FB or CAPE credits may apply to the U of T Engineering Registrar's Office to have the Faculty of Arts & Science equivalent courses listed on their transcript as "Extra" courses; the course equivalencies are those in place at the time of first registration. These credits may be counted towards any Arts & Science degree designation and may be used as pre-requisites for any higher level course in the Faculty of Arts & Science.

Students wishing to pursue a Major or Specialist designation must apply to the Faculty of Arts & Science for admission for a second degree.

Note: In some disciplines, the Faculty of Arts & Science has found it necessary to restrict enrolment in upper-level courses to their own students. Students planning to pursue minors should consult the department concerned regarding the availability of courses.

Engineering Minors Courses

Aerospace Science and Engineering

AER301H1 - Dynamics

Credit Value: 0.50
Hours: 38.4L/12.8T

Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. D'Alembert's and Hamilton's principle. Orbital dynamics. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Model analysis. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Goldstein, Classical Mechanics.

Prerequisite: AER210H1, MAT185H1 and PHY180H1
Exclusion: MIE301H1
Total AUs: 44.80

AER336H1 - Scientific Computing

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduces numerical methods for scientific computation which are relevant to the solution of a wide range of engineering problems. Topics addressed include interpolation, integration, linear systems, least-squares fitting, nonlinear equations and optimization, initial value problems, and partial differential equations. The assignments require programming of numerical algorithms.

Prerequisite: ESC103H1 and MAT185H1
Total AUs: 44.80

AER407H1 - Space Systems Design

Credit Value: 0.50
Hours: 38.4P

Introduction to the conceptual and preliminary design phases for a space system currently of interest in the Aerospace industry. A team of visiting engineers provide material on typical space systems design methodology and share their experiences working on current space initiatives through workshops and mock design reviews. Aspects of operations, systems, electrical, mechanical, software, and controls are covered. The class is divided into project teams to design a space system in response to a Request for Proposals (RFP) formulated by the industrial team. Emphasis is placed on standard top-down design practices and the tradeoffs which occur during the design process. Past projects include satellites such as Radarsat, interplanetary probes such as a solar sailer to Mars, a Mars surface rover and dextrous space robotic systems.

Prerequisite: AER301H1, AER372H1
Total AUs: 51.28

AER507H1 - Introduction to Fusion Energy

Credit Value: 0.50
Hours: 38.4L/12.8T

Nuclear reactions between light elements provide the energy source for the sun and stars. On earth, such reactions could form the basis of an essentially inexhaustible energy resource. In order for the fusion reactions to proceed at a rate suitable for the generation of electricity, the fuels (usually hydrogen) must be heated to temperatures near 100 million Kelvin. At these temperatures, the fuel will exist in the plasma state. This course will cover: (i) the basic physics of fusion, including reaction cross-sections, particle energy distributions, Lawson criterion and radiation balance, (ii) plasma properties including plasma waves, plasma transport, heating and stability, and (iii) fusion plasma confinement methods (magnetic and inertial). Topics will be related to current experimental research in the field.

Total AUs: 44.80

AER525H1 - Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course addresses fundamentals of analytical robotics as well as design and control of industrial robots and their instrumentation. Topics include forward, inverse, and differential kinematics, screw representation, statics, inverse and forward dynamics, motion and force control of robot manipulators, actuation schemes, task-based and workspace design, mobile manipulation, and sensors and instrumentation in robotic systems. A series of experiments in the Robotics Laboratory will illustrate the course subjects.

Prerequisite: AER301H1 and AER372H1
Exclusion: ECE470H1
Total AUs: 54.40

Applied Science and Engineering (Interdepartmental)

APS305H1 - Energy Policy

Credit Value: 0.50
Hours: 38.4L/12.8T

Complimentary Studies Elective
Core Course in the Sustainable Energy Minor
Introduction to public policy including the role and interaction of technology and regulation, policy reinforcing/feedback cycles; procedures for legislation and policy setting at the municipal, provincial and federal levels; dimensions of energy policy; energy planning and forecasting including demand management and conservation incentives; policy institution, analysis, implementation, evaluation and evolution; Critical analyses of case studies of energy and associated environmental policies with respect to conservation and demand management for various utilities and sectors; policy derivatives for varied economic and social settings, developing countries and associated impacts.

Exclusion: ENV350H1
Total AUs: 44.80

APS360H1 - Applied Fundamentals of Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T

A basic introduction to the history, technology, programming and applications of the fast evolving field of machine learning. Topics to be covered may include neural networks, autoencoders/decoders, recurrent neural networks, natural language processing, and generative adversarial networks. Special attention will be paid to fairness and ethics issues surrounding machine learning. An applied approach will be taken, where students get hands-on exposure to the covered techniques through the use of state-of-the-art machine learning software frameworks.

Prerequisite:
APS105H1/APS106H1/ESC180H1/CSC180H1; APS163/MAT187H1/ESC195H1; MAT185H1/MAT188H1
Recommended Preparation:
CHE223H1/CME263H1/ECE302H1/MIE231H1/MIE236H1/MSE238H1/STA286H1/ECE286H1
Total AUs: 44.80

APS420H1 - Technology, Engineering and Global Development

Credit Value: 0.50
Hours: 38.4L

Humanities and Social Science Elective

The role of technology and engineering in global development is explored through a combination of lectures, readings, case studies, and analysis of key technologies, including energy, information and communications technologies, water and healthcare. Topics include a brief history and basic theories of international development and foreign aid, major government and non-government players, emerging alternative models (social entrepreneurship, microfinance, risk capital approaches), major and emerging players in social venture capital and philanthropy, the role of financial markets, environmental and resource considerations/sustainable development, technology diffusion models and appropriate technologies.

Exclusion: APS520H1, APS420H1
Total AUs: 38.40

APS500H1 - Negotiations in an Engineering Context

Credit Value: 0.50
Hours: 38.4L

Instruction of concepts, theories, and research but most importantly the practice of negotiation skills. The course will cover all kinds of negotiations scenarios that individuals might face in the course of their careers as Engineers; this could include a range of single-issue single-party negotiations to multi-party multi-issues negotiations.

Recommended Preparation: JRE420H1 or equivalent
Total AUs: 38.40

APS502H1 - Financial Engineering

Credit Value: 0.50
Hours: 38.4L

This course will focus on capital budgeting, financial optimization, and project evaluation models and their solution techniques. In particular, linear, non-linear, and integer programming models and their solutions techniques will be studied. The course will give engineering students a background in modern capital budgeting and financial techniques that are relevant in practival engineering and commercial settings.

Prerequisite: MAT186H1, MAT187H1, MAT188H1, MIE236H1, MIE237H1, or equivalent.
Exclusion: MIE375H1
Total AUs: 19.20

APS510H1 - Innovative Technologies and Organizations in Global Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

A broad range of global energy systems are presented including electricity generation, electricity end use, transportation and infrastructure. Discussions are based on two key trends: (a) the increasing ability to deploy technologies and engineering systems globally, and (b) innovative organizations, many driven by entrepreneurship (for profit and social) and entrepreneurial finance techniques. The course considers these types of innovations in the context of developed economies, rapidly developing economies such as India and China, and the developing world. The course will interweave a mix of industry examples and more in-depth case studies. The examples and cases are examined with various engineering, business and environmental sustainability analysis perspectives.

Prerequisite: Undergraduate economics course
Exclusion: APS310H1
Total AUs: 44.80

APS511H1 - Inventions and Patents for Engineers

Credit Value: 0.50
Hours: 38.4L

Teaches the process of preparing a patent application for an invention for engineers and scientists. Teaches methods to take an invention from conception to a level that a patent application can be filed on it. Describes how to write an invention disclosure. Describes how to prepare the background section, brief listing of figures, detailed description of the invention, independent and dependent claims, abstract, and artwork. Teaches use of patent search engines.

Total AUs: 38.40

APS530H1 - Appropriate Technology & Design for Global Development

Credit Value: 0.50
Hours: 38.4L

Engineering design within the context of global society, emphasizing the needs of users in order to support appropriate, sustainable technology. A design project will comprise the major component of the course work. The course will take the approach of "design for X". Students are expected to be familiar with design for functionality, safety, robustness, etc. This course will extend the students' understanding of design methodologies to design for "appropriateness in developing regions". Readings and discussions will explore the social, cultural, economic, educational, environmental and political contexts in which third world end users relate to technology. Students will then incorporate their deepened understanding of this context in their design project. The projects will be analyzed for functionality as well as appropriateness and sustainability in the third world context. Upon completion of the course, students should have a deeper appreciation of the meaning of appropriate technology in various international development sectors such as healthcare, water & sanitation, land management, energy, infrastructure, and communications in both urban and rural settings.

Total AUs: 38.40

Biomaterials and Biomedical Engineering

BME205H1 - Fundamentals of Biomedical Engineering

Credit Value: 0.50
Hours: 25.6L/12.8T/19.2P

Introduction to connecting engineering and biological approaches to solve problems in medicine, science, and technology. Emphasis is placed on demonstrating the connection between organ level function with cellular mechanisms. Topics may include, but are not limited to: design principles of biological systems, medical devices, overviews of anatomy and physiology, and cellular mechanisms as they relate to biotechnological and medical technology applications. Laboratories will provide hands-on experiences with selected concepts and encourage students to understand how to connect their own vital and physiologic signs to current medical technologies.

Exclusion: CHE353H1 or BIO130H1
Total AUs: 41.60

BME330H1 - Patents in Biology and Medical Devices

Credit Value: 0.50
Hours: 38.4L

The emphasis of the course is on applying the logic of patents to diverse cases of products through biology and biomedical engineering. A commercial context will be ever present the case studies. Students will work in teams on these problems in class. Students will learn to apply tests for obviousness, inventiveness, novelty and enablement based on the use of these tests in technology patents in the past. Claim construction will be introduced towards the end of the course to learn how technologies can be protected in considering a patent. There will be papers for reading in this course but no textbook. This course is designed for senior undergraduate students (3-4 year).

Prerequisite: CHE353H1 or BME205H1
Total AUs: 38.40

BME331H1 - Physiological Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Introduces physiological concepts and selected physiological control systems present in the human body, and proposes quantitative modeling approaches for these systems. Topics covered will include (1) the endocrine system and its subsystems, including glucose regulation and the stress response, (2) the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation, and (3) the nervous and musculoskeletal systems, including the control of voluntary motion. Linear control theory will be used to develop skills in system modeling and examine concepts of system response and system control in the context of a healthy human body.

Prerequisite: CHE353H1
Total AUs: 51.20

BME346H1 - Biomedical Engineering and Omics Technologies

Credit Value: 0.50
Hours: 25.6L/51.2P

An introduction to the principles and design of fundamental technologies used in biomedical engineering and "omics" research. Topics may include but are not limited to tissue culture; spectroscopy; electrophoresis; PCR, genomics, sequencing technologies, and gene expression measurement; protein expression assays and tagging strategies; fluorescence labeling tools, microscopy, and high content imaging; DNA manipulation and transfection, RNAi, and other genetic and molecular tools for transformation of organisms. Laboratories will provide hands-on experience with selected technologies. Students will engage in a major design project in which they will design an experimental plan to investigate a specific research question, also of their design, utilizing available laboratory technologies.

Prerequisite: BME205H1
Exclusion: BME340H1, BME440H1
Total AUs: 51.20

BME350H1 - Biomedical Systems Engineering I: Organ Systems

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

An introduction to human anatomy and physiology with selected focus on the nervous, cardiovascular, respiratory, renal, and endocrine systems. The structures and mechanisms responsible for proper function of these complex systems will be examined in the healthy and diseased human body. The integration of different organ systems will be stressed, with a specific focus on the structure-function relationship. Application of biomedical engineering technologies in maintaining homeostasis will also be discussed.

Prerequisite: BME205H1
Corequisite: BME395H1
Total AUs: 57.60

BME395H1 - Biomedical Systems Engineering II: Cells and Tissues

Credit Value: 0.50
Hours: 25.6L/25.6T/12.8P

Tissue engineering is largely based on concepts that emerged from developmental biology. This course provides an introduction to the study of animal development, both at the cellular and molecular levels. Topics include developmental patterning, differential gene expression, morphogenesis, stem cells, repair and regeneration.

Corequisite: BME350H1
Exclusion: CHE353H1

BME435H1 - Biostatistics

Credit Value: 0.50
Hours: 38.4L/12.8T

This is intended to provide students interested in biomedical research with an introduction to core statistical concepts and methods, including experimental design. The course also provides a good foundation in the use of discovery tools provided by a data analysis and visualization software. The topics covered will include: i) Importance of being uncertain; ii) Error bars; iii) Significance, p-values and t-tests; iv) Power and sample size; v) Visualizing samples with box plots; vi) Comparing samples; vii) Non parametric tests; viii) Designing comparative experiments; ix) Analysis of variance and blocking; x) Replication; xi) Two-factor designs; xii) Association, correlation and causation; xiii) Simple linear regression; xiv) Regression diagnostics. The concepts will be illustrated with realistic examples that are commonly encountered by biomedical researchers (as opposed to the simpler examples described in entry-level textbooks). The statistical softwares used in this course are JMP and R Studio.

Total AUs: 44.80

BME440H1 - Biomedical Engineering Technology and Investigation

Credit Value: 0.50
Hours: 25.6L/51.2P

Fundamental biomedical research technologies with specific focus on cellular and molecular methodologies. Examples include DNA and protein analysis and isolation, microscopy, cell culture and cellular assays. Combines both theoretical concepts and hand-on practical experience via lectures and wet labs, respectively. Specific applications as applied to biotechnology and medicine will also be outlined and discussed.

Prerequisite: CHE353H1
Total AUs: 51.20

BME445H1 - Neural Bioelectricity

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Generation, transmission and the significance of bioelectricity in neural networks of the brain. Topics covered include: (i) Basic features of neural systems. (ii) Ionic transport mechanisms in cellular membranes. (iii) Propagation of electricity in neural cables. (iv) Extracellular electric fields. (v) Neural networks, neuroplasticity and biological clocks. (vi) Learning and memory in artificial neural networks. Laboratory experiences include: (a) Biological measurements of body surface potentials (EEG and EMG). (b) Experiments on computer models of generation and propagation of neuronal electrical activities. (c) Investigation of learning in artificial neural networks. This course was previously offered as ECE445H1.

Prerequisite: ECE159H1/ECE110H1
Total AUs: 54.40

BME455H1 - Cellular and Molecular Bioengineering II

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Engineering and biophysical tools are used to integrate and enhance our understanding of animal cell behaviour from the molecular to the tissue level. Quantitative methods are used to mathematically model the biology of cell growth, division and differentiation to tissue formation. Specific topics include receptor-ligand interactions, cell adhesion and migration, signal transduction, cell growth and differentiation. Examples from the literature are used to highlight applications in cellular and tissue engineering.

Prerequisite: CHE353H1 and CHE354H1
Total AUs: 54.40

BME498Y1 - Biomedical Engineering Capstone Design

Credit Value: 1.00
Hours: 25.6L/12.8T/38.4P

In this project-based design course, teams of students from diverse engineering disciplines (enrolled in the biomedical engineering minor) will engage in the biomedical technology design process to identify, invent and implement a solution to an unmet clinical need defined by external clients and experts. This course emphasizes "hands-on" practicums and lectures to support a student-driven design project. The UG Office will reach out in the summer to 4th year BME Minor students regarding course registration. For A&S students, approval to register in the course must be obtained from the course instructor by completing the application available through the BME UG Office.

Total AUs: 44.80

BME499Y1 - Applied Research in Biomedical Engineering

Credit Value: 1.00
Hours: 12.8L/89.6P

This course provides the opportunity to gain immersive experiences in dynamic biomedical research laboratories. Students will be required to perform two modules (one is completed in the Fall semester and the second is completed in the Winter semester); each module will provide minimum 90 hours of hands-on and/or observational activity. Students will select opportunities with faculty in laboratories classified within two (of four) different themes at the Institute of Biomaterials and Biomedical Engineering (IBBME). Activities will provide exposure to experimental design, the use of analytical equipment, and assessment of relevant literature (scientific, patent, and regulatory) related to the research topic identified by the faculty member.

You may only register in this course after obtaining approval from the BME Undergraduate Office.

Prerequisite: CHE353H1 or equivalent
Corequisite: MIE331H1
Total AUs: 57.60

BME595H1 - Medical Imaging

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

An introductory course to medical imaging and is designed as a final year course for engineers. The main clinical imaging modalities are covered: magnetic resonance imaging, ultrasound imaging, x-ray and computed tomography, nuclear medicine, and clinical optical imaging. Emphasis is placed on the underlying physical and mathematical concepts behind each modality, and applications are discussed in the context of how different modalities complement one another in the clinical setting. Early year engineering concepts are extensively used, including: basic electromagnetics theory, fields and waves, signals and systems, digital signal processing, differential equations and calculus, and probability and random processes. The laboratories involve image reconstruction and analysis for the various imaging modalities and a live animal imaging session.

Total AUs: 51.20

Chemical Engineering and Applied Chemistry

CHE230H1 - Environmental Chemistry

Credit Value: 0.50
Hours: 38.4L/25.6T

The chemical phenomena occurring in environmental systems are examined based on fundamental principles of organic, inorganic and physical chemistry. The course is divided into sections describing the chemistry of the atmosphere, natural waters and soils. The principles applied in the course include reaction kinetics and mechanisms, complex formation, pH and solubility equilibria and adsorption phenomena. Molecules of biochemical importance and instrumental methods of analysis relevant to environmental systems are also addressed. (formerly EDC230H1S)

Total AUs: 51.20

CHE249H1 - Engineering Economic Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering analysis and design are not ends in themselves, but they are a means for satisfying human wants. Thus, engineering concerns itself with the materials used and forces and laws of nature, and the needs of people. Because of scarcity of resources and constraints at all levels, engineering must be closely associated with economics. It is essential that engineering proposals be evaluated in terms of worth and cost before they are undertaken. In this course we emphasize that an essential prerequisite of a successful engineering application is economic feasibility. Hence, investment proposals are evaluated in terms of economic cost concepts, including break even analysis, cost estimation and time value of money. Effective interest rates, inflation and deflation, depreciation and income tax all affect the viability of an investment. Successful engineering projects are chosen from valid alternatives considering such issues as buy or lease, make or buy, cost and benefits and financing alternatives. Both public sector and for-profit examples are used to illustrate the applicability of these rules and approaches.

Total AUs: 44.80

CHE260H1 - Thermodynamics and Heat Transfer

Credit Value: 0.50
Hours: 38.4L/12.8T/6.4P

Classical thermodynamics and its applications to engineering processes. Concepts of energy, heat, work and entropy. First and second laws of thermodynamics. Properties of pure substances and mixtures. Phase equilibrium. Ideal heat engines and refrigerators. Mechanisms of heat transfer: conduction, convection and radiation. Steady state heat transfer. Solution of conduction equation. Convective heat transfer coefficients. Momentum and heat transfer analogies. Basics of radiative heat transfer..

Exclusion: CHE210H1, CHE323H1, CHE326H1, CHE119H1, MSE202H1 or MIE210H1
Recommended Preparation: MAT195H1
Total AUs: 48.00

CHE322H1 - Process Control

Credit Value: 0.50
Hours: 38.4L/25.6T

The major goal of this course is to teach students how to design control strategies for chemical processes. The first part of the course focuses on the types of interconnections encountered in chemical engineering, namely feedback, parallel and series connections, and their effect on the process dynamics. The second part of the course looks at the design of feedback, feedforward, cascade and multivariable control strategies for these processes and interprets these types of engineered interconnections in terms of the effect they have on the performance of the overall system. This course makes extensive use of active learning through computer simulation based on MATLAB/Simulink and Aspen Plus Dynamics software.

Total AUs: 51.20

CHE323H1 - Engineering Thermodynamics

Credit Value: 0.50
Hours: 38.4L/25.6T

Classical thermodynamics and its applications to engineering processes are introduced. Topics include: the concepts of energy, work and entropy; the first and second laws of thermodynamics; properties of pure substances and mixtures; the concepts of thermal equilibrium, phase equilibrium and chemical equilibrium; and heat engines and refrigeration cycles.

Total AUs: 51.20

CHE353H1 - Engineering Biology

Credit Value: 0.50
Hours: 25.6L/25.6T

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.

Exclusion: BME205H1
Total AUs: 38.40

CHE354H1 - Cellular and Molecular Biology

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses.

Prerequisite: CHE353H1
Total AUs: 57.60

CHE374H1 - Economic Analysis and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

Economic evaluation and justification of engineering projects and investment proposals. Cost estimation; financial and cost accounting; depreciation; inflation; equity, bond and loan financing; after tax cash flow; measures of economic merit in the private and public sectors; sensitivity and risk analysis; single and multi-attribute decisions. Introduction to micro-economic. Applications: retirement and replacement analysis; make-buy and buy-lease decisions; economic life of assets; capital budgeting; selection from alternative engineering proposals; production planning; investment selection.

Prerequisite: MAT194H1, ESC103H1
Exclusion: CHE249H1, CME368H1/MIE258H1
Total AUs: 44.80

CHE416H1 - Chemical Engineering in Human Health

Credit Value: 0.50
Hours: 38.4L/12.8T

Life expectancy has consistently increased over the past 70 years due to advances in healthcare and sanitation. Engineers have played key roles in developing technologies and processes that enabled these critical advances in healthcare to occur. This course will provide an overview of areas in which chemical engineers directly impacted human health. We will study established processes that had transformative effects in the past as well as new emerging areas that chemical engineers are developing today to impact human health. Emphasis will be placed on quantitative approaches. Engineering tools, especially derived from transport phenomena and chemical kinetics will be used. Required readings, including scientific papers, will be assigned. Industrial visit and/or a hands-on project will be included.

