Computer Science (COMP)

Computer Science (COMP) Courses

Notes:

1. Some of the following Computer Science courses are cross-listed from other parts of the Calendar. In every such case, only one course is actually offered and the two numbers are alternate identifiers for this single course. Students in the B.C.S. program should register in such a course under the Computer Science (COMP) number.

COMP 1001 [0.5 credit]
Introduction to Computational Thinking for Arts and Social Science Students
An introduction to computational thinking and its applications to the arts and social sciences. Students will gain computational thinking skills by exploring data representation, basic programming concepts, a selection of algorithms, and advanced usage of software packages for the arts and social sciences.
Precludes additional credit for COMP 1004 (no longer offered). This course cannot be taken for credit by students in Business, Engineering, Computer Science, Mathematics or Science.
Lectures three hours a week.

COMP 1005 [0.5 credit]
Introduction to Computer Science I
Introduction to computer science and programming. Topics include: algorithm design; control structures; variables and types; linear collections; functions; debugging and testing. Special attention is given to procedural programming in a modern language, computational thinking skills, and problem decomposition.
Includes: Experiential Learning Activity
Also listed as COMP 1405.
Precludes additional credit for BIT 1400, CGSC 1005, ECOR 1031, ECOR 1041, ECOR 1042, ECOR 1051, ECOR 1606, ITEC 1400, ITEC 1401, SYSC 1005.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1006 [0.5 credit]
Introduction to Computer Science II
A second course in programming emphasizing problem solving and computational thinking in an object-oriented language. Topics include abstraction, mutable data structures, methods, inheritance, polymorphism, recursion, program efficiency, testing and debugging.
Includes: Experiential Learning Activity
Also listed as COMP 1406.
Precludes additional credit for BIT 2400, BUSI 2402, ITEC 2400, ITEC 2401, SYSC 2004.
Prerequisite(s): COMP 1005 or COMP 1405.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1008 [0.5 credit]
Math for Game Programmers
Math for building 3D games. Points, vectors, normals. Dot and cross products. Transformations and inverses in left- and right-handed systems. Uses for controlling objects, cameras, and texture manipulation. Bounding boxes, planes, frustums for collision detection and visibility, fast billboarding techniques, point and sphere sweeping. Quaternions.
Prerequisite(s): one Grade 12 university preparation mathematics course.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1405 [0.5 credit]
Introduction to Computer Science I
Introduction to computer science and programming, for computer science students. Topics include: algorithm design; control structures; variables and types; linear collections; functions; debugging and testing. Special attention is given to procedural programming in a modern language, computational thinking skills, and problem decomposition.
Includes: Experiential Learning Activity
Also listed as COMP 1005.
Precludes additional credit for BIT 1400, CGSC 1005, ECOR 1031, ECOR 1041, ECOR 1042, ECOR 1051, ECOR 1606, ITEC 1400, ITEC 1401, SYSC 1005.
Prerequisite(s): restricted to students registered in the B.C.S. program, B.Cyber. program, B.D.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1406 [0.5 credit]
Introduction to Computer Science II
A second course in programming for BCS students, emphasizing problem solving and computational thinking in an object-oriented language. Topics include abstraction, mutable data structures, methods, inheritance, polymorphism, recursion, program efficiency, testing and debugging.
Includes: Experiential Learning Activity
Also listed as COMP 1006.
Precludes additional credit for BIT 2400, BUSI 2402, ITEC 2400, ITEC 2401, SYSC 2004.
Prerequisite(s): COMP 1005 or COMP 1405. Restricted to students registered in the B.C.S. program, B.Cyber. program, B.D.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1501 [0.5 credit]
Introduction to Computer Game Design
Introduction to game design and prototyping. Topics include: formal theories of fun; the mechanics-dynamics-aesthetics framework; game economies; game balance; statistical tools for analyzing game mechanics; game settings; and storytelling. Special attention is given to the attributes of games and what makes a game fun.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1005 or COMP 1405.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 1601 [0.5 credit]
Introduction to Mobile Application Development
Introduction to developing mobile applications using the Mac OS X platform. Topics include: the Objective-C programming language; development tools; framework API's; and the Quartz graphic system. Extensive practical experience with development for Apple mobile devices such as the iPhone.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1005 or COMP 1405.
Lecture/lab four hours a week.

