

## Computer Science (COMP)

School of Computer Science  
Faculty of Science

**Note:** 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/95) number.

### COMP 1001 [0.5 credit] (formerly 95.101\*) **Introduction to Computers for the Arts and Social Sciences**

This course is intended to give students in the arts and social sciences a working knowledge of computers and their applications; computer fundamentals; use of computing facilities; introduction to graphical user interfaces; a sampling of software packages applied to problems in the arts and social sciences.

Precludes additional credit for COMP 1000 and COMP 1004. This course cannot be taken for credit by students in Business, Engineering, Computer Science, Mathematics or Science.

Lectures three hours a week.

### COMP 1002 [0.5 credit] (formerly 95.102\*) **Introduction to Systems Programming**

Introduction to programming with procedures and primitive data types. Topics include: arrays, strings, pointers, heap and stack memory allocation and deallocation, iterative and recursive linked list manipulations, system/library calls.

Precludes additional credit for COMP 1007, COMP 1402, SYSC 1102 and ECOR 1606.

Prerequisite: COMP 1005.

Lectures three hours a week.

### COMP 1004 [0.5 credit] (formerly 95.104\*) **Introduction to Computers for the Sciences**

Working knowledge of computers and their applications with particular reference to problems in Science. Computer fundamentals and the use of application packages such as spreadsheets, databases and symbolic Mathematics programs. A basic familiarity with computers is assumed.

Precludes additional credit for COMP 1001. This course cannot be taken for credit by students in the B.C.S. program or combined programs in Computer Science.

Lectures three hours a week.

### COMP 1005 [0.5 credit] (formerly 95.105\*) **Introduction to Object-Oriented Programming**

A first course in problem solving and computer programming designed for students wishing to specialize in Computer Science. Introduction to object-oriented programming: syntactic constructs, data abstraction, classification and inheritance, typing and polymorphism, testing and debugging.

Precludes additional credit for COMP 1405 and SYSC 1100.

Lectures three hours a week and one hour tutorial.

### COMP 1006 [0.5 credit] (formerly 95.106\*) **Design and Implementation of Computer Applications**

A continuation of COMP 1005, focusing on the design and implementation of complete applications including the user interface, the software architecture, and the interacting domain objects. Brief introduction to UML. Possible application topics include a testing framework, user-interface architectures and managing persistence.

Precludes additional credit for COMP 1406 and SYSC 1101.

Prerequisites: a grade of C- or better in COMP 1005.

Lectures three hours a week.

### COMP 1007 [0.5 credit] (formerly 95.107\*) **Introduction to Structured Programming**

A first course in computer programming using a procedural language. Introduces basic sequencing, alternation, and looping control constructs, functional and procedural

abstractions, data abstraction, and problem solving in the context of computer programming.

Precludes additional credit for ECOR 1606.

This course cannot be taken for credit by students in the B.C.S. program or combined programs in Computer Science.

Lectures three hours a week.

### COMP 1402 [0.5 credit] (formerly 95.142\*) **Introduction to Systems Programming**

Introduction to programming with procedures and primitive data types, designed for honours students in Computer Science. Topics include: arrays, strings, pointers, heap and stack memory allocation and deallocation, iterative and recursive linked list manipulations, system/library calls.

Precludes additional credit for COMP 1002, COMP 1007, SYSC 1102, and ECOR 1606.

Prerequisite: COMP 1405. Restricted to students registered in the B.C.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.

Lectures three hours a week.

### COMP 1405 [0.5 credit] (formerly 95.145\*) **Introduction to Object-Oriented Programming**

A first course in problem solving and computer programming designed for Honours students in Computer Science. Introduction to object-oriented programming; syntactic constructs, data abstraction, classification and inheritance, typing and polymorphism, testing and debugging.

Precludes additional credit for COMP 1005 and SYSC 1100.

Prerequisite: Restricted to students registered in the B.C.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.

Lectures three hours a week and one hour tutorial.

### COMP 1406 [0.5 credit] (formerly 95.146\*) **Design and Implementation of Computer Applications**

A continuation of SYSC 1405 focusing on the design and implementation of complete applications including the user interface, the software architecture, and the interacting domain objects. Brief introduction to UML. Possible application topics include a testing framework, user-interface architectures and managing persistence.

Precludes additional credit for COMP 1006 and SYSC 1101.

Prerequisite: COMP 1405 (with a grade of C- or better). Restricted to students registered in the B.C.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.

