2018-2019 Graduate Calendar

The information published in this Graduate Calendar outlines the rules, regulations, curricula, programs and fees for the 2018-2019 academic year, including the Summer Semester 2018, Fall Semester 2018 and the Winter Semester 2019.

For your convenience the Graduate Calendar is available in PDF format.

If you wish to link to the Graduate Calendar please refer to the Linking Guidelines.

The University is a full member of:

• Universities of Canada

Contact Information:

University of Guelph
Guelph, Ontario, Canada
N1G 2W1
519-824-4120

Revision Information:

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1, 2018</td>
<td>Initial Publication</td>
</tr>
<tr>
<td>August 10, 2018</td>
<td>Revision 1</td>
</tr>
<tr>
<td>December 13, 2018</td>
<td>Revision 2</td>
</tr>
<tr>
<td>February 15, 2019</td>
<td>Revision 3</td>
</tr>
<tr>
<td>March 1, 2019</td>
<td>Revision 4</td>
</tr>
</tbody>
</table>
Disclaimer
The Office of Graduate Studies has attempted to ensure the accuracy of this on-line Graduate Calendar. However, the publication of information in this document does not bind the university to the provision of courses, programs, schedules of studies, fees, or facilities as listed herein.

Limitations
The University of Guelph reserves the right to change without notice any information contained in this calendar, including any rule or regulation pertaining to the standards for admission to, the requirements for the continuation of study in, and the requirements for the granting of degrees or diplomas in any or all of its programs.
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 the faculty, staff or students of the university or by others, civil unrest or disobedience, Public Health Emergencies, or any other cause of any kind beyond the reasonable control of the university.
The University of Guelph reaffirms section 1 of the Ontario Human Rights Code, 1981, which prohibits discrimination on the grounds of race, ancestry, place of origin, colour, ethnic origin, citizenship, creed, sex, sexual orientation, handicap, age, marital status or family status.
The university encourages applications from women, aboriginal peoples, visible minorities, persons with disabilities, and members of other under-represented groups.
Introduction

Collection, Use and Disclosure of Personal Information

Personal information is collected under the authority of the University of Guelph Act (1964), and in accordance with Ontario's Freedom of Information and Protection of Privacy Act (FIPPA) http://www.e-laws.gov.on.ca/DLB/Laws/Statutes/English/90f31_e.htm. This information is used by University officials in order to carry out their authorized academic and administrative responsibilities and also to establish a relationship for alumni and development purposes. Certain personal information is disclosed to external agencies, including the Ontario Universities Application Centre, the Ministry of Advanced Education and Skills Development, and Statistics Canada, for statistical and planning purposes, and is disclosed to other individuals or organizations in accordance with the Office of Registrarial Services Departmental Policy on the Release of Student Information. For details on the use and disclosure of this information call the Office of Registrarial Services at the University at (519) 824-4120 or see https://www.uoguelph.ca/registrar/.

Statistics Canada - Notification of Disclosure

For further information, please see Statistics Canada's web site at http://www.statcan.gc.ca and Section XIV Statistics Canada.

Address for University Communication

Depending on the nature and timing of the communication, the University may use one of these addresses to communicate with students. Students are, therefore, responsible for checking all of the following on a regular basis:

Email Address

The University issued email address is considered an official means of communication with the student and will be used for correspondence from the University. Students are responsible for monitoring their University-issued email account regularly.

Home Address

Students are responsible for maintaining a current mailing address with the University. Address changes can be made, in writing, through Registrarial Services.

Name Changes

The University of Guelph is committed to the integrity of its student records, therefore, each student is required to provide either on application for admission or on personal data forms required for registration, his/her complete, legal name. Any requests to change a name, by means of alteration, deletion, substitution or addition, must be accompanied by appropriate supporting documentation.

Student Confidentiality and Release of Student Information Policy Excerpt

The University undertakes to protect the privacy of each student and the confidentiality of his or her record. To this end the University shall refuse to disclose personal information to any person other than the individual to whom the information relates where disclosure would constitute an unjustified invasion of the personal privacy of that person or of any other individual. All members of the University community must respect the confidential nature of the student information which they acquire in the course of their work.

Complete policy at https://www.uoguelph.ca/secretariat/office-services/university-secretariat/university-policies.
# Table of Contents

**Engineering** .......................................................... 74  
  Administrative Staff .................................................. 74  
  Graduate Faculty ...................................................... 74  
  Associated Graduate Faculty ........................................ 75  
  MASc Program ............................................................. 75  
  MEng Program ............................................................. 75  
  PhD Program ..................................................................... 76  
  Graduate Diplomas in Water Resources ............................ 76  
  Interdepartmental Programs ............................................ 77  
  Collaborative Specializations .......................................... 77  
  Courses ............................................................................. 77
Engineering

The graduate degree programs offered in the School of Engineering include a course-work MEng and research thesis programs at the MASc and PhD levels. All programs are offered as full- or part-time studies. These programs provide for specialization in six fields of study: 1) Biological Engineering 2) Computer Engineering 3) Environmental Engineering 4) Engineering Systems and Computing 5) Mechanical Engineering 6) Water Resources Engineering. In addition, the School of Engineering offers two graduate diploma programs: Modelling Applications in Water Resources Engineering and Engineering Design of Sustainable Water Resource Systems.

- **Biological Engineering** is broadly categorized as bio-process, food, biomedical or biomechanical engineering. Research is conducted in many areas such as: physical, chemical and thermal processing of food, biomaterials or waste; physical properties of biological materials; process control; remote sensing; medical imaging; bioinstrumentation design and the development of medical diagnostics; ergonomic and prosthetic biomechanics; design of implants and surgical tools for human and veterinary applications.

- **Computer Engineering** is about the design and implementation of computer devices and systems. Driven by the ubiquity of integrated computing systems, Computer Engineering has expanded from a discipline with a few core areas, mainly focused on the design of microchips, to a broad field with widespread ramifications. It involves mapping computing ideas into physical implements and software components. Some active research areas include: integrated circuits and microprocessors, digital systems design and computer architecture, high-performance and configurable computing, telecommunication and cloud-computing networks, operating systems and software engineering.

