

Undergraduate Courses

Anthropology

Course Code	Course Title	Course Description
ANTH 330	Cultural Ecology	An examination of the relationships among environment, technology, society, and culture. The increasing levels of complexity will be considered in the context of hunting and foraging bands, horticultural tribes and chiefdoms, pastoral tribes and agricultural peasantry.
ANTH 321	Archaeology of Complex Cultures	Cultural development from the agricultural revolution to the rise of literacy. Special attention to the development of agriculture as a means of subsistence and to the rise of early civilization. Areas and periods of emphasis will vary from year to year.

Arts

Course Code	Course Title	Course Description
ARTS 304	Designing Computer Simulations and Games for Learning	This is a project-based course in which interdisciplinary student teams will design and prototype a computer simulation or game for learning using a 3-dimensional game engine. Projects will address real world educational challenges proposed by clients including University of Waterloo faculty or staff members.

Biology

Course Code	Course Title	Course Description
BIOL 488	Ecotoxicology and Watershed Management	The course will explore the scientific principles affecting the ecological structure and function of watersheds as well as emerging threats to environmental quality. The course will explore the scientific principles affecting the ecological structure and function of watersheds as well as emerging threats to environmental quality. Case studies, with an emphasis on Canadian and local examples, will be used to more fully understand scientific principles and explore the impacts of

		natural and human activities on the ecology of drainage basins.
BIOL 350	Ecosystem Ecology	This course provides an overview of the dynamic interactions among microbes, plants, animals and their physical environment with emphasis on ecosystem structure and function. Topics include the hydrological cycle, biogeochemical cycling, ecological energetics, roles of population and community interactions, paleoecology and current topics in ecosystem science.

Combinatorics and Optimization

Course Code	Course Title	Course Description
CO 456	Introduction to Game Theory	A broad introduction to game theory and its applications to the modeling of competition and cooperation in business, economics and society. Two-person games in strategic form and Nash equilibria. Extensive form games, including multi-stage games. Coalition games and the core. Bayesian games, mechanism design and auctions.
CO 450	Combinatorial Optimization	Characterizations of optimal solutions and efficient algorithms for optimization problems over discrete structures. Topics include network flows, optimal matchings, T-joins and postman tours, matroid optimization.

Computer Science

Course Code	Course Title	Course Description
CS 466	Algorithm Design and Analysis	<p>This course continues the discussion of algorithms started in CS 341. Whereas CS 341 focuses on worst-case behaviour of deterministic algorithms, in this course students are exposed to algorithmic approaches and methods for assessment that reflect a broad spectrum of criteria.</p> <p>The particular problems and algorithms studied will be chosen by the instructor from application areas such as computational geometry, algebraic algorithms, distributed and parallel algorithms,</p>

		machine learning, and other areas of active research.
CS 462	Formal Languages and Parsing	Building on CS 360, this course discusses more advanced topics in formal languages and automata theory, with applications to compiler writing. In particular, several practical parsing methods are discussed.
CS 436	Networks and Distributed Computer Systems	An introduction to networks, protocols, and distributed systems. Layered models, resource management, naming, addressing and routing, reliable communication, security, and higher-level services.
CS 371	Introduction to Computational Mathematics	A rigorous introduction to the field of computational mathematics. The focus is on the interplay between continuous models and their solution via discrete processes. Topics include: pitfalls in computation, solution of linear systems, interpolation, discrete Fourier transforms and numerical integration. Applications are used as motivation.
CS 360	Introduction to the Theory of Computing	Models of computers including finite automata and Turing machines. Basics of formal languages with applications to the syntax of programming languages. Alternate characterizations of language classes. Proving unrecognizability. Unsolvability problems and their relevance to the semantics of programming.

Digital Arts Communication

Course Code	Course Title	Course Description
DAC 304	Designing Computer Simulations and Games for Learning	This is a project-based course in which interdisciplinary student teams will design and prototype a computer simulation or game for learning using a 3-dimensional game engine. Projects will address real world educational challenges proposed by clients including University of Waterloo faculty or staff members.