Lectures three hours a week.

### COMP 1805 [0.5 credit] (formerly 95.185\*) **Discrete Structures I**

Introduction to discrete mathematics and discrete structures. Topics include: propositional and predicate calculus, Boolean algebra, introduction to complexity of algorithms, mathematical reasoning, counting, recurrences, relations, introduction to graphs. (Also listed as MATH 1805.)

Prerequisites: two OACs in Mathematics or two Grade 12 university preparation Mathematics courses (after Summer 2002), and one of COMP 1405, COMP 1005, COMP 1007 or Engineering SYSC 1100 (which may be taken concurrently).

Lectures three hours a week.

### COMP 2002 [0.5 credit] (formerly 95.202\*) **Abstract Data Types and Algorithms**

Introduction to the design and implementation of abstract data types and to the 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 COMP 2402 and SYSC 2002.

Prerequisites: a grade of C- or better in COMP 1006.

Lectures three hours a week.

COMP 2003 [0.5 credit] (formerly 95.203\*)

### Computer Organization

A thorough treatment of computer system organization. Processor architectures (RISC, CISC, superscalar). Instruction sets and addressing modes. Assembly language. Basics of digital logic and hardware construction. Memory organization and cache principles. System buses. Input/output methods and devices.

Precludes additional credit for SYSC 2003, SYSC 3006 for students in the Computer Science program and in combined programs with Mathematics or Chemistry.

Prerequisite: one of COMP 1402, COMP 1002 or ECOR 1606.

Lectures three hours a week.

COMP 2004 [0.5 credit] (formerly 95.204\*)

### Programming in C++

In-depth study of the language C++ from a software engineering perspective, with emphasis on features supporting the development of large efficient and reusable systems. Topics include: encapsulation, templates, references, constructors and destructors, overloading, memory management, exception handling, and the standard template library.

Precludes additional credit for COMP 2404 and SYSC 2004. Prerequisites: COMP 1002 and COMP 1005 with a grade of C- or better in each.

Lectures three hours a week.

COMP 2005 [0.5 credit] (formerly 95.205\*)

### Internet Application Programming

Design and implementation of Internet application programs. Topics include: fundamentals of the Web, introduction to client/server architectures, Internet programming, Web browsers, hypertext links, network programming.

Precludes additional credit for COMP 2405. Prerequisites: COMP 1002 and COMP 1006 or equivalent.

Lectures three hours a week.

COMP 2402 [0.5 credit] (formerly 95.242\*)

### 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 COMP 2002 and SYSC 2002. Prerequisite: COMP 1406 (with a grade of C- or better). Restricted to students registered in the B.C.S. program, combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Statistics.

Lectures three hours a week.

COMP 2404 [0.5 credit] (formerly 95.244\*)

### Programming in C++

In-depth study of the language C++ from a software engineering perspective, with emphasis on features supporting the development of large efficient and reusable systems. Topics include: encapsulation, templates, references, constructors and destructors, overloading, memory management, exception handling, and the standard template library.

Precludes additional credit for COMP 2004 and SYSC 2002. Prerequisite: COMP 1402 and COMP 1405 with a grade of C- or better in each. Restricted to students registered in the B.C.S. program, the combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.

Lectures three hours a week.

COMP 2405 [0.5 credit] (formerly 95.245\*)

### Internet Application Programming

Design and implementation of Internet application programs. Topics include: fundamentals of the Web, introduction to client/server architectures, Internet programming, Web browsers, hypertext links, network programming.

Precludes additional credit for COMP 2005. Prerequisite: COMP 1402 and COMP 1406.

Restricted to students registered in the B.C.S. program,

combined Honours in Computer Science and Mathematics, Honours Computer Mathematics, and Honours Computer Statistics.

Lectures three hours a week.

COMP 2805 [0.5 credit] (formerly 95.285\*)

### Discrete Structures II

A second course in theoretical aspects of computer science. Topics include: formal languages and automata theory, computability theory, complexity theory, graph theory and algorithms, NP-completeness.

Prerequisite: COMP 1805.

Lectures three hours a week.

COMP 3000 [0.5 credit] (formerly 95.300\*)

### Operating Systems

A first course in operating systems stressing fundamental issues in design: process management; memory management; process co-ordination and synchronization; interprocess communication; real-time clock management; i/o device drivers; file systems; frame-level network communication. Assignments involve the use, modification, and extension of a multitasking operating system.

