Computer Science

This section presents the requirements for programs in:

- **Computer Science B.C.S. Honours**
- **Computer Science Industrial Applications Internship Option B.C.S. Honours**
- **Computer Science Algorithms Stream B.C.S. Honours**
- **Computer Science Artificial Intelligence and Machine Learning Stream B.C.S. Honours**
- **Computer Science Management and Business Systems Stream B.C.S. Honours**
- **Computer Science Software Engineering Stream B.C.S. Honours**
- **Computer Science Cybersecurity Stream B.C.S. Honours**
- **Computer Science Computer Game Development Stream B.C.S. Honours**
- **Computer Science B.C.S. Major**
- **Computer Science and Mathematics: Concentration in Computing Theory and Numerical Methods B. Math. Combined Honours**
- **Computer Science and Mathematics: Concentration in Statistics and Computing B. Math. Combined Honours**
- **Minor in Computer Science**

Program Requirements

Course Categories

The following categories of courses are used in defining the program requirements in Computer Science.

Computer Science (COMP)

In addition to the courses with subject code COMP, the following courses offered by the Faculty of Engineering and Design are relevant to the B.C.S. program and the Combined Honours programs. These courses are counted as Computer Science credits in B.C.S., Minor in Computer Science, and Combined Honours program requirements:

SYSC 3303 [0.5]	Real-Time Concurrent Systems
SYSC 4005 [0.5]	Discrete Simulation/Modeling
SYSC 4106 [0.5]	The Software Economy and Project Management

Breadth Electives

All courses offered by the Faculty of Arts and Social Sciences, the Faculty of Public Affairs, the Sprott School of Business and the Faculty of Science except for courses in COMP, MATH, STAT and the Prohibited Courses category.

Free Electives

All courses offered by the Faculty of Arts and Social Sciences, the Faculty of Public Affairs, the Sprott School of Business and the Faculty of Science except for courses in the Prohibited Courses category. Free electives can include COMP, MATH and STAT courses.

Natural Science Electives

This category is defined with the B.Math. programs. See the Course Categories section on the Mathematics Program page of this Calendar for details.

Prohibited Courses

The following courses cannot be used for credit in the B.C.S., the Computer Science Minor, or any Combined Computer Science program. **Please note that any courses cross-listed with those on the list are also prohibited**:

BUSI 1401 [0.5]	Foundations of Information Systems
BUSI 2401 [0.5]	Introduction to Data Analytics
BUSI 2402 [0.5]	Business Applications Development
BUSI 3400 [0.5]	Database Design
CGSC 1005 [0.5]	Computational Methods in Cognitive Science
COMP 1001 [0.5]	Introduction to Computational Thinking for Arts and Social Science Students
ECON 1401/ MATH 1401 [0.5]	Elementary Mathematics for Economics I
ECON 1402/ MATH 1402 [0.5]	Elementary Mathematics for Economics II
MATH 1009 [0.5]	Mathematics for Business
MATH 1119 [0.5]	Linear Algebra: with Applications to Business

all 0000-level MATH courses

and all courses in BIT, IMD, IRM, MPAD, NET, OSS, PLT and ITEC except for the following: BIT 1000, BIT 1001, BIT 1100, BIT 1101, BIT 1200, BIT 1201, BIT 2000, BIT 2004, BIT 2005, BIT 2007, BIT 2100, BIT 2300.

Bachelor of Computer Science Honours
Bachelor of Computer Science Honours Streams

B.C.S. Honours students may either register in the B.C.S. Honours degree below, or in one of the B.C.S. Honours streams that follow.