COMP 1805 [0.5 credit]
Discrete Structures I
Introduction to discrete mathematics and discrete structures. Topics include: propositional logic, predicate calculus, set theory, complexity of algorithms, mathematical reasoning and proof techniques, recurrences, induction, finite automata and graph theory. Material is illustrated through examples from computing.
Includes: Experiential Learning Activity
Precludes additional credit for MATH 1800.
Prerequisite(s): one Grade 12 university preparation mathematics course.
Lectures three hours a week, tutorial one hour a week.

COMP 1910 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. This course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): Permission of the School and registration in internship option.

COMP 1911 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. The course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1910 and registration in internship option.

COMP 2008 [0.5 credit]
User Interaction Design and Prototyping
Introduction to the principles of interaction design, including the human-centred design process, creative ideation, requirements gathering, prototyping, ethical considerations in design, rapid usability evaluation, and iterative design in a variety of user interaction paradigms.
Includes: Experiential Learning Activity
Precludes additional credit for IMD 3004.
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 2108 [0.5 credit]
Applied Cryptography and Authentication
Practical aspects of cryptography. Topics include: stream and block ciphers; modes of operation; hash functions; message and user authentication; authenticated key establishment protocols; random number generation; entropy; proof of knowledge; secret sharing; key distribution; pitfalls deploying public-key encryption and digital signatures.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 3109 (no longer offered), COMP 4109 (no longer offered), CSEC 2108.
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-, and COMP 2804.
Lectures three hours a week.

COMP 2109 [0.5 credit]
Introduction to Security and Privacy
A tour of Internet security and privacy. Societal impacts and case studies. Topics from: protection goals of stakeholders; history of public key cryptography; programming languages and security; security engineering and testing; cybercrime and malware; Internet privacy and anonymity; government surveillance; regulation; ethics; blockchain applications.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-, and COMP 2401 with a minimum grade of C-.
Lectures three hours a week.

COMP 2401 [0.5 credit]
Introduction to Systems Programming
Introduction to system-level programming with fundamental OS concepts, procedures, primitive data types, user-defined types. Topics may include process management, memory management, process coordination and synchronization, inter-process communication, file systems, networking, pointers, heap and stack memory management, and system/library calls.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 1006, SYSC 2006.
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 2402 [0.5 credit]
Abstract Data Types and Algorithms
Introduction to the design and implementation of abstract data types and to complexity analysis of data structures. Topics include: stacks, queues, lists, trees and graphs. Special attention is given to abstraction, interface specification and hierarchical design using an object-oriented programming language.
Precludes additional credit for SYSC 2100.
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-.
Lectures three hours a week.

COMP 2404 [0.5 credit]
Introduction to Software Engineering
Introduction to object-oriented software development, with emphasis on the design and implementation of maintainable, reusable software. Topics include abstraction, modularity, encapsulation, and an introduction to design patterns.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3010, SYSC 3110.
Prerequisite(s): COMP 2401 with a minimum grade of C-.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 2406 [0.5 credit]
Fundamentals of Web Applications
Introduction to Internet application development; emphasis on computer science fundamentals of technologies underlying web applications. Topics include: scripting and functional languages, language-based virtual machines, database query languages, remote procedure calls over the Internet, and performance and security concerns in modern distributed applications.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4504.
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 2501 [0.5 credit]
Computer Game Design and Development
Introduction to the practical development of computer games and engine architecture. Topics include: vector and matrix operations; coordinate systems and transformations; physical simulation; collision detection; AI; path planning; hardware-accelerated real-time rendering. Special attention is given to implementation of real-time rendering in a low-level language.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2401 with a minimum grade of C-, and (MATH 1104 or MATH 1107).
Lectures three hours a week, tutorial one and a half hours a week.