Precludes additional credit for SYSC 3001.

Prerequisites: one of COMP 2402, COMP 2002 or SYSC 2002, and one of COMP 2003 or SYSC 3003.

Lectures three hours a week.

COMP 3002 [0.5 credit] (formerly 95.302\*)

### 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: COMP 2404.

Lectures three hours a week.

COMP 3004 [0.5 credit] (formerly 95.304\*)

### Object-Oriented Software Engineering

Theory and development software systems. This course will discuss computer ethics. Possible topics include: software development processes, requirement specification, class and scenario modeling, state modeling, UML, design patterns, traceability. Students are to complete a team project using a CASE tool.

Precludes additional credit for SYSC 3100 and SYSC 4800. Prerequisites: COMP 2004.

Lectures three hours a week.

COMP 3005 [0.5 credit] (formerly 95.305\*)

### 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 and SYSC 3001. Prerequisites: COMP 2002 or COMP 2402, and COMP 2004 or COMP 2404; alternatively, SYSC 2100 and SYSC 2101.

Lectures three hours a week.

COMP 3007 [0.5 credit] (formerly 95.307\*)

### Programming Paradigms

An introduction to functional and logic programming. Topics include: semantics of functional programming, assignment-free programming, the meta-circular interpreter, recursive functions, Prolog, backtracking, cutting, negation.

Precludes additional credit for 95.207\*.

Prerequisite: two of COMP 2402, COMP 2404, COMP 2405 or their equivalents.

Lectures three hours a week.

COMP 3008 [0.5 credit] (formerly 95.308\*)

### User Interface Architecture

Fundamentals of designing, prototyping and evaluating user interfaces. Topics may include: user and task analysis and its application to U.I. design, task and goal-centered development, U.I. tools and design principles, usability

testing and heuristic evaluation, web design issues.  
Prerequisites: one of COMP 1006 or COMP 1406, and one of COMP 2004 or COMP 2404.

COMP 3104 [0.5 credit] (formerly 95.314\*)

**Foundations of Software Engineering**

A survey of the software engineering field. Possible topics include: processes, project management, requirements engineering, formal specifications, software design, software reliability, reuse, computer-aided software engineering, configuration management, maintenance and re-engineering.

Precludes additional credit for SYSC 4800.

Prerequisite: COMP 3004.

Lectures three hours a week.

COMP 3200 [0.5 credit] (formerly 95.320\*)

**Co-operative Work Term Report 1**

Prerequisites: Registration in the Co-operative Education Option of the Bachelor of Computer Science program, completion of the Co-op preparation classes offered by the Co-op office and permission of the School.

COMP 3201 [0.5 credit] (formerly 95.321\*)

**Co-operative Work Term Report 2**

Prerequisites: Registration in the Co-operative Education Option of the Bachelor of Computer Science program and permission of the School.

COMP 3202 [0.5 credit] (formerly 95.322\*)

**Co-operative Work Term Report 3**

Prerequisites: Registration in the Co-operative Education Option of the Bachelor of Computer Science program and permission of the School.

COMP 3203 [0.5 credit] (formerly 95.323\*)

**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.

Precludes additional credit for SYSC 4602.

Prerequisites: COMP 3000.

Lectures three hours a week.

COMP 3804 [0.5 credit] (formerly 95.384\*)

**Design and Analysis of Algorithms I**

An introduction to the design and analysis of algorithms. Topics include: recurrence relations, sorting and searching, divide-and-conquer, dynamic programming, greedy algorithms, amortized analysis. (Also listed as MATH 3804.)

Prerequisites: COMP 2002 or COMP 2402, and either COMP 2805 or both of MATH 2007 and MATH 2108, or equivalents.

Lectures three hours a week.

COMP 3805 [0.5 credit] (formerly 95.385\*)

**Discrete Structures and Applications**

Enumeration: elementary methods, inclusion and exclusion, recurrence relations, generating functions and applications. Graph theory and algorithms: connectivity, planarity, Hamilton and Euler paths. Error-correcting codes. (Also listed as MATH 3805.)

Prerequisites: One of Mathematics MATH 2108 or MATH 3101, MATH 2100.

COMP 3806 [0.5 credit] (formerly 95.386\*)

**Numerical Analysis**

Elementary discussion of error, polynomial interpolation, quadrature, linear systems of equations and matrix inversion, non-linear equations, difference equations and ordinary differential equations. (Also listed as MATH 3806.)