Computer Science
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.0 credits)

1. 6.5 credits in:		6.5
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 1805 [0.5]	Discrete Structures I	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	

COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I

2. 0.5 credit in COMP at the 2000-level or above 0.5

3. 2.0 credits from: 2.0

COMP 4905 [0.5] and 1.5 credits in COMP at the 4000-level, or

COMP 4906 [1.0] and 1.0 credit in COMP at the 4000-level, or

2.0 credits in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (11.0 credits)

4. 1.5 credits in: 1.5

| MATH 1007 [0.5] | Elementary Calculus I |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science |

0.5 credit in MATH at the 2000-level or above

5. 0.5 credit in: 0.5

| STAT 2507 [0.5] | Introduction to Statistical Modeling I |

6. 5.0 credits in Breadth Electives 5.0

7. 4.0 credits in free electives. 4.0

Total Credits **20.0**

Computer Science
Industrial Applications Internship Option
B.C.S. Honours (20.0 credits)

Registration in the internship option is by permission of the School only.

A. Credits Included in the Major CGPA (13.0 credits)

1. 10.5 credits in: 10.5

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 1910 [0.5]	Internship
COMP 1911 [0.5]	Internship
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 2910 [0.5]	Internship
COMP 2911 [0.5]	Internship
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I
COMP 3910 [0.5]	Internship
COMP 3911 [0.5]	Internship
COMP 4910 [0.5]	Internship
COMP 4911 [0.5]	Internship

2. 0.5 credit in COMP at the 2000-level or above 0.5

3. 2.0 credits from: 2.0

COMP 4905 [0.5] and 1.5 credits in COMP at the 4000-level, or

COMP 4906 [1.0] and 1.0 credit in COMP at the 4000-level, or

2.0 credits in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (7.0 credits)

4. 1.5 credits in: 1.5

| MATH 1007 [0.5] | Elementary Calculus I |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science |

0.5 credit in MATH at the 2000-level or above

5. 0.5 credit in: 0.5

| STAT 2507 [0.5] | Introduction to Statistical Modeling I |

6. 5.0 credits in Breadth Electives 5.0

Total Credits **20.0**

Computer Science
Algorithms Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.0 credits)

1. 6.5 credits in: 6.5

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I

2. 1.5 credits in: 1.5

COMP 3801 [0.5]	Algorithms for Modern Data Sets
COMP 3803 [0.5]	Introduction to Theory of Computation
COMP 4804 [0.5]	Design and Analysis of Algorithms II

3. 0.5 credit in: 0.5

| COMP 4001 [0.5] | Distributed Computing |

4. 1.5 credits from: 1.5

COMP 4905 [0.5] and 1.0 credit in COMP at the 4000-level, or

COMP 4906 [1.0] and 0.5 credit in COMP at the 4000-level, or

1.5 credits in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (10.0 credits)

5. 1.5 credits in: 1.5

| MATH 1007 [0.5] | Elementary Calculus I |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science |

0.5 credit in MATH at the 2000-level or above

6. 0.5 credit in: 0.5

STAT 2507 [0.5]	Introduction to Statistical Modeling I

7. 5.0 credits in Breadth Electives   5.0

8. 3.0 credits in free electives   3.0

Total Credits   **20.0**

Computer Science
Artificial Intelligence and Machine Learning Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.5 credits)

1. 6.5 credits in: 6.5

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I

2. 1.5 credits in: 1.5

COMP 3105 [0.5]	Introduction to Machine Learning
COMP 3106 [0.5]	Introduction to Artificial Intelligence
COMP 4107 [0.5]	Neural Networks

3. 1.5 credits from: 1.5

COMP 4905 [0.5] and 1.0 credit in COMP at the 4000-level, or

COMP 4906 [1.0] and 0.5 credit in COMP at the 4000-level, or

1.5 credits in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (10.5 credits)

4. 1.0 credit in: 1.0

MATH 1007 [0.5]	Elementary Calculus I
MATH 1104 [0.5]	Linear Algebra for Engineering or Science

5. 0.5 credit from: 0.5

STAT 2605 [0.5]	Probability Models

or 0.5 credit in MATH at the 2000-level or above

6. 0.5 credit in: 0.5

STAT 2507 [0.5]	Introduction to Statistical Modeling I

7. 5.0 credits in Breadth Electives   5.0

8. 3.5 credits in free electives   3.5

Total Credits   **20.0**

Computer Science
Management and Business Systems Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.0 credits)

