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.

- **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.

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Graduate Faculty

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Graduate Faculty

MEng Program

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 and Postdoctoral 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:

- Circuit Analysis
- Programming
- Digital Systems

- Microelectronics
- Computer Organization
- Telecommunications

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

- Introduction to Environmental Engineering
- Engineering Unit Operations
- Water Quality
- Air Quality
- Solid Waste Management
- Water and Wastewater Treatment

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

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

Engineering Systems and Computing applicants must have a minimum of three of the following courses or equivalents:

- Electric Circuits
- Digital Systems
- Systems and Control Theory
- Programming
- Electronics
- Robotics

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

- Thermo-fluids
- Heat Transfer
- Solid mechanics
- Material science
- Dynamic System and controls
- Manufacturing processes
- Electrical circuits
- Machine Design
- Quality control
- Intelligent manufacturing

Applicant qualifications may be assessed via an entrance interview/oral examination conducted by the proposed advisor and one member of the School of Engineering Graduate Program Committee. 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.

Learning Outcomes

By the end of the MEng, student should be able to:

1. Demonstrate specialized and advanced knowledge within one's field of engineering.
2. Apply an existing body of knowledge to solve problems, make justified decisions, and develop informed judgements on complex issues.
3. Find, summarize, analyze, and synthesize information from primary literature, reviews, textbooks, and other sources.
4. Recognize the quality, validity, significance, and limitations of current research and research methods in the field, such as through the medium of literature review.
5. Demonstrate an appreciation for the impact of engineering decisions on goals of global significance, such as sustainability, resilience, and equity.
6. Effectively communicate (sometimes across cultures) engineering information in written, visual, and oral forms appropriate for general and specialist audiences.
7. Demonstrate the growth of professionalism.
8. Apply concepts of academic integrity in generating written and oral communications.
9. Apply ethical reasoning, teamwork, and collaboration in the completion of coursework and during interpersonal interactions with people from diverse backgrounds.
10. MRP option: Develop, with guidance and advice from faculty, an application- or industry-based project that aligns a review of existing knowledge with a rationale for proposed research, and development of a clearly stated problem, hypothesis, or question.
11. MRP option: Demonstrate an understanding of relevant research methods or approaches by applying them to new problems.
12. MRP option: Express one's research as a final project report written to high academic standard that describes a practical solution to an engineering problem.

Program Requirements

The objective of the course-work master's degree program (MEng) is to provide an opportunity for engineering graduates, usually practicing engineers, to advance their understanding of engineering principles and increase their grasp on the application of these principles to the solution of complex, practical problems. Many of these students are returning to school to learn about recent technological developments that have occurred since graduation in their field.

All incoming MEng students will be enrolled in the "Coursework" study option by default.

Coursework

Students must complete 4.5 credits according to the following:

1. 9 courses;
2. No more than 1.0 credits from senior undergraduate engineering courses;
3. No more than 1.0 credits from outside engineering; and
4. A minimum of 3.5 credits from engineering.

At least 2.5 credits of coursework must be field-specific (see the MEng section of the School of Engineering website for lists of courses).

Remaining credits should be chosen in consultation with the Associate Director, Graduate Studies.

Coursework and Major Research Project (MRP)

Students must complete 4.5 credits according to the following:

1. 7 courses and a Final Project Course (1.0);
2. No more than 1.0 credits from senior undergraduate engineering courses;
3. No more than 1.0 credits from outside engineering; and
4. A minimum of 3.5 credits from engineering (including a Final Project Course).

At least 2.5 credits of coursework must be field-specific (see the MEng section of the School of Engineering website for lists of courses). Remaining credits should be chosen in consultation with the Associate Director, Graduate Studies or the student's advisor.

Any MEng students may choose to complete the multi-disciplinary, group-based Major Research Project (ENGG*6970 Applied Engineering Design Ii: Major Research Project). The pre-requisite course (ENGG*6960 Applied Engineering Design I) must be taken prior to enrolment in ENGG*6970. Any MEng students may choose to complete ENGG*6960 Applied Engineering Design I and they may choose not to complete ENGG*6970 Applied Engineering Design Ii: Major Research Project.