Prerequisite: CHE353H1, CHE354H1/MIE331H1; BME205H1
Total AUs: 44.80

CHE441H1 - Engineering Materials

Credit Value: 0.50
Hours: 38.4L/12.8T

This course advances the understanding of the use of materials in engineering design, with special emphasis on corrosion and the effect of chemical environment on long term failure modes. Students will learn how to apply material property data to specify materials for load bearing applications, thermal and other non-structural applications, and chemical containment and transport. Topics will include strength of materials concepts, an introduction to computerized materials databases, material failure modes and criteria, principles of corrosion, and practical applications of corrosion prediction and mitigation. Students are required to design a component of their choice and do a detailed materials selection as a major design project.

Total AUs: 44.80

CHE450H1 - Bioprocess Technology and Design

Credit Value: 0.50
Hours: 38.4L/12.8T/8.448P

Building upon CHE353 and CHE354, the aim of this course is to learn and apply engineering principles relevant to bioprocess engineering, including energetics and stoichiometry of cell growth, cell and enzyme kinetics, metabolic modeling, bioreactor design, and bioseparation processes. In addition to course lectures, students will complete two laboratory exercises that will provide hands-on learning in bioreactor set-up and use.

Prerequisite: CHE353H1 and CHE354H1
Total AUs: 49.02

CHE451H1 - Petroleum Processing

Credit Value: 0.50
Hours: 38.4L

This course is aimed at surveying the oil industry practices from the perspective of a block flow diagram. Oil refineries today involve the large scale processing of fluids through primary separation techniques, secondary treating plus the introduction of catalyst for molecular reforming in order to meet the product demands of industry and the public. Crude oil is being shipped in increasing quantities from many parts of the world and refiners must be aware of the properties and specifications of both the crude and product slates to ensure that the crude is a viable source and that the product slate meets quality and quantity demands thus assuring a profitable operation. The course content will examine refinery oil and gas operations from feed, through to products, touching on processing steps necessary to meet consumer demands. In both course readings and written assignments, students will be asked to consider refinery operations from a broad perspective and not through detailed analysis and problem solving.

Total AUs: 38.40

CHE460H1 - Environmental Pathways and Impact Assessment

Credit Value: 0.50
Hours: 38.4L/25.6T

Review of the nature, properties and elementary toxicology of metallic and organic contaminants. Partitioning between environmental media (air, aerosols, water, particulate matter, soils, sediments and biota) including bioaccumulation. Degradation processes, multimedia transport and mass balance models. Regulatory approaches for assessing possible effects on human health and ecosystems.

Total AUs: 51.20

CHE462H1 - Food Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The quantitative application of chemical engineering principles to the large-scale production of food. Food processing at the molecular and unit operation levels. The chemistry and kinetics of specific food processes. The application of chemical engineering unit operations (distillation, extraction, drying) and food specific unit operations such as extrusion, thermal processing refrigeration/freezing.

Total AUs: 44.80

CHE467H1 - Environmental Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor A course which treats environmental engineering from a broad based but quantitative perspective and covers the driving forces for engineering activities as well as engineering principles. Models which are used for environmental impact, risk analysis, health impact, pollutant dispersion, and energy system analysis are covered.

Total AUs: 44.80

CHE469H1 - Fuel Cells and Electrochemical Conversion Devices

Credit Value: 0.50
Hours: 38.4L/12.8T

The objective of this course is to provide a foundation for understanding the field of electrochemical conversion devices with particular emphasis on fuel cells. The topics will proceed from the fundamental thermodynamic in-system electodics and ionic interaction limitations to mass transfer and heat balance effects,t o the externalities such as economics and system integration challenges. Guest lecturers from the fuel cell industry will be invited to procide an industrial perspective. Participants will complete a paper and in-class presentation.

Exclusion: MIE517H1
Total AUs: 44.80

CHE471H1 - Modelling in Biological and Chemical Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course outlines the methodology for the modelling of biological systems and its applications. Topics will include a review of physical laws, selection of balance space, compartmental versus distributed models, and applications of the conservation laws for both discrete and continuous systems at the level of algebraic and ordinary differential equations. The course covers a wide range of applications including environmental issues, chemical and biochemical processes and biomedical systems.

Total AUs: 44.80

CHE475H1 - Biocomposites: Mechanics and Bioinspiration

Credit Value: 0.50
Hours: 38.4L/12.8T

An overview on structure, processing and application of natural and biological materials, biomaterials for biomedical applications, and fibre-reinforced eco-composites based on renewable resources will be provided. Fundamental principles related to linear elasticity, linear viscoelasticity, dynamic mechanical response, composite reinforcement mechanics, and time-temperature correspondence will be introduced. Novel concepts in comparative biomechanics, biomimetic and bio-inspired material design, and materials' ecological and environmental impact will be discussed. In addition, key material processing methods and testing and characterization techniques will be presented. Structure-property relationships for materials broadly ranging from natural materials, including wood, bone, cell, and soft tissue, to synthetic composite materials for industrial and biomedical applications will be covered.

Total AUs: 44.80

CHE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MIE488H1, MSE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

CHE507H1 - Data-based Modelling for Prediction and Control

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will teach students how to build mathematical models of dynamic systems and how to use these models for prediction and control purposes. The course will deal primarily with a system identification approach to modelling (using observations from the system to build a model). Both continuous time and discrete time representations will be treated along with deterministic and stochastic models. This course will make extensive use of interactive learning by having students use computer based tools available in the Matlab software package (e.g. the System Identification Toolbox and the Model Predictive Control Toolbox).

Total AUs: 44.80

CHE561H1 - Risk Based Safety Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an introduction to Process Safety Management. The historical drivers to improve safety performance are reviewed and the difference between safety management and occupational health and safety is discussed. National and international standards for PSM are reviewed. Risk analysis is introduced along with techniques for process hazard analysis and quantification. Consequence and frequency modelling is introduced. Rsik based decision making is introduced, and the course concludes with a discussio of the key management systems required for a successful PSM system.

Total AUs: 44.80

CHE562H1 - Applied Chemistry IV - Applied Polymer Chemistry, Science and Engineering

Credit Value: 0.50
Hours: 38.4L

This course serves as an introduction to concepts in polymer chemistry, polymer science and polymer engineering. This includes a discussion of the mechanisms of step growth, chain growth and ring-opening polymerizations with a focus on industrially relevant polymers and processes. The description of polymers in solution as well as the solid state will be explored. Several modern polymer characterization techniques are introduced including gel permeation chromatography, differential scanning calorimetry, thermal gravimetric analysis and others.

Exclusion: CHM426H1
Recommended Preparation: CHE213H1, CHE220H1 or equivalents
Total AUs: 38.40

CHE564H1 - Pulp and Paper Processes

Credit Value: 0.50
Hours: 38.4L/12.8T

The processes of pulping, bleaching and papermaking are used to illustrate and integrate chemical engineering principles. Chemical reactions, phase changes and heat, mass and momentum transfer are discussed. Processes are examined on four scales: molecular, diffusional, unit operations and mill. In the tutorial each student makes several brief presentations on selected topics and entertains discussion.

Total AUs: 44.80

CHE565H1 - Aqueous Process Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2) treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

Total AUs: 44.80

CHE566H1 - Elements of Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

A first course in nuclear engineering intended to introduce students to all aspects of this interdisciplinary field. Topics covered include nuclear technology, atomic and nuclear physics, thermonuclear fusion, nuclear fission, nuclear reactor theory, nuclear power plants, radiation protection and shielding, environment and nuclear safety, and the nuclear fuel cycle.

Total AUs: 51.20

CHE568H1 - Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamental and applied aspects of nuclear engineering. The structure of the nucleus; nuclear stability and radioactive decay; the interaction of radiation with matter including radiological health hazards; the interaction of neutrons including cross-sections, flux, moderation, fission, neutron diffusion and criticality. Poison buildup and their effects on criticality. Nuclear engineering of reactors, reactor accidents, and safety issues.

Exclusion: MIE414H1
Total AUs: 44.80

Civil Engineering

CIV220H1 - Urban Engineering Ecology

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor Basic concepts of ecology within the context of urban environments. Response of organisms, populations, dynamic predator-prey and competition processes, and ecosystems to human activities. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Biogeochemical cycles, habitat fragmentation and bioaccumulation. Introduction to industrial ecology and life cycle assessment principles. Urban metabolism and material flow analysis of cities. Response of receiving waters to pollution and introduction to waste water treatment. Emphasis is on identifying the environment/engineering interface and minimizing environmental impacts.

Prerequisite: CHE112H1
Total AUs: 44.80

CIV250H1 - Hydraulics and Hydrology

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The hydrologic processes of precipitation and snowmelt, evapotranspiration, ground water movement, and surface and subsurface runoff are examined. Water resources sustainability issues are discussed, including water usage and water shortages, climate change impacts, land use impacts, and source water protection. Conceptual models of the hydrologic cycle and basics of hydrologic modelling are developed, including precipitation estimation, infiltration and abstraction models, runoff hydrographs, the unit hydrograph method and the Rational method. Methods for statistical analysis of hydrologic data, concepts of risk and design, and hydrological consequences of climate change for design are introduced. Principles of open channel hydraulics are introduced. Energy and momentum principles are studied with application to channel transitions, critical flow, choked flow, and hydraulic jumps.

Prerequisite: CME270H1
Total AUs: 54.40

CIV300H1 - Terrestrial Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

Exclusion: ENV346H1
Total AUs: 51.20

CIV342H1 - Water and Wastewater Treatment Processes

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Principles involved in the design and operation of water and wastewater treatment facilities are covered, including physical, chemical and biological unit operations, advanced treatment and sludge processing.

Total AUs: 51.20

CIV375H1 - Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T/4.224000168P

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.

Exclusion: CIV575H1
Total AUs: 53.31

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

CIV488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered in other Departments: MSE488H1, MIE488H1, ECE488H1 and CHE488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

CIV531H1 - Transport Planning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course is intended to provide the student with the following: the ability to design and execute an urban transportation planning study; a working knowledge of transportation planning analysis skills including introductions to travel demand modelling, analysis of environmental impacts, modelling transportation - land use interactions and transportation project evaluation; an understanding of current transportation planning issues and policies; and an understanding of the overall process of transportation planning and its role within the wider context of transportation decision-making and the planning and design of urban areas. Person-based travel in urban regions is the focus of this course, but a brief introduction to freight and intercity passenger transportation is also provided. A "systems" approach to transportation planning and analysis is introduced and maintained throughout the course. Emphasis is placed throughout on designing transportation systems for long-run environmental, social, and economic sustainability.

Prerequisite: CME368H1 or equivalent
Total AUs: 44.80

CIV536H1 - Urban Activity, Air Pollution, and Health

Credit Value: 0.50
Hours: 38.4L

This is an interdisciplinary course where the challenge of air pollution is introduced with a focus on urban areas. The interdependencies between transportation, air quality, and health are demonstrated. The city and the behaviour of its inhabitants constitute the context for the following course topics: overview of air pollutants in urban areas, urban air quality monitoring networks, mobile source emissions, air pollution and meteorology, atmospheric dispersion, chemical processes specific to cities, personal mobility and exposure to traffic-related air pollution, epidemiology of air pollution.

Total AUs: 38.40

CIV541H1 - Environmental Biotechnology

Credit Value: 0.50
Hours: 38.4L

Principles involved in the design and operation of biologically-based treatment facilities are covered with considerations for energy efficiency and sustainability. The course includes water / wastewater biological unit operations, advanced treatment, sludge processing and composting, natural treatment systems and specialized bioengineered systems such as groundwater remediation and biological air treatment.

Prerequisite: CIV342H1 or equivalent
Total AUs: 38.40

CIV549H1 - Groundwater Flow and Contamination

Credit Value: 0.50
Hours: 38.4L/12.8T

Mechanics of saturated and unsaturated fluid flow in porous media. Confined and unconfined flow. Flow to wells. Analytical and numerical solutions of groundwater flow equations. Non-reactive and reactive contaminant transport on groundwater systems. Analytical and numerical solutions of contaminant transport equations. Flow and solute transport in fractured porous media. Assessment of environmental impacts of waste disposal operations. Remediation of contaminated groundwater.

Prerequisite: CME270H1, CIV250H1 or equivalent
Total AUs: 44.80

CIV550H1 - Water Resources Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

Global and national water problems, law and legislation. Hydraulic structures. Reservoir analysis. Urban drainage and runoff control: meteorologic data analysis, deterministic and stochastic modelling techniques. Flood control: structural and nonstructural alternatives. Power generation: hydro and thermal power generation. Low flow augmentation. Economics and decision making.

Prerequisite: CIV250H1, CIV340H1 or equivalent
Total AUs: 51.20

CIV575H1 - Studies in Building Science

Credit Value: 0.50
Hours: 38.4L/25.6T

This course examines the basic principles governing the control of heat, moisture and air movement in buildings and presents the fundamentals of building enclosure design. With this background, students are required to research advanced topics related to emerging areas of Building Science, and to write and present to the class an individual comprehensive paper related to their research. Lectures for this course will be jointly offered with those of CIV375H1.

Exclusion: CIV375H1
Total AUs: 51.20

CIV576H1 - Sustainable Buildings

Credit Value: 0.50
Hours: 38.4L/12.8T

Building systems including the thermal envelope, heating and cooling systems, as well as water and lighting systems are examined with a view to reducing the net energy consumed within the building. Life-cycle economic and assessment methods are applied to the evaluation of various design options including considerations of embodied energy and carbon sequestration. Green building strategies including natural ventilation, passive solar, photovoltaics, solar water heaters, green roofs and geothermal energy piles are introduced. Following the application of these methods, students are introduced to efficient designs including LEED designs that lessen the impact of buildings on the environment. Exemplary building designs will be presented and analyzed.

Prerequisite: CIV375H1/CIV575H1 or equivalent
Total AUs: 44.80

CIV577H1 - Infrastructure for Sustainable Cities

Credit Value: 0.50
Hours: 38.4L/12.8T

Developing infrastructure for sustainable cities entails understanding the connection between urban morphology and physiology. This course uses a systems approach to analyzing anthropogenic material flow and other components of urban metabolism, linking them to the design of urban infrastructure. Elements of sustainable transportation, green buildings, urban climatology, urban vegetation, water systems and local energy supply are integrated in the design of sustainable urban neighbourhoods.

Prerequisite: CIV340H1, [CIV375H1/CIV575H1]
Total AUs: 44.80

CIV578H1 - Design of Building Enclosures

Credit Value: 0.50
Hours: 38.4L/25.6T

A brief summary of the science involved in controlling heat, moisture and air movement in buildings is presented at the outset of the course. With this background, methods of designing enclosures for cold, mixed, and hot climates are examined. Design principles related to the design of walls, windows and roofs are presented and applied. In particular, topics related to the control of rain penetration, air movement, and interstitial condensation are studied in detail. Emphasis is placed on developing designs based on fundamentals which can be verified with computer modelling solutions.

Prerequisite: CIV375H1/CIV575H1 or equivalent
Total AUs: 51.20

Civil and Mineral Engineering

CME259H1 - Technology in Society and the Biosphere I

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science Elective
This course teaches future engineers to look beyond their specialized domains of expertise in order to understand how technology functions within human life, society and the biosphere. By providing this context for design and decision-making, students will be enabled to do more than achieve the desired results by also preventing or significantly reducing undesired consequences. A more preventively-oriented mode of practicing engineering will be developed in four areas of application: materials and production, energy, work and cities. The emphasis within these topics will reflect the interests of the class.

Exclusion: ESC203H1
Total AUs: 44.80

CME368H1 - Engineering Economics and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

The incorporation of economic and non-monetary considerations for making decision about public and private sector engineering systems in urban and other contexts. Topics include rational decision making; cost concepts; time value of money and engineering economics; microeconomic concepts; treatment of risk and uncertainty; and public project evaluation techniques incorporating social and environmental impacts including benefit cost analysis and multi-objective analysis.

Total AUs: 44.80

CME500H1 - Fundamentals of Acid Rock Drainage

Credit Value: 0.50
Hours: 38.4L/12.8T/25.6P

Geochemistry of acid rock / acid mine drainage (ARD/AMD) which covers the role of bacteria in generating this global mining pollution issue and how mines currently treat and attempt to prevent it. An introduction to the underlying chemical reactions involved, the role of microbes in these processes and the mitigation and treatment strategies currently available.

* Course offering pending Faculty Council approval for 2018-19 academic year.

Prerequisite: APS110H1/CHE112H1 or equivalent
Total AUs: 57.60

Computer Science

CSC343H1 - Introduction to Databases

Credit Value: 0.50
Hours: 36L

Introduction to database management systems. The relational data model. Relational algebra. Querying and updating databases: the query language SQL. Application programming with SQL. Integrity constraints, normal forms, and database design. Elements of database system technology: query processing, transaction management.

Prerequisite: CSC111H1/ CSC165H1/ CSC240H1/ (MAT135H1, MAT136H1)/ MAT135Y1/ MAT137Y1/ MAT157Y1/ (MAT186H1, MAT187H1)/ (MAT194H1, MAT195H1)/ (ESC194H1, ESC195H1); CSC207H1/ CSC207H5/ CSCB07H3/ ECE345H1/ ESC190H1
Exclusion: CSC443H1. NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Total AUs: 34.00

CSC384H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 24L/12T

Theories and algorithms that capture (or approximate) some of the core elements of computational intelligence. Topics include: search; logical representations and reasoning, classical automated planning, representing and reasoning with uncertainty, learning, decision making (planning) under uncertainty. Assignments provide practical experience, in both theory and programming, of the core topics.

Prerequisite: (CSC263H1/ CSC265H1/ CSC263H5/ CSCC63H3/ ECE345H1/ ECE358H1/ MIE335H1, STA237H1/ STA247H1/ STA255H1/ STA257H1/ STA237H1/ STAB57H3/ STAB52H3/ ECE302H1/ STA286H1/ CHE223H1/ CME263H1/ MIE231H1/ MIE236H1/ MSE238H1/ ECE286H1)
Exclusion: NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Recommended Preparation: CSC324H1
Total AUs: 32.00

Electrical and Computer Engineering

ECE313H1 - Energy Systems and Distributed Generation

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Three-phase systems; steady-state transmission line model; symmetrical three-phase faults; power system stability; symmetrical components; unsymmetrical faults and fault current calculation; distribution network; equivalent steady-state model of voltage-sourced converter; distributed energy resources (DR); distributed energy storage; interface between DR and power system.

Exclusion: ECE413H1
Total AUs: 70.40

ECE314H1 - Fundamentals of Electrical Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Introduction to 3-phase systems, single line diagrams and complex power flow. Energy conversion via switch-mode power electronic circuits: DC/DC converters, DC/AC converters. Energy conversions via magnetic devices: Faraday's law for time varying fields, characterization of hysteresis and eddy current losses in magnetic materials, modelling of magnetic circuits, transformer and inductor modelling and design. Introduction to electromechanical energy conversion: Lorentz Force, concepts of energy, co-energy, forces between ferromagnetic materials carrying flux, simple magnetic actuators.

Prerequisite: ECE212H1 and ECE221H1 and ECE231H1
Exclusion: ECE315H1
Total AUs: 54.40

ECE316H1 - Communication Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in analog and digital communication systems. Analog and digital signals. Signal representation and Fourier transforms; energy and power spectral densities; bandwidth. Distortionless analog communication; amplitude, frequency and phase modulation systems; frequency division multiplexing. Sampling, quantization and pulse code modulation (PCM). Baseband digital communication; intersymbol interference (ISI); Nyquist's ISI criterion; eye diagrams. Passband digital communications; amplitude-, phase- and frequency-shift keying; signal constellations. Performance analysis of analog modulation schemes in the presence of noise. Performance analysis of PCM in noise.

Prerequisite: (MAT290H1, ECE216H1) /(MAT389H1, ECE355H1)
Total AUs: 53.40

ECE330H1 - Quantum and Semiconductor Physics

Credit Value: 0.50
Hours: 38.4L/25.6T

The course introduces the principles of quantum physics and uses them to understand the behaviour of semiconductors. Topics to be covered include wave-particle duality, Schrodinger's equation, energy quantization, quantum mechanical tunnelling, electrons in crystalline semiconductors and other physical concepts that form the basis for nanotechnology, microelectronics, and optoelectronics.

Prerequisite: ECE221H1/ECE231H1
Exclusion: MSE235H1
Total AUs: 51.20

ECE335H1 - Introduction to Electronic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

Electrical behaviour of semiconductor structures and devices. Metal-semiconductor contacts; pn junctions, diodes, photodetectors, LED's; bipolar junction transistors, Ebers-Moll and hybrid-pi models; field effect transistors, MOSFET, JFET/MESFET structures and models; thyristors and semiconductor lasers.

Prerequisite: MAT291H1 and ECE221H1 and ECE231H1
Exclusion: MSE235H1
Total AUs: 51.20

ECE344H1 - Operating Systems

Credit Value: 0.50
Hours: 38.4L/38.4P

Operating system structures, concurrency, synchronization, deadlock, CPU scheduling, memory management, file systems. The laboratory exercises will require implementation of part of an operating system.

Prerequisite: ECE244H1 and ECE243H1
Exclusion: ECE353H1
Total AUs: 53.40

ECE345H1 - Algorithms and Data Structures

Credit Value: 0.50
Hours: 38.4L/25.6T

Design and analysis of algorithms and data structures that are essential to engineers in every aspect of the computer hardware and software industry. Recurrences, asymptotics, summations, trees and graphs. Sorting, search trees and balanced search trees, amortized analysis, hash functions, dynamic programming, greedy algorithms, basic graph algorithms, minimum spanning trees, shortest paths, introduction to NP completeness and new trends in algorithms and data structures.

