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 Management and Business Systems Stream B.C.S. Honours
- Computer Science Software Engineering Stream B.C.S. Honours
- Computer Science Network Computing Stream B.C.S. Honours
- Computer Science Computer and Internet Security Stream B.C.S. Honours
- Computer Science Mobile Computing Stream B.C.S. Honours
- Computer Science Computer Game Development Stream B.C.S. Honours
- Computer Science B.C.S. Major
- 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
- SYSC 4507 [0.5] Computer Systems Architecture

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.

Natural Science Electives

This category is defined with the B.Math. programs. See the Mathematics Program section 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:

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

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:

- 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

3. 2.0 credits in:

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

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

4. 1.5 credits from:

- MATH 1007 [0.5] Elementary Calculus I

2021-2022 Carleton University Undergraduate Calendar 1
### B.C.S. Honours (20.0 credits)

**Computer Science**

**Industrial Applications Internship Option**

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

#### Courses Delivered at the Premises of the Industrial Partner - 4.0 credits

- **Internship Courses - 4.0 credits**
  - COMP 1910 [0.5] Internship
  - COMP 1911 [0.5] Internship
  - COMP 2910 [0.5] Internship
  - COMP 2911 [0.5] Internship
  - COMP 3910 [0.5] Internship
  - COMP 3911 [0.5] Internship
  - COMP 4910 [0.5] Internship
  - COMP 4911 [0.5] Internship

#### Courses to be Delivered On-Campus - 11.0 credits

- **Core BCS Courses - 11.0 credits**
  - 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 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 3008 [0.5] Design and Analysis of Algorithms I
  - 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

#### Breadth Electives - 5.0 credits

- Elective 1 [0.5]
- Elective 2 [0.5]
- Elective 3 [0.5]
- Elective 4 [0.5]
- Elective 5 [0.5]
- Elective 6 [0.5]
- Elective 7 [0.5]
- Elective 8 [0.5]
- Elective 9 [0.5]
- Elective 10 [0.5]

**B.C.S. Honours (20.0 credits)**

**Computer Science Algorithms Stream**

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

1. **6.5 credits in:**
   - 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 3008 [0.5] Design and Analysis of Algorithms I

2. **1.5 credits in:**
   - 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:**
   - COMP 4001 [0.5] Distributed Computing

4. **1.5 credits in:**
   - COMP 4905
   - COMP 4906

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

5. **1.5 credits from:**
   - 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:**
   - STAT 2507 [0.5] Introduction to Statistical Modeling I

7. **5.0 credits in Breadth Electives**

8. **3.0 credits in free electives**

**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)**

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

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

**3. 2.0 credits in: | 2.0**

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

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

<table>
<thead>
<tr>
<th>4. 1.5 credits from:</th>
<th>1.5</th>
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</thead>
<tbody>
<tr>
<td>MATH 1007 [0.5]</td>
<td>Elementary Calculus I</td>
</tr>
<tr>
<td>MATH 1104 [0.5]</td>
<td>Linear Algebra for Engineering or Science</td>
</tr>
<tr>
<td>0.5 credit in MATH at the 2000-level or above</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. 0.5 credit in:</th>
<th>0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 2507 [0.5]</td>
<td>Introduction to Statistical Modeling I</td>
</tr>
</tbody>
</table>

**6. 1.0 credit from: | 1.0**

| BUSI 1003 and 0.5 credit in BUSI at the 2000-level, or |
|-------------------|-----|
| BUSI 1001 [0.5] | Principles of Financial Accounting |
| & BUSI 1002 [0.5] | Management Accounting |

**7. 2.0 credits in: | 2.0**

<table>
<thead>
<tr>
<th>BUSI 2121 [0.5]</th>
<th>Introduction to Organizational Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUSI 2301 [0.5]</td>
<td>Introduction to Supply and Operations Management</td>
</tr>
<tr>
<td>BUSI 2503 [0.5]</td>
<td>Introduction to Finance</td>
</tr>
<tr>
<td>BUSI 3402 [0.5]</td>
<td>Systems Analysis and Design</td>
</tr>
</tbody>
</table>

**8. 1.0 credit in: | 1.0**

<table>
<thead>
<tr>
<th>ECON 1001 [0.5]</th>
<th>Introduction to Microeconomics</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 1002 [0.5]</td>
<td>Introduction to Macroeconomics</td>
</tr>
</tbody>
</table>