If students wish to complete an independent, discipline-specific Major Research Project (ENGG*6180 Final Project in Biological Engineering, ENGG*6390 Final Project in Mechanical Engineering, ENGG*6590 Final Project in Engineering Systems and Computing, ENGG*6900 Final Project in Water Resources Engineering, ENGG*6950 Final Project in Environmental Engineering, or ENGG*6990 Final Project in Computer Engineering) they must contact potential advisors within their first semester of study. This study option must be confirmed and approved by the Associate Director, Graduate Studies at the beginning of the student's second semester.

MASc Program

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 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 and Postdoctoral Studies.
- Bachelor of Science degree or equivalent. At least a 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.

Learning Outcomes

By the end of the MASc program, students should be able to:

1. Demonstrate specialized and advanced knowledge within one's field of engineering.
2. Apply an existing body of knowledge to solve problems, make justified decisions, and develop informed judgements on complex issues.
3. Find, summarize, analyze, and synthesize information from primary literature, reviews, textbooks, and other sources.
4. Recognize the quality, validity, significance and limitations of current research and research methods in the field, such as through the medium of literature review.
5. Demonstrate an appreciation for the impact of engineering decisions on goals of global significance, such as sustainability, resilience, and equity.
6. Effectively communicate (sometimes across cultures) engineering information in written, visual, and oral forms appropriate for general and specialist audiences.
7. Demonstrate the growth of professionalism.
8. Apply concepts of academic integrity in generating written and oral communications.
9. Apply ethical reasoning, teamwork, and collaboration in the completion of coursework and during interpersonal interactions with people from diverse backgrounds.
10. Demonstrate, through the master's thesis, critical awareness of current issues within one's field of engineering, as well as relevant knowledge outside the field.
11. Develop, with advice from their advisory committee, a research project that aligns a review of existing knowledge with a rationale for proposed research, and development of a clearly stated problem, hypothesis, or question.
12. Demonstrate mastery of relevant research methods or approaches by applying them to new problems.
13. Contribute to the improvement of engineering skills, techniques, tools, practices, theories, approaches, or materials.
14. Discuss the importance, broader implications, and limitations of one's own work, and recommend future work.
15. Express one's research as a thesis written to high academic standard that describes a practical solution to an engineering problem.
16. Demonstrate the growth of intellectual independence.

Program 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.

The prescribed program of study must consist of no fewer than 2.0 credits, of which at least 1.0 must be engineering graduate courses. Of the remaining 1.0 credits, 0.5 credits must be at the graduate level, and the other 0.5 credits may be graduate credits or senior undergraduate engineering credits. 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.

PhD Program

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.

Learning Outcomes

By the end of the PhD, students should be able to:

1. Demonstrate specialized and advanced knowledge within one's field of engineering.
2. Apply an existing body of knowledge to solve problems, make justified decisions, and develop informed judgements on complex issues.
3. Find, summarize, analyze, and synthesize information from primary literature, reviews, textbooks, and other sources.
4. Recognize the quality, validity, significance and limitations of current research and research methods in the field, such as through the medium of literature review.
5. Demonstrate an appreciation for the impact of engineering decisions on goals of global significance, such as sustainability, resilience, and equity.
6. Effectively communicate (sometimes across cultures) engineering information in written, visual, and oral forms appropriate for general and specialist audiences.
7. Demonstrate the growth of professionalism.
8. Apply concepts of academic integrity in generating written and oral communications.
9. Apply ethical reasoning, teamwork, and collaboration in the completion of coursework and during interpersonal interactions with people from diverse backgrounds.
10. Demonstrate, through the qualifying examination, thorough understanding of a substantial body of knowledge that is at the forefront of one's engineering field, as well as relevant knowledge outside the field.
11. Develop an advanced and original research project that aligns a review of existing knowledge with a rationale for proposed research, and development of a clearly stated problem, hypothesis, or question.
12. Independently apply established or modified research methods to generate new knowledge at the leading edge of the field.
13. Contribute significantly to the advancement in engineering skills, techniques, tools, practices, theories, approaches, or materials.
14. Evaluate the importance, broader implications, and limitations of one's own work, and recommend future work.
15. Express one's original and creative research as a written thesis of a quality to satisfy peer review and merit publication.
16. Demonstrate intellectual independence and emerging research leadership.

Program Requirements

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.