- **Environmental Engineering** involves methods to prevent or mitigate damage to the environment by the reduction, treatment, or reclamation of solid, liquid, or gaseous by-products of industrial, agricultural and municipal activities. Emphasis is on the behaviour and fate of contaminants in the environment. Recent research topics include the following: composting of organic solids; control and remediation of chemical spills; wastewater treatment; soil/site remediation technology; policy innovations; air pollution and meteorology; vapour exchange and supercritical fluid extraction; air-surface pollutant exchange measurement; bio-filtration and membrane technologies; modelling of environmental processes.

- **Engineering Systems and Computing** involves development of digital or microelectronic devices, computer or robotic technologies and their application to manufacturing, computing, mechatronic or embedded systems. Some active research areas include: soft computing and neural networks; autonomous robots; intelligent control systems; micro-electromechanical (MEMS) devices; embedded systems and special purpose computing; VLSI circuit design and layout; analog integrated circuits and system-on-chip design; integrated sensor systems and networks; digital devices and signal processing; wireless and optical communication systems; cryptographic systems.

- **Mechanical Engineering** combines individual depth of experience and competence in a particular chosen major specialty with a strong background in the basic and engineering sciences. It strives to develop professional independence, creativity, leadership, and the capacity for continuing professional and intellectual growth. To help support the objectives of graduate degree programs at Guelph, an interdisciplinary learning environment is provided. Research areas that are pertinent and in line with Guelph’s vision include: sustainable energy, sustainable mobility, sustainable design, life-cycle design and assessment, systems modernization, materials and manufacturing, thermo-fluids, solid mechanics, remanufacturing, intelligent control system, closed-loop supply chain management, product life assessment and engineering management.

- **Water Resources Engineering** involves investigation, analysis and design of systems for control and utilization of land and water resources as part of the management of urban and rural watersheds. Research areas include: water quality control and safety; resource use and groundwater quality; hydrologic modelling; design and planning of urban water and sewage infrastructure; rural waste treatment systems; erosion control; non-point source pollution and mitigation; Geographic Information Systems (GIS); sediment and contaminant transport; irrigation and drainage modelling.

Administrative Staff

**Interim Director**
John Runciman (Thornborough 2408, Ext. 52430)
soedir@uoguelph.ca

**Associate Director, Undergraduate Studies**
Andrea Bradford (Thornborough 1342, Ext. 52485)
abradfor@uoguelph.ca

**Associate Director, Graduate Studies**
Bahram Gharabaghi (Thornborough 1407, Ext. 52404)
soeadr@uoguelph.ca

**Graduate Program Assistant**
Natasha Wismark (Thornborough 1407, Ext. 52404)
soeograd@uoguelph.ca

Graduate Program Assistant
Jacqueline Floyd (Thornborough 1405, Ext. 56187)
soeograd@uoguelph.ca

Academic and Administrative Support Secretary
Robin Van Alstine (Thornborough 1404, Ext. 58764)
soe.gradmiss@uoguelph.ca

Graduate Faculty

Bassim Abbassi
BSc Yarmouk Univ., MSc Jordan Univ. of Science and Technology, PhD Univ. of Bremen - Associate Professor

Hussein A. Abdullah
BSc Univ. of Technology, MSc, PhD Glasgow, P.Eng - Professor and Director

Wael Ahmed
BSc, MSc Alexandria University, PhD McMaster, P.Eng - Associate Professor

Amir Abbas Aliabadi
BASc, MASc Toronto, PhD British Columbia - Assistant Professor

Manick Annamalai
BE, ME Tamilnadu Agricultural University, PhD Manitoba, P.Eng - Associate Professor

Shawki Areibi
BASc Al-Fateh, MASc Waterloo, PhD Waterloo, P.Eng - Professor

Alexander Bardelech
BASc, MASc, PhD Waterloo - Assistant Professor

Mohammad Biglarbegian
BSc Tehran, MA Toronto, PhD Waterloo, P.Eng - Associate Professor

Andrew Binns
BSc, MSc, PhD Queen’s - Assistant Professor

Andrea L. Bradford
BSc, PhD Queen's, P.Eng - Associate Professor

Scott Brandon
BSc Western, MSc, PhD Queen’s - Assistant Professor

Sheng Chang
BEng Chengdu Univ., PhD New South Wales, P.Eng - Associate Professor

Emily Chiang
BASc, MSc Toronto, PhD Univ. of Leuven, P.Eng - Assistant Professor

Ryan Clemen
BSc, PhD Waterloo, P.Eng - Associate Professor

Christopher Collier
BMus Toronto, BASc, PhD British Columbia - Assistant Professor

Prasad Daggupati
BS Acharya, MS, PhD Kansas State - Assistant Professor

Fantahun Defersha
BSc Ethiopia, MEng India, PhD Concordia, P.Eng - Associate Professor

Ibrahim Deib
BSc, MSc Kuwait Univ., PhD McMaster, P.Eng - Associate Professor

John Donald
BASc, MASc, PhD Waterloo - Associate Professor

Robert Dony
BASc, MASc Waterloo, PhD McMaster, P.Eng, FIET, FEC - Associate Professor

Animesh Dutta
BSc Bangladesh, MEng Thailand, PhD Dalhousie, P.Eng - Associate Professor

Abdallah Elsayed
BEng, MASc, PhD Ryerson - Assistant Professor

Mostafa Elsharqawy
BSc, MSc Aj Shum, PhD Petroleum & Minerals - Assistant Professor

Andrew Gadsden
BEng, PhD McMaster, P. Eng, P.M.P. - Assistant Professor

Bahram Gharabaghi
BSc Iran Univ. of Science and Technology, MSc Sharif Univ. of Science and Technology, PhD Guelph, P.Eng - Professor

Karen D. Gordon
BSc Guelph, PhD Western Ontario, P.Eng - Associate Professor and Associate Dean (Academic), College of Engineering and Physical Science