1. 6.5 credits in: 6.5

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I

2. 0.5 credit in COMP at the 2000-level or above   0.5

3. 2.0 credits from: 2.0

COMP 4905 [0.5] and 1.5 credits in COMP at the 4000-level, or

COMP 4906 [1.0] and 1.0 credit in COMP at the 4000-level, or

2.0 credits in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (11.0 credits)

4. 1.5 credits in: 1.5

MATH 1007 [0.5]	Elementary Calculus I
MATH 1104 [0.5]	Linear Algebra for Engineering or Science

0.5 credit in MATH at the 2000-level or above

5. 0.5 credit in: 0.5

STAT 2507 [0.5]	Introduction to Statistical Modeling I

6. 1.0 credit from: 1.0

BUSI 1003 and 0.5 credit in BUSI at the 2000-level, or

BUSI 1001 [0.5] & BUSI 1002 [0.5]	Principles of Financial Accounting Management Accounting

7. 2.0 credits in: 2.0

BUSI 2121 [0.5]	Introduction to Organizational Behaviour
BUSI 2301 [0.5]	Introduction to Supply and Operations Management
BUSI 2503 [0.5]	Introduction to Finance
BUSI 3402 [0.5]	Systems Analysis and Design

8. 1.0 credit in: 1.0

ECON 1001 [0.5]	Introduction to Microeconomics
ECON 1002 [0.5]	Introduction to Macroeconomics

9. 1.5 credit in BUSI at the 3000-level or above   1.5

10. 3.5 credits in free electives.   3.5

Total Credits   **20.0**

Computer Science
Software Engineering Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.5 credits)

1. **6.5 credits in:**		6.5
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 1805 [0.5]	Discrete Structures I	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3007 [0.5]	Programming Paradigms	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
2. **0.5 credit in:**		0.5
COMP 3008 [0.5]	Human-Computer Interaction	
3. **1.5 credits in:**		1.5
COMP 4004 [0.5]	Software Quality Assurance	
SYSC 3303 [0.5]	Real-Time Concurrent Systems	
SYSC 4106 [0.5]	The Software Economy and Project Management	
4. **1.0 credit from:**		1.0
COMP 4905 [0.5] and 0.5 credit in COMP at the 4000-level, or		
COMP 4906 [1.0], or		
1.0 credit in COMP at the 4000-level		

B. Credits Not Included in the Major CGPA (10.5 credits)

5. **1.5 credits from:**		1.5
MATH 1007 [0.5]	Elementary Calculus I	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
0.5 credit in MATH at the 2000-level or above		
6. **0.5 credit in:**		0.5
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
7. **5.0 credits in** Breadth Electives		5.0
8. **3.5 credits in** free electives.		3.5
Total Credits		**20.0**

Computer Science
Cybersecurity Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.0 credits)

1. **6.5 credits in:**		6.5
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 1805 [0.5]	Discrete Structures I	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3007 [0.5]	Programming Paradigms	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
2. **2.0 credits in:**		2.0
COMP 2108 [0.5]	Applied Cryptography and Authentication	
COMP 3008 [0.5]	Human-Computer Interaction	
COMP 3203 [0.5]	Principles of Computer Networks	
COMP 4108 [0.5]	Computer Systems Security	
3. **1.5 credits from:**		1.5
COMP 4905 [0.5] and 1.0 credit in COMP at the 4000-level, or		
COMP 4906 [1.0] and 0.5 credit in COMP at the 4000-level, or		
1.5 credits in COMP at the 4000-level		

B. Credits Not Included in the Major CGPA (10.0 credits)

4. **1.5 credits in:**		1.5
MATH 1007 [0.5]	Elementary Calculus I	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
0.5 credit in MATH at the 2000-level or above		
5. **0.5 credit in:**		0.5
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
6. **5.0 credits in** Breadth Electives		5.0
7. **3.0 credits in** free electives		3.0
Total Credits		**20.0**