Prerequisite: ECE244H1 or equivalent with the permission of the Chair of the AI certificate/minor.
Total AUs: 50.40

ECE349H1 - Introduction to Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Established and emerging sources of electrical energy: hydroelectric, thermal, wind, and solar. Three-phase AC systems and complex power. Mechanisms for electrical-electrical energy conversion: power electronic systems for DC-DC conversion, single-phase DC-AC and three-phase DC-AC conversion, transformers for single-phase and three-phase AC-AC conversion. Electro-mechanical energy conversion via the synchronous machine. Fundamentals of AC electrical energy networks: frequency regulation, voltage regulation, and protection.

Prerequisite: ECE259H1
Exclusion: ECE314H1
Total AUs: 54.40

ECE350H1 - Semiconductor Electronic Devices

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An explanation of the basic operation, design and limitations of semiconductor electronic devices, such as diodes and transistors. The topics covered include: electrons in semiconductors, semiconductors in equilibrium, transport of carriers, p-n diodes, metal-semiconductor contacts, bipolar junction transistors, metal-oxide-semiconductor (MOS) capacitors, and MOS field effect transistors. In addition, optoelectronic devices (e.g. photodiodes, light emitting diodes and lasers), semiconductor heterostructures, nanostructures (quantum dots, qubits) and transistor scaling will be discussed.

Prerequisite: PHY294H1
Exclusion: ECE335H1, ECE330H1
Total AUs: 54.40

ECE353H1 - Systems Software

Credit Value: 0.50
Hours: 38.4L/38.4P

Operating system structure, processes, threads, synchronization, CPU scheduling, memory management, file systems, input/output, multiple processor systems, virtualization, protection, and security. The laboratory exercises will require implementation of part of an operating system.

Prerequisite: ESC190H1
Exclusion: ECE344H1, CSC369H1
Total AUs: 57.60

ECE356H1 - Introduction to Control Theory

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introduction to dynamic systems and their control. Differential equation models of physical systems using transfer functions and state space models. Linearization. Initial and input response. Stability theory. Principle of feedback. Internal Model Principle. Frequencey response. Nyquist stability. Loop shaping theory. Computer aided design using MATLAB and Simulink.

Prerequisite: MAT292H1
Exclusion: ECE311H1, AER372H1
Total AUs: 54.40

ECE358H1 - Foundations of Computing

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamentals of algorithm design and computational complexity, including: analysis of algorithms, graph algorithms, greedy algorithms, divide-and-conquer, dynamic programming, network flow, approximation algorithms, the theory of NP-completeness, and various NP-complete problems.

Prerequisite: ESC190H1
Exclusion: ECE345H1
Total AUs: 44.80

ECE363H1 - Communication Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in analog and digital communication systems. Analog and digital signals. Probability and random processes. Energy and power spectral densities; bandwidth. Distortionless analog communication; amplitude, frequency and phase modulation systems; frequency division multiplexing. Sampling, quantization and pulse code modulation (PCM). Baseband digital communication; intersymbol interference

(ISI); Nyquist's ISI criterion; eye diagrams. Passband digital communications; amplitude-, phase- and frequency-shift keying; signal constellations. Performance analysis of analog modulation schemes in the presence of noise. Performance analysis of PCM in noise.

Prerequisite: MAT389H1, ECE355H1
Exclusion: ECE316H1
Total AUs: 54.40

ECE367H1 - Matrix Algebra and Optimization

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will provide students with a grounding in optimization methods and the matrix algebra upon which they are based. The first past of the course focuses on fundamental building blocks in linear algebra and their geometric interpretation: matrices, their use to represent data and as linear operators, and the matrix decompositions (such as eigen-, spectral-, and singular-vector decompositions) that reveal structural and geometric insight. The second part of the course focuses on optimization, both unconstrained and constrained, linear and non-linear, as well as convex and nonconvex; conditions for local and global optimality, as well as basic classes of optimization problems are discussed. Applications from machine learning, signal processing, and engineering are used to illustrate the techniques developed.

Prerequisite: AER210H1/MAT290H1, MAT185H1/MAT188H1
Total AUs: 51.20

ECE368H1 - Probabilistic Reasoning

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will focus on different classes of probabilistic models and how, based on those models, one deduces actionable information from data. The course will start by reviewing basic concepts of probability including random variables and first and second-order statistics. Building from this foundation the course will then cover probabilistic models including vectors (e.g., multivariate Gaussian), temporal (e.g., stationarity and hidden Markov models), and graphical (e.g., factor graphs). On the inference side topics such as hypothesis testing, marginalization, estimation, and message passing will be covered. Applications of these tools cover a vast range of data processing domains including machine learning, communications, search, recommendation systems, finance, robotics and navigation.

Prerequisite: ECE286H1/ECE302H1
Exclusion: CSC412H1
Total AUs: 44.80

ECE410H1 - Linear Control Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

State space analysis of linear systems, the matrix exponential, linearization of nonlinear systems. Structural properties of linear systems: stability, controllability, observability, stabilizability, and detectability. Pole assignment using state feedback, state estimation using observers, full-order and reduced-order observer design, design of feedback compensators using the separation principle, control design for tracking. Control design based on optimization, linear quadratic optimal control, the algebraic Riccati equation. Laboratory experiments include computer-aided design using MATLAB and the control of an inverted pendulum on a cart.

Prerequisite: ECE311H1
Exclusion: ECE557H1
Total AUs: 53.40

ECE411H1 - Real-Time Computer Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Digital Control analysis and design by state-space methods. Introduction to scheduling of control tasks using fixed-priority protocols. Labs include control design using MATLAB and Simulink, and computer control of the inverted pendulum using a PC with real-time software.

Prerequisite: ECE311H1 or ECE356H1
Total AUs: 54.40

ECE419H1 - Distributed Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Design issues in distributed systems: heterogeneity, security, transparency, concurrency, fault-tolerance; networking principles; request-reply protocol; remote procedure calls; distributed objects; middleware architectures; CORBA; security and authentication protocols; distributed file systems; name services; global states in distributed systems; coordination and agreement; transactions and concurrency control; distributed transactions; replication.

Prerequisite: ECE344H1 or ECE353H1
Total AUs: 53.40

ECE421H1 - Introduction to Machine Learning

Credit Value: 0.50
Hours: 38.4L/25.6T

An Introduction to the basic theory, the fundamental algorithms, and the computational toolboxes of machine learning. The focus is on a balanced treatment of the practical and theoretical approaches, along with hands on experience with relevant software packages. Supervised learning methods covered in the course will include: the study of linear models for classification and regression, neural networks and support vector machines. Unsupervised learning methods covered in the course will include: principal component analysis, k-means clustering, and Gaussian mixture models. Theoretical topics will include: bounds on the generalization error, bias-variance tradeoffs and the Vapnik-Chervonenkis (VC) dimension. Techniques to control overfitting, including regularization and validation, will be covered.

Prerequisite: ECE286H1/STA286H1, ECE302H1/MIE231H1/CHE223H1/MIE236H1/MSE238H1
Exclusion: CSC411H1, ECE521H1
Total AUs: 51.20

ECE427H1 - Photonic Devices

Credit Value: 0.50
Hours: 38.4L/25.6T

The human visual interface is rapidly evolving with the emergence of smart glasses, AR/VR wearable display, and autonomous vehicles. This course examines the photonic devices and integrated systems that underline such technologies, and how they are shaped by human visual perception and acuity. Advanced integrated photonic systems in optical display and sensing will be deconstructed and the underlying fundamental concepts studied. Topics include introduction to: heads up and wearable display, optical lidar, optical fiber, waveguide circuits, holography, optical switches, light sources (LED, laser), detectors and imaging sensors.

Prerequisite: ECE318H1/ECE320H1/ECE357H1
Total AUs: 51.20

ECE431H1 - Digital Signal Processing

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

An introductory course in digital filtering and applications. Introduction to real world signal processing. Review of sampling and quantization of signals. Introduction to the discrete Fourier transform and its properties. The fast Fourier transform. Fourier analysis of signals using the discrete Fourier transform. Structures for discrete-time systems. Design and realization of digital filters: finite and infinite impulse response filters. DSP applications in areas such as communications, multimedia, video coding, human computer interaction and medicine.

Total AUs: 54.40

ECE444H1 - Software Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T/38.4P

The software development process. Software requirements and specifications. Software design techniques. Techniques for developing large software systems; CASE tools and software development environments. Software testing, documentation and maintenance.

Prerequisite: ECE344H1 or ECE353H1
Exclusion: CSC444H1
Total AUs: 64.00

ECE446H1 - Sensory Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Physical acoustics, acoustic measurements, electroacoustic transducers, and physiological acoustics. Speech processing, speech recognition algorithms and signal processing by the auditory system. Engineering aspects of acoustic design. Electrical models of acoustic systems. Noise, noise-induced hearing loss, and noise control. Introduction to vision and other modalities. Musical and psychoacoustics.

Total AUs: 54.40

ECE448H1 - Biocomputation

Credit Value: 0.50
Hours: 38.4L/25.6T

Modern technologies in the biosciences generate tremendous amounts of biological data ranging from genomic sequences to protein structures to gene expression. Biocomputations are the computer algorithms used to reveal the hidden patterns within this data. Course topics include basic concepts in molecular cell biology, pairwise sequence alignment, multiple sequence alignment, fast alignment algorithms, deep learning approaches, phylogentic prediction, structure-based computational methods, gene finding and annotation.

Total AUs: 51.20

ECE454H1 - Computer Systems Programming

Credit Value: 0.50
Hours: 38.4L/38.4P

Fundamental techniques for programming computer systems, with an emphasis on obtaining good performance. Topics covered include: how to measure and understand program and execution and behaviour, how to get the most out of an optimizing compiler, how memory is allocated and managed, and how to exploit caches and the memory hierarchy. Furthermore, current trends in multicore, multithreaded and data parallel hardware, and how to exploit parallelism in their programs will be covered.

Total AUs: 53.40

ECE463H1 - Electric Drives

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Electro-mechanical mechanisms for force and torque production in rotating machines. DC machine theory and DC machine dynamics, synchronous machines and their dynamics, stepper motors. Introduction to space vectors and vector control of AC machines. Steady state and variable speed operation of the induction machine via V/f control.

Prerequisite: ECE314H1/ECE315H1/ECE349H1/ECE359H1, ECE311H1/ECE356H1/AER372H1
Corequisite: ECE311H1/ECE356H1/AER372H1
Total AUs: 53.40

ECE470H1 - Robot Modeling and Control

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Classification of robot manipulators, kinematic modeling, forward and inverse kinematics, velocity kinematics, path planning, point-to-point trajectory planning, dynamic modeling, Euler-Lagrange equations, inverse dynamics, joint control, computed torque control, passivity-based control, feedback linearization.

Prerequisite: ECE311H1 or ECE356H1
Exclusion: AER525H1
Total AUs: 53.40

ECE472H1 - Engineering Economic Analysis & Entrepreneurship

Credit Value: 0.50
Hours: 38.4L/25.6T

The economic evaluation and justification of engineering projects and investment proposals are discussed. Cost concepts; financial and cost accounting; depreciation; the time value of money and compound interest; inflation; capital budgeting; equity, bond and loan financing; income tax and after-tax cash flow in engineering project proposals; measures of economic merit in the public sector; sensitivity and risk analysis. Applications: evaluations of competing engineering project alternatives; replacement analysis; economic life of assets; lease versus buy decisions; break-even and sensitivity analysis. Entrepreneurship and the Canadian business environment will be discussed.

Total AUs: 50.40

ECE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: MSE488H1, MIE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

ECE516H1 - Intelligent Image Processing

Credit Value: 0.50
Hours: 38.4L/38.4P

This course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics, including "Wearable Computing", "Personal Technologies", "Human Computer Interaction (HCI)," "Mobile Multimedia," "Augmented Reality," "Mediated Reality," CyborgLogging," and the merging of communications devices such as portable telephones with computational and imaging devices. The focus is on fundamental aspects and new inventions for human-computer interaction. Topics to be covered include: mediated reality, Personal Safety Devices, lifelong personal video capture, the Eye Tap principle, collinearity criterion, comparametric equations, photoquantigraphic imaging, lightvector spaces, anti-homomorphic imaging, application of personal imaging to the visual arts, and algebraic projective geometry.

Total AUs: 57.60

ECE520H1 - Power Electronics

Credit Value: 0.50
Hours: 38.4L/12.8T/16.2P

Focuses on power electronic converters utilized in applications ranging from low-power mobile devices to higher power applications such as electric vehicles, server farms, microgrids, and renewable energy systems. Concepts covered include the principles of efficient electrical energy processing (dc-dc, dc/ac, and ac/ac) through switch-mode energy conversion, converter loss analysis, large- and small-signal modeling of power electronic circuits and controller design.

Prerequisite: ECE314H1/ECE349H1/ECE359H1
Exclusion: ECE514H1, ECE533H1
Total AUs: 52.90

ECE526H1 - Power System Protection and Automation

Hours: 38.4L/12.8T/16.2P

Presents the concepts of short-circuit fault analysis, protective relaying, and automation in power systems. The course starts by discussing the causes and types of short-circuit faults using real-world examples. The consequences of faults for different power system components will be reviewed using event reports from field data. The method of symmetrical components for analyzing unbalanced three-phase systems will be introduced. Analytical methods and computer-based approaches for deriving fault voltages and currents will be discussed and the effect of system grounding during transient conditions, including faults, will be introduced. Students will also learn the concept of power system automation and its role in monitoring, protection. and control of modern power systems. Critical devices used in an automation system, such as breakers, relays, reclosers, capacitor bank controllers, and tap changer controllers will be presented.

Prerequisite: ECE313H1/ECE314H1/ECE349H1
Total AUs: 52.90

ECE532H1 - Digital Systems Design

Credit Value: 0.50
Hours: 38.4L/38.4P

Advanced digital systems design concepts including project planning, design flows, embedded processors, hardware/software interfacing and interactions, software drivers, embedded operating systems, memory interfaces, system-level timing analysis, clocking and clock domains. A significant design project is undertaken and implemented on an FPGA development board.

Prerequisite: ECE342H1 or ECE352H1
Total AUs: 57.60

ECE557H1 - Linear Control Theory

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

State-space approach to linear system theory. Mathematical background in linear algebra, state space equations vs. transfer functions, solutions of linear ODE's, state transition matrix, Jordan form, controllability, eigenvalue assignment using state feedback, observability, designing observers, separation principle, Kalman filters, tracking and the regulator problem, linear quadratic optimal control, stability. Laboratories cover the state space control design methodology.

Prerequisite: ECE356H1/AER362H1
Exclusion: ECE410H1
Total AUs: 54.40

ECE568H1 - Computer Security

Credit Value: 0.50
Hours: 38.4L/38.4P

As computers permeate our society, the security of such computing systems is becoming of paramount importance. This course covers principles of computer systems security. To build secure systems, one must understand how attackers operate. This course starts by teaching students how to identify security vulnerabilities and how they can be exploited. Then techniques to create secure systems and defend against such attacks will be discussed. Industry standards for conducting security audits to establish levels of security will be introduced. The course will include an introduction to basic cryptographic techniques as well as hardware used to accelerate cryptographic operations in ATM's and webservers.

Prerequisite: ECE344H1 or ECE353H1
Total AUs: 53.40

Engineering Science

ESC203H1 - Engineering and Society

Credit Value: 0.50
Hours: 25.6L/25.6T

Through this course, students will examine the relationship between engineering and society, emphasizing a humanities and social sciences perspective. Building on the Praxis courses, students will develop and apply an understanding of ethics and equity to broader sociotechnical systems and challenges. Using models of critical thinking, active learning activities and discussion seminars, students will develop an understanding of the social and environmental impacts of technology. Students will further develop their communication, teamwork and professional skills through persuasive writing, facilitation and formal debate. Upon completion of the course, students will have an appreciation for the complex interaction between human society and technology, and will be able to analyze and evaluate the social, technological, political, and ethical dimensions of technology.

Humanities and Social Science elective.

Exclusion: CME259H1
Recommended Preparation: ESC102H1
Total AUs: 44.80

Forestry

FOR308H1 - Discovering Wood and its Role in Societal Development

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science elective

Trees and their components have been used through the centuries for shelter, heat, entertainment, weapons, sport, furnishings, communication, food and medicines. This course explores the co-evolution of nature and culture by examining the social and economic impacts that the forest and its exploitation had in the development of societies throughout the ages. Focus will be on the cultural history of wood and products derived from it and its influence on developing societies from biblical times to modern day. The course will examine how wood's versatility and usefulness in varied applications has been discovered by society as needs for survival to austerity develop. The unique properties of woody materials will be examined to expose its ability to meet the varied demands of societies throughout the ages. This course will allow students to explore the place and role of wood derived products in sustainable society.

Total AUs: 44.80

FOR421H1 - Green Urban Infrastructure: Sustainable City Forests

Credit Value: 0.50
Hours: 25.6L

Complementary Studies elective

With over 80% of the world's population now living in cities, tomorrow's forests will be urban. Increasing global recognition of nature deficit disorder and the values of green infrastructure to mitigate broader human impacts gives a new meaning to the term 'urban forestry', coined here at UofT and now recognized widely. Trees in and around the city are key to providing multiple engineered and ecological services that only recently have been brought into the responsible fiscal planning of every municipality around the globe. If managed properly (a key concept), urban forests mitigate climate change and urban heat island effects, act as carbon sinks, air filters, water purifiers, air conditioners, noise dampeners, wildlife and/or biodiversity refuges, and green spaces for the human spirit. Here, we explore the challenges and opportunities of this exciting new applied field at the cross-roads of ecology, engineering and planning to ensure future global sustainability.

Exclusion: FOR416H1
Total AUs: 25.60

FOR424H1 - Innovation and Manufacturing of Sustainable Materials

Credit Value: 0.50
Hours: 25.6L/12.8T

Sustainable materials are a mandate for sustainable societies. This course will explore the manufacturing, engineering principles and design fundamentals for creating sustainable materials from renewable resources. Special emphasis will be on bioplastics, biofibre, nanobiofibre, biocomposites and nanobiocomposites. Written communication and design skills will be developed through tutorials and assignments.

Exclusion: FOR423H1
Recommended Preparation: Basic knowledge of materials science.
Total AUs: 32.00

FOR425H1 - Bioenergy and Biorefinery Technology

Credit Value: 0.50
Hours: 25.6L/25.6T

Technological advances and approaches in deriving biofuels, chemical feedstocks from forest and other biomass resources. Fundamental chemical attributes of biomass, as they affect the fuel value and potential for deriving liquid, solid and gaseous fuels and valuable chemicals for other applications will be explored.

Exclusion: FOR410H1
Total AUs: 38.40

Geography

GGR252H1 - Marketing Geography

Credit Value: 0.50
Hours: 24L/4T

Geography matters in the success of both public and private sector organisations. Using mostly retail examples contemporary location problems are addressed. The geographies of demand and supply are analysed and trade area and site selection techniques are applied. The relevance of the planning context and utility of geovisualisation techniques such as GIS are also briefly considered.

Exclusion: GGR252H5
Total AUs: 27.60

History and Philosophy of Science

HPS210H1 - Scientific Revolutions I

Credit Value: 0.50
Hours: 24L

Case studies in the history of science from antiquity to 1800, including the revolutionary work of Copernicus, Kepler, Galileo, Descartes, Newton, Linnaeus, Lavoisier, and Herschel. The course is designed to be accessible to science students and non-scientists alike.

Exclusion: HPS200Y1
Total AUs: 32.00

HPS283H1 - The Engineer in History

Credit Value: 0.50
Hours: 25.6L/12.8T

Humanities and Social Science elective

The emphasis in this course will be more on the history of engineers as workers, members of professional groups, and managers rather than engineering proper, although obviously engineering cannot be ignored when we talk about engineers' work. The aim of the course is to give an understanding of the heritage of engineers as participants in the economy and society.

Total AUs: 32.00

Joint Courses

JRE300H1 - Fundamentals of Accounting and Finance

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

Introduces a brief overview of essential concepts in accounting and corporate finance. The first part of the course covers the fundamentals of accounting. We start by exploring the basic language of accounting and the fundamental concepts of financial reporting. Students learn to read and analyze basic financial statements including the statements of financial position, comprehensive income, changes in equity, and cash flows. We then introduce key management accounting concepts and explore various methods of costing for decision-making. The second part of the course covers the fundamentals of corporate finance. In the second half, students will learn how to make financial projections and how to value complex investment opportunities. Following this, students learn various techniques for controlling risk and how to determine the appropriate cost of capital. Finally, the course considers issues in cash flow management and overviews project valuation as it relates to corporate mergers.

Exclusion: CHE375H1
Total AUs: 44.80

JRE410H1 - Markets and Competitive Strategy

Credit Value: 0.50
Hours: 25.6L/25.6P

Complementary Studies elective

Introduces the basic concepts, frameworks and methodologies useful to managers in crafting and executing entrepreneurial business strategies in technology-based companies. In the first part of the course, students gain an understanding of the external, internal, and dynamic environments of a business and the elements of a superior competitive position. In the second part, we focus on designing and delivering customer value, which involves strategic decisions about segmentation, targeting and positioning, and tactical decisions related to product introductions, marketing communications, distribution channels and pricing. In the third part of the course, we build on these fundamentals and examine challenges related to innovation and industry dynamics, such as industry life cycles, disruptive technologies, product renewal, and the relationship between R&D and commercialization.

Total AUs: 38.40

JRE420H1 - People Management and Organizational Behaviour

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

This module spans three inter-related topics: leadership, people management and organization behaviour. It provides students with both the theory and practice in how to design, lead and manage organizations. Topics include theories of leadership, strategy, ethics, designing organizations for rapid change and differing cultural environments, communication, job design, managing and motivating people, fostering creativity, and team work. In addition to traditional lectures, exercises and case studies will be used throughout.

Exclusion: IRE260H1
Total AUs: 44.80

Mathematics

MAT336H1 - Elements of Analysis

Credit Value: 0.50
Hours: 36L/12T

This course provides the foundations of analysis and rigorous calculus for students who will take subsequent courses where these mathematical concepts are central of applications, but who have only taken courses with limited proofs. Topics include topology of Rn, implicit and inverse function theorems and rigorous integration theory.