Stefano Gregori
Laurea, Doctorate Univ. of Pavia - Associate Professor

Marwan Hassan
BS Helwan Univ., MS Tuskegee Univ., PhD McMaster, P.Eng - Professor

Hadis Karimipour
BSc Ferdowsi, MSc Shahrood, PhD Alberta - Assistant Professor

Jana Levison
BASc, PhD Queens, EIT - Assistant Professor

William David Lubitz
BSc, MSc, PhD California, P.Eng - Associate Professor
Shohel Mahmud
BSc, MSc Bangladesh Univ. of Engineering and Technology, PhD Waterloo, P.Eng - Associate Professor
Mario Martinez Martinez
BSc, MSc, PhD Valladolid - Assistant Professor
Edward McBean
BASC, UBC, S.M., C.E., PhD Massachusetts Institute of Technology, P.Eng - Professor
Manjusri Misra
BSc, MSc, MPhil, PhD Utkal - Professor
Medhat A. Moussa
BSc American, MASc Moncton, PhD Waterloo, P.Eng - Professor
Soha Moussa
BSc American, MASc Moncton, P.Eng - Assistant Professor
Radu Muresan
Dipl. Engg Technical Univ. of Cluj-Napoca (Romania); MASc, PhD Waterloo, P.Eng - Associate Professor
Michele L. Oliver
BPE McMaster, MPE, MSc, PhD New Brunswick, P.Eng - Professor
Beth Parker
BS Pennsylvania, MS North Carolina, PhD Waterloo - Professor
Erica Pensini
BSc, MASc Milano, PhD Toronto - Assistant Professor
Ramesh P. Rudra
BSc Punjab Agricultural, MS, PhD Pennsylvania State, P.Eng, FCSBE, FISAE - Professor
R. John Runciman
BSc Queen's, MSc Queen's, PhD (Strathclyde), P.Eng - Associate Professor and Associate Director, Undergraduate Studies
Rafael Santos
BASC, MASc Toronto, PhD Keuven - Assistant Professor
Hari Simha
BE India, M.SE, PEng Austin - Assistant Professor
Ashutosh Singh
Btech Vellore, MSc, PhD McGill - Assistant Professor
Petros Spachos
Diplom Crete, MASc, PhD Toronto - Assistant Professor
Graham Taylor
BASC, MASc Waterloo, PhD Toronto - Associate Professor
Julie Vale
BASC, MASc, PhD Waterloo, P.Eng - Associate Professor
Bill Van Heyst
BASC, MASc, PhD Waterloo, P.Eng - Professor
Mary Wells
BEng McGill, PhD British Columbia - Dean, College of Engineering and Physical Sciences
Simon X. Yang
BSc Peking, MSc Sinica, MSc Houston, PhD Alberta - Professor
Hongde Zhou
BSc Jiangsu, MSc China, PhD Alberta, P.Eng - Professor
Richard G. Zytnier
BASC, MASc, PhD Windsor, P.Eng, FEC - Professor and Interim Dean, College of Engineering and Physical Science

Associated Graduate Faculty
Sherif Abdou
BSc Ain Sams, MASc, PhD McMaster - Senior R & D Scientist Vida Fresh Air Corp
Bishnu Acharya
BEng Tribhuvan, Meng Asian Institute of Technology, PhD Dalhousie - Assistant Professor UPEI
Arafat Al-Dweik
BSc Yarmouk, MSc Cleveland State, PhD Cleveland State - Associate Professor Khalifa University
John Cherry
BSc Saskatchewan, MSc California, PhD Illinois - Retired Professor University of Waterloo
Donald Donald
BASC, MSc, Ph.D., P.Eng, Waterloo - Contractually Limited Faculty
Douglas M. Joy
BASC Toronto, MASc Ottawa, PhD Waterloo, P.Eng - Retired Faculty
Yiping Guo
BEng Zhejiang, MASC Toronto, PhD Toronto - Professor McMaster
Gordon Hayward
BASC, MASc, PhD Waterloo - Professor Emeritus
April Khademi

Graduate Programs, Engineering

Admission Requirements

The MASc program is intended to provide advanced training in engineering sciences, analysis, design, and research methodology. This objective is achieved through a combination of course work, applied research, and thesis writing. Upon graduation students will be able to analyse and research an engineering problem and apply their acquired skills and knowledge in a practical solution. A final examination is conducted following a public seminar presentation of the student's thesis.

In addition to the general admission standards of the university, the school has adopted additional admissions criteria for MASc studies. Applicants must meet one of the following requirements:

- Baccalaureate degree in engineering or equivalent. Applicant must be a graduate from an honours engineering program with at least a 75% average in the past four full-time semesters or the equivalent.
- Bachelor of Science degree or equivalent. At least a 'B+' or 75% average in the work of the last four full-time semesters or the last two complete undergraduate years of an honours science degree. Applicants must demonstrate acceptable analytical ability by having taken a sufficient number of courses in mathematics and the physical sciences (chemistry and physics). Applicants lacking background in specific topics related to their research project must be prepared to complete make-up undergraduate courses without receiving graduate credit.

Degree Requirements

The prescribed program of study must consist of no fewer than 2.0 credits, of which at least 1.5 credits must be at the graduate level, and at least 1.0 must be engineering graduate courses. Under special circumstances the school may reduce the 1.5 credit requirement; however, the 1.0 graduate-engineering-course credit requirement will not be changed. In all cases the remaining courses must be acceptable for graduate credit; that is, they must be either graduate courses or senior undergraduate courses. Depending on the student's background, the advisory committee may specify more than four courses, including undergraduate make-up courses. If make-up courses are deemed necessary, they will be considered additional courses.

MEng Program

The objective of the course-work master's degree program (MEng) is to provide an opportunity for engineering graduates, usually practising engineers, to advance their understanding of engineering principles and increase their grasp of the application of these principles to the solution of complex, practical problems. Many of these students are returning to school in order to learn about recent technological developments that have occurred since graduation. The objective is achieved through selecting from a number of core and elective courses and completing a major project. The project requires a final written report that is presented in a public seminar followed by an oral examination of the candidate.