Prerequisites: i) MATH 1002, MATH 1005 or MATH 2007 (or MATH 2001 or MATH 2002); and ii) MATH 1102 or MATH 2107; and (iii) knowledge of a computer language.

Lectures three hours a week and one hour tutorial.

COMP 3807 [0.5 credit] (formerly 95.387\*)

**Mathematical Software**

Incorporation of basic numerical methods into efficient, reliable software. The course includes examination of existing software

systems, e.g. linear systems, non-linear systems, optimization, or differential equations. (Also listed as MATH 3807.)

Prerequisite: COMP 3806.

COMP 4000 [0.5 credit] (formerly 95.400\*)

**Distributed Operating Systems**

An advanced course emphasizing the principles of distributed operating systems including networking protocols, distributed file systems, remote IPC mechanisms, graphical user interfaces, load balancing, and process migration. Case studies include current "standards" as well as novel systems under development.

Prerequisite: COMP 3000.

Lectures three hours a week.

COMP 4001 [0.5 credit] (formerly 95.401\*)

**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).

Prerequisite: COMP 3203.

Lectures three hours a week.

COMP 4002 [0.5 credit] (formerly 95.402\*)

**Computer Graphics**

Principles and techniques of real-time 2D and 3D graphics: raster graphics algorithms, transformations (scaling, translation, rotations) and viewing, object modeling, texture mapped rendering, illumination, ray tracing, hidden line and surface elimination. Other possible topics include: camera control, collision detection, articulated figures, 3D game engine development.

Prerequisite: COMP 2404.

Lectures three hours a week.

COMP 4003 [0.5 credit] (formerly 95.403\*)

**Transaction Processing Systems**

Investigates concepts of on-line transaction processing. Traces transaction processes from their initiation (WWW Interfaces) to their completion in client/server environments under concurrent executions and system failures. Topics include: transaction properties and models, embedded-SQL and database applications, query processing, concurrency, recovery, and some case studies.

Prerequisites: COMP 2004 or COMP 2404, and COMP 3005 or SYSC 3001.

Lectures three hours a week.

COMP 4004 [0.5 credit] (formerly 95.404\*)

**Software Quality Assurance**

Introduction to the theory and practice of Software Quality Assurance. Topics include: functional requirements analysis, system requirement analysis, verification and validation, traceability, white box testing, integration testing, object-oriented testing, tools, and management issues.

Prerequisite: COMP 3004.

Lectures three hours a week.

COMP 4009 [0.5 credit] (formerly 95.409\*)

**Introduction to Parallel and Systolic Computing**

Introduction to algorithms, architectures, and languages for parallel computing. Topics include: models of computation, parallel programming languages, performance measures for parallel algorithms, shared memory parallel machines, VLSI design methodologies, processor arrays, hypercube multiprocessors, parallel algebraic operations, parallel data structures and parallel searching, parallel geometric processing.

Prerequisite: COMP 3804.

Lectures three hours a week.

COMP 4100 [0.5 credit] (formerly 95.410\*)

**Multimedia Systems**

Introduction to Multimedia Systems and Virtual Reality. Topics include: basic sound and video formats, compression, image- and geometry-based model creation, stereo

displays, immersion, texture mapping, VRML and virtual environments.

Prerequisites: two of COMP 2402, COMP 2404, and COMP 2405 or their equivalents.

Lectures three hours a week.

COMP 4101 [0.5 credit] (formerly 95.411\*)

### **Distributed Object Management and Transaction Processing Systems**

Study of the principles involved in the design and implementation of distributed object management, CORBA-based transaction services and distributed object-based applications. Topics include: Distributed Object Management Architectures, Transactional Middleware, Combining Java, Web and CORBA Objects within Heterogeneous Systems, Interoperability, Security, Scalability and Performance Measures.

Prerequisite: COMP 3000 and COMP 3005.

Lectures three hours a week.

COMP 4104 [0.5 credit] (formerly 95.414\*)

### **Distributed Programming in Java**

Advanced course on distributed programming in Java. Introduces students to standard design patterns for implementing components that solve common distributed programming challenges in Java. Topics covered include: threads, message passing, coordination, distributed object technology, web-based services, and collaborative applications.

Prerequisites: one of COMP 2005 or COMP 2405, and COMP 3004.