COMP 2601 [0.5 credit]
Mobile Applications
Development of applications for mobile environments taking advantage of gesture-based input and using location and presence services. Topics include introduction to low-level network services and mobile platforms, description of architectural patterns, principles of mobile development and interaction styles for network service usage.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1601.
Lecture/lab four hours a week.

COMP 2801 [0.5 credit]
Introduction to Robotics
A course on programming simulated mobile robots with various sensors such as wheel encoders, distance sensors, cameras, compasses, accelerometers, and laser range finders. Topics include: programming robot behaviour; performing position estimation; implementing algorithms related to navigation, mapping, path planning, area coverage, and localization.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 1807 (no longer offered).
Prerequisite(s): (COMP 1006 or COMP 1406) with a minimum grade of C-.
Lecture/lab four hours a week.

COMP 2804 [0.5 credit]
Discrete Structures II
A second course in discrete mathematics and discrete structures. Topics include: counting, sequences and sums, discrete probability, basic statistics, recurrence relations, randomized algorithms. Material is illustrated through examples from computing.
Prerequisite(s): COMP 1805 with a minimum grade of C-, or permission of the School of Computer Science for those in Combined Honours in Computer Science and Mathematics.
Lectures three hours a week.

COMP 2910 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. The course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1911 and registration in internship option.

COMP 2911 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. The course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2910 and registration in internship option.

COMP 3000 [0.5 credit]
Operating Systems
Operating system implementation course stressing fundamental issues in design and how they relate to modern computer architectures. Assignments involve the modification and extension of a multitasking operating system.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4001.
Prerequisite(s): COMP 2401 with a minimum grade of C- and COMP 2402.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 3002 [0.5 credit]
Compiler Construction
The structure, organization and design of the phases of a compiler are considered: lexical translators, syntactical translators, scope handlers, type checkers, code generators and optimizers. Components of a compiler will be implemented.
Prerequisite(s): COMP 2402.
Lectures three hours a week.

COMP 3004 [0.5 credit]
Object-Oriented Software Engineering
Development of object-oriented software systems: theory and practice. Topics include: Computer ethics, software development processes, requirement specification, class and scenario modeling, state modeling, UML, design patterns, traceability. Students are to complete a team project.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3020, SYSC 3120, SYSC 4120.
Prerequisite(s): COMP 2401 with a minimum grade of C-, (COMP 2404 or SYSC 3010 or SYSC 3110) with a minimum grade of C-, and (COMP 2406 or SYSC 4504).
Lectures three hours a week.

COMP 3005 [0.5 credit]
Database Management Systems
Introduces students to concepts of database management systems, database design and file structures. Topics include: entity-relationship modeling and object oriented database design, data models (relational, network and object oriented), the relational algebra, SQL, normalization theory, physical data organization, object oriented databases and OQL.
Precludes additional credit for BUSI 3400.
Prerequisite(s): COMP 1805 with a minimum grade of C-, and either COMP 2402 or (SYSC 2004 and SYSC 2100).
Lectures three hours a week.

COMP 3007 [0.5 credit]
Programming Paradigms
An introduction to alternative programming paradigms such as functional, constraint-based, concurrent, and logic programming.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3101.
Prerequisite(s): COMP 1805 with a minimum grade of C-, COMP 2401 with a minimum grade of C-, COMP 2402, (COMP 2404 or SYSC 3010 or SYSC 3110) and (COMP 2406 or SYSC 4504).
Lectures and tutorials three to four and a half hours a week.

COMP 3008 [0.5 credit]
Software Structures for User Interfaces
Concepts and principles related to building user interfaces, and applications in implementing interfaces in "front-end" programming contexts. Topics may include: reactive programming, input and output factors, application interfaces and infrastructure, typical patterns used to implement them, and organization and management of these aspects within software.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4130.
Prerequisite(s): (COMP 2404 or SYSC 3010 or SYSC 3110) and (COMP 2406 or SYSC 4504).
Lectures three hours a week.