Admission Requirements

Applicants must be graduates of an honours engineering program with at least a 70% average in the past four full semesters or the last two complete undergraduate years or the equivalent. International degree and grade equivalents will be determined by the Office of Graduate Studies.

Applicants must demonstrate acceptable analytical ability by having taken a sufficient number of courses in mathematics, and the physical sciences. Biological Engineering applicants must have a minimum of three of the following courses or equivalents:

- Biological/Food/Bioprocess Engineering
- Engineering Unit Operations
- Bioreactor Design
- Bioinstrumentation Design
- Food Process Engineering Design
- Digital Process Control Design
- Heat and Mass Transfer
- Process Engineering

Computer Engineering applicants must have a minimum of three of the following courses or equivalents:

March 1, 2019
Admission Requirements
The minimum academic requirement for admission to the PhD program is normally a recognized Master's degree in engineering. Applicants are usually required to have completed a Bachelor's and a Master's degree from a recognized post-secondary institution and must have achieved a minimum B average in their Master's program. Applicants must also have demonstrated strong potential for research. A strong recommendation from the MASc advisor is necessary. Direct admission to the PhD program from a Bachelor's program is rarely granted. Applicants requesting direct admission must hold a bachelor's degree with exceptionally high academic standing and have related research experience. Such applicants should discuss this option with the Associate Director, Graduate Studies at the earliest opportunity.

Degree Requirements
The prescribed program of study must consist of no fewer than 2.0 credits in addition to those taken as part of the MASc degree. At least 1.5 of the credits must be at the graduate level, and at least 1.0 must be engineering graduate courses. Under special circumstances and with the approval of the Director, the school may reduce the requirement for 1.5 credit course requirement; however, the 1.0 graduate-engineering-course credit requirement will not be changed. In all cases the remaining courses must be acceptable for graduate credit; that is, they must be either graduate courses or senior undergraduate courses. Depending on the student's background, the advisory committee may specify more than four courses, including undergraduate make-up courses. If make-up courses are deemed necessary, they will be considered additional courses.

The qualifying examination as outlined in the Graduate Calendar is held by the end of the fourth semester but no later than the fifth semester after the student has completed the required courses.

Graduate Diplomas in Water Resources
The objective of the graduate diploma is to provide mid-career, engineering professionals from Canada and abroad with post graduate education and training to improve their job-related expertise within an 8 month period. The program enhances the ability of these professionals to gain employment in the field of Water Resources engineering by developing specialized knowledge in one of two areas of Water Resources. The first area will emphasize higher learning in the application of Modelling in a Water Resources context. Application of existing tools, particularly GIS, to a variety of contemporary water resources problems will be emphasized. The second area focuses on the Design of Sustainable Water Resources Systems that will be sustainable in today's development environment.

Admission Requirements
Students with an honours degree will be considered for the Graduate Diploma program provided they have satisfactory preparation in mathematical and physical sciences. A minimum average grade of 70% for the last four full-time semesters, or the last two complete undergraduate years, prior to entry will normally be required.

Since an adequate background in undergraduate engineering courses is prerequisite for courses offered in the program, there is a requirement of the following courses or equivalent.

ENGG*2230 Fluid Mechanics
ENGG*3650 Hydrology
ENGG*3340 Geographic Information Systems

The qualification will be assessed by transcripts supplied by the student at the time of application. Students deficient in certain areas will be required to take make-up undergraduate courses. Such students will be admitted and allowed to continue on provisional status for a maximum of two semesters or until the requirements are completed. These courses will not count toward the student's graduate credit requirements.

Graduate Programs, Engineering

PhD Program
The PhD program prepares candidates for a career in engineering teaching, research, or consulting. The program is designed to provide both broad knowledge of engineering science and training in advanced research. Doctoral research carries the expectation of making an original contribution to the body of existing knowledge or technology. It is also expected that the responsibility of problem definition and solution is that of the student, and that the student's advisor acts truly in an advisory capacity. Therefore, graduates are expected to have acquired autonomy in defining and analysing problems, conducting research, and preparing scholarly publications. These objectives are achieved through a combination of course work, independent research, a qualifying examination, and the production and defence of a research dissertation.

Department of Chemical Engineering

Water Resources Engineering applicants must have a minimum of three of the following courses or equivalents:

Mechanical Engineering applicants must have a minimum of three of the following courses or equivalents:

- Fluid Mechanics
- Water Management
- Hydrology
- Water Quality
- Urban Water Systems
- Watershed Structures
- Soil and Water Conservation

These courses will not count toward the student's graduate credit requirements.

Degree of Doctor of Philosophy

PhD Program
The PhD program prepares candidates for a career in engineering teaching, research, or consulting. The program is designed to provide both broad knowledge of engineering science and training in advanced research. Doctoral research carries the expectation of making an original contribution to the body of existing knowledge or technology. It is also expected that the responsibility of problem definition and solution is that of the student, and that the student's advisor acts truly in an advisory capacity. Therefore, graduates are expected to have acquired autonomy in defining and analysing problems, conducting research, and preparing scholarly publications. These objectives are achieved through a combination of course work, independent research, a qualifying examination, and the production and defence of a research dissertation.

Admission Requirements
The minimum academic requirement for admission to the PhD program is normally a recognized Master's degree in engineering. Applicants are usually required to have completed a Bachelor's and a Master's degree from a recognized post-secondary institution and must have achieved a minimum B average in their Master's program. Applicants must also have demonstrated strong potential for research. A strong recommendation from the MASc advisor is necessary. Direct admission to the PhD program from a Bachelor's program is rarely granted. Applicants requesting direct admission must hold a bachelor's degree with exceptionally high academic standing and have related research experience. Such applicants should discuss this option with the Associate Director, Graduate Studies at the earliest opportunity.