Earth Sciences

Course Code	Course Title	Course Description
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EARTH 458L	Field Methods in Hydrogeology	This course exposes students to a wide variety of field and laboratory techniques for collecting hydrogeologic data and to gain experience in interpreting the data. Advantages and limitations of various measurement and data reduction techniques are discussed along with the practical question of how much data is enough. Case studies will be presented to illustrate the complexity of natural systems and the need for good data collection and interpretation skills when characterizing contaminated sites
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Economics

Course Code	Course Title	Course Description
ECON 405	Topics in Financial Econometrics	This course is one of the topic courses in Econometrics. The course will focus on both the Econometric theory and applications in Economics and Finance. Topics may include several main components, such as regression theory (linear/non-linear regression models, multivariate regressions), estimation methodology (OLS, MLE, GMM, WLS/GLS, Monte Carlo simulations), and time series analysis/financial modelling (stochastic process, general ARMA process, autoregressive conditional heteroskedasticity model, stochastic volatility model, high frequency data analysis, nonstationarity for time series and co-integration, continuous time stochastic process).

Electrical and Computer Engineering

Course Code	Course Title	Course Description
ECE 457A	Cooperative and Adaptive Algorithms	The course starts by addressing the ill-structured problems and need for computational intelligence methods. It introduces the concepts of heuristics and their use in conjunction with search methods, solving problems using heuristics and metaheuristics, constraints satisfaction. The course also introduces the concepts of cooperation and adaptations and how they are influencing new methods for solving complex problems. The course starts by illustrating how the

		<p>concepts of cooperation and adaptation are manifested in nature and how such models are inspiring new types of solutions methods. Topics to be covered include: search algorithms, game playing, constraints satisfaction, meta-heuristics, evolutionary computing methods, swarm intelligence, ant-colony algorithms, particle swarm methods, adaptive and learning algorithms and the use of these algorithms in solving continuous and discrete problems that arise in engineering applications.</p>
ECE 457B	Fundamentals of Computational Intelligence	<p>Introduces novel approaches for computational intelligence based techniques including: knowledge based reasoning, expert systems, fuzzy inferencing and connectionist modeling based on artificial neural networks. The focus is on the use of soft computing approaches to deal effectively with real world complex systems for which their mathematical or physical models are either non-tractable or are difficult to obtain. The main thrust is on designing computationally intelligent systems with human like capabilities in terms of reasoning, learning and adaptation. Tools of computational intelligence could be used in a wide range of engineering applications involving real world problems such as in: planning problems, intelligent control, autonomous robotics, speech understanding, pattern analysis, network design, face recognition, communication systems to name a few</p>

English

Course Code	Course Title	Course Description
ENGL 392B	Visual Rhetoric	<p>This course introduces students to the study of images from a rhetorical perspective, including the interaction of texts and images in such professional writing fields as advertising, book illustration, technical documentation, journalism, and public relations. Issues may include visual and textual literacy, the semiotics and rhetoric of design, and the ideological basis of social communication.</p>

Environment and Resource Studies

Course Code	Course Title	Course Description
ERS 372	First Nations and the Environment	ERS 372 will take a holistic approach to the topic area of First Nations and the environment. First Nation environmental issues are often complex and require a holistic approach where the lines between different disciplines (e.g., natural, physical, health, and social sciences) are often obscured. The environment as defined in this course includes the natural (biological) and built (social, cultural, political) settings. Case studies will be used to illustrate significant issues. This course is intended as a general introduction to the area of First Nations and the environment.

Geography and Environmental Management

Course Code	Course Title	Course Description
GEOG 461	Food Systems and Sustainability	This course examines dimensions of food systems sustainability and food security, from production to consumption, from local to global scales, in the Global North and South. Specific themes covered in the course include technological and genetic change in food production, resource depletion and wider environmental impacts of the industrial food system, and policy, market-oriented, and civil society initiatives to bring about change in the food system, including organic production and localizing food systems.
GEOG 459	Energy and Sustainability	Renewable and non-renewable energy supply systems are compared using economic and environmental measures. Consumption trends and conservation options are considered at the local and global level. Projects are used to demonstrate the economic and environmental challenges in the design of a sustainable energy system.
GEOG 450	Changing Form and Structure of Metropolitan Canada	Selected analysis of processes, problems and planning issues associated with the internal growth and spatial reorganization of Canadian metropolitan areas. Three or four topics are chosen for detailed investigation.

