

ENGINEERING (ENGG)

ENGG*1070 Occupational Health and Safety Fall Only (LEC: 2) [0.25]

This course presents the legal implications of occupational health and safety as expressed in the Environmental and Occupational Health and Safety Act, and exposes students to methodologies designed to ensure compliance with the Act. The course stresses safety initiatives and deals with specific safety issues such as noise levels, biosafety, hazardous waste management, safety in the workplace, radiation safety and industrial safety.

Restriction(s): Registration in the BENG or BENG:C Programs.

Department(s): School of Engineering

Location(s): Guelph

ENGG*1100 Engineering and Design I Fall Only (LEC: 2, LAB: 4) [0.75]

This course provides an introduction to engineering and design. An overview of design processes is covered and students experience a defined, open-ended design project. Physical design development is emphasized, supplemented by elements of analysis. Engineering communications emphasize the visual form and span engineering drawings across a spectrum of engineering disciplines (2D and 3D, realistic and symbolic). Sketching and computer aided tools are both developed. Written communications (individual and team) focus on design. The practice of professional engineering, ethical principles and the engineer's role and obligations in society are all introduced. The coursework is team-based to reflect the practice of engineering and the character of the School of Engineering.

Restriction(s): Registration in the BENG or BENG:C Programs.

Department(s): School of Engineering

Location(s): Guelph

ENGG*1210 Engineering Mechanics I Winter Only (LEC: 3, LAB: 2) [0.50]

This course presents the fundamental principles of Newtonian mechanics; distributed loading; free body diagrams; rigid body equilibrium; structural analysis; internal loading of structural members; friction; dynamics of particles; linear and angular momentum of rigid bodies; conservation of energy; principles of impulse and momentum, and plane motion of rigid bodies.

Prerequisite(s): MATH*1200, PHYS*1130

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*1410 Introductory Programming for Engineers Fall Only (LEC: 3, LAB: 3) [0.50]

This course is for students requiring an introduction and understanding of programming. The goal of this course is to introduce students to the basics of computer software and understand how to use it for problem solving. Topics include the structure of computers, developing and debugging software, data representation and manipulation, functions and program modularization, complex data types, pointers, strings, recursion, file I/O, and simple data structures. Students planning to take additional CIS courses require this course. Previous programming experience is recommended. Students lacking programming experience should consult with their program counsellor.

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG, ESC and Undeclared specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*1420 Object-Oriented Programming for Engineers Winter Only (LEC: 3, LAB: 3) [0.50]

This course introduces the Object Oriented (OO) approach to software from an engineering perspective. It culminates in a substantial team-based software development project. Topics include defining classes and objects, inheritance, overloading, polymorphism, data encapsulation, interfaces, files and streams, exception handling, dynamic memory, and namespaces.

Prerequisite(s): ENGG*1410

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*1500 Engineering Analysis Fall and Winter (LEC: 3, LAB: 1) [0.50]

This course deals with engineering applications of matrix algebra, vector spaces and computer techniques to solve linear systems. Topics include theory and applications of linear transformations, eigenvalues and eigenvectors, diagonalization, complex-variable algebra, and multi-variable functions.

Restriction(s): MATH*1160, MATH*2150, MATH*2160. This is a Priority Access Course. Enrolment may be restricted to students in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2010 Introduction to Biological Engineering Fall Only (LEC: 3, LAB: 1) [0.50]

This course deals with the basic concepts and fundamental principles of biological and biochemical engineering. Topics including dimensional analysis, reactive and non-reactive material balance, equilibrium, energy balance with applications in food and bioprocessing.

Prerequisite(s): CHEM*1040, (MATH*1090 or MATH*1210)

Restriction(s): ENGG*2660. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2100 Engineering and Design II Fall and Winter (LEC: 2, LAB: 4) [0.75]

This course is a progression in engineering design skills with particular emphasis on computer usage in design, oral communication of solutions and team skills. Computer usage in design will include advanced CAD/CAM/CAE tools; and database management software. An introduction to safety in engineering practice and design, and the concept of sustainable development are covered.

Prerequisite(s): Completion of 4.00 credits including ENGG*1100

Restriction(s): Registration in the BENG or BENG:C Programs.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2120 Material Science Fall and Winter (LEC: 3, LAB: 2) [0.50]

Study of the mechanical, electrical, magnetic, optical and thermal properties of solids. Atomic order and disorder in solids, single-phase metals, and multiphase materials (their equilibria and micro-structure) are examined as a basis for understanding the causes of material properties. Interwoven throughout the course is an introduction to materials selection and design considerations.

Prerequisite(s): PHYS*1130, (CHEM*1040 or CHEM*1140)

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits

Department(s): School of Engineering

Location(s): Guelph

ENGG*2130 Introduction to Environmental Engineering Fall Only (LEC: 1.5, LAB: 3) [0.50]

This course introduces the field of environmental engineering, including minimizing the negative effects of human activities, responsible resource use and recovery, and remediation of soil, water and air pollution.

Students will explore relevant ethical issues as well as regulations and policies in diverse areas of environmental engineering. Skills development integrated throughout the course elements will emphasize writing, teamwork, the collaborative nature of the field, engineering tools used in environmental engineering, and data management and analysis.

Prerequisite(s): 4.00 credits

Restriction(s): Registration in BENG.ENVE or BENG.ENVE:C.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2160 Engineering Mechanics II Fall Only (LEC: 3, LAB: 1) [0.50]

Fundamental principles of the mechanics of deformable materials; stress and strain; Mohr's circle for transformation of stress and strain; deflection under load; design of beams, shafts, columns and pressure vessels; failure theory and design.

Prerequisite(s): ENGG*1210, ENGG*1500, 0.50 credits in calculus

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BME and MECH specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2180 Introduction to Manufacturing Processes Winter Only (LEC: 3, LAB: 2) [0.50]

This course is designed to provide students with an overview of a wide variety of manufacturing processes involved in industrial activities. While most of the manufacturing processes are to be introduced during the course, more emphasis will be given on those processes which are more common in industry, namely material removal processes, casting, and forming. In addition to introducing the various manufacturing process, mathematical models and several empirical data and equations describing the various manufacturing processes will be covered in order to provide the students with a better understanding of the relations between the parameters involved.

Prerequisite(s): ENGG*2160

Co-requisite(s): ENGG*2120

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2230 Fluid Mechanics Fall and Winter (LEC: 3, LAB: 2) [0.50]

Analysis of steady ideal and viscous fluid flow systems using the Continuity, Bernoulli and Momentum equations. Boundary layer theory is treated in terms of viscous and pressure drag, lift and its importance in heat and mass transfer. Dimensional analysis and dynamic similitude are studied to provide an understanding of flow systems analysis and modeling. Introduction to pipe flow and open channel flow.

Prerequisite(s): ENGG*1210, MATH*1210

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2340 Kinematics and Dynamics Winter Only (LEC: 3, LAB: 2) [0.50]

The course will cover kinematic and dynamic analysis including graphical and analytical methods for kinematic analysis of space, mechanisms and elementary body motion in space, static and dynamic force analyses of mechanisms, gyroscopic forces, dynamics of reciprocating and rotating machinery, cam and gear mechanisms and specifications.