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 1.0 of the credits must be engineering graduate courses. Of the remaining 1.0 credits, 0.5 credits must be at the graduate level, and the other 0.5 credits may be graduate credits or senior undergraduate engineering credits. Depending on the student's background, the advisory committee may specify more than 2.0 credits, 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.

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 (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/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 (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/artificial-intelligence/) listing for more information.

Regenerative Medicine

The School of Engineering participates in the collaborative specialization in Regenerative Medicine. MASc and Doctoral students wishing to undertake thesis research or their major research paper/project with

an emphasis on regenerative medicine are eligible to apply to register concurrently in Engineering and the collaborative specialization. Students should consult the Regenerative Medicine (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/regenerative-medicine/) listing for more information.

One Health

The School of Engineering participates in the collaborative specialization in One Health. Master's and Doctoral students wishing to undertake thesis research or their major research paper/project with an emphasis on one health are eligible to apply to register concurrently in Engineering and the collaborative specialization. Students should consult the One Health (calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/one-health/) listing for more information.

Courses

ENGG*6000 Advanced Heat and Mass Transfer Unspecified [0.50]
Basic physical principles of transport phenomena. Heat and mass transfer methods for physical systems. Time and volume averaging. Dimensional analysis.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6010 Assessment of Engineering Risk Unspecified [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. Students are expected to have already taken a relevant undergraduate course in statistics (STAT*2040, STAT*2120, or equivalent).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6020 Advanced Fluid Mechanics Unspecified [0.50]
Laminar and turbulent flow. Turbulence and turbulence modelling. Boundary-layer flow. Compressible flow. Potential flow.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6030 Finite Difference Methods Unspecified [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
Location(s): Guelph

ENGG*6050 Finite Element Methods Unspecified [0.50]
Boundary-value problems. Methods of approximation. Time dependent problems. Isoparametric elements. Numerical integration. Computer implementation. Mesh generation and layouts. Two-dimensional finite elements.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6060 Engineering Systems Modelling and Simulation Unspecified [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
Location(s): Guelph

ENGG*6070 Medical Imaging Unspecified [0.50]
Digital image processing techniques including filtering and restoration; physics of image formation for such modalities as radiography, MRI, ultrasound. Offered in conjunction with ENGG*4660. Extra work is required for graduate students.
Prerequisite(s): ENGG*3390
Restriction(s): Credit may be obtained for only one of ENGG*4660 or ENGG*6070.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6080 Engineering Seminar Unspecified [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
Location(s): Guelph

ENGG*6090 Special Topics in Engineering Unspecified [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
Location(s): Guelph

ENGG*6100 Machine Vision Unspecified [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
Location(s): Guelph

ENGG*6110 Food and Bio-Process Engineering Unspecified [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
Location(s): Guelph

ENGG*6120 Fermentation Engineering Unspecified [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. An ndergraduate course in each of microbiology, heat and mass transfer, and biochemistry or bioprocess engineering is required for this course.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6130 Physical Properties of Biomaterials Unspecified [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
Location(s): Guelph

ENGG*6140 Optimization Techniques for Engineering Unspecified [0.50]
This course serves as a graduate introduction into combinatorics and optimization. Optimization is the main pillar of Engineering and the performance of most systems can be improved through intelligent use of optimization algorithms. Topics to be covered: Complexity theory, Linear/Integer Programming techniques, Constrained/Unconstrained optimization and Nonlinear programming, Heuristic Search Techniques such as Tabu Search, Genetic Algorithms, Simulated Annealing and GRASP.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6150 Bio-Instrumentation Unspecified [0.50]
Instrumentation systems. Transducers. Amplifier circuits. Recording methods. Spectroscopy & colorimetry. Radiation, humidity, pH and noise measurements. Chromatography.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6160 Advanced Food Engineering Unspecified [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
Location(s): Guelph

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

ENGG*6180 Final Project in Biological Engineering Unspecified [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): Restricted to Master of Engineering students in the biological engineering field.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6190 Special Topics in Biological Engineering Unspecified [0.50]
A course of directed study involving selected readings and analyses in developing knowledge areas of biological engineering.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6260 Colloids, Interfaces and Emulsions: Concepts and Practical Applications Winter Only [0.50]
This course focuses on the theory and the applications of colloid and interface science in the environmental, chemical, and food sectors. Major topics include the forces of interactions between colloids, the stabilization and destabilization of emulsions and foams, and polymeric fluids and gels.
Prerequisite(s): CHEM*1040 and CHEM*1050
Department(s): School of Engineering
Location(s): Guelph