Computer Science
Computer Game Development Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.0 credits)

1. **6.5 credits in:**		6.5
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 1805 [0.5]	Discrete Structures I	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3007 [0.5]	Programming Paradigms	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	

2. 2.0 credits in: 2.0

COMP 1501 [0.5]	Introduction to Computer Game Design
COMP 2501 [0.5]	Computer Game Design and Development
COMP 3501 [0.5]	Foundations of Game Programming and Computer Graphics
COMP 4501 [0.5]	Advanced Facilities for Real-Time Games

3. 1.5 credits from: 1.5

COMP 4905 [0.5] and 1.0 credit in COMP at the 4000-level, or	
COMP 4906 [1.0] and 0.5 credit in COMP at the 4000-level, or	
1.5 credits in COMP at the 4000-level	

B. Credits Not Included in the Major CGPA (10.0 credits)

4. 1.5 credits in: 1.5

MATH 1007 [0.5]	Elementary Calculus I
MATH 1104 [0.5]	Linear Algebra for Engineering or Science
0.5 credit in MATH at the 2000-level or above	

5. 0.5 credit in: 0.5

STAT 2507 [0.5]	Introduction to Statistical Modeling I

6. 5.0 credits in Breadth electives 5.0

7. 3.0 credits in free electives 3.0

Total Credits 20.0

Computer Science
B.C.S. Major (20.0 credits)

A. Credits Included in the Major CGPA (7.5 credits)

1. 6.0 credits in: 6.0

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms

2. 1.0 credit in COMP at the 3000-level or above 1.0

3. 0.5 credit in COMP at the 4000-level 0.5

B. Credits Not Included in the Major CGPA (12.5 credits)

4. 1.0 credit in: 1.0

MATH 1007 [0.5]	Elementary Calculus I
MATH 1104 [0.5]	Linear Algebra for Engineering or Science

5. 0.5 credit in: 0.5

STAT 2507 [0.5]	Introduction to Statistical Modeling I

6. 5.0 credits in Breadth Electives 5.0

7. 6.0 credits in free electives. 6.0

Total Credits 20.0

Computer Science and Mathematics
B.Math. Combined Honours

Students must register in one of the two concentrations below, each of which adds 5.0 credits to the Major CGPA.

Computer Science and Mathematics: Concentration in Computing Theory and Numerical Methods
B. Math. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (16.0 credits)

1. 4.5 credits in: 4.5

MATH 1052 [0.5]	Calculus and Introductory Analysis I
MATH 1152 [0.5]	Introductory Algebra I
MATH 1800 [0.5]	Introduction to Mathematical Reasoning
MATH 2000 [1.0]	Multivariable Calculus and Fundamentals of Analysis
MATH 2052 [0.5]	Calculus and Introductory Analysis II
MATH 2100 [1.0]	Algebra
MATH 2152 [0.5]	Introductory Algebra II

2. 6.0 credits in: 6.0

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3804 [0.5]	Design and Analysis of Algorithms I
COMP 3805 [0.5]	Discrete Structures and Applications (Honours)

3. 0.5 credit from: 0.5

COMP 4905 [0.5]	Honours Project
MATH 4905 [0.5]	Honours Project (Honours)

Concentration in Computing Theory and Numerical Methods

4. 3.0 credits in: 3.0

MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
MATH 3801 [0.5]	Linear Programming
MATH 3806 [0.5]	Numerical Analysis (Honours)
COMP 4804 [0.5]	Design and Analysis of Algorithms II

5. 0.5 credit from:		0.5
MATH 3001 [0.5]	Real Analysis I (Honours)	
MATH 3002 [0.5]	Real Analysis II (Honours)	
MATH 3003 [0.5]	Advanced Differential Calculus (Honours)	
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	