COMP 3009 [0.5 credit]
Computer Graphics
An overview of computer graphics covering rendering, modeling, and animation. Topics include geometric primitives and modeling; image formation algorithms such as ray tracing and the Z-buffer; lighting, shading, and texture; and introduction to physics-based animation and character animation.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2401 with a minimum grade of C-, COMP 2402, MATH 1007, and (MATH 1104 or MATH 1107).
Lectures/lab four hours a week.

COMP 3105 [0.5 credit]
Introduction to Machine Learning
An introduction to methods for automated learning of relationships on the basis of empirical data. Includes topics in supervised and unsupervised machine learning and deeper knowledge of specific algorithms and their applications. Evaluation and quantification of performance of ML systems. Discussion of data ethics.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4105 (no longer offered), SYSC 4415.
Prerequisite(s): COMP 2402 and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2804 and (MATH 1104 or MATH 1107).
Lectures three hours a week.

COMP 3106 [0.5 credit]
Introduction to Artificial Intelligence
Principles and tools used in Artificial Intelligence. Fundamentals of Knowledge Representation and Reinforcement Learning and Nature-Based computing. Methods for non-adversarial problem solving including non-exhaustive and heuristic-based strategies for searching the state space. Methods for adversarial problem solving, modeled as two-person and multi-person games.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4106 (no longer offered), SYSC 4416.
Prerequisite(s): COMP 2402 and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2804.
Lectures three hours a week.

COMP 3203 [0.5 credit]
Principles of Computer Networks
This is an introductory course to the field of Network Computing. Topics include: Protocol Architectures and Internetworking, Types of Networks, Communication Protocols, End-System and Network Traffic Management, Structure of Routing and Congestion Control.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3512, SYSC 4602.
Prerequisite(s): COMP 2401 with a minimum grade of C-, and COMP 2402.
Lectures and tutorials three to four and a half hours a week.

COMP 3301 [0.5 credit]
Technical Writing for Computer Science
Technical communication for computer science majors, concentrating on writing scientific papers and technical reports. Principles of clarity and precision in writing and communication. Practical exercises and readings from recent technical publications will be used.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2402 and (COMP 2404 or SYSC 3010 or SYSC 3110).
Lectures three hours a week.

COMP 3308 [0.5 credit]
Bioinformatics
This practical interdisciplinary course will provide a broad overview of bioinformatics in which computer science and mathematics are applied to solve problems in molecular biology. Topics include gene prediction, sequence alignment, phylogeny, molecular interactions, macromolecular structure prediction and biological databases.
Includes: Experiential Learning Activity
Also listed as BIOL 3008.
Precludes additional credit for BIOC 3008 (no longer offered).
Prerequisite(s): BIOC 2200 or BIOL 2200, or BIOL 2201, or permission of the Biochemistry Institute.
Lecture two hours a week, computer workshop three hours a week.

COMP 3400 [0.5 credit]
Computational Logic and Automated Reasoning
Applications of formal logic in computer science. Symbolic logics such as classical predicate calculus are used to represent domain knowledge, to model computational problems and to solve them by means of automated reasoners. Applications include artificial intelligence, software engineering, data management and hardware verification.
Prerequisite(s): COMP 2804.
Lectures three hours a week.

COMP 3501 [0.5 credit]
Foundations of Game Programming and Computer Graphics
The theory and practice of 3D graphics for computer games. Topics include: vectors and quaternions; hierarchical transformations; camera and perspective; hardware-accelerated real-time rendering; texture and texture mapping; illumination; and particle systems. Additional topics may include rigid-body motion, character animation, shadows, and screen-space special effects.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2402 and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2501.
Lectures three hours a week.