Lectures three hours a week.

COMP 4106 [0.5 credit] (formerly 95.416\*)

### **Topics in Artificial Intelligence**

Several areas in knowledge-based systems are covered, including recent approaches to machine learning and data mining, inference methods, knowledge-based and fuzzy systems, heuristic search, and natural language processing.

Precludes additional credit for 95.407\*.

Prerequisite: COMP 3007.

Lectures three hours a week.

COMP 4107 [0.5 credit] (formerly 95.417\*)

### **Evolutionary Computation and Artificial Life**

Study of algorithms based upon biological theories of evolution, applications to machine learning and optimization problems. Genetic Algorithms, Classifier Systems, and Genetic Programming in details. Recent work in the fields of Artificial Life (swarm intelligence, distributed agents, behavior-based AI) and of connectionism is also studied.

Prerequisite: COMP 3007 and COMP 4106.

Lectures three hours a week.

COMP 4108 [0.5 credit]

### **Computer Systems Security**

Introduction to information security in computer and communications systems, including network, operating systems, web and software security; Passwords, authentication applications, privacy, data integrity, anonymity, secure email, IP security, security infrastructures, firewalls, viruses, intrusion detection, network attacks.

Precludes additional credit for COMP 4103.

Prerequisites: COMP 3000, COMP 3203, and COMP 3804.

Lectures three hours a week.

COMP 4109 [0.5 credit]

### **Applied Cryptography**

Practical aspects of cryptography. Pseudo random number generation, symmetric cryptography (stream and block ciphers), modes of operation, hash functions, message and entity authentication protocols, zero knowledge, pitfalls deploying public-key encryption and digital signatures, key distribution, secret-sharing.

Precludes additional credit for COMP 4103.

Prerequisites: MATH 3809 and COMP 3804 and COMP 1402.

Lectures three hours a week.

COMP 4200 [0.5 credit] (formerly 95.420\*)

### **Co-operative Work Term Report 4**

Prerequisites: Registration in the Co-operative Education Option of the Bachelor of Computer Science program and permission of the School.

COMP 4201 [0.5 credit] (formerly 95.421\*)

### **Co-operative Work Term Report 5**

Prerequisites: Registration in the Co-operative Education Option of the Bachelor of Computer Science program and permission of the School.

COMP 4803 [0.5 credit] (formerly 95.483\*)

### **Computable Functions**

Recursive functions and computability, algorithms, Church's thesis, Turing machines, computational logic, NP-completeness. (Also listed as MATH 4803.)

Prerequisite: MATH 2100 or COMP 3805 or permission of the School.

COMP 4804 [0.5 credit] (formerly 95.484\*)

### **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, approximation algorithms, randomized algorithms. Also offered at the graduate level, with additional or different requirements, as COMP 5703, for which additional credit is precluded.

Prerequisite: COMP 3804 or permission of the School.

Lectures three hours a week.

COMP 4805 [0.5 credit] (formerly 95.485\*)

### **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: COMP 3805 or MATH 3100 or permission of the School.

Lectures three hours a week.

COMP 4806 [0.5 credit] (formerly 95.486\*)

### **Numerical Linear Algebra**

Study of matrix inversion techniques; techniques of finding eigenvalues and eigenvectors, solution of systems of linear equations; direct and indirect methods, their comparison and error analysis; applications in optimization and other areas. (Also listed as MATH 4806.)

Prerequisites: MATH 1102 or MATH 2107; and MATH 2000 or MATH 3009, or permission of the School.

Lectures three hours a week.

COMP 4900 [0.5 credit] (formerly 95.490\*)

### **Advanced Topics in Computer Science**

Selected topics in Computer Science offered by members of the School of Computer Science.

Prerequisite: permission of the School of Computer Science.

Lectures three hours a week.

COMP 4901 [0.5 credit] (formerly 95.491\*)

### **Directed Studies**

A course of 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 programs.

Prerequisite: permission of the School of Computer Science.

COMP 4905 [0.5 credit] (formerly 95.495\*)

### **Honours Project**

B.C.S. students are required to select and complete a major project in computer science in fourth year. Students are required to submit written project proposals to the Honours Project Co-ordinator for approval normally during the term preceding the term of registration. Consult the Honours Project Co-ordinator for details.

Prerequisite: registration in the B.C.S. program or one of the Combined Computer Science Honours programs and permission of the School of Computer Science.