6. 1.0 credit from:		1.0
MATH 4109 [0.5]	Fields and Coding Theory (Honours)	
MATH 4801 [0.5]	Topics in Combinatorics (Honours)	
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)	
MATH 4803 [0.5]	Computable Functions (Honours)	
MATH 4805 [0.5]	Theory of Automata (Honours)	
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)	
MATH 4807 [0.5]	Game Theory (Honours)	
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)	
MATH 4811 [0.5]	Combinatorial Design Theory (Honours)	
MATH 4816 [0.5]	Numerical Analysis for Differential Equations (Honours)	
MATH 4821 [0.5]	Quantum Computing (Honours)	
MATH 4822 [0.5]	Wavelets and Digital Signal Processing (Honours)	

7. 0.5 credit in COMP at the 3000 level or above.		0.5

B. Credits Not Included in the Major CGPA (4.0 credits)

8. 4.0 credits not in MATH, STAT, or COMP consisting of:		4.0
a. 1.0 credit in Natural Science electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		

Total Credits		**20.0**

Note:

The following courses offered by the School of Business and the Faculty of Engineering are treated as Computer Science courses in this program:

Business

BUSI 4400 [0.5]	IS Management and Strategy

Engineering

SYSC 3303 [0.5]	Real-Time Concurrent Systems
SYSC 4005 [0.5]	Discrete Simulation/Modeling
SYSC 4507 [0.5]	Computer Systems Architecture

Computer Science and Mathematics: Concentration in Statistics and Computing B. Math. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (16.5 credits)

1. 5.0 credits in:		5.0
MATH 1052 [0.5]	Calculus and Introductory Analysis I	
MATH 1152 [0.5]	Introductory Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
MATH 2000 [1.0]	Multivariable Calculus and Fundamentals of Analysis	
MATH 2052 [0.5]	Calculus and Introductory Analysis II	
MATH 2100 [1.0]	Algebra	
MATH 2152 [0.5]	Introductory Algebra II	
STAT 1500 [0.5]	Introduction to Statistical Computing	

2. 6.0 credits in:		6.0
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
COMP 3805 [0.5]	Discrete Structures and Applications (Honours)	

3. 0.5 credit from:		0.5
COMP 4905 [0.5]	Honours Project	
STAT 4905 [0.5]	Honours Project (Honours)	

Concentration in Statistics and Computing:

4. 3.0 credits in:		3.0
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	

5. 0.5 credit from:		0.5
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	

6. 1.0 credit in STAT at the 4000 level		1.0
7. 0.5 credit in COMP at the 4000 level		0.5

B. Credits Not Included in the Major CGPA (3.5 credits)

8. 3.5 credits not in MATH, STAT, or COMP consisting of:		3.5
a. 1.0 credit in Natural Science electives		
b. 2.5 credits from Natural Science, or Approved Arts and Social Sciences electives		

Total Credits		**20.0**

Minor in Computer Science (4.0 credits)

Only students pursuing an undergraduate program requiring at least 20.0 credits to graduate and who have completed at least 4.0 credits toward their degree with a minimum Overall CGPA of 7.0 may be admitted to the Minor in Computer Science, except for the following:

- Bioinformatics B.Sc. Honours
- Cognitive Science with Concentration in Cognition and Computation Bachelor of Cognitive Science Honours
- Computational Biochemistry B.Sc. Honours
- Computer Science B.C.S. Honours, including all streams
- Computer Science and Mathematics: Concentration in Computing Theory and Numerical Methods B.Math. Combined Honours
- Computer Science and Mathematics: Concentration in Statistics and Computing B.Math. Combined Honours
- Computer Systems Engineering Bachelor of Engineering
- Economics B.Econ. Honours with Concentration in Computational Analysis
- Information Resource Management B.I.T.
- Interactive Multimedia and Design B.I.T.
- Linguistics with a Concentration in Linguistic Theory (Computer Science) B.Sc. Honours
- Linguistics with a Concentration in Psycholinguistics and Communication Disorders (Computer Science) B.Sc. Honours
- Network Technology B.I.T.
- Optical Systems and Sensors B.I.T.
- Software Engineering Bachelor of Engineering

Enrolment is limited. Students who are required to leave the Minor due to a low Minor CGPA may not return to the Minor at any subsequent date.