COMP 3801 [0.5 credit]
Algorithms for Modern Data Sets
Algorithm design techniques for modern data sets arising in, for example, data mining, web analytics, epidemic spreads, search engines and social networks. Topics may include: data mining, hashing, streaming, clustering, recommendation systems, link analysis, dimensionality reduction, online, social networking, game theoretic and probabilistic algorithms.
Prerequisite(s): COMP 2804 with a minimum grade of B+.
Lecture three hours a week.

COMP 3803 [0.5 credit]
Introduction to Theory of Computation
Theoretical aspects of computer science. Topics include: formal languages and automata theory, computability theory.
Precludes additional credit for COMP 2805 (no longer offered).
Prerequisite(s): COMP 2804.
Lectures three hours a week.

COMP 3804 [0.5 credit]
Design and Analysis of Algorithms I
An introduction to the design and analysis of algorithms. Topics include: divide-and-conquer, dynamic programming, linear programming, greedy algorithms, graph algorithms, NP-completeness.
Also listed as MATH 3804.
Prerequisite(s): COMP 2402 and one of (COMP 2804 or MATH 3855 or MATH 3825 or COMP 3805).
Lectures and tutorials three to four and a half hours a week.

COMP 3805 [0.5 credit]
Discrete Structures and Applications (Honours)
Enumeration: inclusion and exclusion, recurrence relations, generating functions and applications. Graph theory: connectivity, planarity, Hamilton paths and Euler trails. Error-correcting codes. Designs and finite geometries. Symmetry and counting.
Also listed as MATH 3855.
Precludes additional credit for MATH 3805 (no longer offered) and MATH 3825.
Prerequisite(s): MATH 2100 or a grade of B or higher in MATH 2108 or MATH 3101.
Lectures three hours a week and one hour tutorial.

COMP 3807 [0.5 credit]
Mathematical Software
Implementation of numerical methods using numerical software packages. Development of scientific and/or operations research applications using application programming interfaces of numerical or optimization libraries. Functional programming for data analysis and machine learning. Experience working with Python, C++, or Java is essential.
Includes: Experiential Learning Activity
Also listed as MATH 3807.
Prerequisite(s): A grade of C- or higher in MATH 3806.

COMP 3910 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. The course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2911 and registration in internship option.

COMP 3911 [0.5 credit]
Internship
The internship exposes students to industrial software development via placement in a local enterprise. The course may only be taken by students participating in one of the School's industrial partnerships and can only be used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3910 and registration in internship option.

COMP 3999 [0.0 credit]
Co-operative Work Term
Includes: Experiential Learning Activity

COMP 4000 [0.5 credit]
Distributed Operating Systems
An advanced course on the software infrastructure supporting large-scale cloud computing applications. Topics may include: distributed file systems, distributed databases, overlay networks, container orchestration, coordination services, security and privacy services, and large-scale AI pipelines.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 3000 or SYSC 4001) and (COMP 3203 or SYSC 4602).
Also offered at the graduate level, with different requirements, as COMP 5102, for which additional credit is precluded.
Lectures three hours a week.

COMP 4001 [0.5 credit]
Distributed Computing
Overview of distributed computing. Topics include: computational models, communication complexity, design and analysis of distributed algorithms and protocols, fault-tolerant protocols, synchronous computations. Applications may include: communication in data networks, control in distributed system (e.g., election, distributed mutual exclusion), manipulation of distributed data (e.g., ranking).
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1805 with a minimum grade of C-, COMP 2401 with a minimum grade of C-, and (COMP 2406 or SYSC 4504).
Lectures three hours a week.

COMP 4002 [0.5 credit]
Real-Time 3D Game Engines
The design and implementation of game engines for real-time 3D games including topics such as camera control, environmental effects, articulated models, terrain, vegetation, collision detection, particles, emitters, triggers, portals, waypoints, mirrors, and shadows.
Prerequisite(s): COMP 2404 or SYSC 3010 or SYSC 3110.
Lectures three hours a week.

COMP 4003 [0.5 credit]
Transaction Processing Systems
Concepts and architectures of transaction processing systems and on-line transaction processing, with emphasis on data integration systems. Transaction properties and models, embedded-SQL, active rules, consistency maintenance, serializability, concurrency control, recovery, data integration systems and federated databases, introduction to transactions in web services and workflow systems.
Prerequisite(s): (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 3005.
Lectures three hours a week.