Prerequisite: MAT223H1/MATA23H3/MAT223H5/MAT240H1/MAT240H5, MAT235Y1/MAT235Y5/(MAT232H5, MAT236H5)/(MATB41H3, MATB42H3)/MAT237Y1/(MATB41H3, MATB42H3, MATB43H3)/MAT237Y5; (for FASE students, MAT185H, MAT195H/ESC195H)
Exclusion: MAT257Y1, MAT337H1
Total AUs: 38.40

MAT389H1 - Complex Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Course examines the following: analytic functions, Cauchy-Reimann equations, contour integration, Cauchy's theorem, Taylor and Laurent series, singularities, residue calculus, conformal mapping, harmonic functions, Dirichlet and Neumann problems and Poisson integral formulas. Course includes studies of linear differential equations in the complex plane, including Bessel and Legendre functions.

Prerequisite: MAT195H1, MAT292H1
Exclusion: MAT290H1
Total AUs: 44.80

Mechanical and Industrial Engineering

MIE242H1 - Psychology For Engineers

Credit Value: 0.50
Hours: 38.4L/38.4P

Introduction to neuroanatomy and processes that are core to perception, cognition, language, decision making, and action. Use of experiments to test hypotheses concerning brain activities and computations. Conducting and reporting experimental research, use of elementary statistics, and satisfaction of research ethics requirements.

Total AUs: 57.60

MIE243H1 - Mechanical Engineering Design

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

Introduction to basic mechanical parts and mechanisms: gears, cams, bearings, linkages, actuators and motors, chain and belt drives, brakes and clutches, hydraulics and pneumatics. Tutorials on engineering drawing, sketching, and CAD/CAM in SolidWorks: views and drawing types, 2D sketching, 3D modeling and engineering drawing generation, modeling of assembly and motion analysis/animation. Conceptual design examples and mechanical engineering design process, including selection and applications of mechanisms. Dissection and reverse engineering of selected mechanical devices, mechanisms, and subsystems. Competitive group design project including technical report and 3D printing.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 64.00

MIE258H1 - Engineering Economics and Accounting

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering economic and accounting concepts needed in the design of engineering systems. Financial analysis topics include: financial statements, depreciation, income tax, and basic accounting techniques. Project analysis topics includes: time value of money, evaluation of cash flows, defining alternatives, analysis of independent projects, acceptance criteria, buy or lease, make or buy, replacement analysis, economic analysis in the public sector, project risk and uncertainty. Inflation concepts.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Exclusion: CHE249H1, CHE374H1, CME368H1, ECE472H1, MIE358H1
Total AUs: 44.80

MIE301H1 - Kinematics and Dynamics of Machines

Credit Value: 0.50
Hours: 38.4L/25.6T/38.4P

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented methods, gears, geartrains, cams, flywheels, mechanism dynamics.

Instruction and assessment of engineering communication that will form part of an ongoing design portfolio.

Prerequisite: MIE100H1
Total AUs: 70.40

MIE304H1 - Introduction to Quality Control

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Introduction to quality engineering. Quality standards and certification. TQM. Modeling processes with simulation. Making inferences about product quality from real or simulation output data. Introduction to statistical process control. Control charts for variables and attributes. Process capability analysis. Lot Acceptance Sampling.

Prerequisite: MIE231 or equivalent
Total AUs: 57.60

MIE311H1 - Thermal Energy Conversion

Credit Value: 0.50
Hours: 38.4L/38.4P

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework. Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Refrigeration, psychrometry and air conditioning. Fossil fuel combustion and advanced systems includes fuel cells.

Prerequisite: MIE210H1, MIE313H1
Total AUs: 57.60

MIE313H1 - Heat and Mass Transfer

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Exact and numerical analysis of steady and transient conduction in solids. Solutions of one-dimensional and multidimensional systems. Principles of convection and solutions under laminar and turbulent flow over flat plates and inside and over pipes. Free convection. Thermal radiation between multiple black and grey surfaces. Analysis of open-ended design problems for improving thermal transport in commercial products.

Prerequisite: MAT234H1, MIE210H1, MIE230H1, MIE312H1 or equivalent
Total AUs: 60.80

MIE315H1 - Design for the Environment

Credit Value: 0.50
Hours: 38.4L/12.8T

Life Cycle Assessment for the measurement of environmental impacts of existing products and processes. Design for Environment principles for the reduction of environmental impacts in new product and process designs. Functional, economic, and societal analysis taught for use in a major team-written project to compare and contrast two product or process alternatives for a client.

Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.

Total AUs: 44.80

MIE335H1 - Algorithms & Numerical Methods

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Algorithmic analysis, big-O asymptotic analysis; numerical linear algebra, solution techniques for linear and non-linear systems of equations; matrix factorization, LU and Cholesky factorization, factorization in the revised simplex method; Newton's method, Gale-Shapley method, greedy methods for combinatorial optimization, branch-and-bound search methods; graph theory and graph theoretic algorithms; design and implementation of algorithms to optimize mathematical models.

Prerequisite: MIE262H1
Total AUs: 51.20

MIE342H1 - Circuits with Applications to Mechanical Engineering Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course presents analysis of complex circuits and application of circuit principles to design circuits for mechanical engineering systems. Discussions will centre around circuits and instrumentation. In-depth discussions will be given on a number of topics: (1) Mechatronics design applications of circuit principles; (2) Network theorems, node-voltage, mesh-current method, Thévenin equivalents; (3) Operational amplifier circuits; (4) 1st and 2nd order circuits; (5) Laplace transform, frequency response; (6) Passive and active filter design (low- and high-pass filters, bandpass and bandreject filters); (7)

Interface/readout circuits for mechanical engineering systems, sensors, instrumentation; (8) Inductance, transformers, DC/AC machines; (9) Digital circuit and data sampling
introduction.

Prerequisite: MAT186H1 and MAT187H1
Recommended Preparation: ECE110H1 or ECE159H1
Total AUs: 54.40

MIE343H1 - Industrial Ergonomics and the Workplace

Credit Value: 0.50
Hours: 38.4L/38.4P

The Biology of Work: anatomical and physiological factors underlying the design of equipment and work places. Biomechanical factors governing physical workload and motor performance. Circadian rhythms and shift work. Measurement and specification of heat, light, and sound with respect to design of the work environment.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 57.60

MIE346H1 - Analog and Digital Electronics for Mechatronics

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

A study of the fundamental behaviour of the major semiconductor devices (diodes, bipolar junction transistors and field effect transistors). Development of analysis and design methods for basic analog and digital electronic circuits and devices using analytical, computer and laboratory tools. Application of electronic circuits to instrumentation and mechatronic systems.

Prerequisite: MIE230H1, MAT234H1, MIE342H1
Total AUs: 54.40

MIE354H1 - Business Process Engineering

Credit Value: 0.50
Hours: 38.4L/25.6P

This course focuses on understanding multiple perspectives for grouping, assessing, designing and implementing appropriately integrated and distributed information systems to support enterprise objectives. The emphasis is on understanding how Business Process Management techniques and tools can contribute to align an organization's business and information technology perspectives, as well as the characteristics of application and system types and the implications for their design, operation and support of information needs, including those associated with different platforms and technology infrastructure e.g., legacy systems, client/server, the Internet and World Wide Web including the emergence of a web-service-based service oriented architecture. Students will work in the laboratory to develop business processes that can be specified and executed by information systems supporting BPEL, a widely supported standard for describing web-service-based business process.

Prerequisite: MIE253H1 or permission of the instructor
Total AUs: 51.20

MIE368H1 - Analytics in Action

Credit Value: 0.50
Hours: 25.6L/12.8T/38.4P

This course showcases the impact of analytics focusing on real world examples and case studies. Particular focus on decision analytics, where data and models are combined to ultimately improve decision-making. Methods include: linear and logistic regression, classification and regression trees, clustering, linear and integer optimization. Application areas include: healthcare, business, sports, manufacturing, finance, transportation, public sector.

Prerequisite: MIE237H1/ECE286H1, MIE262H1/MIE376H1, MIE263H1/STA347H1, or permission of the instructor
Total AUs: 51.20

MIE369H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 38.4L/25.6P

Introduction to Artificial Intelligence. Search. Constraint Satisfaction. Propositional and First-order Logic Knowledge Representation. Representing Uncertainty (Bayesian networks). Rationality and (Sequential) Decision Making under Uncertainty. Reinforcement Learning. Weak and Strong AI, AI as Engineering, Ethics and Safety in AI.

Prerequisite:
MIE250H1/ECE244H1/ECE345H1/CSC263H1/CSC265H1, MIE236H1/ECE286H1/ECE302H1
Exclusion: ROB311H1, CSC384H1
Total AUs: 52.20

MIE407H1 - Nuclear Reactor Theory and Design

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the neutronic design and analysis of nuclear fission reactors with a focus on Generation IV nuclear systems. Topics include radioactivity, neutron interactions with matter, neutron diffusion and moderation, the fission chain reaction, the critical reactor equation, reactivity effects and reactor kinetics. Multigroup neutron diffusion calculations are demonstrated using fast-spectrum reactor designs.

Prerequisite: MIE230H1 or equivalent
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE408H1 - * Thermal and Machine Design of Nuclear Power Reactors

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.

Prerequisite: MIE407H1/MIE222H1, MIE312H1, MIE313H1 or equivalents
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE422H1 - Automated Manufacturing

Credit Value: 0.50
Hours: 25.6L/38.4P

Introduction to Computer Integrated Manufactuing. Definitions, terminology. Organization of manufacturing systems. Introduction to NC machines. Introduction to robotics. Types of robot motion. Robot kinematics. Jacobians, singularities. Robot motion trajectories. Interpolation, spline fits. Robot joint control. Flexible manufacturing systems, justification. Robot cell design. Group technology. Design of group technology cell. Programmable logic controllers. Limited enrolment.

Prerequisite: MIE221H1 or equivalent
Total AUs: 44.80

MIE424H1 - Optimization in Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

1. To enable deeper understanding and more flexible use of standard machine learning methods, through development of machine learning from an Optimization perspective.

2. To enable students to apply these machine learning methods to problems in finance and marketing, such as stock return forecasting, credit risk scoring, portfolio management, fraud detection and customer segmentation.

Prerequisite: MIE365H1/MIE376H1/ECE367H1/ROB310H1, or equivalent
Total AUs: 51.20

MIE438H1 - Microprocessors and Embedded Microcontrollers

Credit Value: 0.50
Hours: 25.6L/38.4P

Review (number systems, CPU architecture, instruction sets and subroutines); Interfacing Memory; Interfacing Techniques; Transistors and TTL/CMOS Logic; Mechanical Switches & LED Displays; Interfacing Analog, A/D & D/A Conversions; Stepper Motors & DC Motors; RISC Technology and Embedded Processors; DAS Systems; Embedded Microcontroller System Design; CPU-based Control.

Exclusion: ECE243H1, ECE352H1
Total AUs: 44.80

MIE439H1 - Biomechanics I

Credit Value: 0.50
Hours: 38.4L/25.6P

Introduction to the application of the principles of mechanical engineering - principally solid mechanics, fluid mechanics, and dynamics - to living systems. Topics include cellular mechanics, blood rheology, circulatory mechanics, respiratory mechanics, skeletal mechanics, and locomotion. Applications of these topics to biomimetic and biomechanical design are emphasized through a major, integrative group project.

Total AUs: 51.20

MIE440H1 - * Design of Innovative Products

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Recently developed methods applied at different stages of the design process include: Identification of unmet/underserved user needs through a modified definition of lead users (those who experience needs in advance of the mainstream population) including identifying/studying lead users, identifying which lead-user needs are relevant to the general population; Roles of function and affordance in successful products; Obstacles of fixation and cognitive bias to creativity; Concept generation methods including TRIZ/TIPS (Theory of Inventive Problem Solving, use of unrelated stimuli and analogy (e.g., from biology); Configuration design methods including design for transformation, design for assembly and end-of-life, e.g., reuse, repair and recycling. Hands-on experience of these topics in lectures, tutorials, and labs support successful application of the methods for the course project, as well as future design activities.

Total AUs: 44.80

MIE441H1 - * Design Optimization

Credit Value: 0.50
Hours: 38.4L/25.6P

Problem definition and formulation for optimization, optimization models, and selected algorithms in optimization. Design for Tolerancing, Design for Manufcaturing, and Design for Assembly. State of the are Computer Aided Design packages are introduced with case studies. Emphasis is placed on gaining practical skills by solving realistic design problems.

Prerequisite: MIE341H1, MIE222H1 or equivalents
Total AUs: 51.20

MIE442H1 - Machine Design

Credit Value: 0.50
Hours: 38.4L/38.4T/19.2P

Introduction to the fundamental elements of mechanical design including the selection of engineering materials, load determination and failure analysis under static, impact, vibration and cyclic loads. Surface failure and fatigue under contact loads, lubrication and wear. Consideration is given to the characteristics and selection of machine elements such as bearings, shafts, power screws and couplings.

Prerequisite: MIE320H1
Total AUs: 67.20

MIE443H1 - * Mechatronics Systems: Design and Integration

Credit Value: 0.50
Hours: 25.6L/64P

The course aims to raise practical design awareness, provide pertinent project engineering methodology, and generate a know-how core in integration of complex automation. This course has mainly practical content, and is integral and useful in the training and education of those students who plan to be employed in areas related to intelligent automation, as well as to the breadth of knowledge of all others. Although emphasis will be on robotic-based automation (mechatronics), the learning will be useful in all domains of system integration. This course will introduce students to the basics of integration, methodology of design, tools, and team project work. The course will be monitored based on projects from a selected list of topics. The lectures will be in format of tutorials as preparation and discussions on project related issues. A main goal is to bring the methods, means and spirit of the industrial design world to the class room. Emphasis will be on understanding the elements of integration, methodology and approaches, and will involve numerous case studies. Specifically the course will provide a practical step-by-step approach to integration: specifications, conceptual design, analysis, modeling, synthesis, simulation and bread-boarding, prototyping, integration, verification, installation and testing. Issues of project management, market, and economics will be addressed as well. Limited Enrolment.

Prerequisite: MIE346H1
Total AUs: 57.60

MIE444H1 - * Mechatronics Principles

Credit Value: 0.50
Hours: 25.6L/38.4P

This course provides students with the tools to design, model, analyze and control mechatronic systems (e.g. smart systems comprising electronic, mechanical, fluid and thermal components). This is done through the synergic combination of tools from mechanical and electrical engineering, computer science and information technology to design systems with built-in intelligence. The class provides techniques for the modeling of various system components into a unified approach and tools for the simulation of the performance of these systems. The class also presents the procedures and an analysis of the various components needed to design and control a mechatronic system including sensing, actuating, and I/O interfacing components.

Prerequisite: MIE342H1, MIE346H1
Total AUs: 44.80

MIE451H1 - Decision Support Systems

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Provides students with an understanding of the role of a decision support system in an organization, its components, and the theories and techniques used to construct them. Focuses on information analysis to support organizational decision-making needs and covers topics including information retrieval, descriptive and predictive modeling using machine learning and data mining, recommendation systems, and effective visualization and communication of analytical results.

Prerequisite: MIE253H1, MIE350H1
Total AUs: 51.20

MIE457H1 - Knowledge Modelling and Management

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

This course explores both the modelling of knowledge and its management within and among organizations. Knowledge modelling will focus on knowledge types and their semantic representation. It will review emerging representations for knowledge on the World Wide Web (e.g., schemas, RDF). Knowledge management will explore the acquisition, indexing, distribution and evolution of knowledge within and among organizations. Emerging Knowledge Management System software will be used in the laboratory.

Prerequisite: MIE253H1, MIE350H1
Total AUs: 51.20

MIE458H1 - Biofluid Mechanics

Credit Value: 0.50
Hours: 38.4L/12.8T

This course will teach students how to apply fundamental fluid mechanics to the study of biological systems. The course is divided into three modules, with the focus of the first two modules on the human circulatory and respiratory systems, respectively. Topics covered will include blood rheology, blood flow in the heart, arteries, veins and microcirculation, the mechanical properties of the heart as a pump; air flow in the lungs and airways, mass transfer across the walls of these systems, the fluid mechanics of the liquid-air interface of the alveoli, and artificial mechanical systems and devices for clinical aid. The third and final module will cover a range of other fluid problems in modern biology.

Prerequisite: MIE312H1 or equivalent
Total AUs: 44.80

MIE469H1 - Reliability and Maintainability Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the life-cycle costing concept for equipment acquisition, operation, and replacement decision-making. Designing for reliability and determination of optimal maintenance and replacement policies for both capital equipment and components. Topics include: identification of an items failure distribution and reliability function, reliability of series, parallel, and redundant systems design configurations, time-to-repair and maintainability function, age and block replacement policies for components, the economic life model for capital equipment, provisioning of spare parts.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE258H1
Total AUs: 51.20

MIE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MSE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

MIE505H1 - Micro/Nano Robotics

Credit Value: 0.50
Hours: 38.4L/38.4P

This course will cover the design, modeling, fabrication, and control of miniature robot and micro/nano-manipulation systems for graduate and upper level undergraduate students. Micro and Nano robotics is an interdisciplinary field which draws on aspects of microfabrication, robotics, medicine and materials science.

In addition to basic background material, the course includes case studies of current micro/nano-systems, challenges and future trends, and potential applications. The course will focus on a team design project involving novel theoretical and/or experimental concepts for micro/nano-robotic systems with a team of students. Throughout the course, discussions and lab tours will be organized on selected topics.

Total AUs: 57.60

MIE506H1 - * MEMS Design and Microfabrication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

This course will present the fundamental basis of microelectromechanical systems (MEMS). Topics will include: micromachining/microfabrication techniques, micro sensing and actuation principles and design, MEMS modeling and simulation, and device characterization and packaging. Students will be required to complete a MEMS design term project, including design modeling, simulation, microfabrication process design, and photolithographic mask layout.

Prerequisite: MIE222H1, MIE342H1
Total AUs: 54.40

MIE507H1 - Heating, Ventilating, and Air Conditioning (HVAC) Fundamentals

Credit Value: 0.50
Hours: 38.4L/25.6T

Introduction to the fundamentals of HVAC system operation and the relationship between these systems, building occupants and the building envelope. Fundamentals of psychrometrics, heat transfer and refrigeration; determination of heating and cooling loads driven by occupant requirements and the building envelope; heating and cooling equipment types and HVAC system configurations; controls and maintenance issues that influence performance; evaluation of various HVAC systems with respect to energy and indoor environmental quality performance.

Total AUs: 51.20

MIE515H1 - Alternative Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

This course covers the basic principles, current technologies and applications of selected alternative energy systems. Specific topics include solar thermal systems, solar photovoltaic systems, wind, wave, and tidal energy, energy storage, and grid connections issues. Limited enrolment.

Prerequisite: MIE210H1,MIE312H1 and MIE313H1 (or equivalent courses).
Total AUs: 44.80

MIE516H1 - Combustion and Fuels

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to combustion theory. Chemical equilibrium and the products of combustion. Combustion kinetics and types of combustion. Pollutant formation. Design of combustion systems for gaseous, liquid and solid fuels. The use of alternative fuels (hydrogen, biofuels, etc.) and their effect on combustion systems.

Total AUs: 44.80

MIE517H1 - Fuel Cell Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation, including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

Total AUs: 44.80

MIE520H1 - Biotransport Phenomena

Credit Value: 0.50
Hours: 38.4L/12.8T

Application of conservation relations and momentum balances, dimensional analysis and scaling, mass transfer, heat transfer, and fluid flow to biological systems, including: transport in the circulation, transport in porous media and tissues, transvascular transport, transport of gases between blood and tissues, and transport in organs and organisms.

Prerequisite: MIE312H1 /AER210H1 /equivalent
Total AUs: 44.80

MIE523H1 - Engineering Psychology and Human Performance

Credit Value: 0.50
Hours: 38.4L/38.4P

An examination of the relation between behavioural science and the design of human-machine systems, with special attention to advanced control room design. Human limitations on perception, attention, memory and decision making, and the design of displays and intelligent machines to supplement them. The human operator in process control and the supervisory control of automated and robotic systems. Laboratory exercises to introduce techniques of evaluating human performance.

Prerequisite: MIE231H1/MIE236H1/ECE286H1 or equivalent required; MIE237H1 or equivalent recommended
Total AUs: 57.60

MIE540H1 - * Product Design

Credit Value: 0.50
Hours: 38.4L/12.8T

This course takes a 360° perspective on product design: beginning at the market need, evolving this need into a concept, and optimizing the concept. Students will gain an understanding of the steps involved and the tools utilized in developing new products. The course will integrate both business and engineering concepts seamlessly through examples, case studies and a final project. Some of the business concepts covered include: identifying customer needs, project management and the economics of product design. The engineering design tools include: developing product specifications, concept generation, concept selection, Product Functional Decomposition diagrams, orthogonal arrays, full and fractional factorials, noises, interactions, tolerance analysis and latitude studies. Specific emphasis will be placed on robust and tunable technology for product optimization.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE243H1 or instructor's permission
Total AUs: 44.80

MIE561H1 - Healthcare Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

MIE 561 is a "cap-stone" course. Its purpose is to give students an opportunity to integrate the Industrial Engineering tools learned in previous courses by applying them to real world problems. While the specific focus of the case studies used to illustrate the application of Industrial Engineering will be the Canadian health care system, the approach to problem solving adopted in this course will be applicable to any setting. This course will provide a framework for identifying and resolving problems in a complex, unstructured decision-making environment. It will give students the opportunity to apply a problem identification framework through real world case studies. The case studies will involve people from the health care industry bringing current practical problems to the class. Students work in small groups preparing a feasibility study discussing potential approaches. Although the course is directed at Industrial Engineering fourth year and graduate students, it does not assume specific previous knowledge, and the course is open to students in other disciplines.