Students are required to present a Minor CGPA of 4.00 or higher at graduation in order to be awarded a Minor in Computer Science.

Requirements

1. 2.5 credits in:		2.5
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
2. 1.0 credit from:		1.0
COMP 1805 [0.5]	Discrete Structures I (and/or COMP at the 2000-level or above)	
3. 0.5 credit in COMP at the 3000-level or above		0.5
4. Course equivalencies and transfer credits can be used for at most 2.0 credits of the minor; the remaining 2.0 credits must be courses listed in the COMP section of this Calendar		
5. The remaining requirements of the major discipline(s) and degree must be satisfied.		
Total Credits		**4.0**

Regulations

In addition to the program requirements described here, students must satisfy the University regulations common to all undergraduate students (see the *Academic Regulations of the University* section of this Calendar).

Students should consult with the School when planning their program and selecting courses.

Co-operative Education

For more information about how to apply for the Co-op program and how the Co-op program works please visit the Co-op website.

All students participating in the Co-op program are governed by the Undergraduate Co-operative Education Policy.

Undergraduate Co-operative Education Policy

Admission Requirements

Students can apply to Co-op in one of two ways: directly from high school, or after beginning a degree program at Carleton.

If a student applies to a degree program with a Co-op option from high school, their university grades will be reviewed two terms to one year prior to their first work term to ensure they meet the academic requirements after their first or second year of study. The time at which the evaluation takes place depends on the program of study. Students will automatically receive an admission decision via their Carleton email account.

Students who did not request Co-op at the time they applied to Carleton can request Co-op after they begin their university studies. To view application instructions and deadlines, please visit carleton.ca/co-op.

To be admitted to Co-op, a student must successfully complete 5.0 or more credits that count towards their degree, meet the minimum CGPA requirement(s) for the student's Co-op option, and fulfil any specified course prerequisites. To see the unique admission and continuation requirements for each Co-op option, please refer to the specific degree programs listed in the Undergraduate Calendar.

Participation Requirements

COOP 1000

Once a student has been given admission or continuation confirmation to the co-op option s/he must complete and pass COOP 1000 (a mandatory online 0.0 credit course). Students will have access to this course a minimum of two terms prior to their first work term and will be notified when to register.

Communication with the Co-op Office

Students must maintain contact with the co-op office during their job search and while on a work term. All email communication will be conducted via the students' Carleton email account.

Employment

Although every effort is made to ensure a sufficient number of job postings for all students enrolled in the co-op option of their degree program, no guarantee of employment can be made. Carleton's co-op program operates a competitive job search process and is

dependent upon current market conditions. Academic performance, skills, motivation, maturity, attitude and potential will determine whether a student is offered a job. It is the student's responsibility to actively conduct a job search in addition to participation in the job search process operated by the co-op office. Once a student accepts a co-op job offer (verbally or written), his/her job search will end and access to co-op jobs will be removed for that term. Students that do not successfully obtain a co-op work term are expected to continue with their academic studies. The summer term is the exception to this rule. Students should also note that hiring priority is given to Canadian citizens for co-op positions in the Federal Government of Canada.

Registering in Co-op Courses

Students will be registered in a Co-op Work Term course while at work. The number of Co-op Work Term courses that a student is registered in is dependent upon the number of four-month work terms that a student accepts.

While on a co-op work term students may take a maximum of 0.5 credit throughout each four-month co-op work term. Courses must be scheduled outside of regular working hours.

Students must be registered as full-time before they begin their co-op job search. All co-op work terms must be completed before the beginning of the final academic term. Students may not finish their degree on a co-op work term.

Work Term Assessment and Evaluation

To obtain a Satisfactory grade for the co-op work term students must have:

1. A satisfactory work term evaluation by the co-op employer;
2. A satisfactory grade on the work term report.

Students must submit a work term report at the completion of each four-month work term. Reports are due on the 16th of April, August, and December and students are notified of due dates through their Carleton email account.