COMP 4004 [0.5 credit]
Software Quality Assurance
Introduction to the theory and practice of Software Quality Assurance. Topics include: equivalence partitioning, test-driven testing, unit testing patterns, refactoring, software metrics, requirements engineering, scenario modeling and acceptance testing, model-based testing, state machine testing, software testing theory and tools.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4101.
Prerequisite(s): COMP 3004.
Lectures three hours a week.

COMP 4008 [0.5 credit]
Evaluation and Research Methods for Human-Computer Interaction
Fundamental Human-Computer Interaction (HCI) research and evaluation methods. Topics may include: HCI research methodologies, research ethics, expert evaluation, user studies, qualitative and quantitative data collection, statistical data analysis, information visualization, and specifying practical implications of findings.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2008, COMP 3008, and STAT 2509 with a minimum grade of C- in each.
Also offered at the graduate level, with different requirements, as HCIN 5403, for which additional credit is precluded.
Lectures three hours a week, tutorial one and a half hours a week.

COMP 4009 [0.5 credit]
Programming for Clusters and Multi-Core Processors
Introduction to parallel architectures, programming languages and algorithms for processor clusters and multi-core processors. Distributed memory architectures, cluster computing, message passing parallel programming, multi-core processors, shared memory parallel programming, use of thread libraries, parallel performance analysis.
Prerequisite(s): COMP 2402 and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2804.
Lectures three hours a week.

COMP 4010 [0.5 credit]
Introduction to Reinforcement Learning
Learn about designing and programming reinforcement learning agents to perform complex tasks in interactive environments. Topics include Markov decision processes, dynamic programming methods, Monte Carlo methods, temporal difference learning, prediction/control with function approximation, policy gradient, and deep reinforcement learning algorithms.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 2402, (COMP 2404 or SYSC 3010 or SYSC 3110), MATH 1007 and (MATH 1104 or MATH 1107), STAT 2507.
Lectures three hours a week.

COMP 4102 [0.5 credit]
Computer Vision
The basic ideas and techniques of computer vision. The central theme is reconstructing 3D models from 2D images. Topics include: image formation, image feature extraction, camera models, camera calibration, structure from motion, stereo, recognition, augmented reality, image searching.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 2404 or SYSC 3010 or SYSC 3110) and (MATH 1104 or MATH 1107).
Lectures three hours a week.

COMP 4107 [0.5 credit]
Neural Networks
An introduction to neural networks and deep learning. Theory and application of Neural Networks to problems in machine learning. Various network architectures will be discussed. Methods for improving optimization and generalization of neural networks. Neural networks for unsupervised learning.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 5206.
Prerequisite(s): (COMP 3105 or SYSC 4415) and (MATH 1104 or MATH 1107).
Lectures three hours a week.

COMP 4108 [0.5 credit]
Computer Systems Security
Information security in computer and communications systems. Topics include: design principles; operating system security and access control; web and software security; malicious software, security infrastructure; secure email; network authentication; firewalls; intrusion detection; IP security; network attacks; wireless security.
Includes: Experiential Learning Activity
Precludes additional credit for CSEC 3108 and SYSC 4810.
Prerequisite(s): COMP 2108 and (COMP 3000 or SYSC 4001).
Lectures three hours a week.

COMP 4111 [0.5 credit]
Data Management for Business Intelligence
Application of computational techniques to support business activities, such as decision making, business understanding, data analysis, business process automation, learning from data, producing and using data-centric business models, ontology-based data access and integration, data quality assessment and cleaning and use of contextual data.
Prerequisite(s): COMP 3005.
Also offered at the graduate level, with different requirements, as COMP 5111, for which additional credit is precluded.
Lectures three hours a week.