**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
#### Network Computing Stream

**B.C.S. Honours (20.0 credits)**

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

<table>
<thead>
<tr>
<th>1. 6.5 credits in:</th>
<th>6.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 1405 [0.5]</td>
<td>Introduction to Computer Science I</td>
</tr>
<tr>
<td>COMP 1406 [0.5]</td>
<td>Introduction to Computer Science II</td>
</tr>
<tr>
<td>COMP 1805 [0.5]</td>
<td>Discrete Structures I</td>
</tr>
<tr>
<td>COMP 2401 [0.5]</td>
<td>Introduction to Systems Programming</td>
</tr>
<tr>
<td>COMP 2402 [0.5]</td>
<td>Abstract Data Types and Algorithms</td>
</tr>
</tbody>
</table>

**1. 0.5 credit in: | 0.5**

| COMP 3008 [0.5] | Human-Computer Interaction |

**3. 1.5 credits in: | 1.5**

<table>
<thead>
<tr>
<th>COMP 4004 [0.5]</th>
<th>Software Quality Assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSC 3303 [0.5]</td>
<td>Real-Time Concurrent Systems</td>
</tr>
<tr>
<td>SYSC 4106 [0.5]</td>
<td>The Software Economy and Project Management</td>
</tr>
</tbody>
</table>

**4. 1.0 credit from: | 1.0**

| COMP 4905 and 0.5 credit in COMP at the 4000-level, or |
|-------------------|-----|
| COMP 4906 [1.0] | Honours Thesis |

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

<table>
<thead>
<tr>
<th>5. 1.5 credits from:</th>
<th>1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1007 [0.5]</td>
<td>Elementary Calculus I</td>
</tr>
<tr>
<td>MATH 1104 [0.5]</td>
<td>Linear Algebra for Engineering or Science</td>
</tr>
<tr>
<td>0.5 credit in MATH at the 2000-level or above</td>
<td></td>
</tr>
</tbody>
</table>

**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**
B.C.S. Honours (20.0 credits)

Computer Science

1. 6.5 credits in:
   - 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:
   - COMP 3008 [0.5] Human-Computer Interaction
   - COMP 3109 [0.5] Applied Cryptography and Authentication
   - COMP 3203 [0.5] Principles of Computer Networks
   - COMP 4108 [0.5] Computer Systems Security

3. 1.0 credit in COMP at the 4000-level including one of
   - COMP 4905 [0.5] Honours Project
   - COMP 4906 [1.0] Honours Thesis

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

4. 1.5 credits from:
   - MATH 1007 [0.5] Elementary Calculus I
   - MATH 1104 [0.5] Linear Algebra for Engineering or Science

5. 0.5 credit in:
   - STAT 2507 [0.5] Introduction to Statistical Modeling I

6. 5.0 credits in Breadth Electives

7. 3.5 credits in free electives.

Total Credits 20.0

Computer Science

Mobile Computing Stream

B.C.S. Honours (20.0 credits)

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

1. 6.5 credits in:
   - 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 1601 [0.5] Introduction to Mobile Application Development
   - COMP 2601 [0.5] Mobile Applications

3. 0.5 credit from
   - COMP 4601 [0.5] Intelligent Web-based Information Systems
   - COMP 4602 [0.5] Social Networking

4. 1.5 credits in:
   - COMP 4905 and 1.0 credit in COMP at the 4000-level, or
   - COMP 4906 and 0.5 credit in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (10.5 credits)
### Computer Science
#### Computer Game Development Stream

**B.C.S. Honours (20.0 credits)**

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>COMP 1405</td>
<td>Introduction to Computer Science I</td>
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<tr>
<td>COMP 1406</td>
<td>Introduction to Computer Science II</td>
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<tr>
<td>COMP 1805</td>
<td>Discrete Structures I</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 2401</td>
<td>Introduction to Systems Programming</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 2402</td>
<td>Abstract Data Types and Algorithms</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 2404</td>
<td>Introduction to Software Engineering</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 2406</td>
<td>Fundamentals of Web Applications</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 2804</td>
<td>Discrete Structures II</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 3000</td>
<td>Operating Systems</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 3004</td>
<td>Object-Oriented Software Engineering</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 3005</td>
<td>Database Management Systems</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 3007</td>
<td>Programming Paradigms</td>
<td>0.5</td>
</tr>
<tr>
<td>COMP 3804</td>
<td>Design and Analysis of Algorithms I</td>
<td>0.5</td>
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</table>