Degree Requirements
The prescribed program of study must consist of no fewer than 2.0 credits in addition to those taken as part of the MASc degree. At least 1.5 of the credits must be at the graduate level, and at least 1.0 must be engineering graduate courses. Under special circumstances and with the approval of the Director, the school may reduce the requirement for 1.5 credit course requirement; however, the 1.0 graduate-engineering-course credit requirement will not be changed. In all cases the remaining courses must be acceptable for graduate credit; that is, they must be either graduate courses or senior undergraduate courses. Depending on the student's background, the advisory committee may specify more than four courses, including undergraduate make-up courses. If make-up courses are deemed necessary, they will be considered additional courses.

The qualifying examination as outlined in the Graduate Calendar is held by the end of the fourth semester but no later than the fifth semester after the student has completed the required courses.

Graduate Diplomas in Water Resources
The objective of the graduate diploma is to provide mid-career, engineering professionals from Canada and abroad with post graduate education and training to improve their job-related expertise within an 8 month period. The program enhances the ability of these professionals to gain employment in the field of Water Resources engineering by developing specialized knowledge in one of two areas of Water Resources. The first area will emphasize higher learning in the application of Modelling in a Water Resources context. Application of existing tools, particularly GIS, to a variety of contemporary water resources problems will be emphasized. The second area focuses on the Design of Sustainable Water Resources Systems that will be sustainable in today's development environment.

Admission Requirements
Students with an honours degree will be considered for the Graduate Diploma program provided they have satisfactory preparation in mathematical and physical sciences. A minimum average grade of 70% for the last four full-time semesters, or the last two complete undergraduate years, prior to entry will normally be required.

Since an adequate background in undergraduate engineering courses is prerequisite for courses offered in the program, there is a requirement of the following courses or equivalent.

ENGG*2230 Fluid Mechanics
ENGG*3650 Hydrology
ENGG*3340 Geographic Information Systems

The qualification will be assessed by transcripts supplied by the student at the time of application. Students deficient in certain areas will be required to take make-up undergraduate courses. Such students will be admitted and allowed to continue on provisional status for a maximum of two semesters or until the requirements are completed. These courses will not count toward the student's graduate credit requirements.

1 Only required for students in the Modelling Applications in Water Resources Systems Diploma Program

Diploma Requirements
The prescribed program consists of 2.0 credits acceptable at the graduate level.

Modelling Applications in Water Resource Engineering

The core courses consist of a total of 2.0 credits. 1.5 credits must come from the list below. One of these must be ENGG*6800.

ENGG*6800 [0.50] Deterministic Hydrological Modelling
ENGG*6740 [0.50] Ground Water Modelling
ENGG*6840 [0.50] Open Channel Hydraulics
ENGG*6880 [0.50] Soil Erosion and Fluvial Sedimentation
ENGG*6030 [0.50] Finite Difference Methods
ENGG*6050 [0.50] Finite Element Methods
ENGG*4510 [0.50] Risk Assessment and Management
ENGG*6060 [0.50] Engineering Systems Modelling and Simulation

In addition, the student must complete ENGG*6910. This is a 0.5 credit, 1 semester course.

This special topics course will focus on one of the following areas:

- Watershed Systems Design
- Soil-Water Conservation Systems Design
- Urban Water Systems Design
- And include a project utilizing a GIS-based modeling approach.

2018-2019 Graduate Calendar
March 1, 2019
Engineering Design of Sustainable Water Resource Systems

The courses consist of a total of 2.0 credits. Two courses (1.0 credits) must be selected from the following courses:

- ENGG*6610 [0.50] Urban Stormwater Management
- ENGG*6860 [0.50] Stream and Wetland Restoration Design
- ENGG*6840 [0.50] Open Channel Hydraulics
- ENGG*6140 [0.50] Optimization Techniques for Engineering
- ENGG*4510 [0.50] Risk Assessment and Management
- ENGG*6680 [0.50] Advanced Water and Wastewater Treatment
- ENVS*6280 [0.50] Soil Physics
- RPD*6310 [0.50] Environmental Impact Assessment
- ENGG*4250 [0.50] Watershed Systems Design
- ENGG*4360 [0.50] Soil-Water Conservation Systems Design
- ENGG*4370 [0.50] Urban Water Systems Design

In addition to the courses above, the course ENGG*6910 must be completed. This is a 0.5 credit, one semester course. For each of these an area of emphasis from one of the following three areas must be selected:

- Watershed Systems Design
- Soil-Water Conservation Systems Design
- Urban Water Systems Design

For this special topics course the project must focus on sustainability of water resources within the area of emphasis selected.

Interdepartmental Programs

MSC Food Safety and Quality Assurance

The School of Engineering participates in the MSc program in food safety and quality assurance. Those faculty members whose research and teaching expertise includes aspects of food safety and quality assurance may serve as advisors for MSC students. Please consult the Food Safety and Quality Assurance listing for a detailed description of the MSc program.

Collaborative Specializations

International Development Studies

The School of Engineering participates in the MEng, MASc and PhD collaborative specialization in International Development Studies (IDS). The International Development Studies collaborative specialization provides an interdisciplinary framework for the study of international development combining training in a selected academic discipline with exposure to a broad range of social science perspectives. This collaborative specialization will add the designation “International Development Studies” to your program. Applicants apply directly through the School of Engineering and must meet the University of Guelph and department program admission requirements. Students should consult the International Development Studies listing to confirm the IDS collaborative specialization requirements.

Artificial Intelligence

The School of Engineering participates in the collaborative specialization in Artificial Intelligence. MASc students wishing to undertake thesis research with an emphasis on artificial intelligence are eligible to apply to register concurrently in Engineering and the collaborative specialization. Students should consult the Artificial Intelligence listing for more information.

