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:

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<td>Initial Publication</td>
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<td>August 10, 2018</td>
<td>Revision 1</td>
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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/DBLaws/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.
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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 and manufacturing, life-cycle design and assessment, systems modernization, materials and manufacturing processes, 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 (Thornbrough 2408, Ext. 52430)
soedir@uoguelph.ca

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

Associate Director, Graduate Studies
Bahram Gharabaghi (Thornbrough 1407, Ext. 52404)
soeadgr@uoguelph.ca

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

Graduate Program Assistant
You Jia Lee (Thornbrough 1405, Ext. 56187)
soeograd@uoguelph.ca

Academic and Administrative Support Secretary
Lauren Fyke (Thornbrough 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 AI-Fateh, MASc Waterloo, PhD Waterloo, P.Eng - Professor

Alexander Bardelech
BASc, MASc, PhD Waterloo - Assistant Professor

Mohammad Biglarbegan
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, MASc Toronto, PhD Univ. of Leuven, P.Eng - Assistant Professor

Ryan Clemmer
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, BASc Waterloo, PhD McMaster, P.Eng, FIET, FEC - Associate Professor

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

Abdallah Elsayed
BEng, BASc, PhD Ryerson - Assistant Professor

Mustafa Elsharqawy
BSc, MSc Ai Sham, PhD Petroleum & Minerals - Assistant Professor

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

Bhalam 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

2018-2019 Graduate Calendar
August 10, 2018
Admission Requirements

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

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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 course requirement; however, the 1.0 graduate-engineering-course credit requirement will not be reduced. 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.

MASc Program

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.

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MAEng Program

The objective of the course-work master's degree program (MAEng) 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 in their field. 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 following by an oral examination of the candidate.

Admission Requirements

Applicants must be graduates of an honours engineering program with at least a 75% average in the past four full-time semesters or the equivalent. International degree and grade equivalents will be determined by the Office of Graduate Studies.

- 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 engineering courses without receiving graduate credit.

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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 as decided by the Graduate Program Committee. The student will be admitted on probation until the requirements have been completed. These courses will not count toward the student graduate degree requirement.

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

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*6820 [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.
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** Urban Stormwater Management [0.50]
- **ENGG*6680** Stream and Wetland Restoration Design [0.50]
- **ENGG*6840** Open Channel Hydraulics [0.50]
- **ENGG*6140** Optimization Techniques for Engineering [0.50]
- **ENGG*4510** Risk Assessment and Management [0.50]
- **ENGG*6680** Advanced Water and Wastewater Treatment [0.50]
- **ENVS*6280** Soil Physics [0.50]
- **RPD*6310** Environmental Impact Assessment [0.50]
- **ENGG*4250** Watershed Systems Design2 [0.50]
- **ENGG*4360** Soil-Water Conservation Systems Design2 [0.50]
- **ENGG*4370** Urban Water Systems Design2 [0.50]

In addition to the above courses, 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

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

2 Only one of these courses may be selected.

3 If one of the undergraduate courses listed above are selected, the area of emphasis for this course must differ from the undergraduate course.

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 admission requirements. Students should consult the International Development Studies listing to confirm the IDS collaborative specialization requirements.

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*2400 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 four 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
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)
Restriction(s): Instructor consent required.
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

Computer Engineering

ENGG*6450 Queuing 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 circuits, 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 integration/intergration; 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 surcharged 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

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENGG*6100</td>
<td>Machine Vision U [0.50]</td>
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<tr>
<td>ENGG*6140</td>
<td>Optimization Techniques for Engineering U [0.50]</td>
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<tr>
<td>ENGG*6500</td>
<td>Introduction to Machine Learning U [0.50]</td>
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<tr>
<td>ENGG*6540</td>
<td>Advanced Robotics U [0.50]</td>
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<tr>
<td>ENGG*6560</td>
<td>Advanced Digital Signal Processing U [0.50]</td>
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<tr>
<td>ENGG*6590</td>
<td>Final Project in Engineering Systems and Computing U [1.00]</td>
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<tr>
<td>ENGG*6600</td>
<td>Special Topics in Engineering Systems and Computing U [0.50]</td>
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<tr>
<td>ENGG*6290</td>
<td>Special Topics in Mechanical Engineering U [0.50]</td>
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### Water Resources Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENGG*6740</td>
<td>Ground Water Modelling U [0.50]</td>
<td></td>
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<tr>
<td>ENGG*6750</td>
<td>Deterministic Hydrological Modelling U [0.50]</td>
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</tbody>
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### Department(s):

- School of Engineering
- Mechanical Engineering
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites/Restrictions</th>
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</thead>
<tbody>
<tr>
<td>ENGG*6820</td>
<td>Measurement of Water Quantity and Quality</td>
<td>0.50</td>
<td>School of Engineering</td>
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<tr>
<td></td>
<td>This course covers techniques used to measure rates of movement and amounts of</td>
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<td>water occurring as precipitation, soil water, ground water and streamflow.</td>
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<td>Available measurements of water quality are surveyed. Calculation procedures</td>
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<td>involved in the use of indirect indicators of water quantity and quality</td>
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<td>individually and in combination are described.</td>
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<tr>
<td>ENGG*6840</td>
<td>Open Channel Hydraulics</td>
<td>0.50</td>
<td>School of Engineering</td>
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<td>Basic concepts, energy principle; momentum principle; flow resistance; non-</td>
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<td>uniform flow; channel controls and transitions; unsteady flow; flood routing.</td>
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<tr>
<td>ENGG*6860</td>
<td>Stream and Wetland Restoration Design</td>
<td>0.50</td>
<td>School of Engineering</td>
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<td>Explores the multi-disciplinary principles of stream and wetland restoration</td>
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<td>and the tools and techniques for restoration design. Restoration design is</td>
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<td>approached from a water resources engineering perspective with emphasis on</td>
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<td>hydrological and hydraulic techniques. Numerous case studies are examined as</td>
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<td>a means to identify more successful design approaches.</td>
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<td>Prerequisite(s): ENGG*3650 or equivalent.</td>
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<tr>
<td>ENGG*6880</td>
<td>Soil Erosion and Fluvial Sedimentation</td>
<td>0.50</td>
<td>School of Engineering</td>
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<td>Students will be able to (i) describe processes related to soil erosion by</td>
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<td>water, (ii) describe processes related to fluvial sedimentation, (iii)</td>
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<td>evaluate and prescribe structural and non-structural control methods, and (iv)</td>
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<td>run at least one soil erosion/fluvial sedimentation computer model if the</td>
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<td>course is satisfactorily completed.</td>
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<tr>
<td>ENGG*6900</td>
<td>Final Project in Water Resources Engineering</td>
<td>1.00</td>
<td>School of Engineering</td>
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<td>A project course in which an advanced design problem in the area of watershed</td>
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<td>engineering is established, a feasibility investigation performed and a final</td>
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<td>Water resources MEng program</td>
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<td>design presented.</td>
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<tr>
<td>ENGG*6910</td>
<td>Special Topics in Water Resources Engineering</td>
<td>0.50</td>
<td>School of Engineering</td>
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<td>A course of directed study involving selected readings and analyses in</td>
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<td>developing knowledge areas of water resources engineering.</td>
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