ENGG*6270 Advanced Estimation Theory Winter Only [0.50]
This course provides a theoretical and practical understanding of advanced state and parameter estimation theory. Topics include, but are not limited to: linear and nonlinear models, system and measurement noise distributions, observers, optimal filters, robust strategies, and written communication skills. Students should have background knowledge in linear algebra, programming, and systems and control theory.
Prerequisite(s): ENGG*2400 or ENGG*3410
Department(s): School of Engineering
Location(s): Guelph

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

ENGG*6300 Research Methods in Bioengineering Unspecified [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.
Offering(s): Alternate years
Restriction(s): Instructor consent required.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6310 Advanced Electromechanical Devices Unspecified [0.50]
Course covers: switched reluctance motor, brushless motor, linear motor, axial flux motor, and harmonic drive motor with applicable actuators. Other topics introduced include: Electromagnetic micro power generation, design and analysis of cooling systems and control mechanism. Background in electromagnetism required.
Offering(s): Alternate years
Department(s): School of Engineering
Location(s): Guelph

ENGG*6320 Advanced Topics in Mechatronics Unspecified [0.50]
This course covers materials related to mechatronics systems in terms of dynamics, control, sensing, estimation. The course covers advanced topics in these areas and provides students the tools to model, analyze, and control these systems. The focus is on vehicles and robots (mobile robots).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6330 Thermal Design of Heat Exchangers Winter Only [0.50]
This course provides students with practical experience in designing and modeling of heat exchangers for different applications. Students will apply theory and knowledge of heat and mass transfer, thermodynamics, and fluid mechanics to the design of heat exchanger devices for different applications. Students are expected to have already taken relevant undergraduate courses (ENGG*2230, ENGG*3260, ENGG*3370 and ENGG*3430, or equivalents).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6340 Bioenergy and Biofuels Unspecified [0.50]
Theoretical and hands-on experience in bio-renewable energy areas prepares students from diverse backgrounds for a career in the biorefinery industry, academia, or entrepreneurial endeavors. Also deals with the technologies of converting biomass into upgraded energy, value added products, fuels, and chemicals. Thermodynamics background helpful.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6350 Flow Induced Vibrations Unspecified [0.50]
Course covers fluid-structure interaction problems with an emphasis on analytical and numerical methods. Topics include vortex and turbulence induced vibration, galloping and flutter, fluid-elastic instability, and acoustic resonance. Various case studies and applications will be discussed. Background in fluid mechanics and vibrations required.
Offering(s): Annually
Department(s): School of Engineering
Location(s): Guelph

ENGG*6360 Fuel Cell Technology Unspecified [0.50]
Examination of principles governing fuel cell technology and the technical challenges associated with developing fuel cell systems. Topics include the chemical thermodynamics and electrochemical kinetics of fuel cells, the evolution of fuel cell technology, and fuel cell system design. Background in materials and thermodynamics required.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6370 Heat Transfer in Porous Medium Unspecified [0.50]
Course covers general conservation equations for studying the flow and heat transfer through porous media. Application and case studies of porous materials will be discussed. Modelling techniques will be shown for a particular application area. Background in Heat Transfer required.
Offering(s): Annually
Department(s): School of Engineering
Location(s): Guelph

ENGG*6380 Simulation Analysis of Discrete Event Systems Unspecified [0.50]
Many complex engineering, operations, and business systems can be modeled as discrete-event systems. Efficient management and operation of these systems requires simulation to study their performance. Case studies and applications will be presented and discussed.
Offering(s): Annually
Department(s): School of Engineering
Location(s): Guelph