Courses

General

- ENGG*6000 Advanced Heat and Mass Transfer U [0.50]
  Department(s): School of Engineering

- ENGG*6010 Assessment of Engineering Risk U [0.50]
  The question of "how safe is safe enough?" has no simple answer. In response, this course develops the bases by which we can assess and manage risk in engineering. Course deals with fate and transport issues associated with risk, as relevant to engineering and how these aspects are employed in the making of decisions. 
  Prerequisite(s): STAT*2040 or STAT*2120
  Department(s): School of Engineering

- ENGG*6020 Advanced Fluid Mechanics U [0.50]
  Department(s): School of Engineering

- ENGG*6030 Finite Difference Methods U [0.50]
  Numerical solution of partial differential equations of flow through porous media; flow of heat and vibrations; characterization of solution techniques and analysis of stability; convergence and compatibility criteria for various finite difference schemes. 
  Department(s): School of Engineering

- ENGG*6050 Finite Element Methods U [0.50]
  Department(s): School of Engineering

- ENGG*6060 Engineering Systems Modelling and Simulation U [0.50]
  A study of theoretical and experimental methods for characterizing the dynamic behaviour of engineering systems. Distributed and lumped parameter model development. Digital simulation of systems for design and control. 
  Department(s): School of Engineering

- ENGG*6080 Engineering Seminar U [0.00]
  The course objective is to train the student in preparing, delivering and evaluating technical presentations. Each student is required to: (a) attend and write critiques on a minimum of six technical seminars in the School of Engineering; and (b) conduct a seminar, presenting technical material to an audience consisting of faculty and graduate students in the school. This presentation will then be reviewed by the student and the instructor. 
  Department(s): School of Engineering

- ENGG*6090 Special Topics in Engineering U [0.50]
  A course of directed study involving selected readings and analyses in developing knowledge areas which are applicable to several of the engineering disciplines in the School of Engineering. 
  Department(s): School of Engineering

Biological Engineering

- ENGG*6110 Food and Bio-Process Engineering U [0.50]
  Kinetics of biological reactions, reactor dynamics and design. Food rheology and texture; water activity and the role of water in food processing; unit operations design-thermal processing; and drying, freezing and separation processes. 
  Department(s): School of Engineering

- ENGG*6120 Fermentation Engineering U [0.50]
  Modelling and design of fermenter systems. Topics include microbial growth kinetics, reactor design, heat and mass transfer. Instrumentation and unit operations for feed preparation and product recovery. Prerequisite: undergraduate course in each of microbiology, heat and mass transfer, and biochemistry or bioprocess engineering. 
  Department(s): School of Engineering

- ENGG*6130 Physical Properties of Biomaterials U [0.50]
  Rheology and rheological properties. Contact stresses between bodies in compression. Mechanical damage. Aerodynamic and hydro-dynamic characteristics. Friction. 
  Department(s): School of Engineering

- ENGG*6150 Bio-Instrumentation U [0.50]
  Restriction(s): ENGG*3450 or equivalent. 
  Department(s): School of Engineering

- ENGG*6160 Advanced Food Engineering U [0.50]
  Application of heat and mass transfer, fluid flow, food properties, and food-processing constraints in the design and selection of food process equipment. Development of process specifications for the control of the flow of heat and moisture and the associated microbial, nutritional and organoleptic change in foods. Food system dynamics and process development. 
  Department(s): School of Engineering

- ENGG*6170 Special Topics in Food Engineering U [0.50]
  A course of directed study involving selected readings and analyses in developing knowledge areas of food engineering. 
  Department(s): School of Engineering

- ENGG*6180 Final Project in Biological Engineering U [1.00]
  A project course in which a problem of advanced design or analysis in the area of biological engineering is established, an investigation is performed and a final design or solution is presented. 
  Restriction(s): This course is open only to students in the biological MEng program. 
  Department(s): School of Engineering
ENGG*6190 Special Topics in Biological Engineering U [0.50]
A course of directed study involving selected readings and analyses in developing knowledge areas of biological engineering.
Department(s): School of Engineering
Restriction(s): Instructor consent required.

ENGG*6300 Research Methods in Bioengineering U [0.50]
Research methodologies used in bioengineering are reviewed and assessed in the context of a diverse range of applications: biomechanics, control and instrumentation, ergonomics, diagnostic tools, biomaterials and food safety. The scientific method is discussed in terms of defining research problems, appropriate tests and hypotheses, experimental methods, data analysis and drawing conclusions. The objective is to guide students as they develop a coherent research proposal and deepen their understanding of the breadth of the discipline. (Offered in alternate years)
Department(s): School of Engineering

ENGG*6440 Advanced Biomechanical Design U [0.50]
Biomechanical Design from concept through prototyping and testing. This course will investigate and apply techniques used for biomechanical design including reverse engineering, solid modelling, geometric tolerancing, testing and rapid prototyping. Instructor's signature required.
Department(s): School of Engineering

ENGG*6450 Queueing Theory & Traffic Modeling in Data Networks U [0.50]
Restriction(s): Engineering graduate students. Instructor consent required.
Department(s): School of Engineering

ENGG*6510 Analog Integrated Circuit Design U [0.50]
In this course, operating principles and design techniques of analog integrated circuits are introduced with emphasis on device and system modelling. These circuits include analog and switched-capacitor filters, data converters, amplifiers, oscillators, modulators, circuits for communications, sensor readout channels, and circuits for integrated memories. It is recommended that students are familiar with the fundamentals of linear systems, circuit analysis, and electronic devices.
Department(s): School of Engineering

ENGG*6520 VLSI Digital Systems Design U [0.50]
This course will introduce the principles of VLSI MOSFET digital design from a circuit and system perspective. Advanced topics include: power issues related to each level of design abstraction; voltage and frequency scaling; power to speed tradeoffs;ASIC digital design flow; Verilog integrationintegration;ASIC case studies. It is recommended that students are familiar with the fundamentals of digital circuits and electronic devices.
Department(s): School of Engineering

ENGG*6530 Reconfigurable Computing U [0.50]
This course serves as a graduate introduction into reconfigurable computing systems. It introduces students to the analyses, synthesis and design of embedded systems and implementing them using Field Programmable Gate Arrays. Topics include: Programmable Logic devices, Hardware Description Languages, Computer Aided Design Flow, Hardware Accelerators, Hardware/Software Co-design techniques, Run Time Reconfiguration, High Level Synthesis. It is recommended that students are familiar with the fundamentals of digital design and hardware description languages.
Department(s): School of Engineering