Workplace performance will be assessed by the workplace supervisor. Should a student receive an unsatisfactory rating from their co-op employer, an investigation by the co-op program manager will be undertaken. An unsatisfactory employer evaluation does not preclude a student from achieving an overall satisfactory rating for the work term.

Graduation with the Co-op Designation

In order to graduate with the co-op designation, students must satisfy all requirements for their degree program in addition to the requirements according to each co-op program (i.e. successful completion of three or four work terms).

Note: Participation in the co-op option will add up to one additional year for a student to complete their degree program.

Voluntary Withdrawal from the Co-op Option

Students may withdraw from the co-op option of their degree program during a study term ONLY. Students at work may not withdraw from the work term or the co-op option until s/he has completed the requirements of the work term.

Students are eligible to continue in their regular academic program provided that they meet the academic standards required for continuation.

Involuntary or Required Withdrawal from the Co-op Option

Students may be required to withdraw from the co-op option of their degree program for one or any of the following reasons:

1. Failure to achieve a grade of SAT in COOP 1000
2. Failure to pay all co-op related fees
3. Failure to actively participate in the job search process
4. Failure to attend all interviews for positions to which the student has applied
5. Declining more than one job offer during the job search process
6. Continuing a job search after accepting a co-op position
7. Dismissal from a work term by the co-op employer
8. Leaving a work term without approval by the Co-op manager
9. Receipt of an unsatisfactory work term evaluation
10. Submission of an unsatisfactory work term report

Standing and Appeals

The Co-op and Career Services office administers the regulations and procedures that are applicable to all co-op program options. All instances of a student's failure during a work term or other issues directly related to their participation in the co-op option will be reported to the academic department.

Any decision made by the Co-op and Career Services office can be appealed via the normal appeal process within the University.

International Students

All International Students are required to possess a Co-op Work Permit issued by Immigration, Refugees and Citizenship Canada before they can begin working. It is illegal to work in Canada without the proper authorization. Students will be provided with a letter of support to accompany their application. Students must submit their application for their permit before being permitted to view and apply for jobs on the Co-op Services database. Confirmation of a position will not be approved until a student can confirm they have received their permit. Students are advised to discuss the application process and requirements with the International Student Services Office.

Bachelor of Computer Science Honours and Major: Co-op Admission and Continuation Requirements

- Maintain full-time status in each study term;
- Be eligible to work in Canada (for off-campus work);
- Have successfully completed COOP 1000 .

In addition to the following:

1. Registered as a full-time student in the B.CS Honours or Major program;
2. Successfully completed 5.0 or more credits;
3. Successfully completed, by the start-date of the first work term, COMP 2404;
4. Obtained an Overall CGPA of at least 8.00 and a Major CGPA of at least 8.00. These CGPAs must be maintained throughout the duration of the degree.

B.CS Honours and Major students must successfully complete four (4) work terms to obtain the Co-op Designation.

Co-op Work Term Course: COMP 3999
Work/Study Pattern:

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern
Fall	S	Fall	S	Fall	W	Fall	S	Fall	S
Winter	S	Winter	S	Winter	S	Winter	W	Winter	S
Summer		Summer	W	Summer	W	Summer	W		

Legend
S: Study
W: Work

Admissions Information

Admission Requirements are for the 2024-25 year only, and are based on the Ontario High School System. Holding the minimum admission requirements only establishes eligibility for consideration. The cut-off averages for admission may be considerably higher than the minimum. See also the **General Admission and Procedures** section of this Calendar. An overall average of at least 70% is normally required to be considered for admission. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. The overall average required for admission is determined each year on a program by program basis. Consult admissions.carleton.ca for further details.

Note: Courses listed as *recommended* are not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Admissions Information

Admission requirements are based on the Ontario High School System. Prospective students can view the admission requirements through the Admissions website at admissions.carleton.ca. The overall average required for admission is determined each year on a program-by-program basis. Holding the minimum admission requirements only establishes eligibility for consideration; higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. All programs have limited enrolment and admission is not guaranteed. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Consult admissions.carleton.ca for further details.