ENGG*6390 Final Project in Mechanical Engineering Unspecified [1.00]
A project course in which a problem of advanced design or analysis in the area of mechanical engineering is established, an investigation is performed and a final design or solution is presented.
Restriction(s): Restricted to Master of Engineering students in the mechanical engineering field.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6400 Mobile Devices Application Development Unspecified [0.50]
This course provides an introduction to developing applications for mobile devices. The emphasis will be on the fundamentals of mobile application programming. This is primarily a project-based course in which the goal is to produce a working app by the end of the course. The purpose of this course is to create new inter-disciplinary applications of mobile devices. Graduate students from all disciplines at the University of Guelph are invited to take the course for credit.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6410 Professionalism and Ethics Fall and Winter [0.50]
This course provides a background for the reflective engineer who wants to explore the positive effect of ethics on engineering practice. It helps design practitioners understand how technology and its impact on society can be positively shaped by consideration of non-engineering values during the design process and how these values can be introduced into designs.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6440 Advanced Biomechanical Design Unspecified [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.
Restriction(s): Instructor signature required.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6450 Queueing Theory and Traffic Modeling Modeling Data Unspecified [0.50]
Network traffic modeling. Transient and steady-state analysis of Markov chains. Queueing analysis. Admission and access control. Flow control protocols. Congestion control. End-to-end performance bounds analysis.
Restriction(s): Instructor consent required.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6460 Engineering Leadership Winter Only [0.50]
This course introduces engineering students to leadership concepts and theory in the context of application to the engineering profession and practice. The focus is on developing practical leadership knowledge, skills and attitudes, starting from the personal level and extending to application in the organizations and society. The content is presented and assessed through a blend of lectures, readings, case studies, discussions, presentations, workshops, reflective practice and a major project.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6470 Solidification and Processing of Metals and Alloys Winter Only [0.50]
This course examins the fundamental principles of metal and alloy solidification. Aspects of nucleation, grain, growth, dendrite formation in casting and welding processes are examined. Thermal analysis, solidification defects and alloy characterization are also covered. Students are expected to have already taken undergraduate courses in materials science and manufacturing processes (ENGG*2120 and ENGG*2180, or equivalents).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6480 Advanced Topics in Mechanical Systems Design Unspecified [0.50]
Introduces advanced design methodologies applicable to mechanical systems. Includes the following topics: materials selection; specialized design methods such as concurrent engineering, design for reliability and life cycle design; application of biologically inspired modeling, optimization methods and finite element analysis; integration of various tools to solve a specific engineering problem; implications of design decisions on sustainability and environment; and utilizing different software packages. Students are expected to have already taken undergraduate courses in materials science and machine design (ENGG*2120 and ENGG*3280, or equivalents).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6490 Nonlinear and Intelligent Control With Applications to Mechatronic Systems Winter Only [0.50]
The aim of this course is about nonlinear and intelligent control systems for mechatronics applications (mixture of theory and applications). Students will also learn about nonlinear systems and important concepts associated with them. Important control techniques both for lienar and nonlinear systems will be taught (focus will be on nonlinear). Applications of various control techniques for vehicles and robotic systems will be taught as well. This course is suitable for students who have some background in control and mechatronics (ENGG*2400 and ENGG*3410, or equivalents).
Department(s): School of Engineering
Location(s): Guelph

ENGG*6500 Introduction to Machine Learning Unspecified [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
Location(s): Guelph

ENGG*6510 Analog Integrated Circuit Design Unspecified [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
Location(s): Guelph

ENGG*6520 VLSI Digital Systems Design Unspecified [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 intergrationintegration; ASIC case studies. It is recommended that students are familiar with the fundamentals of digital circuits and electronic devices.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6530 Reconfigurable Computing Systems Unspecified [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
Location(s): Guelph

ENGG*6540 Advanced Robotics Unspecified [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.
Restriction(s): Instructor's signature required.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6550 Intelligent Real-Time Systems Unspecified [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
Location(s): Guelph

ENGG*6560 Advanced Digital Signal Processing Unspecified [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
Location(s): Guelph

ENGG*6570 Advanced Soft Computing Unspecified [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
Department(s): School of Engineering
Location(s): Guelph

ENGG*6580 Advanced Control Systems Unspecified [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 infinite control and uncertainty and robustness in control systems will be addressed.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6590 Final Project in Engineering Systems and Computing Unspecified [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): Restricted to Master of Engineering students in the engineering systems and computing field.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6600 Special Topics in Engineering Systems and Computing Unspecified [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
Location(s): Guelph

ENGG*6610 Urban Stormwater Management Unspecified [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
Location(s): Guelph

ENGG*6630 Environmental Contaminants: Fate Mechanisms Unspecified [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
Location(s): Guelph