Prerequisite(s): ENGG*1210

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the MECH specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2400 Engineering Systems Analysis Fall Only (LEC: 3, LAB: 1) [0.50]

This course provides the foundational skills required to model and analyze elementary dynamic engineering systems. The course will focus on basic mechanical, electrical, thermal and hydraulic systems under the assumptions of linearity and time invariance. Students will learn to identify relevant elements and generate system models. System behaviours will be analyzed by solving for such responses as the impulse response, step response, and sinusoidal steady-state response using differential equations, Laplace transform methods, and computer-based methods. The relationship of such system parameters as time constant, degree of damping and resonance frequencies with the transient and steady-state responses will be examined. The complex valued system transfer function will be defined and analyzed.

Prerequisite(s): ENGG*1210, ENGG*1500, MATH*1200, MATH*1210, PHYS*1010

Co-requisite(s): MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2410 Digital Systems Design Using Descriptive Languages Fall Only (LEC: 3, LAB: 3) [0.50]

Review of Boolean algebra and truth tables, Karnaugh maps. Design, synthesis and realization of combinational circuits. Design, synthesis and realization of sequential circuits. VHDL: structural modeling, data flow modeling, synchronous & asynchronous behavior descriptions, algorithmic modeling. Designing with PLDs. Digital design with SM charts. Designing with PGAs and complex programmable logical devices. Hardware testing and design for testability. Hierarchy in large designs. The course will primarily be concerned with the design of multi-input, multi-output digital controllers which provide the central control signals that orchestrate the collection of hardware devices (from SSI to VLSI) found in a digital system. An introduction to FPGA-based, as well as microprocessor-based digital systems design will be given. Design examples will include systems such as UART, microcontroller CPU, ALU and data acquisition system.

Prerequisite(s): PHYS*1130, (1 of CIS*1300, CIS*1500, ENGG*1410)

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG and ESC specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2450 Electric Circuits Winter Only (LEC: 3, LAB: 2) [0.50]

This course explores the fundamentals of electric circuit analysis. Course topics include: lumped circuit abstraction; circuit elements and their characteristics; nodal and mesh analysis; linearity and superposition principles; fundamental circuit theorems; Thevenin and Norton equivalent circuits; introduction to the ideal operational amplifier and operational-amplifier circuits; dynamics of first and second order circuits including switched circuits; coupled inductors and transformers; alternate-current circuits and sinusoidal steady-state analysis with phasor methods.

Prerequisite(s): PHYS*1010

Co-requisite(s): MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2540 Water and Climate Justice Winter Only (LEC: 3) [0.50]

This course introduces culturally specific ways in which practices and technologies related to water have evolved and emphasizes climate and environmental justice. Global water challenges are examined to underscore the importance of clean and adequate water for healthy environments and communities. Steps towards addressing consequences of colonialism on the environment and Indigenous peoples in Canada will be discussed. The course will help students improve the effectiveness of their writing.

Prerequisite(s): 5.00 credits

Restriction(s): ENGG*2550. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2560 Environmental Engineering Systems Winter Only (LEC: 3, LAB: 2) [0.50]

Analysis techniques for natural and engineered systems including chemical, physical and biological processes. Mass balance analysis for steady state and unsteady state situations. Analysis under both equilibrium and non-equilibrium conditions. Reactor types including batch, plug-flow, CSTR. Noise pollution, control and prevention.

Prerequisite(s): CHEM*1050, MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*2910 Mathematics for Artificial Intelligence Fall Only (LEC: 3, LAB: 2) [0.50]

This course explores how mathematics and computation are unified for reasoning about data and making discoveries about the world. The emphasis is on fundamentals of mathematics required for AI and machine learning. Topics include computational methods for solving systems of linear equations including matrix decompositions, analytic geometry, solutions of nonlinear equations, functions of two or more variables, partial derivatives, and gradient-based optimization including second-order methods.

Prerequisite(s): ENGG*1410, ENGG*1500, MATH*1210

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3000 Engineering for Inclusion: Addressing Systemic Issues in Design and Engineering Winter Only (LEC: 3, LAB: 1) [0.50]

This course is designed for engineering students who are committed to challenging and dismantling systemic issues within their profession. By fostering critical thinking, reflective decision-making, and effective action, this course empowers students to become inclusive engineers who can drive meaningful social change. Throughout the course, students will engage in interactive discussions and collaborate with members of the local community who will provide valuable insights and lead discussions on specific issues in the design process and engineering field. The course covers a range of pertinent subjects, including racism, intersectionality, Indigenous issues, gender-based discrimination, and more.

Prerequisite(s): 11.00 credits

Restriction(s): Restricted to students in BENG

Department(s): School of Engineering

Location(s): Guelph

ENGG*3010 Introduction to Bioprocess Engineering Fall Only (LEC: 3, LAB: 2) [0.50]

This course deals with principles of Bioprocess Engineering. Topics including enzyme process kinetics, immobilized enzyme systems, metabolic pathways, stoichiometry of microbial growth, bioreactor scale-up, operation and control, batch and continuous bioreactor operations, product recovery and purification.

Prerequisite(s): BIOC*2580, CHEM*1050, ENGG*2010

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3020 Heat and Mass Transfer in Biological and Bioenvironmental Systems Fall Only (LEC: 3, LAB: 2) [0.50]

This course deals with the basic concepts and application of heat and mass transfer in biological and bioenvironmental systems. Heat transfer topics including steady and unsteady state heat transfer, convective and heat transfer with change of phase. Mass transfer topics include steady and unsteady state mass transfer, convective mass transfer, gas-liquid mass transfer, and membrane transport processes.

Prerequisite(s): ENGG*2010

Co-requisite(s): ENGG*3260

Restriction(s): ENGG*3160, ENGG*3430. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3040 Mechatronic Systems Design I Winter Only (LEC: 3, LAB: 3) [0.75]

This course introduces the design of mechatronics systems, which are synergistic, combinations of components and controls drawn from mechanical engineering, electronics, and computer engineering. Topics include micro-electromechanical systems, smart materials, modern actuators, and multi-agent mechatronic systems, and mechatronics for manufacturing.

Prerequisite(s): ENGG*2340, ENGG*2450, ENGG*3410

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3050 Embedded Reconfigurable Computing Systems Fall Only (LEC: 3, LAB: 2) [0.50]

This course introduces the students to the analysis, synthesis and design of embedded systems and the implementation of embedded systems using Field Programmable Gate Arrays. Topics include: review of digital design concepts; Programmable Logic Devices; Field Programmable Logic Devices; physical design automation (partitioning, placement and routing); Hardware Descriptive Languages; VHDL; Verilog; High Level Languages; System-C; Handle-C; Fixed Point and Floating Point Arithmetic; Hardware Accelerators; Reconfigurable Instruction Set Computers; Hardware Software Co-design techniques; Application of Field Programmable Logic in Embedded Systems.

Prerequisite(s): ENGG*2410, ENGG*3380

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3060 Machine Elements Winter Only (LEC: 3, LAB: 3) [0.50]

This course covers concepts, procedures, and analysis techniques necessary to design mechanical elements that are part of mechatronic devices. Structural design against static and fatigue is covered. Component design includes screws, fasteners, shafts, bearings, flexible couplings and gears. Selection of motors and motion control will also be covered.

Prerequisite(s): ENGG*2120, ENGG*2160, ENGG*2340, ENGG*2450

Restriction(s): ENGG*3280. This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3070 Integrated Manufacturing Systems Fall Only (LEC: 3, LAB: 2) [0.50]

Common production machines and manufacturing systems are dealt with, particularly automated systems, robotics, computer control and integration techniques, materials handling, inspection processes and process control. The course addresses societal and environmental issues related to manufacturing.