Total AUs: 51.20

MIE562H1 - Scheduling

Credit Value: 0.50
Hours: 38.4L/25.6T

This course takes a practical approach to scheduling problems and solution techniques, motivating the different mathematical definitions of scheduling with real world scheduling systems and problems. Topics covered include: job shop scheduling, timetabling, project scheduling, and the variety of solution approaches including constraint programming, local search, heuristics, and dispatch rules. Also covered will be information engineering aspects of building scheduling systems for real world problems.

Prerequisite: MIE262H1
Total AUs: 51.20

MIE566H1 - Decision Making Under Uncertainty

Credit Value: 0.50
Hours: 38.4L/25.6T/25.6P

The purpose of this course is to provide a working knowledge of methods of analysis of problem and of decision making in the face of uncertainty. Topics include decision trees, subjective probability assessment, multi-attribute utility approaches, goal programming, Analytic Hierarchy Process and the psychology of decision making.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Total AUs: 64.00

Mineral Engineering

MIN330H1 - Mining Environmental Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

Total AUs: 44.80

MIN511H1 - Integrated Mine Waste Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The engineering design of conventional mine waste management systems, including tailings ponds, rock dumps, and underground mine backfill systems, is considered first. Emerging trends in integrated mine waste management systems, including paste stacking and "paste rock" on surface, and cemented paste backfill forunderground mining will then be covered. Engineering case studies will be used throughout, and each case study will be evaluated in terms of how the mine waste systems used contribute to the economic and environmental sustainability of the mining operation.

Prerequisite: CME321H1
Total AUs: 44.80

Materials Science and Engineering

MSE343H1 - Biomaterials

Credit Value: 0.25
Hours: 26L/13P

Provides an overview of the field of biomaterials, introducing fundamental biological and materials design and selection concepts, and is open to CHE students. Key applications of materials for biomedical devices will be covered, along with an introduction to the expected biological responses. The concept of biocompatibility will be introduced along with the essential elements of biology related to an understanding of this criterion for biomaterial selection and implant design. In addition, structure-property relationships in both biological and bio-inspired materials will be highlighted.

Total AUs: 44.80

MSE355H1 - Materials Production

Credit Value: 0.50
Hours: 38.4L/12.8T

Materials life cycle, primary and secondary resources, resource life and sustainability. Technologies and unit operations used in the production of light metals, non-ferrous and ferrous metals. Energy use and conservation in production of materials. Benefits and technologies of recycling. Treatment of waste streams for value recovery and safe disposal

Total AUs: 44.80

MSE415H1 - Environmental Degradation of Materials

Credit Value: 0.50
Hours: 38.4L/25.6T

This course deals with four major areas: electrochemistry of low temperature aqueous solvents, the corrosion of materials, mechano-chemical effects in materials and corrosion prevention in design. Electrochemistry deals with thermodynamics of material-electrolyte systems involving ion-solvent, ion-ion interactions, activity coefficients, Nernst equation and Pourbaix diagrams, and rate theory through activation and concentration polarization. Corrosion of metallic, polymeric, ceramic, composite, electronic and biomaterials will be explored along with mechano-chemical effects of stress corrosion, hydrogen embrittlement and corrosion fatigue. Corrosion prevention in terms of case histories and the use of expert systems in materials selection.

Total AUs: 51.20

MSE419H1 - Fracture and Failure Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Fracture mechanisms and mechanics of solid materials. Topics include: nature of brittle and ductile fracture, macro-phenomena and micro-mechanisms of failure of various materials, mechanisms of fatigue; crack nucleation and propagation, Griffith theory, stress field at crack tips, stress intensity factor and fracture toughness, crack opening displacement, energy principle and the J-integral, fracture mechanics in fatigue, da/dN curves and their significance. Practical examples of fatigue analysis and fundamentals of non-destructive testing.

Total AUs: 44.80

MSE421H1 - Solid State Processing and Surface Treatment

Credit Value: 0.50
Hours: 38.4L/25.6T

The fundamentals and technologies of mechanical forming (rolling, forging, extrusion, drawing, sheet-metal forming), sintering and powder forming, thermo-mechanical processing and heat treatment are discussed. Various means to enhance surfaces for the purposes of i) improving corrosion and erosion properties, ii) change mechanical, chemical or electric properties, iii) produce a visually more appealing surface are also covered. Techniques include galvanizing, hot dipping, nitriding, vapour deposition, plasma spraying.

Total AUs: 51.20

MSE430H1 - Electronic Materials

Credit Value: 0.50
Hours: 26L/13T

Materials parameters and electronic properties of semiconductors are discussed as basic factors in the engineering of semiconductor devices. Materials parameters are related to preparation and processing methods, and thus to the electronic properties. The implications of materials parameters and properties on selected simple devices are discussed.

Total AUs: 32.00

MSE431H1 - Forensic Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The course provides participants with an understanding of scientific and engineering investigation methods and tools to assess potential sources, causes and solutions for prevention of failure due to natural accidents, fire, high and low speed impacts, design defects, improper selection of materials, manufacturing defects, improper service conditions, inadequate maintenance and human error. The fundamentals of accident reconstruction principles and procedures for origin and cause investigations are demonstrated through a wide range of real world case studies including: medical devices, sports equipment, electronic devices, vehicular collisions, structural collapse, corrosion failures, weld failures, fire investigations and patent infringements. Compliance with industry norms and standards, product liability, sources of liability, proving liability, defense against liability and other legal issues will be demonstrated with mock courtroom trial proceedings involving invited professionals to elucidate the role of an engineer as an expert witness in civil and criminal court proceedings.

Prerequisite: MSE101H1/APS104H1/MSE260H1 or MSE160H1
Total AUs: 44.80

MSE438H1 - Computational Materials Design

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

Introduces computational design of materials at atomic scale by focusing on two of the most powerful techniques - density functional theory (DFT) and molecular dynamics (MD). At the heart of both these techniques lies atomistic understanding originating from quantum mechanics; thus the initial lectures will review basics of quantum mechanics to inspire the foundational principles of modern-day DFT approaches. Thereafter theoretical background of DFT and its implementation and application for materials design will be covered. Specific topics on DFT will include Kohn-Sham equations, plane-wave basis sets, exchange and correlation, and nudged-elastic band calculations. Topics concerning MD will include foundational principles, Born-Oppenheimer hypothesis, time integration schemes such as velocity-verlet scheme, and interatomic potential functions. Finally, students will be exposed to the concepts and case-studies pertaining to multi-scale modeling. A particular emphasis of the course is providing hands-on training on open source software packages such as VESTA, Quantum-ESPRESSO, and LAMMPS.

Prerequisite:
MSE335H1/PHY356H1/PHY452H1/ECE330H1
Total AUs: 44.80

MSE440H1 - BIomaterial Processing and Properties

Credit Value: 0.50
Hours: 39L/13T

Currently used biomaterials for formation of surgical implants and dental restorations include selected metals, polymers, ceramics, and composites. The selection and processing of these materials to satisfy biocompatibility and functional requirements for applications in selected areas will be presented. Materials used for forming scaffolds for tissue engineering, and strategies for repair, regeneration and augmentation of degenerated or traumatized tissues will be reviewed with a focus on biocompatibility issues and required functionality for the intended applications.

Prerequisite: MSE343H1
Total AUs: 44.80

MSE443H1 - Composite Materials Engineering

Credit Value: 0.50
Hours: 38.4L

This course is designed to provide an integrated approach to composite materials design, and provide a strong foundation for further studies and research on these materials. Topics include: structure, processing, and properties of composite materials; design of fillers reinforcements and matrices reinforcements, reinforcement forms, nanocomposites systems, manufacturing processes, testing and properties, micro and macromechanics modeling of composite systems; and new applications of composites in various sectors.

Exclusion: CHE461H1 and MSE330H1
Total AUs: 38.40

MSE451H1 - Advanced Physical Properties of Structural Nanomaterials

Credit Value: 0.50
Hours: 39L/13T/39P

This course deals with the physical properties of bulk nanostructured materials. Included are mechanical properties (elastic behavior, tensile and compressive strength, creep, wear and fatigue properties) electrical properties (electrical transport phenomena, electrical resistivity) magnetic properties (paramagnetic, diamagnetic, soft and hard ferromagnetic, superparamagnetic and antiferromagnetic properties), thermodynamic properties (interfacial enthalpy, thermal stability, phase transformations, heat capacity). The considerable differences observed for nanocrystalline solids compared to conventional polycrystalline and amorphous solids will be discussed in terms of the microstructural differences for these materials.

Total AUs: 57.60

MSE455H1 - Process Simulation and Computer Design

Credit Value: 0.50
Hours: 38.4L/25.6T

Various production processes use simulation software to shorten the route from the initial design to finished product. Simulation software provides the designer and practicing engineer with a powerful tool in the tasks of improving and optimizing the industrial processes. Expensive trials can be avoided and the quality of the finished product secured from the beginning of production. First, this course will cover the basics of the process simulation used in industrial setting. Subsequently, the course will focus on industrial process simulation software used extensively in foundry industry worldwide. Essential elements of CAD/CAM techniques will be covered. Numerical simulation of the filling and solidification in castings will be presented. Calculation of foundry processes with multiple production cycles will be analyzed. Another course feature will be the graphical presentation of the results on the screen. Limited enrolment.

Total AUs: 51.20

MSE458H1 - Nanotechnology in Alternate Energy Systems

Credit Value: 0.50
Hours: 38.4L/25.6T

The unique surface properties and the ability to surface engineer nanocrystalline structures renders these materials to be ideal candidates for use in corrosion, catalysis and energy conversion devices. This course deals with the fabrication of materials suitable for use as protective coatings, and their specific exploitation in fields of hydrogen technologies (electrolysis, storage, and fuel cells) linked to renewables. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nanocrystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A major team design project along with demonstrative laboratory exercises constitutes a major portion of this course. Limited Enrolment.

Total AUs: 51.20

MSE459H1 - Synthesis of Nanostructured Materials

Credit Value: 0.50
Hours: 39L/26P

Various synthesis techniques to produce nanostructured materials will be introduced. These include methods involving the vapor phase (physical and chemical vapor deposition, organometallic chemical vapor deposition), the liquid phase (rapid solidification, spark erosion), the solid phase, (mechanical attrition, equal channel deformation) as well techniques producing these structures from solution (electrodeposition, electroless processing, precipitation). Secondary processing techniques to produce final products or devices will also be discussed.

Total AUs: 51.20

MSE461H1 - Engineered Ceramics

Credit Value: 0.50
Hours: 39L/24T

The unique combinations of physical, electrical, magnetic, and thermomechanical properties exhibited by advanced technical ceramics has led to a wide range of applications including automobile exhaust sensors and fuel cells, high speed cutting tool inserts and ball bearings, thermal barrier coatings for turbine engines, and surgical implants. This course examines the crystal and defect structures which determine the electrical and mass transport behaviours and the effects of microstructure on optical, magnetic, dielectric, and thermomechanical properties. The influence of these structure-property relations on the performance of ceramic materials in specific applications such as sensors, solid oxide fuel cells, magnets, and structural components is explored.

Total AUs: 51.20

MSE462H1 - Materials Physics II

Credit Value: 0.50
Hours: 25.6L/12.8T

Electron quantum wave theory of solid-state materials will be introduced. Quantum phenomena in various materials systems, in particular nano materials, will be discussed. Electronic properties of materials such as charge transport, dielectric properties, optical properties, magnetic properties, and thermal properties will be discussed using appropriate quantum theory. Materials systems to be studied may include metals, semiconductors, organics, polymers, and insulators.

Total AUs: 32.00

MSE478H1 - Materials Manufacturing and Design Laboratory II

Credit Value: 0.50
Hours: 12.8L/51.2P

This half year design course focuses on the simulation informed design and execution of a product and continues on the concepts learned in MSE398. Working in small groups, students will use the principles of materials selection and computer simulation to design and build a product of their own choosing. This design focused course will guide students through several iterations of their product design, each iteration further informed by computer simulation. Materials selection will include selection for mechanical design, process, and shape and will also be used to inform each iteration of the design process. Finally, computer simulation results will be experimentally validated in parts of, or the entire the final product. This course will involve significant time involved in hands-on manufacturing. The course is accepted as one of the Advanced Electives for the Advanced Manufacturing Minor.

Prerequisite: MSE398Y1
Total AUs: 38.40

MSE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prizes for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MIE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

Physics

PHY427H1 - Advanced Physics Laboratory

Credit Value: 0.50
Hours: 76.8P

Experiments in this course are designed to form a bridge to current experimental research. A wide range of experiments are available using contemporary techniques and equipment. In addition to the standard set of experiments, a limited number of research projects may be available. This laboratory is a continuation of PHY327H1.

Prerequisite: PHY327H1
Total AUs: 72.00

Robotics

ROB310H1 - Mathematics for Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T

The course addresses advanced mathematical concepts particularly relevant for robotics. The mathematical tools covered in this course are fundamental for understanding, analyzing, and designing robotics algorithms that solve tasks such as robot path planning, robot vision, robot control and robot learning. Topics include complex analysis, optimization techniques, signals and filtering, advanced probability theory, and numerical methods. Concepts will be studied in a mathematically rigorous way but will be motivated with robotics examples throughout the course.

Prerequisite: MAT185H1, MAT292H1
Recommended Preparation: ESC103H1, ECE286H1
Total AUs: 44.80

ROB311H1 - Artificial Intelligence

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to the fundamental principles of artificial intelligence from a mathematical perspective. The course will trace the historical development of AI and describe key results in the field. Topics include the philosophy of AI, search methods in problem solving, knowledge representation and reasoning, logic, planning, and learning paradigms. A portion of the course will focus on ethical AI, embodied AI, and on the quest for artificial general intelligence.

Prerequisite: Prerequisite: ECE286H1/ECE302H1 and ECE345H1/ECE358H1/CSC263H1
Total AUs: 44.80

ROB313H1 - Introduction to Learning from Data

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will introduce students to the topic of machine learning, which is key to the design of intelligent systems and gaining actionable insights from datasets that arise in computational science and engineering. The course will cover the theoretical foundations of this topic as well as computational aspects of algorithms for unsupervised and supervised learning. The topics to be covered include: The learning problem, clustering and k-means, principal component analysis, linear regression and classification, generalized linear models, bias-variance tradeoff, regularization methods, maximum likelihood estimation, kernel methods, the representer theorem, radial basis functions, support vector machines for regression and classification, an introduction to the theory of generalization, feedforward neural networks, stochastic gradient descent, ensemble learning, model selection and validation.

Prerequisite: ECE286H1, MAT185H1, MAT195H1, CSC263H1/ECE358H1
Exclusion: ECE421H1, CSC411H1, STA314H1
Total AUs: 51.20

ROB501H1 - Computer Vision for Robotics

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to aspects of computer vision specifically relevant to robotics applications. Topics include the geometry of image formation, basic image processing operations, camera models and calibration methods, image feature detection and matching, stereo vision, structure from motion and 3D reconstruction. Discussion of moving object identification and tracking as time permits.

Prerequisite: ROB301H1/ECE324H1
Exclusion: CSC420H1
Recommended Preparation: CSC263H1
Total AUs: 44.80

ROB521H1 - Mobile Robotics and Perception

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

The course addresses fundamentals of mobile robotics and sensor-based perception for applications such as space exploration, search and rescue, mining, self-driving cars, unmanned aerial vehicles, autonomous underwater vehicles, etc. Topics include sensors and their principles, state estimation, computer vision, control architectures, localization, mapping, planning, path tracking, and software frameworks. Laboratories will be conducted using both simulations and hardware kits.

Prerequisite: ROB310H1, AER372H1
Total AUs: 54.40

Statistics

STA302H1 - Methods of Data Analysis I

Credit Value: 0.50
Hours: 36L

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression.

Prerequisite: STA238H1/STA248H1/STA255H1/STA261H1/ECO227Y1/STAB57H3/STA258H5/STA260H5/ECO227Y5; CSC108H1/CSC110Y1/CSC120H1/CSC148H1/CSCA08H3/CSCA20H3/CSCA48H3/CSC108H5/CSC148H5; MAT221H1(70%)/MAT223H1/MAT240H1/MATA22H3/MATA23H3/MAT223H5/MAT240H5
Exclusion: STAC67H3, STA302H5
Total AUs: 38.40

STA410H1 - Statistical Computation

Credit Value: 0.50
Hours: 36L

Programming in an interactive statistical environment. Generating random variates and evaluating statistical methods by simulation. Algorithms for linear models, maximum likelihood estimation, and Bayesian inference. Statistical algorithms such as the Kalman filter and the EM algorithm. Graphical display of data.

Prerequisite: STA302H1/STAC67H3/STA302H5; CSC108H1/CSC110Y1/CSC120H1/CSC148H1/CSCA08H3/CSCA48H3/CSCA20H3/CSC108H5/CSC148H5; MAT223H1/MAT240H1/MATA22H3/MATA23H3/MAT223H5/MAT240H5
Total AUs: 38.40

ISTEP

TEP234H1 - Entrepreneurship and Small Business

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 1 of the 2 Part Entrepreneurship Program
The age of enterprise has arrived. Strategic use of technology in all sorts of businesses makes the difference between success and failure for these firms. Wealth creation is a real option for many and the business atmosphere is ready for you! Increasingly, people are seeing the advantages of doing their own thing, in their own way, in their own time. Entrepreneurs can control their own lives, structure their own progress and be accountable for their own success - they can fail, but they can not be fired! After all, engineers are the most capable people to be in the forefront of this drive to the business life of the next century. This course is the first of a series of two dealing with entrepreneurship and management of a small company. It is intended that the student would continue to take the follow up course APS432 as s/he progresses toward the engineering degree. Therefore, it is advisable that the descriptions of both courses be studied prior to deciding to take this one. This is a limited enrolment course. If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of the "Entrepreneur's Test". There will be a certificate awarded upon the successful completion of both courses attesting to the fact that the student has passed this Entrepreneurial Course Series at the University of Toronto. The course is based on real life issues, not theoretical developments or untried options. Topics covered include: Who is an entrepreneur; Canadian business environment; Acquisitions; Different business types (retail, wholesale, manufacturing, and services); Franchising; Human resources, Leadership, Business law; and many others. Several visitors are invited to provide the student with the opportunity to meet real entrepreneurs. There will be several assignments and a session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Exclusion:
CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1/APS281H1
Total AUs: 57.60

TEP343H1 - Engineering Leadership

Credit Value: 0.50
Hours: 12.8L/25.6P

Complementary Studies elective

This course is a practical approach to being a more productive engineer based on the premise that for technology to become a reality it must be translated through people. A key is to understand that engineers lead in ways that reflect their skills and mind set. The course begins with examining: 1) the meaning of leading (Why do something?); 2) the processes of leading (How do you do you create a vision and motivate others?); and 3) the tools of leading (What steps do you take to lead?). Learning frameworks and personal working styles inventories provide practical tools to assist the student to understand human nature and the logic of learning to become a competent leader of self, teams and organizations. The student prepares to become a competent leader by undertaking to learn (understand and integrate) key skills, character attributes and purposeful behaviours. The course presents strategies for development of high performance teams. Special attention is given to a number of subjects: transformational change, organizational culture, high performance work systems, and self-leadership. The course material is delivered through lectures, readings, in-class discussion and a team project. The project is based on the team interviewing the CEO of an engineering-intensive company or senior leader in the community. Students will be required to submit written reflections on course content and their personal experience.

Total AUs: 25.60

TEP432H1 - Entrepreneurship and Business Management

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 2 of the 2 Part Entrepreneurship Program

This is part two of the Entrepreneurship course series. The student considering taking this course would typically plan to pursue a career in small business started by themselves, or in a family enterprise. The skills acquired, however, are very useful in any business where a graduate might end up in their career, without the need for actually being an entrepreneur. Our approach to teaching is based on real-life business experiences and many years of successful practice of "what we preach". The course contains very little theoretical work or academic approaches. It is designed to familiarise you with the kinds of opportunities (problems) likely to be encountered in an entrepreneurial career. If you really want this lifestyle and are prepared to work hard, we will provide you with the practical knowledge and technical skills required to pursue this kind of career. Topics covered in this course include: Marketing and Sales; Legal issues; Financing the business; Human Resources challenges, the Business Plan and many other issues. Note that the course material may be adjusted between the two courses as required.

We recognize the value of communication skills in both the classroom and in project reports. In fact, we require that you learn how to present yourself in a business-like manner. As and when appropriate, outside visitors from the business community will join in and contribute to the class discussions. The course deals with practical concepts, actual past and current events and is presented from the point of view of someone who has "done it all". This means that what you hear is the real stuff. There will be several assignments and the preparation of a full Business Plan as the session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Prerequisite: APS234H1
Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1
Total AUs: 57.60

TEP442H1 - Cognitive and Psychological Foundations of Effective Leadership

Credit Value: 0.50
Hours: 38.4L

Complementary Studies elective

This course investigates the cognitive and psychological foundations of effective leadership. Students will explore current theories driving effective leadership practice including models of leadership, neurophysiological correlates of leadership and psychodynamic approaches to leadership. Students will learn and apply skills including mental modeling, decision-making, teamwork and self-evaluation techniques. This course is aimed at helping Engineering students to gain practical skills that will enhance their impact as leaders throughout their careers.

Total AUs: 38.40

TEP444H1 - Positive Psychology for Engineers

Credit Value: 0.50
Hours: 38.4L

Humanities and Social Science elective

Many disciplines have explored happiness - philosophy, anthropology, psychology, sociology, neurobiology, film, art and literature - to name a few. Why not engineering? During the first part of the course we will play catch-up, examining the scholarly and creative ways that people have attempted to understand what makes for a happy life. Then we turn our attention to our own domain-expertise, applying engineering concepts like "balance", "flow", "amplitude", "dynamic equilibrium""momentum" and others to explore the ways that your technical knowledge can contribute to a deep understanding of happiness. This course is designed to challenge you academically as we analyze texts from a variety of disciplines, but it is also designed to challenge you personally to explore happiness as it relates to yourself, your own personal development and your success and fulfillment as an engineer.