ENGG*6650 Advanced Air Quality Modelling Unspecified [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
Location(s): Guelph

ENGG*6660 Renewable Energy Unspecified [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): Restricted to Engineering students.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6670 Hazardous Waste Management Unspecified [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
Location(s): Guelph

ENGG*6680 Advanced Water and Wastewater Treatment Unspecified [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
Location(s): Guelph

ENGG*6720 Advanced Topics in Groundwater Contamination and Remediation Unspecified [0.50]
This course is an advanced, graduate level, course dealing with the important concepts associated with groundwater flow in fractured rock and field methods for characterizing groundwater flow and quantifying transport in bedrock at both the borehold and flow system scales. Fractured rock hydrology pertains to numerous engineering challenges from mining, waste containment, upstream oil/gas geothermal water supply and watershed/ecosystem management. Students are recommended to have already taken a relevant undergraduate course (ENGG*2230, ENGG*3220 or ENGG*3670).
Offering(s): Alternate years. First offering Fall 2023.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6740 Groundwater Modelling Unspecified [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
Location(s): Guelph

ENGG*6760 Groundwater Flow Systems Unspecified [0.50]
This course concerns groundwater flow systems and the role of aquitards with and without pumping for water supply. Representative geologic domains will be examined using multiple types of evidence to discern flow system characteristics and present various conceptual models from field-based research studies. Students are recommended to have already taken a relevant ungergraduate course (ENGG*2230, ENGG*3220 or ENGG*3670).
Offering(s): Alternative years.
Department(s): School of Engineering
Location(s): Guelph

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

ENGG*6800 Deterministic Hydrological Modelling Unspecified [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
Location(s): Guelph

ENGG*6820 Measurement of Water Quantity and Quality Unspecified [0.50]
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.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6840 Open Channel Hydraulics Unspecified [0.50]
Basic concepts, energy principle; momentum principle; flow resistance; non-uniform flow; channel controls and transitions; unsteady flow; flood routing.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6860 Stream and Wetland Restoration Design Unspecified [0.50]
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.
Prerequisite(s): ENGG*3650
Department(s): School of Engineering
Location(s): Guelph

ENGG*6880 Soil Erosion and Fluvial Sedimentation Unspecified [0.50]
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.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6900 Final Project in Water Resources Engineering Unspecified [1.00]
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.
Restriction(s): Restricted to Master of Engineering students in the water resources engineering field.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6910 Special Topics in Water Resources Engineering Unspecified [0.50]
A course of directed study involving selected readings and analyses in developing knowledge areas of water resources engineering.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6950 Final Project in Environmental Engineering Unspecified [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): Restricted to Master of Engineering students in the environmental engineering field.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6960 Applied Engineering Design I Unspecified [0.50]
This course focuses on applying the knowledge gained in advanced engineering science and design courses on team-based engineering projects that may be community-based or industry sponsored. Students collect and analyze information and synthesize solutions taking into account significant technological, commercial, socio-economical, and environmental considerations. Additionally, the teams prepare a project proposal with a clear problem definition and methodology that may be completed in ENGG*6970.
Restriction(s): Restricted to Master of Engineering students.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6970 Applied Engineering Design II - Major Research Project [1.00]
This course builds upon knowledge foundations and team-based project proposals from ENGG*6960. Student design teams work in consultation with a faculty advisor to develop a design concept through detail design, prototyping (virtual or physical) and testing phases. Students apply advanced engineering science knowledge and develop skills in computer-assisted design, reverse engineering and additive manufacturing. The course culminates with submission of a written report, delivery of an oral presentation and a prototype demonstration. Lecture-based case studies are drawn from across engineering disciplines to illustrate fundamental design principles of reliability, safety, sustainability and cost.
Prerequisite(s): Take ENGG*6960
Restriction(s): Restricted to Master of Engineering students.
Department(s): School of Engineering
Location(s): Guelph

ENGG*6980 Special Topics in Computer Engineering Unspecified [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
Location(s): Guelph

ENGG*6990 Final Project in Computer Engineering Unspecified [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 synthetized and analyzed, and a final model or design is evaluated. Regular meetings, final report, and presentation required.
Restriction(s): Restricted to Master of Engineering students in the computer engineering field.
Department(s): School of Engineering
Location(s): Guelph