COMP 4114 [0.5 credit]
Quantum Computing and Information
Introduction to the ideas and principles of quantum computing and information. Review of mathematical foundations. Discussion of quantum theory, architecture, and quantum gates. Basic algorithms in quantum computing. Theoretical computer science and computation. Applications of quantum computing to cryptography. Quantum information and error correction.
Precludes additional credit for MATH 4821, MATH 5821.
Prerequisite(s): COMP 2804.
Lectures three hours a week

COMP 4115 [0.5 credit]
Introduction to Natural Language Processing
Introduction to the fundamental techniques and models of modern natural language processing. Topics include: word embedding, language models, machine translation, self-attention and transformer, question answering, and pre-trained models.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3105 and (MATH 1104 or MATH 1107).
Lectures three hours a week.

COMP 4116 [0.5 credit]
Multiagent Systems
Multiagent systems is a branch of artificial intelligence that explores the interactions between multiple rational entities, where each may have access to different information and possibly conflicting priorities. This course takes an approach founded on economic game theory.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3106.
Lectures three hours a week.

COMP 4202 [0.5 credit]
Computational Aspects of Geographic Information Systems
Through recent advances in navigation systems, mobile devices, and new software such as Mapquest and Google Earth, GIS is becoming increasingly important and exciting from a CS perspective. This course lays the algorithmic foundations to understand, use and further this technology.

Includes: Experiential Learning Activity
Prerequisite(s): COMP 3804 or MATH 3804.
Also offered at the graduate level, with different requirements, as COMP 5204, for which additional credit is precluded.
Lecture three hours a week.

COMP 4203 [0.5 credit]
Wireless Networks and Security
An introduction to wireless networks covering both networking issues and security aspects of modern wireless environments. Fundamentals of mobile LANs, ad hoc, sensor networks, secure routing, searching, clustering, multicasting, localization, mobile IP/TCP, confidentiality, key establishment, authentication, broadcasting, RFIDs, and rogue attacks.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3203 or SYSC 4602.
Lectures three hours a week.

COMP 4206 [0.5 credit]
Evolving Information Networks
Convergence of social and technological networks. Interplay between information content, entities creating it and technologies supporting it. Structure and analysis of such networks, models abstracting their properties, techniques link analysis, search, mechanism design, power laws, cascading, clustering and connections with work in social sciences.
Prerequisite(s): COMP 1805, (COMP 2401 with a minimum grade of C-) and (COMP 2406 or SYSC 4504). Also offered at the graduate level, with different requirements, as COMP 5310, for which additional credit is precluded.
Lecture three hours a week.

COMP 4501 [0.5 credit]
Advanced Facilities for Real-Time Games
A practical course on the design and implementation of modern game engines and advanced facilities provided by these engines. Such facilities include systems for rendering 3D scenes; simulating physics; playing animations; game AI; and enabling multi-player games. Students will undertake a significant game development project.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3501.
Lectures three hours a week.

COMP 4601 [0.5 credit]
Intelligent Web-based Information Systems
Introduction to the principles and practice of creation, delivery and analysis of multimedia content in web-based systems. Topics include analysis of webs of documents, social network analysis, recommender systems and problems of trust, reputation and influence in e-commerce systems.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 2404 or SYSC 3010 or SYSC 3110) and (COMP 2406 or COMP 2601 or SYSC 4504).
Lecture/lab four hours a week.

COMP 4602 [0.5 credit]
Social Networking
Introduction to virtual communities, overlay networks and social networking. Topics include architectural principles for heterogeneous social networking platforms, trust and reputation as social concepts, agent-based computing, and extraction of trends and patterns from information exchanged between community members.
Precludes additional credit for COMP 3601 (no longer offered).
Prerequisite(s): ((COMP 2404 or SYSC 3010 or SYSC 3110) and (COMP 2406 or SYSC 4504)) or COMP 2601.
Lectures/labs four hours per week.