If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of an in-class assessment completed during the first class.

Total AUs: 38.40

TEP445H1 - The Power of Story: Discovering Your Leadership Narrative

Credit Value: 0.50
Hours: 25.6L/12.8T

Humanities and Social Science elective

This course offers an introduction to relational, authentic and transformational leadership theory by focusing on narrative and the power of story telling. Students will practice story-telling techniques by learning about the mechanics of stories, improve their public speaking by engaging in regular storytelling practice, explore their personal history by reflecting on their identities, and develop critical thinking skills regarding the stories (meta-narratives) that surround us, particularly as they relate to engineering problems/ethics. This is a highly experiential course with a focus on reading, discussion, practice and reflection.

Total AUs: 38.40

TEP447H1 - The Art of Ethical & Equitable Decision Making in Engineering

Credit Value: 0.50
Hours: 38.4L

The primary objective of this course is to help engineering students navigate the ambiguous world of engineering ethics and equity using case studies drawn from the careers of Canadian engineers. In addition to being exposed to a range of ethical theories, the PEO code of ethics and the legal context of engineering ethics, students enrolled in this course will engage in ethical decision-making on a weekly basis.

Total AUs: 38.40

CERTIFICATE IN ARTIFICIAL INTELLIGENCE ENGINEERING (AECERAIEN)

Artificial Intelligence (AI) and Machine learning (ML) have exploded in importance in recent years and garnered attention in a wide variety of application areas, including computer vision (e.g. image recognition), game playing (e.g. AlphaGo), autonomous driving, speech recognition, customer preference elicitation, bioinformatics (e.g. gene analysis) and others. While the topics may appear primarily to reside in the disciplines of computer engineering and computer science, the topics of AI and ML now apply to all disciplines of engineering, such as projection of future road-traffic patterns, applications in industrial automation and robotic control, or the use of AI/ML drug discovery, to name just a few examples.

All undergraduate Engineering students are eligible to participate in this certificate EXCEPT students in the Engineering Science Machine Intelligence Major and the Robotics Major.

The requirements for the Certificate in Artificial Intelligence Engineering in the Faculty of Applied Science and Engineering are the successful completion of the following courses:

Courses		Lect.	Lab.	Tut.	Wgt.
Required Course:					
APS360H1: Applied Fundamentals of Machine Learning	S	3	-	1	0.50
One of:					
ECE345H1: Algorithms and Data Structures	F/S	3	-	2	0.50
ECE358H1: Foundations of Computing	F	3	-	1	0.50
CSC263H1	F/S	2	-	1	0.50
MIE335H1: Algorithms & Numerical Methods	S	3	1	1	0.50
One of:					
ROB311H1: Artificial Intelligence	S	3	-	1	0.50
CSC384H1: Introduction to Artificial Intelligence	F/S	2	-	1	0.50
ECE421H1: Introduction to Machine Learning	S	3	-	2	0.50
CSC311H1: Introduction to Machine Learning	S	2	-	1	0.50
MIE424H1: Optimization in Machine Learning	S	-	-	-	0.00
ROB313H1: Introduction to Learning from Data	S	3	-	2	0.50

Engineering Science students enrolled in the Robotics Major are not eligible for the AI Engineering Certificate due to overlapping core course requirements.

CERTIFICATE IN COMMUNICATION (AECERCOM)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

This certificate creates an opportunity for interested students to gain specialized expertise and recognition for a personal and professional commitment to enhanced communication skills. With the certificate, participating students can establish communication expertise through courses that expand on communication practices in contexts beyond engineering, deepen theoretical understanding of communication, and facilitate professional development in writing, oral communication, and critical thinking.

Students in all disciplines are eligible to participate in this Certificate.

Students pursuing the Certificate in Communication must successfully complete a minimum of 3 courses from the list outlined below:

		Lect.	Lab.	Tut.	Wgt.
TEP281H1: Language and Meaning	S	4	-	-	0.50
TEP320H1: Representing Science on Stage	F	2	-	2	0.50
TEP321H1: Representing Science and Technology in Popular Media	F	2	-	2	0.50
TEP322H1: Language and Power	S	2	-	2	0.50
TEP323H1	F	2	-	2	0.50
TEP324H1: Engineering and Social Justice	S	2	-	2	0.50
TEP325H1: Engineering and Science in the Arts	F	2	-	2	0.50
TEP326H1: Special Topics in Creative Writing	F/S	2	-	2	0.50
TEP445H1: The Power of Story: Discovering Your Leadership Narrative	F	2	-	1	0.50
INI304H1	S	-	-	-	0.50
INI305H1	S	-	-	-	0.50
INI310H1	F	-	-	-	0.50

NOTE:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.
- If a student is pursuing both the Communication Certificate and another Minor or Certificate that lists the course, the courses listed above can only be counted towards one certificate or minor, not both.

CERTIFICATE IN ENGINEERING BUSINESS (AECERBUS)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

The Undergraduate Engineering Business Certificate is a collaborative effort across the Faculty of Applied Science and Engineering and the Rotman School of Management and is open to Engineering students interested in learning more about the business dimension of engineering, from finance and economics to management and leadership. Courses include engineering economics, with a choices of accounting and finance, marketing and strategy, management and organizational behaviour, or entrepreneurship. All undergraduate Engineering students are eligible for this certificate program.

The requirements of the Certificate in Engineering Business in the Faculty of Applied Science and Engineering are the successful completion of the following requirements:

Economics Courses		Lect.	Lab.	Tut.	Wgt.
Choose one of:					
CHE249H1: Engineering Economic Analysis	F	3	-	1	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CME368H1: Engineering Economics and Decision Making	F	3	-	1	0.50
ECE472H1: Engineering Economic Analysis & Entrepreneurship	F/S	3	-	2	0.50
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50

Electives		Lect.	Lab.	Tut.	Wgt.
Choose two of :					
JRE300H1: Fundamentals of Accounting and Finance	F/S	3	-	1	0.50
JRE410H1: Markets and Competitive Strategy	F/S	2	2	-	0.50
JRE420H1: People Management and Organizational Behaviour	F/S	3	-	1	0.50
One choice above can be replaced by one of the following:					
CHE488H1: Entrepreneurship and Business for Engineers	S	3	-	2	0.50
CIV488H1: Entrepreneurship and Business for Engineers	S	3	-	2	0.50
ECE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50
MIE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50
MSE488H1: Entrepreneurship and Business for Engineers	F	3	-	2	0.50

NOTE:

Students may only receive credit on their transcript for one of the Engineering Business Certificate, the Entrepreneurship Certificate, or the Engineering Business Minor.

CERTIFICATE IN ENGINEERING LEADERSHIP (AECERLEAD)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

Leadership education is about learning how to effectively handle complex, human challenges that often mean the difference between success and failure. Engineers are taught to think analytically and systematically. Leadership skills build on these strengths to make you a more effective engineer. More than just important, they are critical. This certificate recognizes a demonstrated focus in leadership courses provided jointly through the Faculty of Applied Science and Engineering and the Institute for Leadership Education in Engineering. Students in all disciplines are eligible to participate in this Certificate.

Students pursuing the Certificate in Engineering Leadership must successfully complete a minimum of 3 courses from the list outlined below:

Courses		Lect.	Lab.	Tut.	Wgt.
Choose 3 of the following:					
TEP322H1: Language and Power	S	2	-	2	0.50
TEP343H1: Engineering Leadership	F/S	1	2	-	0.50
TEP442H1: Cognitive and Psychological Foundations of Effective Leadership	S	3	-	-	0.50
TEP444H1: Positive Psychology for Engineers	F	3	-	-	0.50
TEP445H1: The Power of Story: Discovering Your Leadership Narrative	F	2	-	1	0.50
TEP447H1: The Art of Ethical & Equitable Decision Making in Engineering	S	3	-	-	0.50
TEP448H1	S	2	-	2	0.50

NOTE:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.

- If a student is pursuing both the Engineering Leadership Certificate and another Minor or Certificate that lists the course, the courses listed above can only be counted towards one certificate or minor, not both.

CERTIFICATE IN ENTREPRENEURSHIP, INNOVATION AND SMALL BUSINESS (AECERENTR)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit, can be counted for more than one minor or certificate.

Since the dawn of the industrial revolution, engineers have been among the most successful entrepreneurs, and this is especially true in today's global economy. The enormous growth of the e-Economy has enabled many young people to be successful even earlier than the previous generation did. Wealth creation is a legitimate aspiration today and many of you will be successful in this endeavor. Furthermore, strategic uses of technology in all sorts of businesses make the difference between success and failure for these firms. The entrepreneurial spirit together with drive and persistency are requirements for success. Also, to participate effectively in this global economy, large and medium sized corporations are desperately seeking entrepreneurs, entrepreneurial individuals who prefer to work inside a larger firm rather than to start or run their own business. Owning a business has many advantages. Entrepreneurs can control their own lives, structure their own progress, be accountable for their own success and can see the fruit of their labours in the wealth they create. After all, engineers are the most capable people to be in the forefront of this drive which will depend on the online e-Business environment fostered by the Internet and the Web in the new millennium. The development of these talents is addressed in a set of two courses but be forewarned that these courses require a substantial effort on the part of the student and the instructors. They are unusual in that, to be accepted into them, a student has to possess some of the prerequisite personality traits and some unique abilities required to become a successful entrepreneur.

Prior to being accepted into TEP234H1, a short test is offered to those who believe that they have the drive and talents to start their own business. TEP234H1 is available in the Fall semester in any but the first year of study. TEP432H1 is offered in the Winter and can be taken in the same or a later year. The courses are sequential and the first is the prerequisite of the second.

The following are the required certificate courses:

Required		Lect.	Lab.	Tut.	Wgt.
TEP234H1: Entrepreneurship and Small Business	F	4	-	1	0.50
TEP432H1: Entrepreneurship and Business Management	S	4	-	1	0.50

Economics Elective		Lect.	Lab.	Tut.	Wgt.
Choose one of:					
CHE249H1: Engineering Economic Analysis	F	3	-	1	0.50
CHE374H1: Economic Analysis and Decision Making	F	3	-	1	0.50
CME368H1: Engineering Economics and Decision Making	F	3	-	1	0.50
ECE472H1: Engineering Economic Analysis & Entrepreneurship	F/S	3	-	2	0.50
MIE258H1: Engineering Economics and Accounting	F	3	-	1	0.50

NOTE:

Students may only receive credit on their transcript for one of the Engineering Business Certificate or the Entrepreneurship Certificate, or the Engineering Business Minor.

CERTIFICATE IN FORENSIC ENGINEERING (AECERFORE)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

The Certificate in Forensic Engineering provides a unique opportunity to gain recognition for a personal and professional commitment to enhanced engineering investigation skills. Forensic engineering has traditionally been associated with the investigation of artifacts that fail or do not operate/function as intended, causing personal injury and/or monetary loss, the consequences of which are normally dealt with in a court of law. Forensic engineering training, however, goes well beyond the expert witness in the courtroom. Forensic engineering skills are highly valuable in other activities such as: assessment of deterioration in infrastructure, product quality and procedural practice improvement as a result of investigations, direct impact on improving engineering design practices and revision of codes/standards to improve public safety.

Students in all disciplines are eligible to participate in this Certificate.

Students pursuing the Certificate in Forensic Engineering must successfully complete a minimum of 3 courses as follows:

Courses		Lect.	Lab.	Tut.	Wgt.
MSE431H1: Forensic Engineering	S	3	-	1	0.50
Two of:					
APS440H1: Making Sense of Accidents	S	3	1	-	0.50
CHE441H1: Engineering Materials	F	3	-	1	0.50
CHE467H1: Environmental Engineering	F	3	-	1	0.50
CHE561H1: Risk Based Safety Management	S	3	-	1	0.50
CIV440H1: Environmental Impact and Risk Assessment	S	3	-	1	0.50
CIV510H1: Solid Mechanics II	S	3	-	2	0.50
MIE304H1: Introduction to Quality Control	S	3	1	2	0.50
MIE320H1: Mechanics of Solids II	S	3	1.50	2	0.50
MIE364H1: Quality Control and Improvement	S	3	1	2	0.50
MIE442H1: Machine Design	F	3	1.50	3	0.50
MIE469H1: Reliability and Maintainability Engineering	S	3	-	2	0.50
MSE401H1: Materials Information in Design	F	3	-	-	0.50
MSE415H1: Environmental Degradation of Materials	F	3	-	-	0.50
MSE419H1: Fracture and Failure Analysis	F	3	-	1	0.50

NOTE:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.
- If a student is pursuing both the Forensic Engineering Certificate and a Minor that lists the course, the courses listed above can only be counted towards either the certificate or the minor, not both

CERTIFICATE IN GLOBAL ENGINEERING (U of T Global Scholar) (AECERGLOB)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

The Undergraduate Certificate in Global Engineering is open to Engineering students interested in developing their knowledge of global issues and how engineers can influence and improve conditions around the world. The courses focus on a variety of concepts such as effects of emerging and appropriate technologies in both developed and developing economies, global energy systems, innovative finance techniques, current theories in international development and foreign aid. All undergraduate Engineering students are eligible to participate in this certificate. Students who complete the requirements of the Certificate in Global Engineering are considered University of Toronto Global Scholars.

The requirements for the Certificate in Global Engineering in the Faculty of Applied Science and Engineering are the successful completion of the following courses:

Courses		Lect.	Lab.	Tut.	Wgt.
Choose two of:					
APS299Y0: Summer Research Abroad	Y	-	7	-	1.00
APS510H1: Innovative Technologies and Organizations in Global Energy Systems	F	3	-	1	0.50
APS530H1: Appropriate Technology & Design for Global Development	S	3	-	-	0.50
APS420H1: Technology, Engineering and Global Development	S	3	-	-	0.50
Global Engineering themed capstone (APS490Y, ECE496Y, MIE490Y, CIV498H) as approved by the Director of the Centre for Global Engineering	F/S/Y				0.00
Choose one of:					
ANT204H1 (formerly ANT204Y1): Anthropology of the Contemporary World	F	-	-	-	0.50
ENV333H1	F	-	-	-	0.50
GGR112H1: Geographies of Globalization, Development and Inequality	F	-	-	-	0.50
JGI216H1	S	-	-	-	0.50
POL201Y1	Y	-	-	-	0.50
POL208Y1	Y	-	-	-	0.50
CDN268H1 (formerly UNI268H1): Canada and Globalization	S	-	-	-	0.50

NOTE:

If a student is pursuing both the Certificate in Global Engineering and either the Sustainable Energy Minor or the Environmental Engineering Minor, the courses listed above can only be counted towards either the certificate or the minor, not both, unless they taken as Extra credits or not being counted towards degree requirements.

CERTIFICATE IN MINERAL RESOURCES (AECERMINR)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

The mineral resources sector encompasses many disciplines, and covers endeavours that range from mineral exploration and resource estimation, through mine planning, design and operation, and on to mining finance. Environment protection is foremost in all these, and they all operate under strict international legislative frameworks. The Mineral Resources Certificate provides exposure to the sector for interested candidates, and is arranged in themes to suit a student's specific area of interest.

Students in all disciplines except the Lassonde Mineral Engineering Program are eligible to participate in this Certificate.

All courses indicated below are technical courses, not CS or HSS. Students may take these as either a Free Elective or as a Technical Elective Substitution with the approval of their home department.

Students will receive the Mineral Resources Certificate upon completion of 3 courses as outlined below:

Certificate Courses		Lect.	Lab.	Tut.	Wgt.
Core Requirement:					
MIN120H1: Insight into Mineral Engineering	S	3	2	1	0.50
Two courses from one of the following themes:					
Theme 1: Mine planning and design					
MIN250H1	S	3	-	1	0.50
MIN351H1: Underground Mining	S	3	-	1	0.50
Theme 2: Mineral Resources and Economics					
MIN301H1	S	3	-	1	0.50
MIN450H1: Mineral Economics	F	3	-	1	0.50
Theme 3: Mining and the Environment					
MIN250H1: Surface Mining	S	3	-	1	0.50
MIN330H1: Mining Environmental Management	S	3	-	1	0.50
Theme 4: Assessment & Management of Mineral Resources					
MIN301H1	S	3	-	1	0.50
MIN330H1: Mining Environmental Management	S	3	-	1	0.50

Notes:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.
- Students must secure approval from their home department before selecting any elective outside their departmental approved list.

CERTIFICATE IN MUSIC TECHNOLOGY (AECERMUST)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

This certificate was designed for Engineering undergraduates interested in exploring the intersection between music, technology and engineering. This certificate is open to any student completing an undergraduate degree in the Faculty of Applied Science and Engineering.

Through our partnership with the Faculty of Music, we are able to provide access to a number of technical courses normally only open to their students.

Due to the nature of these courses and the requirements set by the CEAB, there are courses within this program that are only eligible for Free Elective (FE) or Extra course status (EXT). Thus students wishing to pursue this minor must be prepared to be taking on course work above and beyond their degree requirements. ECE446 and Technical courses from the Faculty of Music may be requested as Technical Elective Substitutions (TES) for a student's degree program, subject to the approval of the student's home department.

Students pursuing the Certificate in Music Technology must successfully complete a minimum of 3 courses (1.5 FCE) as follows:

Core Courses		Lect.	Lab.	Tut.	Wgt.
TMU111H1	F/S/Y	-	-	-	0.00
One of:					
ECE446H1: Sensory Communication	F	3	1.50	-	0.50
TMU130H1	F/S	-	-	-	0.50

Electives		Lect.	Lab.	Tut.	Wgt.
One of:					
HMU111H1: Introduction to Music & Society	F/S	-	-	-	0.50
MUS110H1: Introduction to Music History & Culture	F/S	-	-	-	0.50
MUS111H1: Historical Survey of Western Music	F/S	-	-	-	0.50
MUS200H1: Music of the World's Peoples	F/S	-	-	-	0.50
MUS204H1: The Age of Bach and Handel	F/S	-	-	-	0.50
MUS209H1: Performing Arts of South Asia	F/S	-	-	-	0.50
MUS211H1: The World of Popular Music	F/S	-	-	-	0.50
MUS212H1: Music, Sound & Power in the Middle East	F/S	-	-	-	0.50
MUS240H1: Heavy Music	F/S	-	-	-	0.50
MUS302H1: Symphony	F/S	-	-	-	0.50
MUS306H1: Popular Music in North America	F/S	-	-	-	0.50
MUS308H1: Handel	F/S	-	-	-	0.50
MUS335H1: A Social History of the Piano	F/S	-	-	-	0.50
TMU131H1: Music Theory 2	F/S	-	-	-	0.50
TMU313H1: Introduction to Music Recording	F/S	-	-	-	0.50
TMU319H1: Electroacoustic Music I	F/S	-	-	-	0.50
TMU320H1: Electroacoustic Music II	F/S	-	-	-	0.50
TMU330H1: Live Coding: Digital Audio in Real Time	F/S	-	-	-	0.50
TMU406H1: Max/MSP	F/S	-	-	-	0.50

Note: Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.

Note on Electives: The Faculty of Music updates the list of MUS courses offered each year. A final list of MUS electives eligible for the academic year will be posted on the Minors web site in May.

CERTIFICATE IN NUCLEAR ENGINEERING (AECERNUC)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit can be counted for more than one minor or certificate.

Nuclear energy constitutes an important component of the energy mix in most national energy strategies, and its proportion will likely increase in response to growing challenges related to fossil-driven climate change. Modular nuclear systems power space craft and remote sites on earth. Future nuclear power systems will address current concerns regarding safety and the environment, and significant breakthroughs are likely in fusion technology. This certificate provides recognition for an interdisciplinary focus on nuclear systems. Students in all disciplines are eligible to participate in this Certificate.

The requirements for the Certificate in Nuclear Engineering in the Faculty of Applied Science and Engineering are the successful completion of the following courses:

Courses		Lect.	Lab.	Tut.	Wgt.
CHE566H1: Elements of Nuclear Engineering	F	3	-	2	0.50
Choose two of:					
AER507H1: Introduction to Fusion Energy	F	3	-	1	0.50
CHE568H1: Nuclear Engineering	S	3	-	1	0.50
MIE407H1: Nuclear Reactor Theory and Design	F	3	-	2	0.50
* MIE408H1: * Thermal and Machine Design of Nuclear Power Reactors	S	3	-	2	0.50

NOTE:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.
- Students must secure approval from their home department before selecting any elective outside their departmental approved list.
- If a student is pursuing both the Nuclear Engineering Certificate and the Sustainable Energy Minor, the courses listed above can only be counted towards either the certificate or the minor, not both.

CERTIFICATE IN RENEWABLE RESOURCES ENGINEERING (AECERRRE)

Successful completion of an Engineering Certificate is included on transcripts. Note that no course counted for degree credit, can be counted for more than one minor or certificate.

The Forestry faculty at the John H. Daniels Faculty of Architecture, Landscape, and design have expertise in sustainable resource management and bio-economics, sustainable energy production, green manufacturing and sustainable communities. This grouping of courses developed for engineering students reflects the strong interconnections between their work and various branches of Engineering. The Certificate provides recognition for a demonstrated focus in renewable resources. Students in all disciplines are eligible to participate in this Certificate.