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

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>MATH 1007</td>
<td>Elementary Calculus I</td>
<td>0.5</td>
</tr>
<tr>
<td>MATH 1104</td>
<td>Linear Algebra for Engineering or Science</td>
<td>0.5</td>
</tr>
<tr>
<td>STAT 2507</td>
<td>Introduction to Statistical Modeling I</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Total Credits** 20.0

### Computer Science and Mathematics

**B.Math. Combined Honours (20.0 credits)**

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1052</td>
<td>Calculus and Introductory Analysis I</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 1152</td>
<td>Introductory Algebra I</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 1800</td>
<td>Introduction to Mathematical Reasoning</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 2000</td>
<td>Multivariable Calculus and Fundamentals of Analysis</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 2052</td>
<td>Calculus and Introductory Analysis II</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 2100</td>
<td>Algebra</td>
<td>1.0</td>
</tr>
<tr>
<td>MATH 2152</td>
<td>Introductory Algebra II</td>
<td>1.0</td>
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</table>

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

<table>
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<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MATH 1107</td>
<td>Linear Algebra for Engineering or Science</td>
<td>0.5</td>
</tr>
<tr>
<td>STAT 2507</td>
<td>Introduction to Statistical Modeling I</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**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)**

<table>
<thead>
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<th>Title</th>
<th>Credits</th>
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<tbody>
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<td>MATH 1152</td>
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<td>MATH 1800</td>
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<tr>
<td>MATH 2000</td>
<td>Multivariable Calculus and Fundamentals of Analysis</td>
<td>1.0</td>
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<td>Calculus and Introductory Analysis II</td>
<td>1.0</td>
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<tr>
<td>MATH 2100</td>
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<td>1.0</td>
</tr>
<tr>
<td>MATH 2152</td>
<td>Introductory Algebra II</td>
<td>1.0</td>
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</table>

**Total Credits** 20.0
2. 6.0 credits in:
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. 6.0 credits in:
MATH 4811
MATH 4808
MATH 4807
MATH 4806
MATH 4805
MATH 4803
MATH 4802
MATH 4801
MATH 4109
MATH 4002
MATH 3806
MATH 3804
MATH 3803
MATH 3008
MATH 3007
MATH 3006
MATH 3005
MATH 3004
MATH 3003
MATH 3002
MATH 3001
MATH 2804
MATH 2404
MATH 2402
MATH 2401
MATH 2400
MATH 2306
MATH 2305
MATH 2304
MATH 2303
MATH 2302
MATH 2301
MATH 2000
MATH 1800
MATH 1700
MATH 1600
MATH 1500
MATH 1400
MATH 1300
MATH 1200
MATH 1100
MATH 1000

4. 3.0 credits from:
MATH 2454 [0.5] Ordinary Differential Equations (Honours)

5. 3.0 credits from:
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:
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)

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

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

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

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 2400 [0.5] Foundations of Information Systems
BUSI 4400 [0.5] IS Strategy, Management and Acquisition
BUSI 4406 [0.5] Business Analytics

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:
MATH 1052 [0.5] Calculus and Introductory Analysis I
MATH 1152 [0.5] Real Analysis I
MATH 1151 [0.5] Real Analysis II
MATH 1000 [0.5] Advanced Calculus
MATH 2000 [1.0] Multivariable Calculus
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:
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

Total Credits
20.0

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 2400 [0.5] Foundations of Information Systems
BUSI 4400 [0.5] IS Strategy, Management and Acquisition
BUSI 4406 [0.5] Business Analytics

Engineering
SYSC 3303 [0.5] Real-Time Concurrent Systems
SYSC 4005 [0.5] Discrete Simulation/Modeling
SYSC 4507 [0.5] Computer Systems Architecture
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 3805</td>
<td>Discrete Structures and Applications (Honours)</td>
</tr>
</tbody>
</table>