Note: If a course is listed as *recommended*, it is not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Degree
- Bachelor of Computer Science (B.C.S.) (Honours)
- Bachelor of Computer Science (B.C.S.) (Major)

Admission Requirements
First Year
The Ontario Secondary School Diploma (OSSD) or equivalent, including a minimum of six 4U or M courses. The six 4U or M courses must include Advanced Functions, and Calculus and Vectors.

Advanced Standing
Applications for admission beyond first year will be assessed on their merits. Students must typically present a minimum CGPA of 7.00 (B-) in order to be considered for admission. Advanced standing will be granted only for those subjects assessed as being appropriate for the program and the stream selected. Students will not receive credit for courses graded below C-.

Co-op Option
Direct Admission to the First Year of the Co-op Option
Applicants must:

1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Bachelor of Computer Science Honours program;
3. be eligible to work in Canada (for off-campus work placements).

Meeting the above requirements only establishes eligibility for admission to the program. The prevailing job market may limit enrolment in the co-op option.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.

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 0999 [0.0 credit]
COMP Matters

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
Precludes additional credit for BIT 1400, CGSC 1005, COMP 1405, 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
Precludes additional credit for BIT 2400, BUSI 2402, COMP 1406, 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
Precludes additional credit for BIT 1400, CGSC 1005, COMP 1005, 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, 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
Precludes additional credit for BIT 2400, BUSI 2402, COMP 1006, ITEC 2400, ITEC 2401, SYSC 2004.
Prerequisite(s): COMP 1005 or 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, 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.
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 BCS.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1910 and registration in internship option.

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).
Prerequisite(s): (COMP 1006 or COMP 1406 or SYSC 2004) 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 or SYSC 2004) 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 2006.
Prerequisite(s): (COMP 1006 or COMP 1406 or SYSC 2004) 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 or SYSC 2004) 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 or SYSC 2004) 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 1501, COMP 2401 with a minimum grade of C-, and MATH 1104.
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 or SYSC 2004) 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.
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 BCS.
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.
Precludes additional credit for SYSC 3101.
Prerequisite(s): COMP 1805 with a minimum grade of C-, and COMP 2402.
Lectures three hours a week.

COMP 3008 [0.5 credit]
Human-Computer Interaction
Fundamentals of the underlying theories, design principles, development and evaluation practices of human-computer interaction (HCI). Topics may include: theories of interaction, user interface frameworks, desktop, web, mobile, and immersive applications, usability inspection and testing methods, and qualitative and quantitative approaches to HCI research.
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.
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).
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 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 BIOC 3008 and BIOL 3008.
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 either COMP 2804 or (MATH 2007 and MATH 2108).
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
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.
Includes: Experiential Learning Activity
Also listed as MATH 3807.
Prerequisite(s): A grade of C- or higher in COMP 3806 or 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.
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.
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 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 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 SYSC 4810.
Prerequisite(s): (COMP 3000 or SYSC 4001) and COMP 2108.
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 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 4308 [0.5 credit]
Computational Systems Biology
Modeling and simulation of metabolic and regulatory networks towards understanding complex and highly dynamic cellular systems. Biotechnological applications include metabolic engineering, synthetic biology, and drug discovery.
Includes: Experiential Learning Activity
Also listed as BIOC 4008.
Prerequisite(s): BIOC 3101 or permission of the Biochemistry Institute.
Lecture one and a half hours per week, workshop one and a half hours per 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
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.
Prerequisite(s): MATH 2152 or MATH 1102 (no longer offered) or MATH 2107; and MATH 2000 and COMP 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 web site.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4906.
Prerequisite(s): registration in the 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
An independent research project under the direct supervision of a faculty advisor. Permission to register is granted once an approved project 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.
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.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 4910 and registration in internship option.