GEOG 432	Health, Environment, and Planning	A seminar course on the environmental sources and causes of disease and illness, the concepts of health, e.g. medical, scientific, economic, political, etc., the health services and facilities and related technologies and the role and responsibilities of (urban and regional) planners in the creation of a more healthful environment.
GEOG 349	Urban Form and Internal Spatial Structure	An examination of the major factors giving rise to distinctive styles of urban spatial organization. Focus moves from city-wide scale to subareas/sectors - inner city, housing, retailing, etc. Emphasis on understanding and planning for the dynamics of complex environments. Applied issues or problems are dealt with throughout the course.

Gerontology

Course Code	Course Title	Course Description
GERON 400	Multidisciplinary Seminar on Aging	Faculty and students from various departments meet to discuss individual and population aging from a multidisciplinary perspective. Topics include the definition of aging, the demography of aging, evolutionary and genetic factors, aging as a social process, and human aging patterns.

Health Studies

Course Code	Course Title	Course Description
HLTH 452	Decision Making and Decision Support in Health Informatics	One of the major aims of health informatics is to help health professionals make better decisions. To this end, diverse models and methods of decision making and decision support have been developed and implemented in health care settings. This course reviews theories, methods, and technologies for aiding the process of making decisions in health care.
HLTH 333	Experimental Methods and Observational Methods in Epidemiology	Health research addresses a broad range of problems, leading to the use of a diverse range of research strategies and methodologies. This course is offered concurrently with HLTH 344 and will focus on experimental, quasi-experimental and analytical observational (cohort, case control,

		cross-sectional) research designs. The aim of this course is to provide a basic understanding of each of these study designs, including their strengths and weaknesses, threats to validity, and appropriate statistical methods.
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Human Sciences

Course Code	Course Title	Course Description
HUMSC 201	Great Dialogues: Reason and Faith	What is the nature of, and relationship between, reason and faith? Does this fundamental distinction lead to other distinctions such as those between explanation and revelation, the rational and the intuitive? What impact do such modes of thought have on notions such as providence, perception and truth? What comparisons and contrasts can be drawn between each mode and prevailing modern perspectives? This course investigates how a dialogue with core texts (e.g., Boethius, Aquinas, Dante, Bacon, Milton, Descartes, Hume, Austen) offers ways of understanding these issues.
HUMSC 102	Great Dialogues: Politics and Morality	What is the relationship between politics and morality? Are they opposites? Can they be integrated? This course investigates the way our own dialogue with core texts from the Renaissance to the present (authors may include Machiavelli, Shakespeare, Wollstonecraft, Marx, Conrad, and Arendt) offers ways of thinking through the dilemmas and issues raised by these texts and present in our culture.

International Development

Course Code	Course Title	Course Description
INDEV 308	Introduction to Social Entrepreneurship	This course uses the case study method to examine the challenges of starting, funding and operating an early-stage social change venture in a developing country. The focus is on ventures that address urbanization and poverty. Students explore the complexities of managing and sustaining growth, the role of governing boards, and the role of private sector partnerships and

		resources. Innovative public/private partnerships are examined. The challenges and opportunities associated with engaging diverse partners with differing agendas are considered from the perspective of the entrepreneur, investor/donor, local community leaders and legal counsel.
INDEV 200	The Political Economy of Development	This course develops students' understanding of how the complex interplay of international economic and political economy factors influence development initiatives and outcomes. The relation of trade, aid, and international institutions (WTO, IMF, World Bank) on development activity is examined using case studies. Different economic views will be examined.

Management Sciences

Course Code	Course Title	Course Description
MSCI 333	Simulation Analysis and Design	This course introduces the use of discrete event simulation as an approach for understanding and analyzing complex management systems. Topics include an introduction to simulation modeling, general purpose and special purpose simulation languages, designing valid and credible simulation models, input data analysis, output analysis and experimental design.
MSCI 240	Algorithms and Data Structures	Design and analysis of data structures and algorithms. Mathematical and conceptual analysis of algorithms for set operations, sorting, graphs, and priority queues. Comparison of algorithms on different data structures. Algorithmic and data structural solutions to common engineering problems in computer science. Mathematical analysis of space and time complexity as well as other forms of computational complexity in algorithms.