Prerequisite(s): ENGG*2120

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3080 Energy Resources and Technologies Fall Only (LEC: 3, LAB: 2) [0.50]

The challenges of changing the global energy system to reduce dependence on finite fossil energy sources, and transition to environmentally sustainable energy sources, are examined. The reserves, consumption, applications and environmental and human impacts of oil, coal and natural gas usage are examined. The fundamental principles, applications and status of a range of renewable energy sources and technologies will be covered to provide a solid background for further study of sustainable energy.

Co-requisite(s): ENGG*3260

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3090 Digital Systems and Microcontroller Interfacing Fall Only (LEC: 3, LAB: 2) [0.50]

This course focuses on the principles and techniques of modern digital systems and microcontroller interfacing. The course covers fundamental principles of combinational logic circuits, sequential logic circuits, integrated circuit logic families, arithmetic and MSI logic circuits, interfacing with the analog world including sensors and actuators, modern microcontroller basic architectures, instruction set architecture, and common interfacing microcontroller modules. The course introduces practical interfacing applications with microcontrollers, including serial and parallel interfacing and analog input/output interfacing.

Prerequisite(s): ENGG*1410, ENGG*2450

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3100 Engineering and Design III Winter Only (LEC: 2, LAB: 3) [0.75]

This course is the third in the sequence of engineering and design courses. Design teams (frequently crossing engineering disciplines) define a problem of modest complexity, with attention to the benefits and risks to users, the environment and society. Students learn and apply methods for idea generation, evaluation of design alternatives and refinement of solutions, which may include a preliminary simulation or software analysis. Technical writing emphasizes revision for clarity and cohesion. Students learn to develop evidence-based arguments and apply this to defend design solutions in terms of primary function, safety, economics, and environmental and societal risks and benefits. Team skills including leadership, interdisciplinary collaboration and conflict resolution are further developed. Project management, in the context of bringing together time, money and people, is practiced. Students reflect and receive feedback on their design process to foster growth in areas including lifelong learning, teamwork, project management and professional behaviour.

Prerequisite(s): Completion of 6.00 credits of ENGG courses including ENGG*2100

Restriction(s): Registration in the BENG program. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3120 Computer Aided Design and Manufacturing Winter Only (LEC: 3, LAB: 2) [0.75]

The course presents the elements of solid modelling, creation of parts of increasing complexity and the assembly of parts to form a final design, along with mechanism simulation. The operation and programming of CNC machines is covered.

Prerequisite(s): ENGG*2100, ENGG*3280

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3130 Modelling Complex Systems Winter Only (LEC: 3, LAB: 2) [0.50]

This course explores the application of systems thinking to complex global issues. Key topics will include: systems theory, complex adaptive systems, systems tools, and systems approaches. The course will emphasize the role of computational modelling and simulation as a central tool for applying systems thinking to real-world settings.

Prerequisite(s): ENGG*2400, STAT*2120, (1 of CIS*1300, CIS*1500, ENGG*1410)

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the ESC specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3140 Mechanical Vibration Fall Only (LEC: 3, LAB: 3) [0.50]

This course will provide students with an introduction to the fundamental concepts of vibration engineering using both single and multiple degrees of freedom concepts. The free and forced response of these systems will be covered. Emphasis will be placed on the design of vibration suppression and isolation of mechanical systems. Concepts of natural frequencies and mode shapes and their significance in the solution of multiple degrees of freedom problems will be covered. Vibration of rotating machinery, balancing, condition monitoring, and predictive vs. preventative maintenance philosophies will be introduced.

Prerequisite(s): ENGG*2340, MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3150 Engineering Biomechanics Fall Only (LEC: 3, LAB: 2) [0.50]

The following topics related to biomechanics are covered in this course: kinematic and kinetic analysis techniques; electromyography; current techniques in laboratory instrumentation and biomedical applications.

Prerequisite(s): 4.00 ENGG credits, including ENGG*1210

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3170 Biomaterials Winter Only (LEC: 3, LAB: 2) [0.50]

Physical properties of natural and synthetic (e.g. stainless steel, polymers) materials used in biological engineering applications are presented in this course. Topics will include microstructure and mechanical properties of typical biomaterials, quantification of advanced material properties and behaviours, fabrication, compatibility, biodegradation and mechanical failure. Typical applications will include processing of biomaterials as well as equipment and implant design.

Prerequisite(s): ENGG*2120

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BIOE and BME specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3180 Air Quality Fall Only (LEC: 3, LAB: 2) [0.50]

The study of the transport, transformation and deposition processes associated with air pollutants. The chemical and biological nature, impacts, and sources of air pollutants. The physical aspects of the atmospheric boundary layer. The mathematical treatment of diffusion in a homogeneous field in a boundary layer. Regulatory approaches worldwide and their use of air quality modeling. The use of models for the design of stacks and monitoring networks.

Prerequisite(s): ENGG*2230, (1 of ENGG*2010, ENGG*2560, ENGG*2660)

Co-requisite(s): ENGG*3260

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the ENVE specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3210 Communication Systems Winter Only (LEC: 3, LAB: 2) [0.50]

This course is an introduction to the fundamentals of data communication and computer networking. The data communication basics will cover signal transmission and signal encoding techniques such as: multiplexing techniques, signaling, encoding and decoding, error detection and recovery, sliding window techniques. Computer networking basics will cover: communication network components and topologies, multiple access design issues and performance analysis, switching, routing, services and applications, and security. The course will also cover the mathematical tools (Fourier transform, etc.) used in signal analysis.

Prerequisite(s): MATH*2130, STAT*2120

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3220 Groundwater Engineering Winter Only (LEC: 3, LAB: 2) [0.50]

This course introduces water resources engineering and environmental engineering students to the fundamentals of groundwater systems. Emphasis is placed on quantitative analyses required for groundwater resource extraction and quality protection of the saturated zone. Laboratories emphasize problem solving, use of commercial software and practical groundwater engineering investigation.

Prerequisite(s): ENGG*2230

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3240 Engineering Economics Summer and Fall (LEC: 3) [0.50]

This course covers the principles of project evaluation; analysis of capital and operating costs of engineering alternatives, benefit-cost ratio; break-even studies, evaluations recognizing risk, replacement and retirement of assets; tax considerations, influence of sources of funds.

Offering(s): Also offered through Distance Education format.

Prerequisite(s): 10.25 credits including, MATH*1210

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3250 Energy Management and Utilization Winter Only (LEC: 3, LAB: 2) [0.50]

This course introduces notions of energy conservation and efficiency, an integrated approach to energy auditing and examples of typical applications (examples include: steam generation and distribution, process or comfort cooling, pumping and compressed air, human needs for modern living, energy consumption in buildings and industry). It also covers pinch technology and its application for energy recovery in industry, and methods to achieve low energy buildings.

Co-requisite(s): ENGG*3430

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3260 Thermodynamics Fall Only (LEC: 3, LAB: 2) [0.50]

This course covers macroscopic thermodynamics and its applications to engineering practice. Topics include properties of pure substances and equilibrium, the First Law of thermodynamics (energy transfer and energy balance in closed and flow systems), the Second Law of thermodynamics and its applications (entropy analysis of closed and flow systems, quantification of irreversibilities and inefficiencies, quality of energy, etc.), thermodynamic cycles and exergy.