Students pursuing the Certificate in Renewable Resources Engineering Leadership must successfully complete a minimum of 3 courses from the list outlined below:

Courses		Lect.	Lab.	Tut.	Wgt.
Choose three of:					
CHE475H1: Biocomposites: Mechanics and Bioinspiration	S	3	-	1	0.50
FOR308H1: Discovering Wood and its Role in Societal Development	F	3	-	1	0.50
FOR421H1: Green Urban Infrastructure: Sustainable City Forests	F	2	-	-	0.50
FOR424H1: Innovation and Manufacturing of Sustainable Materials	S	2	-	1	0.50
FOR425H1: Bioenergy and Biorefinery Technology	S	2	-	2	0.50

NOTE:

- Availability of the courses (including the foundational courses) for timetabling purposes is not guaranteed; the onus is on the student to ensure compatibility with their timetable.
- Students must secure approval from their home department before selecting any elective outside their departmental approved list.
- If a student is pursuing both the Renewable Resources Engineering Certificate and a Minor that lists the course, the courses listed above can only be counted towards either the certificate or the minor, not both.

Certificate Program Courses

Aerospace Science and Engineering

AER507H1 - Introduction to Fusion Energy

Credit Value: 0.50
Hours: 38.4L/12.8T

Nuclear reactions between light elements provide the energy source for the sun and stars. On earth, such reactions could form the basis of an essentially inexhaustible energy resource. In order for the fusion reactions to proceed at a rate suitable for the generation of electricity, the fuels (usually hydrogen) must be heated to temperatures near 100 million Kelvin. At these temperatures, the fuel will exist in the plasma state. This course will cover: (i) the basic physics of fusion, including reaction cross-sections, particle energy distributions, Lawson criterion and radiation balance, (ii) plasma properties including plasma waves, plasma transport, heating and stability, and (iii) fusion plasma confinement methods (magnetic and inertial). Topics will be related to current experimental research in the field.

Total AUs: 44.80

Applied Science and Engineering (Interdepartmental)

APS299Y0 - Summer Research Abroad

Credit Value: 1.00
Hours: 89.6P

An independent research project conducted in an engineering laboratory at an approved partner institution abroad for 10-16 weeks in the summer term. This course is intended for students who will have completed their 2nd or 3rd year of study by the time they take the course. Students must apply for this program through the Centre for International Experience in the fall term and will be notified by January if they are accepted. Students should inquire with their home department to determine whether the course can count towards their degree requirements. For more information, please contact the Cross-Disciplinary Programs Office at cdp@ecf.utoronto.ca

Prerequisite: Pre-requisite: Students must have a cGPA of at least 3.0 and permission of their department.
Total AUs: 44.80

APS360H1 - Applied Fundamentals of Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T

A basic introduction to the history, technology, programming and applications of the fast evolving field of machine learning. Topics to be covered may include neural networks, autoencoders/decoders, recurrent neural networks, natural language processing, and generative adversarial networks. Special attention will be paid to fairness and ethics issues surrounding machine learning. An applied approach will be taken, where students get hands-on exposure to the covered techniques through the use of state-of-the-art machine learning software frameworks.

Prerequisite:
APS105H1/APS106H1/ESC180H1/CSC180H1; APS163/MAT187H1/ESC195H1; MAT185H1/MAT188H1
Recommended Preparation:
CHE223H1/CME263H1/ECE302H1/MIE231H1/MIE236H1/MSE238H1/STA286H1/ECE286H1
Total AUs: 44.80

APS420H1 - Technology, Engineering and Global Development

Credit Value: 0.50
Hours: 38.4L

Humanities and Social Science Elective

The role of technology and engineering in global development is explored through a combination of lectures, readings, case studies, and analysis of key technologies, including energy, information and communications technologies, water and healthcare. Topics include a brief history and basic theories of international development and foreign aid, major government and non-government players, emerging alternative models (social entrepreneurship, microfinance, risk capital approaches), major and emerging players in social venture capital and philanthropy, the role of financial markets, environmental and resource considerations/sustainable development, technology diffusion models and appropriate technologies.

Exclusion: APS520H1, APS420H1
Total AUs: 38.40

APS440H1 - Making Sense of Accidents

Credit Value: 0.50
Hours: 38.4L/12.8P

Despite the best of engineering practices, spectacular failures of complex technological systems occur regularly. Traditional engineering explanations for the causes of accidents utilize eventchain models and often blame operators. This course highlights the limitations of such models and shows that accidents in sociotechnical systems can be better understood using systems engineering. Further insights are provided by reviewing various sociological theories that have been advanced to explain and prevent accidents.

Total AUs: 44.80

APS510H1 - Innovative Technologies and Organizations in Global Energy Systems

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

A broad range of global energy systems are presented including electricity generation, electricity end use, transportation and infrastructure. Discussions are based on two key trends: (a) the increasing ability to deploy technologies and engineering systems globally, and (b) innovative organizations, many driven by entrepreneurship (for profit and social) and entrepreneurial finance techniques. The course considers these types of innovations in the context of developed economies, rapidly developing economies such as India and China, and the developing world. The course will interweave a mix of industry examples and more in-depth case studies. The examples and cases are examined with various engineering, business and environmental sustainability analysis perspectives.

Prerequisite: Undergraduate economics course
Exclusion: APS310H1
Total AUs: 44.80

APS530H1 - Appropriate Technology & Design for Global Development

Credit Value: 0.50
Hours: 38.4L

Engineering design within the context of global society, emphasizing the needs of users in order to support appropriate, sustainable technology. A design project will comprise the major component of the course work. The course will take the approach of "design for X". Students are expected to be familiar with design for functionality, safety, robustness, etc. This course will extend the students' understanding of design methodologies to design for "appropriateness in developing regions". Readings and discussions will explore the social, cultural, economic, educational, environmental and political contexts in which third world end users relate to technology. Students will then incorporate their deepened understanding of this context in their design project. The projects will be analyzed for functionality as well as appropriateness and sustainability in the third world context. Upon completion of the course, students should have a deeper appreciation of the meaning of appropriate technology in various international development sectors such as healthcare, water & sanitation, land management, energy, infrastructure, and communications in both urban and rural settings.

Total AUs: 38.40

Chemical Engineering and Applied Chemistry

CHE249H1 - Engineering Economic Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering analysis and design are not ends in themselves, but they are a means for satisfying human wants. Thus, engineering concerns itself with the materials used and forces and laws of nature, and the needs of people. Because of scarcity of resources and constraints at all levels, engineering must be closely associated with economics. It is essential that engineering proposals be evaluated in terms of worth and cost before they are undertaken. In this course we emphasize that an essential prerequisite of a successful engineering application is economic feasibility. Hence, investment proposals are evaluated in terms of economic cost concepts, including break even analysis, cost estimation and time value of money. Effective interest rates, inflation and deflation, depreciation and income tax all affect the viability of an investment. Successful engineering projects are chosen from valid alternatives considering such issues as buy or lease, make or buy, cost and benefits and financing alternatives. Both public sector and for-profit examples are used to illustrate the applicability of these rules and approaches.

Total AUs: 44.80

CHE374H1 - Economic Analysis and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

Economic evaluation and justification of engineering projects and investment proposals. Cost estimation; financial and cost accounting; depreciation; inflation; equity, bond and loan financing; after tax cash flow; measures of economic merit in the private and public sectors; sensitivity and risk analysis; single and multi-attribute decisions. Introduction to micro-economic. Applications: retirement and replacement analysis; make-buy and buy-lease decisions; economic life of assets; capital budgeting; selection from alternative engineering proposals; production planning; investment selection.

Prerequisite: MAT194H1, ESC103H1
Exclusion: CHE249H1, CME368H1/MIE258H1
Total AUs: 44.80

CHE441H1 - Engineering Materials

Credit Value: 0.50
Hours: 38.4L/12.8T

This course advances the understanding of the use of materials in engineering design, with special emphasis on corrosion and the effect of chemical environment on long term failure modes. Students will learn how to apply material property data to specify materials for load bearing applications, thermal and other non-structural applications, and chemical containment and transport. Topics will include strength of materials concepts, an introduction to computerized materials databases, material failure modes and criteria, principles of corrosion, and practical applications of corrosion prediction and mitigation. Students are required to design a component of their choice and do a detailed materials selection as a major design project.

Total AUs: 44.80

CHE467H1 - Environmental Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor A course which treats environmental engineering from a broad based but quantitative perspective and covers the driving forces for engineering activities as well as engineering principles. Models which are used for environmental impact, risk analysis, health impact, pollutant dispersion, and energy system analysis are covered.

Total AUs: 44.80

CHE475H1 - Biocomposites: Mechanics and Bioinspiration

Credit Value: 0.50
Hours: 38.4L/12.8T

An overview on structure, processing and application of natural and biological materials, biomaterials for biomedical applications, and fibre-reinforced eco-composites based on renewable resources will be provided. Fundamental principles related to linear elasticity, linear viscoelasticity, dynamic mechanical response, composite reinforcement mechanics, and time-temperature correspondence will be introduced. Novel concepts in comparative biomechanics, biomimetic and bio-inspired material design, and materials' ecological and environmental impact will be discussed. In addition, key material processing methods and testing and characterization techniques will be presented. Structure-property relationships for materials broadly ranging from natural materials, including wood, bone, cell, and soft tissue, to synthetic composite materials for industrial and biomedical applications will be covered.

Total AUs: 44.80

CHE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MIE488H1, MSE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

CHE561H1 - Risk Based Safety Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an introduction to Process Safety Management. The historical drivers to improve safety performance are reviewed and the difference between safety management and occupational health and safety is discussed. National and international standards for PSM are reviewed. Risk analysis is introduced along with techniques for process hazard analysis and quantification. Consequence and frequency modelling is introduced. Rsik based decision making is introduced, and the course concludes with a discussio of the key management systems required for a successful PSM system.

Total AUs: 44.80

CHE566H1 - Elements of Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

A first course in nuclear engineering intended to introduce students to all aspects of this interdisciplinary field. Topics covered include nuclear technology, atomic and nuclear physics, thermonuclear fusion, nuclear fission, nuclear reactor theory, nuclear power plants, radiation protection and shielding, environment and nuclear safety, and the nuclear fuel cycle.

Total AUs: 51.20

CHE568H1 - Nuclear Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamental and applied aspects of nuclear engineering. The structure of the nucleus; nuclear stability and radioactive decay; the interaction of radiation with matter including radiological health hazards; the interaction of neutrons including cross-sections, flux, moderation, fission, neutron diffusion and criticality. Poison buildup and their effects on criticality. Nuclear engineering of reactors, reactor accidents, and safety issues.

Exclusion: MIE414H1
Total AUs: 44.80

Civil Engineering

CIV440H1 - Environmental Impact and Risk Assessment

Credit Value: 0.50
Hours: 38.4L/12.8T

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.

Total AUs: 44.80

CIV488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered in other Departments: MSE488H1, MIE488H1, ECE488H1 and CHE488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

CIV510H1 - Solid Mechanics II

Credit Value: 0.50
Hours: 38.4L/25.6T

This course provides a continuing study of the mechanics of deformable solids. Stress and equilibrium conditions, strain and compatibility conditions, stress-strain relations and yield/failure criteria are considered in the context of civil engineering materials. Two-and three-dimensional elasticity theory is developed, with an introduction to the use of tensor notation. Advanced topics in bending, shear and torsion of beams are also covered, as is elementary plate bending theory. The course concludes with a further development and application of energy methods including virtual work, potential energy, strain energy, and related approaches.

Prerequisite: CME210H1
Total AUs: 51.20

Civil and Mineral Engineering

CME368H1 - Engineering Economics and Decision Making

Credit Value: 0.50
Hours: 38.4L/12.8T

The incorporation of economic and non-monetary considerations for making decision about public and private sector engineering systems in urban and other contexts. Topics include rational decision making; cost concepts; time value of money and engineering economics; microeconomic concepts; treatment of risk and uncertainty; and public project evaluation techniques incorporating social and environmental impacts including benefit cost analysis and multi-objective analysis.

Total AUs: 44.80

Computer Science

CSC384H1 - Introduction to Artificial Intelligence

Credit Value: 0.50
Hours: 24L/12T

Theories and algorithms that capture (or approximate) some of the core elements of computational intelligence. Topics include: search; logical representations and reasoning, classical automated planning, representing and reasoning with uncertainty, learning, decision making (planning) under uncertainty. Assignments provide practical experience, in both theory and programming, of the core topics.

Prerequisite: (CSC263H1/ CSC265H1/ CSC263H5/ CSCC63H3/ ECE345H1/ ECE358H1/ MIE335H1, STA237H1/ STA247H1/ STA255H1/ STA257H1/ STA237H1/ STAB57H3/ STAB52H3/ ECE302H1/ STA286H1/ CHE223H1/ CME263H1/ MIE231H1/ MIE236H1/ MSE238H1/ ECE286H1)
Exclusion: NOTE: Students not enrolled in the Computer Science Major or Specialist program at FAS, UTM, or UTSC, or the Data Science Specialist at FAS, are limited to a maximum of three 300-/400-level CSC/ECE half-courses.
Recommended Preparation: CSC324H1
Total AUs: 32.00

Electrical and Computer Engineering

ECE345H1 - Algorithms and Data Structures

Credit Value: 0.50
Hours: 38.4L/25.6T

Design and analysis of algorithms and data structures that are essential to engineers in every aspect of the computer hardware and software industry. Recurrences, asymptotics, summations, trees and graphs. Sorting, search trees and balanced search trees, amortized analysis, hash functions, dynamic programming, greedy algorithms, basic graph algorithms, minimum spanning trees, shortest paths, introduction to NP completeness and new trends in algorithms and data structures.

Prerequisite: ECE244H1 or equivalent with the permission of the Chair of the AI certificate/minor.
Total AUs: 50.40

ECE358H1 - Foundations of Computing

Credit Value: 0.50
Hours: 38.4L/12.8T

Fundamentals of algorithm design and computational complexity, including: analysis of algorithms, graph algorithms, greedy algorithms, divide-and-conquer, dynamic programming, network flow, approximation algorithms, the theory of NP-completeness, and various NP-complete problems.

Prerequisite: ESC190H1
Exclusion: ECE345H1
Total AUs: 44.80

ECE421H1 - Introduction to Machine Learning

Credit Value: 0.50
Hours: 38.4L/25.6T

An Introduction to the basic theory, the fundamental algorithms, and the computational toolboxes of machine learning. The focus is on a balanced treatment of the practical and theoretical approaches, along with hands on experience with relevant software packages. Supervised learning methods covered in the course will include: the study of linear models for classification and regression, neural networks and support vector machines. Unsupervised learning methods covered in the course will include: principal component analysis, k-means clustering, and Gaussian mixture models. Theoretical topics will include: bounds on the generalization error, bias-variance tradeoffs and the Vapnik-Chervonenkis (VC) dimension. Techniques to control overfitting, including regularization and validation, will be covered.

Prerequisite: ECE286H1/STA286H1, ECE302H1/MIE231H1/CHE223H1/MIE236H1/MSE238H1
Exclusion: CSC411H1, ECE521H1
Total AUs: 51.20

ECE446H1 - Sensory Communication

Credit Value: 0.50
Hours: 38.4L/12.8T/19.2P

Physical acoustics, acoustic measurements, electroacoustic transducers, and physiological acoustics. Speech processing, speech recognition algorithms and signal processing by the auditory system. Engineering aspects of acoustic design. Electrical models of acoustic systems. Noise, noise-induced hearing loss, and noise control. Introduction to vision and other modalities. Musical and psychoacoustics.

Total AUs: 54.40

ECE472H1 - Engineering Economic Analysis & Entrepreneurship

Credit Value: 0.50
Hours: 38.4L/25.6T

The economic evaluation and justification of engineering projects and investment proposals are discussed. Cost concepts; financial and cost accounting; depreciation; the time value of money and compound interest; inflation; capital budgeting; equity, bond and loan financing; income tax and after-tax cash flow in engineering project proposals; measures of economic merit in the public sector; sensitivity and risk analysis. Applications: evaluations of competing engineering project alternatives; replacement analysis; economic life of assets; lease versus buy decisions; break-even and sensitivity analysis. Entrepreneurship and the Canadian business environment will be discussed.

Total AUs: 50.40

ECE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: MSE488H1, MIE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

Forestry

FOR308H1 - Discovering Wood and its Role in Societal Development

Credit Value: 0.50
Hours: 38.4L/12.8T

Humanities and Social Science elective

Trees and their components have been used through the centuries for shelter, heat, entertainment, weapons, sport, furnishings, communication, food and medicines. This course explores the co-evolution of nature and culture by examining the social and economic impacts that the forest and its exploitation had in the development of societies throughout the ages. Focus will be on the cultural history of wood and products derived from it and its influence on developing societies from biblical times to modern day. The course will examine how wood's versatility and usefulness in varied applications has been discovered by society as needs for survival to austerity develop. The unique properties of woody materials will be examined to expose its ability to meet the varied demands of societies throughout the ages. This course will allow students to explore the place and role of wood derived products in sustainable society.

Total AUs: 44.80

FOR421H1 - Green Urban Infrastructure: Sustainable City Forests

Credit Value: 0.50
Hours: 25.6L

Complementary Studies elective

With over 80% of the world's population now living in cities, tomorrow's forests will be urban. Increasing global recognition of nature deficit disorder and the values of green infrastructure to mitigate broader human impacts gives a new meaning to the term 'urban forestry', coined here at UofT and now recognized widely. Trees in and around the city are key to providing multiple engineered and ecological services that only recently have been brought into the responsible fiscal planning of every municipality around the globe. If managed properly (a key concept), urban forests mitigate climate change and urban heat island effects, act as carbon sinks, air filters, water purifiers, air conditioners, noise dampeners, wildlife and/or biodiversity refuges, and green spaces for the human spirit. Here, we explore the challenges and opportunities of this exciting new applied field at the cross-roads of ecology, engineering and planning to ensure future global sustainability.

Exclusion: FOR416H1
Total AUs: 25.60

FOR424H1 - Innovation and Manufacturing of Sustainable Materials

Credit Value: 0.50
Hours: 25.6L/12.8T

Sustainable materials are a mandate for sustainable societies. This course will explore the manufacturing, engineering principles and design fundamentals for creating sustainable materials from renewable resources. Special emphasis will be on bioplastics, biofibre, nanobiofibre, biocomposites and nanobiocomposites. Written communication and design skills will be developed through tutorials and assignments.

Exclusion: FOR423H1
Recommended Preparation: Basic knowledge of materials science.
Total AUs: 32.00

FOR425H1 - Bioenergy and Biorefinery Technology

Credit Value: 0.50
Hours: 25.6L/25.6T

Technological advances and approaches in deriving biofuels, chemical feedstocks from forest and other biomass resources. Fundamental chemical attributes of biomass, as they affect the fuel value and potential for deriving liquid, solid and gaseous fuels and valuable chemicals for other applications will be explored.

Exclusion: FOR410H1
Total AUs: 38.40

Joint Courses

JRE300H1 - Fundamentals of Accounting and Finance

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

Introduces a brief overview of essential concepts in accounting and corporate finance. The first part of the course covers the fundamentals of accounting. We start by exploring the basic language of accounting and the fundamental concepts of financial reporting. Students learn to read and analyze basic financial statements including the statements of financial position, comprehensive income, changes in equity, and cash flows. We then introduce key management accounting concepts and explore various methods of costing for decision-making. The second part of the course covers the fundamentals of corporate finance. In the second half, students will learn how to make financial projections and how to value complex investment opportunities. Following this, students learn various techniques for controlling risk and how to determine the appropriate cost of capital. Finally, the course considers issues in cash flow management and overviews project valuation as it relates to corporate mergers.

Exclusion: CHE375H1
Total AUs: 44.80

JRE410H1 - Markets and Competitive Strategy

Credit Value: 0.50
Hours: 25.6L/25.6P

Complementary Studies elective

Introduces the basic concepts, frameworks and methodologies useful to managers in crafting and executing entrepreneurial business strategies in technology-based companies. In the first part of the course, students gain an understanding of the external, internal, and dynamic environments of a business and the elements of a superior competitive position. In the second part, we focus on designing and delivering customer value, which involves strategic decisions about segmentation, targeting and positioning, and tactical decisions related to product introductions, marketing communications, distribution channels and pricing. In the third part of the course, we build on these fundamentals and examine challenges related to innovation and industry dynamics, such as industry life cycles, disruptive technologies, product renewal, and the relationship between R&D and commercialization.

Total AUs: 38.40

JRE420H1 - People Management and Organizational Behaviour

Credit Value: 0.50
Hours: 38.4L/12.8T

Complementary Studies elective

This module spans three inter-related topics: leadership, people management and organization behaviour. It provides students with both the theory and practice in how to design, lead and manage organizations. Topics include theories of leadership, strategy, ethics, designing organizations for rapid change and differing cultural environments, communication, job design, managing and motivating people, fostering creativity, and team work. In addition to traditional lectures, exercises and case studies will be used throughout.

Exclusion: IRE260H1
Total AUs: 44.80

Mechanical and Industrial Engineering

MIE258H1 - Engineering Economics and Accounting

Credit Value: 0.50
Hours: 38.4L/12.8T

Engineering economic and accounting concepts needed in the design of engineering systems. Financial analysis topics include: financial statements, depreciation, income tax, and basic accounting techniques. Project analysis topics includes: time value of money, evaluation of cash flows, defining alternatives, analysis of independent projects, acceptance criteria, buy or lease, make or buy, replacement analysis, economic analysis in the public sector, project risk and uncertainty. Inflation concepts.

Prerequisite: MIE231H1/MIE236H1 or equivalent
Exclusion: CHE249H1, CHE374H1, CME368H1, ECE472H1, MIE358H1
Total AUs: 44.80

MIE304H1 - Introduction to Quality Control

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

Introduction to quality engineering. Quality standards and certification. TQM. Modeling processes with simulation. Making inferences about product quality from real or simulation output data. Introduction to statistical process control. Control charts for variables and attributes. Process capability analysis. Lot Acceptance Sampling.