Mechanical Engineering

Course Code	Course Title	Course Description
ME 566	Computational Fluid Dynamics for Engineering Design	A course to develop the understanding required to simulate complex fluid flows, such as those found in turbo-machines, duct systems, and other

		engineering hardware. Course topics include: the physics of complex viscous fluid flows, first- and second-order finite control volume discretization methods, iterative algorithms for the solution of sparse matrix equation sets, including multi-grid acceleration, boundary condition modelling, two-equation and Reynolds stress turbulence models, and grid generation techniques. Computational fluid dynamics software is used throughout the course to simulate and analyse complex fluid flows relevant to engineering applications.
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Mechatronics Engineering

Course Code	Course Title	Course Description
MTE 203	Advanced Calculus	Review of Vectors and Vector Operations; 3-D Analytic Geometry and Space Curves; Multivariable Calculus, including Partial Differentiation, Total Differential, Chain Rule, Directional Derivative, Gradient Operator, Maxima and Minima; Multiple Integrals - Surface Area, Volume and Moments of Inertia; Line and Surface Integrals; Vector Theorems; Complex Analysis including Limits, Analytic Functions, Complex Line Integral, Cauchy's Integral Formula; Fourier Series (real and complex) and Fourier Integrals.

Nanotechnology Engineering

Course Code	Course Title	Course Description
NE 336	Micro and Nanosystem Computer-aided Design	Modeling and simulation. Lumped versus distributed approaches. Review of differential-equation systems, constitutive relations, boundary conditions, and solvers for complex, coupled transport problems pertinent to micro and nanosystems. Coupling strategies. Numerical schemes for nonlinear systems. Basic modeling and simulation of micro and nanosystems, and fluidic systems. Relevant nanotechnology applications: optical, thermal, mechanical, and fluidic microstructures, and nanoscale devices.
NE 232	Quantum Mechanics	Historical background; the differential equation approach to quantum mechanics; treatments of

		solvable problems such as the particle-in-a-box, harmonic oscillator, rigid rotor, and the hydrogen atom; introduction to approximation methods for more complex systems; application to solid state problems, including band theory.
NE 113	Engineering Computation	Introduction to digital computers, hardware and software organization. Programming fundamentals. Algorithms and control structures. Computer communication. Spreadsheets for problem solving, plotting, fitting data, building new functions, and making iterations and loops. Problem solution, plotting, and creating complex programs in an engineering prototyping programming environment. Elementary numerical methods (e.g., Taylor-series summations, roots of equations, roots of polynomials, systems of linear and nonlinear algebraic equations, integration). Applications in nanotechnology engineering.
NE 112	Linear Algebra with Numerical Applications	Matrices, operations on matrices. Determinants. Adjoins and inverses. Solution of linear equations: elimination and iterative methods. Eigenvalues and eigenvectors with engineering applications. Numerical methods. Complex numbers.

Physics

Course Code	Course Title	Course Description
PHYS 467	Introduction to Quantum Information Processing	Basics of computational complexity; basics of quantum information; quantum phenomena; quantum circuits and universality; relationship between quantum and classical complexity classes; simple quantum algorithms; quantum Fourier transform; Shor factoring algorithm; Grover search algorithm; physical realization of quantum computation; error-correction and fault-tolerance; quantum key distribution.
PHYS 365	Mathematical Physics 2	Complex variables, Cauchy-Riemann conditions, Cauchy integral formula, Taylor and Laurent expansions, residue theorem, contour integrals and applications. Fourier and Laplace transforms with applications. Introduction to probability and statistics.

Planning

Course Code	Course Title	Course Description
PLAN 349	Urban Form and Internal Spatial Structure	An examination of the major factors giving rise to distinctive styles of urban spatial organization. Focus moves from city-wide scale to subareas/sectors - inner city, housing, retailing, etc. Emphasis on understanding and planning for the dynamics of complex environments. Applied issues or problems are dealt with throughout the course.