Prerequisite(s): ENGG*2230, ENGG*2400, MATH*2270, (CHEM*1040 or CHEM*1140)

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3270 Electromagnetics in Biomedical Engineering Fall Only (LEC: 3, LAB: 2) [0.50]

This course explores the fundamentals of electromagnetics in biomedical engineering. Course topics include the following: vectors and spatial geometry, partial derivatives, multiple integrals, vector calculus, electrostatics, steady-state electric circuits, magnetostatics, Ampere's Law, Faraday's Law, and propagation of electromagnetic waves. Applications within biomedical engineering will be covered, e.g., computerized tomography, electromagnetic radiation safety and physiological effects, magnetic sensitivity of brain and heart tissue, tissue electrical resistances, ophthalmology, and light-tissue interaction.

Prerequisite(s): ENGG*2450

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3280 Machine Design Fall Only (LEC: 3, LAB: 3) [0.75]

This course provides the concepts, procedures, and analysis techniques necessary to design various mechanical elements commonly found in machines. Failure analysis such as yield criteria and fatigue are covered. Component design includes screws, fasteners, shafts, bearings and lubrication, and gears. The emphasis is on the use of readily available materials, standard component, and appropriate design approaches to achieve safe and efficient system design.

Prerequisite(s): ENGG*2120, ENGG*2160, ENGG*2230, ENGG*2340, ENGG*2450

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3340 Geographic Information Systems in Environmental Engineering Fall Only (LEC: 3) [0.50]

Geographical information system structure and functions. Data structuring and application program development. Data input, display and analysis. Applications in environmental engineering and natural resource development/management. Students will be able to use a GIS software package to build geographical information systems.

Prerequisite(s): (1 of CIS*1300, CIS*1500, ENGG*1410), (MATH*1080 or MATH*1200)

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the WRE specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3370 Applied Fluids and Thermodynamics Winter Only (LEC: 3, LAB: 2) [0.50]

This course builds on the fundamentals of fluid dynamics and thermodynamics introduced in previous courses by looking at relevant applications. Topics to be covered include: heating, ventilation and air conditioning (HVAC); heat engine systems such as the Carnot cycle for refrigeration and heat pumps and the Rankine cycle for vapour power systems; compressible flow, turbomachinery such as pumps, turbines, and propellers; and an introduction to combustion.

Prerequisite(s): ENGG*2230, ENGG*3260

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the MECH specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3380 Computer Organization and Design Winter Only (LEC: 3, LAB: 2) [0.50]

This course contains a detailed examination of modern computer organization and techniques for microprocessor architecture design. Topics include - CPU design; instruction set design, addressing modes, operands; data flow design: internal bus structure, data flow signals, registers; control sequence design: hardwired control, decoding, microprogramming; architecture classes: CISC, RISC, and DSP; Memory organization; performance. Students must complete a term project that includes design, implementation, and demonstration of a CPU using a hardware descriptive language like VHDL.

Prerequisite(s): ENGG*2410

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3390 Signal Processing Fall Only (LEC: 3, LAB: 2) [0.50]

This course will establish the fundamental analysis and design techniques for signal processing systems. Topics covered include: definition and properties of linear time-invariant systems; impulse response and convolution; continuous-time Laplace transform, Fourier series, Fourier transform; discrete-time Fourier transform, discrete-time Fourier series, fast Fourier transform, Z transform; complex frequency response; filter analysis and design for both continuous and discrete time systems. Students will be able to design continuous-time filters and both design and implement discrete-time digital filters using computer-based tools.

Prerequisite(s): ENGG*2400

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BME, CENG and ESC specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3410 Systems and Control Theory Winter Only (LEC: 3, LAB: 2) [0.50]

This course introduces the theory and techniques required to analyze and design of closed loop, automatic controllers for engineering systems, with applications in electrical, mechanical, and biomedical systems. Topics include modeling in time and frequency domains (including linear time invariance, causality, and linearization); sketching and interpreting Bode plots; stability of closed loop systems (including analysis via Routh Hurwitz and Nyquist); performance metrics including gain and phase margin, sensitivity, and error tracking; and control using ON/OFF, PID, root locus, and frequency domain (lead/lag) techniques. Computer tools to aid in control design and analysis are a crucial component of the course. Optional advanced topics include but are not limited to state-space control, performance limitations, and control of non-linear systems.

Prerequisite(s): ENGG*2400, MATH*2270

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BME, CENG, ESC and MECH specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3430 Heat and Mass Transfer Winter Only (LEC: 3, LAB: 1) [0.50]

Analysis of steady and transient thermal systems involving heat transfer by conduction, convection and radiation and of mass transfer by molecular diffusion and convection. Other topics include the thermal analysis of heat exchangers and heat transfer systems involving a change of state.

Prerequisite(s): ENGG*2230, ENGG*3260, MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3440 Process Control Winter Only (LEC: 3, LAB: 2) [0.50]

Students will learn about dynamic process behaviour and process control strategies relevant to biological and environmental engineering, including how to analyze, model, predict and control processes in time and frequency domains. Performance and stability parameters will be illustrated with root locus diagrams. Control by on/off and proportional (and its advanced variants) controllers will be applied to feedback control problems including regulating physical and chemical properties, and biological and chemical reactions. This course includes experimental process control laboratory work and use of controller modeling software.

Prerequisite(s): ENGG*2400, MATH*2270

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BIOE and ENVE specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3450 Electronic Devices Fall Only (LEC: 3, LAB: 2) [0.50]

This course explores the theory and principles of modern electronic devices and their applications in circuits. Course topics include: intrinsic and doped semiconductors; drift and diffusion currents; metal-semiconductor contacts and MOS capacitors; pn junctions and breakdown phenomena; solid-state diodes; bipolar and MOS field-effect transistors; current-voltage characteristics and biasing; small-signal models and operation; circuit integration; analysis and design of application circuits, operational transconductance amplifiers, and logic gates.

Prerequisite(s): ENGG*2450

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BIOE, BME, CENG and ESC specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3470 Mass Transfer Operations Winter Only (LEC: 3, LAB: 2) [0.50]

Application of mass transfer principles in natural and engineered systems. Mass transport in the multi-media fate of contaminants in and between air, water and land. Design and analysis of separation processes for emission and pollutant prevention.

Prerequisite(s): ENGG*2230, ENGG*3260, MATH*2270

Co-requisite(s): ENGG*3430

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3490 Introduction to Mechatronic Systems Design Winter Only (LEC: 3, LAB: 2) [0.75]

This course covers the design of mechatronic systems, which are synergistic, combinations of components and controls drawn from mechanical engineering, electronics, and computer engineering. The course covers the following areas: (1) modeling of mechatronic systems (mechanical, electrical/electronic systems) and understanding their behaviour, (2) sensing and measurement including a variety of mechatronics sensors (fundamentals and applications), (3) actuators specific to mechatronics including motors and drivers (fundamentals and applications), (4) basic microcontroller programming as well as sensor/actuator integrations, and (5) control and its applications in mechatronics.

Prerequisite(s): ENGG*2340, ENGG*2450

Co-requisite(s): ENGG*3410

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3510 Electromechanical Devices Fall Only (LEC: 3, LAB: 3) [0.50]

The aim of this course is to develop an understanding of the electrical and electromechanical principles and their applications as devices used in engineering. The course covers magnetic fields of currents and coils; magnetic materials; magnetic circuits; induced, electric and magnetic fields (EMF), inductance, transformers magnetic forces, permanent magnets and electromagnets. The course examines the principles of variable-reluctance devices, stepper motors, moving-coil devices, direct current (DC) and alternating current (AC) motors. Semiconductors materials and devices, diodes, and transistors; principles of modern electronic devices and their applications in circuits; as well as operational amplifiers and digital logics are also studied.