ENGG*6550 Intelligent Real-Time Systems U [0.50]
Soft real-time systems, hard real-time systems, embedded systems, time handling and synchronization, deadlines, preemption, interruption, RTS languages, RTS/operating systems, system life-cycle, petri nets, task scheduling and allocation, fault-tolerance, resource management, RTS/search techniques, dealing with uncertainty.
Department(s): School of Engineering

ENGG*6570 Advanced Soft Computing U [0.50]
Neural dynamics and computation from a single neuron to a neural network architecture. Advanced neural networks and applications. Soft computing approaches to uncertainty representation, multi-agents and optimization.
Prerequisite(s): ENGG*4430 or equivalent
Department(s): School of Engineering

ENGG*6580 Advanced Control Systems U [0.50]
This course will start with state space analysis of multi-input multi-output control systems. Then state space design will be presented. After that, nonlinear control systems and soft computing based intelligent control systems will be studied. Finally, hybrid control systems, H infinity control and uncertainty and robustness in control systems will be addressed.
Department(s): School of Engineering

ENGG*6980 Special Topics in Computer Engineering U [0.50]
This course addresses specialized topics in one or more aspects of Computer Engineering not covered by other graduate courses. Includes selected readings and thorough analyses in emerging knowledge areas, advanced engineering tools, and current technical developments. May be repeated for credit as topics vary.
Department(s): School of Engineering

ENGG*6990 Final Project in Computer Engineering U [1.00]
An independent project carried out under the supervision of a Computer Engineering faculty member in which an advanced modelling or design problem and the desired outcomes are defined, possible solutions are synthesized and analyzed, and a final model or design is evaluated. Regular meetings, final report, and presentation required.
Restriction(s): This course is open only to students in the Computer Engineering MEng program.
Department(s): School of Engineering

Environmental Engineering

ENGG*6610 Urban Stormwater Management U [0.50]
Continuous stormwater management models and model structure. Catchment discretization and process disaggregation. Pollutant build-up, wash off and transport. Flow and pollutant routing in complex, looped, partially saturated pipe/channel networks including pond storage, storage tanks, diversion structures, transverse and side weirs, pump stations, orifices, radical and leaf gates and transient receiving water conditions (including tides). Pollutant removal in sewer networks, storage facilities and treatment plants.
Department(s): School of Engineering

ENGG*6630 Environmental Contaminants: Fate Mechanisms U [0.50]
Analysis of fate mechanisms associated with environmental contaminants. Focus on substances which are generally considered to be hazardous to humans, or other animal life at low concentrations. Study of physicochemical properties and fate estimation on control and remediation strategies. Quantitative analysis of contaminant partitioning and mass flows, including cross-media transport and simultaneous action of contaminant fate mechanisms.
Department(s): School of Engineering

ENGG*6650 Advanced Air Quality Modelling U [0.50]
Analysis of analytical and computational models used to predict the fate of airborne contaminants; role of air quality models for the solution of engineering-related problems; analysis of important boundary layer meteorology phenomena that influence the fate of air pollutants; conservation equations and mathematical solution techniques; model input requirements such as emissions inventories; Gaussian models; higher-order closure models; Eulerian photochemical grid models.
Department(s): School of Engineering

ENGG*6660 Renewable Energy U [0.50]
The engineering principles of renewable energy technologies including wind, solar, geothermal and biomass will be examined, including technology-specific design, economic and environmental constraints. Students will compare the relative merits of different energy technologies and gain a knowledge base for further study in the field.
Restriction(s): Engineering graduate students. Instructor consent required.
Department(s): School of Engineering

ENGG*6670 Hazardous Waste Management U [0.50]
This course will define the different types of hazardous wastes that currently exist and outline the pertinent legislation governing these wastes. Information will be presented on different ways to handle, treat and dispose the hazardous waste, including separation, segregation, minimization, recycling and chemical, physical, biological, and thermal treatment. Also to be discussed are hazardous waste landfills and site remediation technologies. Specifics include design and operation of hazardous landfill sites, handling and treatment of leachate, comparison of pertinent soil remediation technologies. Case studies will be reviewed.
Department(s): School of Engineering

ENGG*6680 Advanced Water and Wastewater Treatment U [0.50]
This design course will discuss advanced technologies not traditionally covered during an undergraduate curriculum. An important consideration will be the reuse of water.
Department(s): School of Engineering
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGG*6790</td>
<td>Special Topics in Environmental Engineering</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6950</td>
<td>Final Project in Environmental Engineering</td>
<td>1.00</td>
</tr>
<tr>
<td>ENGG*6070</td>
<td>Medical Imaging</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6140</td>
<td>Optimization Techniques for Engineering</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6100</td>
<td>Machine Vision</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6500</td>
<td>Introduction to Machine Learning</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6540</td>
<td>Advanced Robotics</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6560</td>
<td>Advanced Digital Signal Processing</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6590</td>
<td>Final Project in Engineering Systems and Computing</td>
<td>1.00</td>
</tr>
<tr>
<td>ENGG*6310</td>
<td>Advanced Electromechanical Devices</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6320</td>
<td>Advanced Topics in Mechatronics</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6340</td>
<td>Bioenergy and Biofuels</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6350</td>
<td>Flow Induced Vibrations</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6360</td>
<td>Fuel Cell Technology</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6370</td>
<td>Heat Transfer in Porous Media</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6380</td>
<td>Simulation Analysis of Discrete Event Systems</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6390</td>
<td>Final Project in Mechanical Engineering</td>
<td>1.00</td>
</tr>
<tr>
<td>ENGG*6740</td>
<td>Ground Water Modelling</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6750</td>
<td>Deterministic Hydrological Modelling</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Engineering Systems and Computing**

- **ENGG*6790** Special Topics in Environmental Engineering (0.50)
  - A course of directed study involving selected readings and analyses in developing knowledge areas of environmental engineering.
  - **Department(s):** School of Engineering