Prerequisite: MIE231 or equivalent
Total AUs: 57.60

MIE320H1 - Mechanics of Solids II

Credit Value: 0.50
Hours: 38.4L/25.6T/19.2P

Three-dimensional stress transformation, strain energy, energy methods, finite element method, asymmetric and curved beams, superposition of beam solutions, beams on elastic foundations, buckling, fracture mechanics, yield criteria, stress concentration, plane stress and strain.

Prerequisite: MIE222H1
Total AUs: 60.80

MIE335H1 - Algorithms & Numerical Methods

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

Algorithmic analysis, big-O asymptotic analysis; numerical linear algebra, solution techniques for linear and non-linear systems of equations; matrix factorization, LU and Cholesky factorization, factorization in the revised simplex method; Newton's method, Gale-Shapley method, greedy methods for combinatorial optimization, branch-and-bound search methods; graph theory and graph theoretic algorithms; design and implementation of algorithms to optimize mathematical models.

Prerequisite: MIE262H1
Total AUs: 51.20

MIE364H1 - Quality Control and Improvement

Credit Value: 0.50
Hours: 38.4L/25.6T/12.8P

In manufacturing and service industries alike, quality is viewed as an important strategic tool for increasing competitiveness. Continuous quality improvement is a key factor leading to a company's success. With more emphasis on quality, the cost and the product cycle time are reduced and the communication between producer and customer is improved. The course focuses on the following topics: introduction to quality engineering, TQM, quality standards, supplier-producer relations and quality certification, costs of quality, statistical process control for long and short production runs, process capability analysis and acceptance sampling, quality certification, six sigma quality, quality improvement using designed experiments and an overview of the Taguchi Methods.

Prerequisite: MIE236H1 or equivalent
Total AUs: 57.60

MIE407H1 - Nuclear Reactor Theory and Design

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the neutronic design and analysis of nuclear fission reactors with a focus on Generation IV nuclear systems. Topics include radioactivity, neutron interactions with matter, neutron diffusion and moderation, the fission chain reaction, the critical reactor equation, reactivity effects and reactor kinetics. Multigroup neutron diffusion calculations are demonstrated using fast-spectrum reactor designs.

Prerequisite: MIE230H1 or equivalent
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE408H1 - * Thermal and Machine Design of Nuclear Power Reactors

Credit Value: 0.50
Hours: 38.4L/25.6T

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.

Prerequisite: MIE407H1/MIE222H1, MIE312H1, MIE313H1 or equivalents
Recommended Preparation: CHE566H1
Total AUs: 51.20

MIE424H1 - Optimization in Machine Learning

Credit Value: 0.50
Hours: 38.4L/12.8T/12.8P

1. To enable deeper understanding and more flexible use of standard machine learning methods, through development of machine learning from an Optimization perspective.

2. To enable students to apply these machine learning methods to problems in finance and marketing, such as stock return forecasting, credit risk scoring, portfolio management, fraud detection and customer segmentation.

Prerequisite: MIE365H1/MIE376H1/ECE367H1/ROB310H1, or equivalent
Total AUs: 51.20

MIE442H1 - Machine Design

Credit Value: 0.50
Hours: 38.4L/38.4T/19.2P

Introduction to the fundamental elements of mechanical design including the selection of engineering materials, load determination and failure analysis under static, impact, vibration and cyclic loads. Surface failure and fatigue under contact loads, lubrication and wear. Consideration is given to the characteristics and selection of machine elements such as bearings, shafts, power screws and couplings.

Prerequisite: MIE320H1
Total AUs: 67.20

MIE469H1 - Reliability and Maintainability Engineering

Credit Value: 0.50
Hours: 38.4L/25.6T

An introduction to the life-cycle costing concept for equipment acquisition, operation, and replacement decision-making. Designing for reliability and determination of optimal maintenance and replacement policies for both capital equipment and components. Topics include: identification of an items failure distribution and reliability function, reliability of series, parallel, and redundant systems design configurations, time-to-repair and maintainability function, age and block replacement policies for components, the economic life model for capital equipment, provisioning of spare parts.

Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE258H1
Total AUs: 51.20

MIE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MSE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

Mineral Engineering

MIN120H1 - Insight into Mineral Engineering

Hours: 38.4L/12.8T/25.6P

A comprehensive introduction into the global minerals industry using international regulatory requirements as a thematic structure. Engineering applications together with current and emerging issues are emphasized throughout. Principal topics include: mineral resources in the economy; land and mineral ownership; legal and environmental issues; mineral exploration; surface and sub-surface mine development and management; fundamentals of mineral processing; mineral industry finance. Graphics communication skills are developed in the associated laboratory sessions, and a visit to an operating mine is used to place the course material in context.

Total AUs: 57.60

MIN250H1 - Surface Mining

Credit Value: 0.50
Hours: 38.4L/12.8T

Operational aspects of open pit mine design and mine planning. Topics will include: open pit design and pit optimization; long term and short term planning considerations; materials handling; equipment selection and optimization; industrial minerals production; mine safety and mine regulations; mining and the environment; mine personnel organization; ethics and professional issues. Pit dewatering, the location and stability of waste dumps and an examination of equipment cost and production statistics are also included.

Total AUs: 44.80

MIN301H1 - Mineral Reserve and Mineral Resource Estimation

Credit Value: 0.50
Hours: 38.4L/12.8T

Introduction to Mineral Resource and Mineral Reserve Estimation is an advanced level course that focuses on the stages of a mineral resource and mineral reserve estimation program from assembling the database through to reporting under industry guidelines. Major course topics include: statistical analysis of sampling data, geologic interpretation and deposit models; mineral resources estimation approaches and methods, mineral reserve estimation, classification of resources and reserves, and reporting under regulatory standards and industry guidelines for professional practice.

Total AUs: 44.80

MIN330H1 - Mining Environmental Management

Credit Value: 0.50
Hours: 38.4L/12.8T

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

Total AUs: 44.80

MIN351H1 - Underground Mining

Credit Value: 0.50
Hours: 38.4L/12.8T

Operational aspects of underground mine design and mine planning. Topics will include: underground mining methods for hard and soft rock; shaft sinking, hoisting and materials handling; equipment selection and optimization; mine safety and mine regulations; mine personnel organization; ethics and professional issues. Development and production costs associated with mining are an inherent aspect of this course.

Exclusion: MIN350H1
Total AUs: 44.80

MIN450H1 - Mineral Economics

Credit Value: 0.50
Hours: 38.4L/12.8T

Course covers the evaluation of mineral projects, mining operations, and mining companies. Topics will include: discounted cash flow techniques including net present value (NPV), internal rate of return (IRR), net asset value (NAV); feasibility studies and due diligence reports; reserves and resources, data sources; metal prices and markets; cash flow modeling including revenue calculations, capital and operating costs, taxes, depreciation, inflation; risk and risk assessment, discount rates, red flags, checklists; financing. Guest lectures will provide industry insights into financing, fund raising, consulting, project control, and evaluation. There are two assignments: review of an annual report; due diligence report and net asset value calculation.

Prerequisite: CIV368H1/CME368H1
Total AUs: 44.80

Materials Science and Engineering

MSE401H1 - Materials Information in Design

Credit Value: 0.50
Hours: 25.6L/12.8T/25.6P

This course presents approaches to composite and structural design, and optimization, for components and products. Tools for optimization, material property data analytics, and structural simulation will be used. We will apply advanced materials selection (and the CES materials database) to product and component design, and hybrid (composite) materials design. Composite mechanics theory and topology optimization will be developed for structural optimization. Finally, modern techniques including AI and machine learning will be presented for aspects of materials selection, composite design and structural optimization. Component design decisions will include both material properties and the capabilities of applicable fabrication processes, to identify the material and process which best satisfy the design requirements.

Total AUs: 44.80

MSE415H1 - Environmental Degradation of Materials

Credit Value: 0.50
Hours: 38.4L/25.6T

This course deals with four major areas: electrochemistry of low temperature aqueous solvents, the corrosion of materials, mechano-chemical effects in materials and corrosion prevention in design. Electrochemistry deals with thermodynamics of material-electrolyte systems involving ion-solvent, ion-ion interactions, activity coefficients, Nernst equation and Pourbaix diagrams, and rate theory through activation and concentration polarization. Corrosion of metallic, polymeric, ceramic, composite, electronic and biomaterials will be explored along with mechano-chemical effects of stress corrosion, hydrogen embrittlement and corrosion fatigue. Corrosion prevention in terms of case histories and the use of expert systems in materials selection.

Total AUs: 51.20

MSE419H1 - Fracture and Failure Analysis

Credit Value: 0.50
Hours: 38.4L/12.8T

Fracture mechanisms and mechanics of solid materials. Topics include: nature of brittle and ductile fracture, macro-phenomena and micro-mechanisms of failure of various materials, mechanisms of fatigue; crack nucleation and propagation, Griffith theory, stress field at crack tips, stress intensity factor and fracture toughness, crack opening displacement, energy principle and the J-integral, fracture mechanics in fatigue, da/dN curves and their significance. Practical examples of fatigue analysis and fundamentals of non-destructive testing.

Total AUs: 44.80

MSE431H1 - Forensic Engineering

Credit Value: 0.50
Hours: 38.4L/12.8T

The course provides participants with an understanding of scientific and engineering investigation methods and tools to assess potential sources, causes and solutions for prevention of failure due to natural accidents, fire, high and low speed impacts, design defects, improper selection of materials, manufacturing defects, improper service conditions, inadequate maintenance and human error. The fundamentals of accident reconstruction principles and procedures for origin and cause investigations are demonstrated through a wide range of real world case studies including: medical devices, sports equipment, electronic devices, vehicular collisions, structural collapse, corrosion failures, weld failures, fire investigations and patent infringements. Compliance with industry norms and standards, product liability, sources of liability, proving liability, defense against liability and other legal issues will be demonstrated with mock courtroom trial proceedings involving invited professionals to elucidate the role of an engineer as an expert witness in civil and criminal court proceedings.

Prerequisite: MSE101H1/APS104H1/MSE260H1 or MSE160H1
Total AUs: 44.80

MSE488H1 - Entrepreneurship and Business for Engineers

Credit Value: 0.50
Hours: 38.4L/25.6T

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prizes for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1, MIE488H1, CHE488H1 and CIV488H1.)

*Complementary Studies Elective

Exclusion: TEP234H1, TEP432H1
Total AUs: 51.20

Robotics

ROB311H1 - Artificial Intelligence

Credit Value: 0.50
Hours: 38.4L/12.8T

An introduction to the fundamental principles of artificial intelligence from a mathematical perspective. The course will trace the historical development of AI and describe key results in the field. Topics include the philosophy of AI, search methods in problem solving, knowledge representation and reasoning, logic, planning, and learning paradigms. A portion of the course will focus on ethical AI, embodied AI, and on the quest for artificial general intelligence.

Prerequisite: Prerequisite: ECE286H1/ECE302H1 and ECE345H1/ECE358H1/CSC263H1
Total AUs: 44.80

ROB313H1 - Introduction to Learning from Data

Credit Value: 0.50
Hours: 38.4L/25.6T

This course will introduce students to the topic of machine learning, which is key to the design of intelligent systems and gaining actionable insights from datasets that arise in computational science and engineering. The course will cover the theoretical foundations of this topic as well as computational aspects of algorithms for unsupervised and supervised learning. The topics to be covered include: The learning problem, clustering and k-means, principal component analysis, linear regression and classification, generalized linear models, bias-variance tradeoff, regularization methods, maximum likelihood estimation, kernel methods, the representer theorem, radial basis functions, support vector machines for regression and classification, an introduction to the theory of generalization, feedforward neural networks, stochastic gradient descent, ensemble learning, model selection and validation.

Prerequisite: ECE286H1, MAT185H1, MAT195H1, CSC263H1/ECE358H1
Exclusion: ECE421H1, CSC411H1, STA314H1
Total AUs: 51.20

ISTEP

TEP234H1 - Entrepreneurship and Small Business

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 1 of the 2 Part Entrepreneurship Program
The age of enterprise has arrived. Strategic use of technology in all sorts of businesses makes the difference between success and failure for these firms. Wealth creation is a real option for many and the business atmosphere is ready for you! Increasingly, people are seeing the advantages of doing their own thing, in their own way, in their own time. Entrepreneurs can control their own lives, structure their own progress and be accountable for their own success - they can fail, but they can not be fired! After all, engineers are the most capable people to be in the forefront of this drive to the business life of the next century. This course is the first of a series of two dealing with entrepreneurship and management of a small company. It is intended that the student would continue to take the follow up course APS432 as s/he progresses toward the engineering degree. Therefore, it is advisable that the descriptions of both courses be studied prior to deciding to take this one. This is a limited enrolment course. If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of the

"Entrepreneur's Test". There will be a certificate awarded upon the successful completion of both courses attesting to the fact that the student has passed this Entrepreneurial Course Series at the University of Toronto. The course is based on real life issues, not theoretical developments or untried options. Topics covered include: Who is an entrepreneur; Canadian business environment; Acquisitions; Different business types (retail, wholesale, manufacturing, and services); Franchising; Human resources, Leadership, Business law; and many others. Several visitors are invited to provide the student with the opportunity to meet real entrepreneurs. There will be several assignments and a session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1/APS281H1
Total AUs: 57.60

TEP281H1 - Language and Meaning

Credit Value: 0.50
Hours: 28.2L/28.2T

Humanities and Social Science elective

As students study how language is used to make meaning in diverse contexts they will hone their own skills in deploying written and oral professional engineering language. The course explores the nature of language across linguistic, discipline and cultural boundaries and students apply the theoretical knowledge of language and language learning to their own written and oral language performances. In conjunction with this, theories of translation and bilingualism will be introduced to challenge assumptions about the universality of meanings. Weekly lecture and tutorial.

Exclusion: APS281H1
Total AUs: 38.40

TEP320H1 - Representing Science on Stage

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

An examination of representations of science/scientists in theatre. Reading and/or viewing of works by contemporary playwrights and related materials on science and culture. Critical essays; in-class discussion and scene study.

Total AUs: 38.40

TEP321H1 - Representing Science and Technology in Popular Media

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course analyzes popular scientific communication critically, starting by establishing a historical and theoretical foundation for understanding the complex relationship between science and the public. We apply this theoretical foundation to contemporary case studies in multiple media (mis)representations of climate, environmental, and biomedical sciences, as well as breakthroughs in engineering. We develop rhetorical strategies for delivering technical information to non-technical readers, including narrative and metaphor.

Total AUs: 38.40

TEP322H1 - Language and Power

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course explores Rhetoric historically to understand its development and practically to understand how ideas are constructed, disseminated, shared or imposed. The course explores worldview - the organizing structure by which we view the world - to position the student as rhetorically effective in multiple contexts. Students analyze political, cultural, and scientific discourse from great speeches to advertising to research papers. Students develop their rhetorical, communication, and persuasive abilities.

Total AUs: 38.40

TEP324H1 - Engineering and Social Justice

Credit Value: 0.50
Hours: 25.6L/25.6T

This course explores the relationship between engineering and the concepts of social justice to develop the skills needed to take practical action in a complex world. It develops personal responses to ideas of justice, bias and marginalization as these affect Engineers and Engineering in general, domestically as well as globally, in projects as well as in contexts such as the workplace and academic environment. Readings will be drawn from current writers on Engineering and Social Justice and students will rehearse action through theatre techniques developed to enable communities to practice and critique action.

Total AUs: 38.40

TEP325H1 - Engineering and Science in the Arts

Credit Value: 0.50
Hours: 25.6L/25.6T

Humanities and Social Science elective

This course examines the connections between engineers, scientists, and artists. Taking examples from architecture, sculpture, painting, and the performing arts, this course will show how these artistic disciplines have grown through their interplay with engineering and science.

Total AUs: 38.40

TEP326H1 - Special Topics in Creative Writing

Credit Value: 0.50
Hours: 25.6L/25.6T

In this course, students will explore the creative writing process, with an emphasis on the giving and receiving of critical feedback. This exploration will reinforce the iterative principles of the engineering design process and will provide students with flexible and transferable tools for them to apply to future engineering work. They will examine up to two genres of creative writing (fiction, science fiction, poetry, creative non-fiction, screenwriting, playwriting, etc.) in order to hone their own creative and critical thinking skills. Students will be introduced to relevant elements of craft, will analyze representative literary examples, will create original creative work both in generative weekly exercises and in longer at-home assignments, will give and receive feedback from their peers through structured in-class workshops, and will apply this feedback to their own writing.

Total AUs: 38.40

TEP343H1 - Engineering Leadership

Credit Value: 0.50
Hours: 12.8L/25.6P

Complementary Studies elective

This course is a practical approach to being a more productive engineer based on the premise that for technology to become a reality it must be translated through people. A key is to understand that engineers lead in ways that reflect their skills and mind set. The course begins with examining: 1) the meaning of leading (Why do something?); 2) the processes of leading (How do you do you create a vision and motivate others?); and 3) the tools of leading (What steps do you take to lead?). Learning frameworks and personal working styles inventories provide practical tools to assist the student to understand human nature and the logic of learning to become a competent leader of self, teams and organizations. The student prepares to become a competent leader by undertaking to learn (understand and integrate) key skills, character attributes and purposeful behaviours. The course presents strategies for development of high performance teams. Special attention is given to a number of subjects: transformational change, organizational culture, high performance work systems, and self-leadership. The course material is delivered through lectures, readings, in-class discussion and a team project. The project is based on the team interviewing the CEO of an engineering-intensive company or senior leader in the community. Students will be required to submit written reflections on course content and their personal experience.

Total AUs: 25.60

TEP432H1 - Entrepreneurship and Business Management

Credit Value: 0.50
Hours: 51.2L/12.8T

Complementary Studies elective

Part 2 of the 2 Part Entrepreneurship Program

This is part two of the Entrepreneurship course series. The student considering taking this course would typically plan to pursue a career in small business started by themselves, or in a family enterprise. The skills acquired, however, are very useful in any business where a graduate might end up in their career, without the need for actually being an entrepreneur. Our approach to teaching is based on real-life business experiences and many years of successful practice of "what we preach". The course contains very little theoretical work or academic approaches. It is designed to familiarise you with the kinds of opportunities (problems) likely to be encountered in an entrepreneurial career. If you really want this lifestyle and are prepared to work hard, we will provide you with the practical knowledge and technical skills required to pursue this kind of career. Topics covered in this course include: Marketing and Sales; Legal issues; Financing the business; Human Resources challenges, the Business Plan and many other issues. Note that the course material may be adjusted between the two courses as required. We recognize the value of communication skills in both the classroom and in project reports. In fact, we require that you learn how to present yourself in a business-like manner. As and when appropriate, outside visitors from the business community will join in and contribute to the class discussions. The course deals with practical concepts, actual past and current events and is presented from the point of view of someone who has "done it all". This means that what you hear is the real stuff. There will be several assignments and the preparation of a full Business Plan as the session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Prerequisite: APS234H1
Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1
Total AUs: 57.60

TEP442H1 - Cognitive and Psychological Foundations of Effective Leadership

Credit Value: 0.50
Hours: 38.4L

Complementary Studies elective

This course investigates the cognitive and psychological foundations of effective leadership. Students will explore current theories driving effective leadership practice including models of leadership, neurophysiological correlates of leadership and psychodynamic approaches to leadership. Students will learn and apply skills including mental modeling, decision-making, teamwork and self-evaluation techniques. This course is aimed at helping Engineering students to gain practical skills that will enhance their impact as leaders throughout their careers.

Total AUs: 38.40

TEP444H1 - Positive Psychology for Engineers

Credit Value: 0.50
Hours: 38.4L

Humanities and Social Science elective

Many disciplines have explored happiness - philosophy, anthropology, psychology, sociology, neurobiology, film, art and literature - to name a few. Why not engineering? During the first part of the course we will play catch-up, examining the scholarly and creative ways that people have attempted to understand what makes for a happy life. Then we turn our attention to our own domain-expertise, applying engineering concepts like "balance", "flow", "amplitude", "dynamic equilibrium""momentum" and others to explore the ways that your technical knowledge can contribute to a deep understanding of happiness. This course is designed to challenge you academically as we analyze texts from a variety of disciplines, but it is also designed to challenge you personally to explore happiness as it relates to yourself, your own personal development and your success and fulfillment as an engineer.

If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of an in-class assessment completed during the first class.

Total AUs: 38.40

TEP445H1 - The Power of Story: Discovering Your Leadership Narrative

Credit Value: 0.50
Hours: 25.6L/12.8T

Humanities and Social Science elective

This course offers an introduction to relational, authentic and transformational leadership theory by focusing on narrative and the power of story telling. Students will practice story-telling techniques by learning about the mechanics of stories, improve their public speaking by engaging in regular storytelling practice, explore their personal history by reflecting on their identities, and develop critical thinking skills regarding the stories (meta-narratives) that surround us, particularly as they relate to engineering problems/ethics. This is a highly experiential course with a focus on reading, discussion, practice and reflection.

Total AUs: 38.40

TEP447H1 - The Art of Ethical & Equitable Decision Making in Engineering

Credit Value: 0.50
Hours: 38.4L

The primary objective of this course is to help engineering students navigate the ambiguous world of engineering ethics and equity using case studies drawn from the careers of Canadian engineers. In addition to being exposed to a range of ethical theories, the PEO code of ethics and the legal context of engineering ethics, students enrolled in this course will engage in ethical decision-making on a weekly basis.

Total AUs: 38.40

TEP448H1 - System Mapping

Credit Value: 0.50
Hours: 25.6L/25.6T

System mapping is a system thinking tool that is frequently used in fields such as public health and environmental policy to describe complex, multi-stakeholder problems. Students will apply system mapping techniques to describe complex problems with techical, social and environmental aspects. Students will explore fields outside of engineering that are critical to these challenges, including public policy, sociology, and law. Students will complete a team project to develop a system map of a complex problem. The emphasis will be on problem definition not problem solution, though it is expected that maps will point to potential paths for solution.

Enrolment Limits: 36
Total AUs: 38.40