Prerequisite(s): ENGG*2450, PHYS*1010

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3570 MEMS and Microfabrication Fall Only (LEC: 3, LAB: 2) [0.50]

This course presents a broad survey of micro-electro-mechanical systems (MEMS) and microfabrication technologies. It covers silicon and non-silicon microfabrication techniques for microsensors, microactuators, and nanotechnology. It introduces CAD tools and mechanical and electrical issues in designing devices such as micromotors, grippers, accelerometers, and pressure sensors. It discusses limitations and challenges in design and fabrication of MEMS and enables the application of general micromachining principles to developing novel devices.

Prerequisite(s): ENGG*2450, PHYS*1010

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3590 Water Quality Fall Only (LEC: 3, LAB: 3) [0.50]

This course builds on the student's experience in chemistry, biology, physics and fluid mechanics, and provides an engineering perspective on: (i) standard methods of water quality analysis for physical, chemical and biological characteristics of water; (ii) significance and interpretation of analytical results, (iii) modeling of water quality in natural systems and (iv) introduction to engineered water and wastewater treatment systems.

Prerequisite(s): ENGG*2230, STAT*2120, (BIOL*1090 or MICR*2420), (ENGG*2010 or ENGG*2560)

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the ENVE and WRE specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3600 Introduction to Thermal-Fluid Sciences Fall Only (LEC: 3, LAB: 3) [0.50]

This course provides an introduction to fluid and thermal systems. Students will identify the properties of solids and fluids, and solve problems involving elementary statics, kinematics, and dynamics of fluids, including internal and external flows. Students will also apply the laws of thermodynamics and analyse energy transfers in a variety of systems. Students will apply their knowledge of thermodynamic cycles and analyze steady and transient thermal systems involving heat transfer by conduction, convection and radiation in practical systems.

Prerequisite(s): CHEM*1140, ENGG*2400

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3640 Microcomputer Interfacing Fall Only (LEC: 3, LAB: 3) [0.50]

This course focuses on the subject of interfacing microcomputers to external equipment. Topics include peripheral devices, hardware interfaces, device driver software and real time programming. Advanced programming: debugging of embedded systems, data structures and subroutine calls, high-level system programming. Interrupts and resets, real time events, signal generation and timing measurements. Synchronous and asynchronous serial communication. Parallel I/O ports and synchronization techniques. I/O interfacing, microcomputer busses, memory interfacing and direct memory access (DMA). Data acquisition topics include signal conditioning analog to digital conversion and digital signal processing.

Prerequisite(s): ENGG*2410, ENGG*2450

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG and ESC specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3650 Hydrology and Hydraulics Fall Only (LEC: 3, LAB: 1) [0.50]

This course provides a quantitative study of natural water circulation systems with emphasis on basic physical principles and interrelationships among major hydrologic and hydraulic processes in watersheds. The characteristics of mass and energy and inputs to and outputs from watersheds are explored. Factors governing precipitation occurrence, evaporation and infiltration rates, groundwater recharge and discharge, runoff generation, methods of streamflow analysis and open channel flow in rivers and streams are considered. Hydrologic field measurements, mathematical modeling of watershed processes and the effects of climate change on precipitation inputs and other watershed processes, are included.

Prerequisite(s): ENGG*2230, (MATH*1210 or MATH*2080), (STAT*2120 or STAT*2040)

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3670 Soil Mechanics and Site Characterization Fall Only (LEC: 3, LAB: 2) [0.50]

This course focuses on the mechanics of soil materials applied to geotechnical engineering problems. It covers soil classification and the physical and chemical properties of soil that relate to its strength. It examines interactive forces in soil water systems and the role of groundwater in geotechnical engineering problems. Topics studied include: effective stress, consolidation, shear strength and lateral earth pressure. Theory is applied to geotechnical problems such as settlement and stability of earth slopes. Students will gain an understanding of approaches to site investigation and will perform testing in the field and laboratory to characterize soil properties. Students will have an opportunity to use software tools that support problem analysis and design.

Prerequisite(s): ENGG*2120, ENGG*2230

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*3700 Optimization for Engineers Fall Only (LEC: 3, LAB: 2) [0.50]

This course serves as an introduction to optimization. Topics to be covered include but are not limited to: linear programming, sensitivity analysis, linear integer programming technique, dynamic programming, Markov chains, transportation method, decision analysis, and queuing theory.

Prerequisite(s): MATH*2130, MATH*2270, (1 of CIS*1300, CIS*1500, ENGG*1410)

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4000 Proposal for Engineering Design IV Summer and Fall [0.00]

In this course students will prepare a proposal for the design project that will be completed in the Engineering Design IV course in their program of study. Teams normally of 3 to 4 students (single student groups not allowed) will prepare the proposal, providing details on the proposed project, identify the group's members and identify the faculty adviser, who has a P.Eng.. Students are responsible for creating their own design group and securing a faculty advisor.

Prerequisite(s): ENGG*3100

Restriction(s): Registration in the semester preceding registration in the capstone ENGG*41x0 Engineering Design IV course. Instructor consent required. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4010 Unit Operations Fall Only (LEC: 3, LAB: 2) [0.50]

This course deals with the concepts of unit operations in biochemical engineering. Analysis and design of separation processes including drying, humidification, adsorption, leaching, membrane separation and centrifugation will be discussed. Topics including fluid properties, flow and dynamics will also be covered.

Prerequisite(s): (ENGG*2230 or FOOD*2620), (1 of ENGG*3020, ENGG*3430, FOOD*3170)

Restriction(s): ENGG*3830. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4020 Engineering Sustainability in Food and Agriculture Fall Only (LEC: 3) [0.50]

This course deals with the process and practices associated with food production and processing globally and in Canada. An insight into the rapidly changing context of the food system, its achievements, vulnerabilities, and innovation for a sustainable food future will be provided. Students will work in groups to develop engineering-based solutions for improvement of the current and future food and agricultural practices.

Prerequisite(s): 10.00 credits

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4030 Manufacturing System Design Winter Only (LEC: 3, LAB: 3) [0.75]

Students work in groups to design a manufacturing system to produce a specific product. Choices must be made about the materials to be used, the methods to manufacture each part of the product and the final assembly and/or packaging process. Attention is paid to economics and efficiency of the overall manufacturing system.

Prerequisite(s): ENGG*2180, ENGG*3070

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4040 Medical Imaging Modalities Fall Only (LEC: 3, LAB: 2) [0.50]

The course will cover the basic knowledge of medical imaging systems, how they operate and to what uses they can be applied. Systems covered will include x-ray radiography, computed tomography, magnetic resonance imaging, positron emission tomography, gamma cameras, and ultrasound imaging. Emphasis will be on the underlying physics and computation, highlighting factors affecting image quality, patient safety, and clinical use.

Prerequisite(s): ENGG*3390 or PHYS*3130

Restriction(s): PHYS*4070. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4050 Quality Control Winter Only (LEC: 3, LAB: 2) [0.50]

The basic techniques and regulations surrounding quality control in a generic manufacturing environment are covered. The topics covered include: total quality management including relevant ISO regulations, six sigma, reliability, statistical process control, acceptance sampling and 2k factorial design of experiments.