- **ENGG*6950** Final Project in Environmental Engineering (1.00)
  - A project course in which a problem of advanced design or analysis in the area of environmental engineering is established, an investigation is performed and a final design or solution is presented.
  - **Restriction(s):** This course is only open to students in the Environmental MEng program.
  - **Department(s):** School of Engineering

- **ENGG*6070** Medical Imaging (0.50)
  - Digital image processing techniques including filtering and restoration; physics of image formation for such modalities as radiography, MRI, ultrasound.
  - **Prerequisite(s):** ENGG*3390 or equivalent
  - **Department(s):** School of Engineering

- **ENGG*6140** Optimization Techniques for Engineering (0.50)
  - This course serves as a graduate introduction into combinatorics and optimization.
  - **Restriction(s):** This course is open only to students in the Environmental MEng program.
  - **Department(s):** School of Engineering

- **ENGG*6100** Machine Vision (0.50)
  - Computer vision studies how computers can analyze and perceive the world using input from imaging devices. Topics covered include image pre-processing, segmentation, shape analysis, object recognition, image understanding, 3D vision, motion and stereo analysis, as well as case studies.
  - **Department(s):** School of Engineering

- **ENGG*6500** Introduction to Machine Learning (0.50)
  - The aim of this course is to provide students with an introduction to algorithms and techniques of machine learning particularly in engineering applications. The emphasis will be on the fundamentals and not specific approach or software tool. Class discussions will cover and compare all current major approaches and their applicability to various engineering problems, while assignments and project will provide hands-on experience with some of the tools.
  - **Department(s):** School of Engineering

- **ENGG*6540** Advanced Robotics (0.50)
  - This course is intended for graduate students who have some knowledge and interest in robotics. The course covers modelling, design, planning control, sensors and programming of robotic systems. In addition to lectures, students will work on a term project in which a problem related to robotics systems will be studied. Instructors signature required.
  - **Department(s):** School of Engineering

- **ENGG*6560** Advanced Digital Signal Processing (0.50)
  - Discrete-time signals and systems, z transform, frequency analysis of signals and systems, fourier transform, fast fourier transform, design of digital filters, signal reconstruction, power spectrum estimation.
  - **Department(s):** School of Engineering

- **ENGG*6590** Final Project in Engineering Systems and Computing (1.00)
  - A project course in which a problem of advanced design or analysis in the area of Engineering Systems and Computing is established by the student, an investigation is performed, and a report on the final design or solution selected is presented.
  - **Restriction(s):** This course is only open to students in the engineering systems and computing MEng program.
  - **Department(s):** School of Engineering

- **ENGG*6600** Special Topics in Engineering Systems and Computing (0.50)
  - A course of directed study involving selected readings and analyses in developing knowledge areas of Engineering Systems and Computing.
  - **Department(s):** School of Engineering

**Mechanical Engineering**

- **ENGG*6290** Special Topics in Mechanical Engineering (0.50)
  - A course of directed study involving selected readings and analyses in developing knowledge areas of mechanical engineering.
  - **Department(s):** School of Engineering

**Water Resources Engineering**

- **ENGG*6740** Ground Water Modelling (0.50)
  - Introduction to current groundwater issues, definition of terms, review of fundamental equations describing fluid and contaminant transport in saturated groundwater zones. Mathematical techniques (analytical, FE and FD) for the solution of the fundamental equations. Application of numerical groundwater models to a variety of situations. Case studies. Review of groundwater models used in industry.
  - **Department(s):** School of Engineering

- **ENGG*6800** Deterministic Hydrological Modelling (0.50)
  - Deterministic hydrological models. Function of watershed models for hydraulic design, environmental assessment, operation of water control structures, flood warning, calculation algorithms.
  - **Department(s):** School of Engineering

March 1, 2019
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
<th>Department(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGG*6820</td>
<td>Measurement of Water Quantity and Quality U [0.50]</td>
<td></td>
<td>This course covers techniques used to measure rates of movement and amounts of water occurring as precipitation, soil water, ground water and streamflow. Available measurements of water quality are surveyed. Calculation procedures involved in the use of indirect indicators of water quantity and quality individually and in combination are described.</td>
<td>School of Engineering</td>
</tr>
<tr>
<td>ENGG*6840</td>
<td>Open Channel Hydraulics U [0.50]</td>
<td></td>
<td>Basic concepts, energy principle; momentum principle; flow resistance; non-uniform flow; channel controls and transitions; unsteady flow; flood routing.</td>
<td>School of Engineering</td>
</tr>
<tr>
<td>ENGG*6860</td>
<td>Stream and Wetland Restoration Design U [0.50]</td>
<td></td>
<td>Explores the multi-disciplinary principles of stream and wetland restoration and the tools and techniques for restoration design. Restoration design is approached from a water resources engineering perspective with emphasis on hydrological and hydraulic techniques. Numerous case studies are examined as a means to identify more successful design approaches.</td>
<td>School of Engineering</td>
</tr>
<tr>
<td>ENGG*6880</td>
<td>Soil Erosion and Fluvial Sedimentation U [0.50]</td>
<td></td>
<td>Students will be able to (i) describe processes related to soil erosion by water, (ii) describe processes related to fluvial sedimentation, (iii) evaluate and prescribe structural and non-structural control methods, and (iv) run at least one soil erosion/fluvial sedimentation computer model if the course is satisfactorily completed.</td>
<td>School of Engineering</td>
</tr>
<tr>
<td>ENGG*6900</td>
<td>Final Project in Water Resources Engineering U [1.00]</td>
<td></td>
<td>A project course in which an advanced design problem in the area of watershed engineering is established, a feasibility investigation performed and a final design presented.</td>
<td>School of Engineering</td>
</tr>
<tr>
<td>ENGG*6910</td>
<td>Special Topics in Water Resources Engineering U [0.50]</td>
<td></td>
<td>A course of directed study involving selected readings and analyses in developing knowledge areas of water resources engineering.</td>
<td>School of Engineering</td>
</tr>
</tbody>
</table>