COMP 4701 [0.5 credit]
Computing, Society, and Ethics
This course examines ethical questions raised by computing technologies - both motivated by recent developments and through the lens of fiction. Students will identify possible ethical issues in future technologies and use formal ethics frameworks to evaluate the merits and pitfalls of different solutions.
Includes: Experiential Learning Activity
Prerequisite(s): Any two of COMP 2108, COMP 3004, COMP 3005, COMP 3008, COMP 3105, COMP 3106, COMP 3308, COMP 3804.
Lectures three hours a week.

COMP 4803 [0.5 credit]
Computable Functions
Recursive functions and computability, algorithms, Church's thesis, Turing machines, computational logic, NP-completeness.
Also listed as MATH 4803.
Prerequisite(s): MATH 2100 or COMP 3805 or permission of the School.

COMP 4804 [0.5 credit]
Design and Analysis of Algorithms II
A second course on the design and analysis of algorithms. Topics include: advanced recurrence relations, algebraic complexity, advanced graph algorithms, amortized analysis, algorithms for NP-complete problems, randomized algorithms.
Prerequisite(s): COMP 3804 or MATH 3804.
Lectures three hours a week.

COMP 4805 [0.5 credit]
Theory of Automata
Finite automata and regular expressions, properties of regular sets, context-free grammars, pushdown automata, deterministic context-free languages. Turing machines, the Chomsky hierarchy. Undecidability, intractable problems.
Also listed as MATH 4805.
Precludes additional credit for MATH 5605.
Prerequisite(s): COMP 3805 or MATH 3106 or MATH 3158 (or MATH 3100) or permission of the School.
Lectures three hours a week.

COMP 4806 [0.5 credit]
Numerical Linear Algebra
Matrix computations, conditioning/stability, direct methods for linear systems, classical iterative methods: Jacobi, Gauss-Seidel; modern iterative methods, Arnoldi decomposition, GMRES and other Krylov subspace-based methods for sparse and structured matrices; numerical solution of eigenvalue problems, implementation using suitable programming language, application to differential equations/optimization problems.
Also listed as MATH 4806.
Prerequisite(s): MATH 2000, (MATH 2107 or MATH 2152), MATH 3806; or permission of the School.
Lectures three hours a week.

COMP 4900 [0.5 credit]
Special Topics in Computer Science
Advanced topics in Computer Science offered by members of the School of Computer Science.
Prerequisite(s): permission of the School of Computer Science.
Lectures three hours a week and up to three hours of tutorials a week.

COMP 4901 [0.5 credit]
Directed Studies
Independent study under the supervision of a member of the School of Computer Science, open only to students in the B.C.S. program. Students are required to obtain their supervisor's written approval prior to registration and are limited to two such courses in their program.
Prerequisite(s): permission of the School of Computer Science.

COMP 4905 [0.5 credit]
Honours Project
Under the supervision of a faculty member, Honours
students complete a major Computer Science project
in fourth year. Permission to register is granted once an
approved project proposal is submitted to the Department.
See deadlines and details on the School website.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4906.
Prerequisite(s): fourth-year standing in a B.C.S. Honours
program or one of the Combined Computer Science
Honours programs and permission of the School of
Computer Science.

COMP 4906 [1.0 credit]
Honours Thesis
Independent research under the direct supervision of a
faculty advisor. Permission to register is granted once an
approved thesis proposal is submitted to the School of
Computer Science. Evaluation is based on a written thesis
and a poster presentation.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4905.
Prerequisite(s): fourth-year standing in a B.C.S. Honours
program with a minimum CGPA of 9.0 in the major and
permission of the School of Computer Science.

COMP 4910 [0.5 credit]
Internship
The internship exposes students to industrial software
development via placement in a local enterprise. The
course may only be taken by students participating in one
of the School's industrial partnerships and can only be
used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3911 and registration in internship
option.

COMP 4911 [0.5 credit]
Internship
The internship exposes students to industrial software
development via placement in a local enterprise. The
course may only be taken by students participating in one
of the School's industrial partnerships and can only be
used as a free elective in the B.C.S. program.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 4910 and registration in internship
option.