Prerequisite(s): STAT*2040 or STAT*2120

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4060 Biomedical Signals Processing Winter Only (LEC: 3, LAB: 2) [0.50]

This course will cover the generation of biomedical signals, detection and measurement, and processing. The physiology of electrical signal generation will cover ionic transport in cellular membranes and propagation of electrical signals in cells and tissues. The range of biomedical signals covered includes such common signals as the electromyogram (EMG), the electrocardiogram (ECG), the electroencephalogram (EEG). Detection and measurement will cover electrode technology, instrumentation amplifiers and safety concerns. Processing includes filtering, frequency content analysis, removal of artifacts, signal correlation, and event detection.

Prerequisite(s): ENGG*3390

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4070 Life Cycle Assessment for Sustainable Design Winter Only (LEC: 3, LAB: 2) [0.50]

This course will introduce students to the fundamental concepts related to interaction of industrial and environmental/ecological systems, sustainability challenges facing the current generation, and systems-based approaches required to create sustainable solutions for society. Students will understand the concepts and the scientific method as it applies to a systems-based, transdisciplinary approach to sustainability, and will be prepared to identify problems in sustainability and formulate appropriate solutions based on scientific research, applied science, social and economic issues. The basic concepts of life cycle assessment (LCA) will be discussed, along with life cycle inventory (LCI) and life cycle impact assessment (LCIA) including the social and economic dimensions. The application of life cycle assessment methodology using appropriate case studies will be presented.

Prerequisite(s): ENGG*2100, ENGG*3240

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4080 Micro and Nano-Scale Electronics Fall Only (LEC: 3, LAB: 2) [0.50]

The purpose of this course is to describe the operating principles of analog integrated micro and nano electronic circuits and to teach how to design and use such circuits systems. Course topics include: device and circuit fabrication in silicon and non-silicon based technologies; operation and layout of active and passive elements; analog and switched-capacitor filters; analog-to-digital and digital-to-analog converters; amplifiers; oscillators and circuits for radio-frequency and optical communications; readout channels for integrated sensors, and analog integrated circuits for mechatronics and bioengineering. The main emphasis is on device models, circuit operation, and design techniques.

Prerequisite(s): ENGG*3450

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4090 Food and Beverage Engineering Winter Only (LEC: 3, LAB: 3) [0.75]

Students work in groups to design a system for manufacturing a specific food or beverage product. Choices are made about the specific processes to be used, the final packaging and marketing of the product. Attention is paid to the economics and efficiency of the overall production process.

Prerequisite(s): ENGG*3070, ENGG*3510, MICR*1020

Co-requisite(s): ENGG*2660, ENGG*4050, ENGG*4280

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4110 Biological Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Biological Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to a problem in a biological system or process. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.BIOE core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4110. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4120 Engineering Systems and Computing Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Engineering Systems and Computing program. Teams normally of 3-4 students apply engineering analysis and design principles to a problem involving control system, computer hardware or computer software technology. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.ESC core courses, ENGG*4000

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4120. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4130 Environmental Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Environmental Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to an environmental engineering problem. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.ENVE core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4130. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4150 Water Resources Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Water Resources Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to a problem involving water resources or wastewater engineering. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.WRE core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4150. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4160 Mechanical Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Mechanical Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to a mechanical engineering problem. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.MECH core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4160. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4170 Computer Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Computer Engineering program. Teams of normally 3-4 students apply engineering analysis and design principles to a computer engineering problem. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.CENG core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4170. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4180 Biomedical Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Biomedical Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to a biomedical engineering problem. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): All 1000 and 2000 level BENG.BME core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4180. Maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4190 Mechatronics Engineering Design IV Fall and Winter (LEC: 2, LAB: 6) [1.00]

This is the capstone design course for the Mechatronics Engineering program. Teams normally of 3-4 students apply engineering analysis and design principles to a mechatronics engineering problem. A completely specified solution at the level of preliminary or final design is required, including assessment of socio-economic and environmental impact. This is a small group design that requires reports and a poster presentation to a professional standard. Ethics and legal case studies relevant to professional engineering practice are presented during the lectures. Only students currently registered in ENGG*4000 will be permitted to select this course.

Prerequisite(s): 19.75 credits towards the BENG MTE major, all 1000 and 2000 level core courses, ENGG*4000.

Restriction(s): Registration in the BENG program. Restricted to students with a maximum of 3.75 credits remaining in their BENG degree, including ENGG*4190. A maximum semester credit load of 3.25 credits. Students must have a minimum cumulative average of 60% or higher in ALL ENGG courses. Restriction waiver requests are handled by the Director, School of Engineering, or designate.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4200 Wireless Sensor Networks Fall Only (LEC: 3, LAB: 2) [0.50]

This course focuses on the fundamentals behind the design of wireless sensor networks. Topics include node architecture, operating systems, prototypes and applications for wireless sensor networks. The course emphasizes basic architectural framework including physical layer, medium access control layer and network layer. It also covers network management topics such as power management, time synchronization and localization. The course has a number of experiments with sensor network software and hardware. The primary focus of the experiments is to give students hands-on programming experience with various microcontrollers and sensing platforms.

Prerequisite(s): ENGG*3640

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4210 Machine Learning Fall Only (LEC: 3) [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 a specific approach or software tool. The course will cover and compare current popular approaches and their applicability to various engineering problems, and will provide hands-on experience with some of the tools.

Prerequisite(s): ENGG*2910, STAT*2120

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4220 Interdisciplinary Mechanical Engineering Design Winter Only (LEC: 3, LAB: 3) [0.75]

This is a general design course for students registered in the B. Eng. major in mechanical engineering who wish to develop a broad based mechanical engineering foundation. Students work in groups to develop a general mechanical engineering design. Special attention is paid to the sustainability of the design, its economic feasibility and overall efficiency.

Prerequisite(s): ENGG*3100

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4230 Energy Conversion Fall Only (LEC: 3, LAB: 3) [0.75]

The course introduces the technical criteria for the design of efficient energy conversion processes and systems. It includes the review of boilers and cycles, fuel and combustion calculations, and fundamentals of both traditional and emerging energy conversion processes and systems for production of thermal, mechanical, and electrical energy. Topics include fossil, biomass and nuclear fuels, as well as wind, solar, geothermal energy and fuel cells. Mechanisms for storing energy generated from each of these are also studied. The course also explores conversion of automobile systems, renovation of old fossil fuel fired plant technology, co-firing of opportunity fuels, waste to energy technology, emissions, and economics of energy projects.

Prerequisite(s): ENGG*3260

Co-requisite(s): ENGG*3080

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4240 Site Remediation Fall Only (LEC: 3, LAB: 1) [0.50]

Remediation of contaminated sites is done to mitigate impacts to the environment and public health. The course will: review the applicable legislation; identify the important soil, water, air and chemical interactions; review the steps of an environmental risk assessment so that contaminated sites can be identified and evaluated to see if remediation is required; and evaluate and appraise various remediation technologies to complete the soil and groundwater remediation.

Co-requisite(s): ENGG*3590, ENGG*3670

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4250 Watershed Systems Design Winter Only (LEC: 3, LAB: 2) [0.75]

This course is a hydrological analysis of watershed systems including stream flow for design of structures and channels, flood warning, flood plain mapping and low-flow characteristics. Hydraulic analysis is applied to the design of dams, reservoirs, control structures, energy dissipation structures, bridges and culverts. An analysis of steady flow profiles, flood waves, and sediment transport is applied in the design of natural and constructed channels and protective works for rivers to achieve environmentally sustainable land use in watershed systems.