Political Science

Course Code	Course Title	Course Description
PSCI 485	Selected Topics in International Political Economy	Contemporary perspectives and issues in international political economy, with particular attention to advanced industrial countries. Topics include political/economic cooperation, the politics of trade, and the politics of adjustment.
PSCI 482	Critical Security Studies	This course reviews critical analytical models for the study of security and covers a range of issues which might be considered non-traditional including environmental security, public safety, cyber security, and counter-terrorism.
PSCI 458	Cultural Explanations of Politics	Critical assessments of selected explanations of political authority, political organization, political conflict and political violence in terms of cultural values.
PSCI 455	Comparative Political Economy	Focusing especially on advanced industrialized countries, this course surveys the key topics in political economy including the influence of politics on social and economic policies in relation to welfare states, labour markets, training, corporate governance and technological innovation. The course also explores the social and economic consequences of politics such as poverty, inequality, growth and decline.
PSCI 389	Global Governance	Global governance is governing beyond the state. An examination of diverse problems - global warming, international human rights, terrorism, property rights disputes, and health crises - which transcend borders and demand cooperative global

		solutions.
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Psychology

Course Code	Course Title	Course Description
PSYCH 392	Research in Human Cognitive Neuroscience	Students will learn how to measure psychophysiological responses to the stimuli in our world (e.g., familiar faces, emotional scenes, video games, etc.). Students will get hands-on training in acquiring and analyzing different types of psychophysiological data such as Galvanic Skin Response, Heart Rate, Heart Rate Variability, and pupil dilation.
PSYCH 321	Conceptual Development	Everyday we use concepts that refer to abstract entities like idea, software, number, or DNA. These entities cannot be perceived directly with our bare senses. How then do we acquire concepts for them? Must they be innate? Or do we start off having only perception as babies and then build up concepts through a complex learning process? Do all cultures have these concepts or do they depend on formal education? Must we have language to acquire them? This course provides an overview of both classic and hot-off-the-presses experimental work designed to answer these questions.

Science

Course Code	Course Title	Course Description
SCI 201	Global Warming and Climate Change	This course will survey a broad spectrum of topics relating to global climate change, with an emphasis on the scientific approaches to address this issue. Topics covered will include natural and anthropogenic causes of climate change, monitoring methods, current and low emission alternatives of energy production. The scientific, economic, public and political aspects of implementation of carbon capture and storage technology and other geo-engineering options to mitigate climate change will also be discussed.

Software Engineering

Course Code	Course Title	Course Description
SE 380	Introduction to Feedback Control	Introduction to control systems. Advantages of closed-loop feedback systems. The role of the system mathematical model. Block diagrams and signal flow graphs. The basic control system design problem, stability in control systems. Frequency response analysis techniques. Root-locus analysis. Elementary lead-lag compensation.

Statistics

Course Code	Course Title	Course Description
STAT 340	Computer Simulation of Complex Systems	Building and validation of stochastic simulation models useful in computing, operations research, engineering and science. Related design and estimation problems. Variance reduction. The implementation and the analysis of the results.

Systems Design Engineering

Course Code	Course Title	Course Description
SYDE 372	Introduction to Pattern Recognition	Pattern recognition as a process of data analysis. Pattern features as components in a random vector representation. Classification techniques: distance measures in feature space, probabilistic (Bayesian) decision theory, linear discriminants. Clustering and feature extraction. Applications: optical character recognition, speech recognition, industrial robot vision, medical diagnosis, remote sensing and satellite image analysis, fault detection and diagnosis in complex systems such as nuclear reactors.
SYDE 332	Societal and Environmental Systems	The interactions of human society with its physical environment are complex and multifaceted. The course will use a systems engineering perspective to investigate pressing large-scale interconnected problems such as global warming, energy shortages, water dead zones, desertification, food crises, overpopulation, poverty and economic

		instability. The course seeks to combine mathematical tools for complex and nonlinear systems; aspects of atmospheric, oceanographic, and ecological science; methods of observation and inference based on remote sensing; and associated societal issues of informed decision making, stakeholder fairness, and decision support systems.
SYDE 252	Linear Systems and Signals	Models and analysis of linear systems. Discrete time systems, continuous time systems; difference and differential equations; impulse and frequency response. Complex frequency, functions of complex variables, transform domain techniques: Z transforms; Fourier analysis, Laplace transform. Transfer functions and frequency response, frequency domain analysis of linear systems; sampling theory, stability, and linear filters.
SYDE 113	Matrices and Linear Systems	Geometry and algebra: root-finding, vectors, coordinate systems, lines and planes, conic sections, complex numbers. Introduction to numerical computation. Floating point arithmetic, accuracy and sources of error. Matrix algebra, inverses. Analytical and numerical techniques for systems of linear equations.