Prerequisite(s): ENGG*2230, ENGG*3650

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the WRE specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4300 Food Processing Engineering Design Winter Only (LEC: 3, LAB: 2) [0.50]

This course covers the design of various food processing operations and the physico-chemical and mechano-biological response of foods to such operations. Topics include: process evaluation; optimization of operations such as thermal and chemical processes; and rheological properties of various food forms.

Prerequisite(s): 1 of ENGG*3020, ENGG*3430, FOOD*3170

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4340 Solid and Hazardous Waste Management Fall Only (LEC: 3, LAB: 2) [0.50]

Solid waste generation rates and waste composition. Integrated waste management: collection, recovery, reuse, recycling, energy-from-waste, and landfilling. Biological treatment of the organic waste fraction - direct land application, composting, anaerobic digestion. Environmental impact of waste management and sustainable development. Cross media issues related to solid waste disposal. An introduction to hazardous waste management and treatment methods.

Prerequisite(s): 1 of ENGG*2010, ENGG*2560, ENGG*2660

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the ENVE specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4360 Soil-Water Conservation Systems Design Fall Only (LEC: 3, LAB: 2) [0.75]

Properties of soils and land use governing the occurrence and magnitude of overland flow, soil erosion, infiltration, percolation of soil water, and variations in soil water storage. Design of soil and water management systems and structures to control soil erosion and protect water quality for environmentally and economically sustainable land use planning. Design of surface and subsurface drainage systems for rural land. Design of sprinkler and trickle irrigation systems.

Prerequisite(s): ENGG*2230, ENGG*3650, ENGG*3670

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4370 Urban Water Systems Design Fall Only (LEC: 3, LAB: 2) [0.75]

Estimation of water quantity and quality needed for urban water supply and drainage. Design of water supply, pumping systems, pipe networks and distributed storage reservoirs from analysis of steady and transient, pressurized and free surface flow. Rates of generation of flows and pollutants to sanitary and storm sewers, design of buried pipe and open channel drainage systems with structures for flow and pollution control. Modeling of water systems for sustainable urban development.

Prerequisite(s): ENGG*2230, ENGG*3650

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4380 Bioreactor Design Fall Only (LEC: 3, LAB: 2) [0.75]

Topics in this course include: modeling and design of batch and continuous bioreactors based on biological growth kinetics and mass balances; gas-liquid mass transfer for aeration and agitation; instrumentation; and control.

Prerequisite(s): ENGG*3160 or (ENGG*3010, ENGG*4010)

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BIOE specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4390 Bio-instrumentation Design Fall Only (LEC: 3, LAB: 2) [0.75]

Theory and selection criteria of devices used in measurements in biological systems; design of complete measurement systems including transducers, signal conditioning and recording components; error analysis. Differences between measurements in biological and physical systems.

Prerequisite(s): ENGG*3450

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the BIOE and BME specializations in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4400 Biomechanical Engineering Design Winter Only (LEC: 3, LAB: 2) [0.75]

This course covers concept development, design, modeling, manufacture and testing of biomechanical devices including athletic equipment, assistive devices, medical implants and tools. Other topics include the biomechanical factors influencing design, regulatory issues, current development trends, and the possible future direction of design and technology.

Prerequisite(s): 6.00 ENGG credits including ENGG*3150

Co-requisite(s): ENGG*3170

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4420 Real-time Systems Design Fall Only (LEC: 3, LAB: 3) [0.75]

This course teaches real-time concepts from a system and computing perspective covering topics related to four major areas. Real-time computer control and system modeling area teaches basic real-time design and system modeling concepts for hard and soft real-time computer control applications. Real-time Operating Systems (RTOS) area introduces common kernel objects and inter-task communication and synchronization using examples from current commercial RTOS. Topics in the area of scheduling present theoretical results related to uniprocessor and multiprocessor scheduling algorithms and topics in the area of fault tolerance and reliability present current techniques at software and hardware level.

Prerequisite(s): ENGG*2400, ENGG*3640

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4430 Neuro-Fuzzy and Soft Computing Systems Winter Only (LEC: 3) [0.50]

This course covers the basics of fuzzy systems, neural networks and neuro-fuzzy systems. The main focus is the concepts and algorithms of fuzzy sets, rules, and reasoning, as well as neural network structures, supervised learning and unsupervised learning of neural networks, and hybrid neuro-fuzzy systems. The applications of neural networks and fuzzy systems to control systems, signal processing, systems modeling and systems identification will be presented through examples.

Prerequisite(s): ENGG*3410

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4440 Computational Fluid Dynamics Winter Only (LEC: 3, LAB: 2) [0.50]

Computational methods for fluid mechanics form the core of the course. The concepts of modelling are covered including numerical analysis, the governing equations for fluid problems and finite discretization methods. Mathematical models for turbulence are presented and the student is exposed to the use of commercial software for the solution of complex problems in fluid dynamics.

Prerequisite(s): ENGG*2230, ENGG*3370

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4450 Large-Scale Software Architecture Engineering Fall Only (LEC: 3, LAB: 2) [0.50]

This course introduces the students to the analysis, synthesis and design of large-scale software systems at the architectural level. This is in contrast to the algorithmic and data structure viewpoint of most software systems. Large-scale software systems are complex, execute on many processors, under different operating systems, use a particular or many language(s) of implementation, and typically rely on system layers, network connectivity, messaging and data management and hardware interfacing. The material covered includes architectural styles, case studies, architectural design techniques, formal models, specifications and architectural design tools. The laboratory sessions will expose the students to analyzing and redesigning an existing large-scale software system.

Prerequisite(s): (CIS*2420 or CIS*2520), ENGG*2100

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4460 Robotic Systems Fall Only (LEC: 3, LAB: 3) [0.50]

This course covers robot technology fundamentals, mathematical representation of kinematics, planning and execution of robot trajectories, introduction to robot languages, programming of robotic systems, different application domains for robots (e.g. assembly, manufacturing, medical, services, etc.), and robot sensors. The goal of this course is to provide students with a comprehensive background, approaches and skills to apply robotics technology to real world engineering applications and problems.

Prerequisite(s): ENGG*1500, ENGG*2400

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4470 Finite Element Analysis Fall Only (LEC: 3, LAB: 2) [0.50]

The theory of finite element analysis is presented including element derivation and solution procedures. Students use a finite element package to solve problems based on static and dynamic applications in mechanical systems. Examples are chosen from classical machines as well as biological systems.

Prerequisite(s): ENGG*2160, MATH*2130, MATH*2270

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4480 Advanced Mechatronic Systems Design Winter Only (LEC: 3, LAB: 3) [0.75]

The course is a follow up to the introductory mechatronics course and aims at covering advanced topics that are necessary in developing mechatronic systems. Topics include: signal conditioning and filtering for mechatronics system including advanced filters such as Kalman filters; important/advanced electronic circuits for mechatronics systems; microcontroller interfacing and programming; design and development of motion control for mechatronics systems including PLC; introduction of integrated complex mechatronics systems: concept, structure, and applications. Through a design project, students will use and apply these concepts in building a complex mechatronics system with advanced features.

Prerequisite(s): ENGG*3490

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4490 Sampled Data Control Design Winter Only (LEC: 3, LAB: 2) [0.75]

This course introduces the theory and techniques required to analyze, design, and implement sampled data controllers on real, continuous time systems. Topics include sampling, system identification and modeling, delay, state-space and frequency domain approaches to control, emulation methods, and direct z-domain methods. In the course project, students will apply the techniques discussed in class to design and implement a computer based controller for a real physical system, then compare the actual results obtained to the expected theoretical results and discuss sources of error and limitations of their approach.

Prerequisite(s): ENGG*3390, ENGG*3410

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the ESC specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4510 Assessment and Management of Risk Winter Only (LEC: 3, LAB: 1) [0.50]

This course will develop the bases by which risk to human health and the environment can be assessed. Issues of hazardous waste cleanups, permitting of water and air discharges, food safety, flood protection, as examples, are addressed. The course also examines how decisions are made to manage the risks to acceptable levels.

Prerequisite(s): STAT*2040 or STAT*2120

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4540 Advanced Computer Architecture Winter Only (LEC: 3, LAB: 2) [0.50]

This course covers topics such as: basics of pipeline structure, advanced pipelining and instruction level parallelism, multiprocessor and thread-level parallelism, memory-hierarchy design (main memory, virtual memory, caches), storage systems, interconnection networks, multiprocessor architectures (centralized and distributed). Advanced topics related to new emerging computer architectures will also be presented. The emphasis in each topic is on fundamental limitations and the trade-offs involved in designing computer systems, including memory and processing bandwidth, network bandwidth and latency, synchronization, and storage system bandwidth and latency.

Prerequisite(s): ENGG*3380

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4550 VLSI Digital Design Winter Only (LEC: 3, LAB: 2) [0.50]

This course introduces the students to the analysis, synthesis and design of Very Large Scale integration (VLSI) digital circuits and implementing them in silicon. The topics of this course are presented at three levels of design abstraction. At device level: MOS diode; MOS (FET) transistor; interconnect wire. At circuit level: CMOS inverter; static CMOS gates (NAND, NOR); dynamic gates (NAND, NOR); static latches and registers; dynamic latches and registers; pipelining principles and circuit styles; BICMOS logic circuits. At system level; implementation strategies for digital ICs; interconnect at system level; timing issues in digital circuits (clock structures); the adder; the multiplier; the shifter; memory design and array structure; low power design circuits and architectures.

Prerequisite(s): ENGG*2410, ENGG*2450, ENGG*3450

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to the CENG specialization in the BENG and BENG:C programs. See department for more information. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4560 Embedded System Design Winter Only (LEC: 3, LAB: 3) [0.75]

This course introduces the basic principles of embedded system design. It utilizes advanced hardware/software abstractions to help design complex systems. Topics include: design of embedded CUPs; embedded architecture cores; system-on-chip designs and integration using processor cores and dedicated core modules; embedded computing platforms; embedded programming design and analysis; processes and operating systems; networks for embedded systems; distributed embedded architectures; design examples that target robotics, automobile, and communication systems.

Prerequisite(s): ENGG*3380 or ENGG*3640

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4580 Sustainable Energy Systems Design Winter Only (LEC: 3, LAB: 3) [0.75]

The analysis and design of sustainable energy systems are presented in this course. Techniques considered include generation of alternative designs to satisfy a problem definition; evaluation of alternative designs; application of modeling simulations and cost analyses.

Prerequisite(s): ENGG*3080, ENGG*3370, ENGG*3430

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4590 Sensors Instrumentation and Measurements Fall Only (LEC: 3, LAB: 3) [0.50]

This course explores the fundamentals of sensing and instrumentation technology, including measurements, mechanisms, and principles of instrumentation with applications to electrical and mechanical systems. The course will discuss transducers, signal conditioning, data acquisition systems and will include examples of measurement of physical quantities such as temperature, force, torque, position, speed, acceleration, pressure, humidity, flow and liquid level.

Prerequisite(s): ENGG*2450, STAT*2120

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4660 Medical Image Processing Winter Only (LEC: 3, LAB: 2) [0.50]

This course covers the fundamentals of medical image processing. Image processing topics covered include: fundamentals of resolution and quantization; linear systems as applied to multi-dimensional continuous and discrete systems; point operations such as contrast enhancement and histogram equalization; geometric operations for distortion correction, including interpolation methods; linear filtering in both the spatial and spatial-frequency domains; and image restoration and inverse filtering. Image segmentation is covered in the framework of pattern recognition using single and multiple dimensional features, and includes the fundamental Bayes classifier as well as machine learning methods for both supervised and unsupervised learning.

Prerequisite(s): ENGG*3390

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4680 Multidisciplinary Engineering Design Winter Only (LEC: 2, LAB: 4) [0.75]

This is a general design course for students registered in the B. Eng. major in Biomedical Engineering and who do not wish to develop a strong specialization in one of the specific areas of the program. Students work in groups to develop a general Biomedical engineering design. Special attention is paid to the sustainability of the design, its economic feasibility and overall efficiency.

Prerequisite(s): ENGG*3100

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4690 Mechatronic Systems Design II Winter Only (LEC: 3, LAB: 3) [0.75]

This course covers advanced topics in the design of mechatronics systems. The course is based on a case studies approach. These include design of microelectromechanical accelerometers, micro positioning systems, and smart material based electrical actuators.

Prerequisite(s): ENGG*3040

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4740 Computational Methods for Data Analysis Fall Only (LEC: 5) [0.50]

This survey course introduces proven, stable computational methods for data analysis of large datasets in engineering. Algorithms to wrangle and analyze engineering data (time history, field variables), images, and motion will be introduced. Algorithms will be implemented in a computing environment and a case study in engineering data analysis will be carried out.

Prerequisite(s): ENGG*2910, MATH*2130, STAT*2120

Restriction(s): This is a Priority Access Course. Enrolment may be restricted to students in the BENG.MTE and BENG.MTE:C programs. Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4760 Biological Wastewater Treatment Design Winter Only (LEC: 3, LAB: 2) [0.50]

The course applies design principles for a variety of biological treatment systems for both municipal and industrial wastewater. This involves the design of suspended growth and attached growth processes, anaerobic digestion, sludge processing and utilization, water reuse and resource recovery facilities.

Prerequisite(s): ENGG*3590

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4770 Physical and Chemical Water and Wastewater Treatment Design Fall Only (LEC: 3, LAB: 2) [0.50]

This course focuses on the theory, application, and design principles of physical and chemical operations and processes for the treatment of water and wastewater. This involves the design of physical and chemical unit operations, and evaluating the optimum combination to satisfy the given design constraints and criteria. The optimum designs integrate engineering science, basic science, economics, and health and safety for workers and the public.

Prerequisite(s): ENGG*3590

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4810 Control of Atmospheric Particulates Fall Only (LEC: 3, LAB: 2) [0.50]

The focus of this course is understanding, analyzing and designing conventional and innovative atmospheric particulate control systems. The properties and transport of atmospheric particulates, and the principles of cyclones, filtration and electrostatic precipitation will be taught through theory, simulations, experiments and a design project.

Prerequisite(s): 6.00 credits of ENGG courses, ENGG*2230, MATH*2130, (ENGG*2450 or PHYS*1010)

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph

ENGG*4820 Atmospheric Emission Control: Combustion Systems Winter Only (LEC: 3, LAB: 2) [0.50]

Combustion systems are an essential part of our society, however, they are also the dominant source of atmospheric pollutants. This course will focus on investigation of combustion systems for the purpose of reducing atmospheric emissions.

Prerequisite(s): ENGG*2560, ENGG*3260

Co-requisite(s): ENGG*3430

Restriction(s): Non-BENG students may take a maximum of 4.00 ENGG credits.

Department(s): School of Engineering

Location(s): Guelph