**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 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.

**Requirements**

<table>
<thead>
<tr>
<th>Component</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2.5 credits in:</td>
<td>2.5</td>
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<tr>
<td>COMP 1005 [0.5]</td>
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<tr>
<td>COMP 1006 [0.5]</td>
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<tr>
<td>COMP 2401 [0.5]</td>
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<td>COMP 2402 [0.5]</td>
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<td>COMP 2404 [0.5]</td>
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<tr>
<td>COMP 3805 [0.5]</td>
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<tr>
<td>COMP 4905 [0.5]</td>
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<tr>
<td>STAT 4905 [0.5]</td>
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<tr>
<td>2. 1.0 credit from:</td>
<td>1.0</td>
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<tr>
<td>COMP 1805 [0.5]</td>
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</tr>
<tr>
<td>3. 0.5 credit in COMP at the 3000-level or above</td>
<td>0.5</td>
</tr>
<tr>
<td>4. Course equivalencies and transfer credits can be used for at least 2.0 credits of the minor; the remaining 2.0 credits must be courses listed in the COMP section of this Calendar</td>
<td></td>
</tr>
<tr>
<td>5. The remaining requirements of the major discipline(s) and degree must be satisfied.</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credits**

| Total Credits | 20.0 |

**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 is admitted to co-op from high school, their grades will be reviewed two terms to one year prior to their first work term to ensure they continue to meet the academic requirements after their 1st or 2nd year of study. The time at which evaluation takes place depends on the program of study. Students will automatically be notified via their Carleton email account if they are permitted to continue.
Students not admitted to Carleton University with the co-op option on their degree can apply for admission via the co-operative education program website. To view application deadlines, visit carleton.ca/co-op.

Admission to the co-op option is based on the completion of 5.0 or more credits at Carleton University, the CGPA requirement for the students’ academic program as well as any course prerequisites. The articulated CGPA for each program is the normal standard for assessment. Please see the specific degree program sections for the unique admission and continuation requirements for each academic program.

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 (2.0 credits). 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 (2.0 credits);
- Be eligible to work in Canada (for off-campus work);
- Have successfully completed COOP 1000 [0.0]

In addition to the following:
1. A major CGPA of 8.00 or higher and an overall CGPA of 8.00 or higher;
2. Successfully completed 3.0 required credits in Computer Science, including one of COMP 2402 or COMP 2404;
3. Registered as a full-time student in the Bachelor of Computer Science program (2.0 credits).

Bachelor of Computer Science Honours and Major students must successfully complete four (4) work terms to obtain the Co-op designation.

Co-op Work Term Course: COMP 3999

<table>
<thead>
<tr>
<th>Work/Study Pattern</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term Pattern</td>
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<td>Pattern</td>
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<td>Term</td>
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<tr>
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<td>Fall W</td>
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<tr>
<td>Winter S</td>
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<td>Winter</td>
<td>Winter S</td>
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<tr>
<td>Summer <strong>O</strong></td>
<td>Summer</td>
<td>Summer</td>
<td>Summer</td>
<td>Summer</td>
<td>W</td>
</tr>
</tbody>
</table>

Legend
- S: Study
- W: Work
- O: Optional
* indicates recommended work study pattern

** student finds own employer for this work-term.

Admissions Information
Admission Requirements are for the 2021-22 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.

Degree
- • B.C.S. (Major)
- • B.C.S. (Honours)

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 individual merits. 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).

Note that 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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 0999</td>
<td>0.0</td>
<td>COMP Matters</td>
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<tr>
<td>COMP 1001</td>
<td>0.5</td>
<td>Introduction to Computational Thinking for Arts and Social Science Students</td>
</tr>
<tr>
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<td>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.</td>
</tr>
<tr>
<td>COMP 1005</td>
<td>0.5</td>
<td>Introduction to Computer Science I</td>
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<tr>
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<td></td>
<td>A first course in programming, emphasizing problem solving and computational thinking. Topics include pseudocode, variables, conditionals, iteration, arrays, objects, functions, sorting, searching, and simulation. Includes: Experiential Learning Activity Precludes additional credit for BIT 1400, 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.</td>
</tr>
<tr>
<td>COMP 1006</td>
<td>0.5</td>
<td>Introduction to Computer Science II</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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 1006, 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.</td>
</tr>
<tr>
<td>COMP 1501</td>
<td>0.5</td>
<td>Introduction to Computer Game Design</td>
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<tr>
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<td></td>
<td>Introduction to computer game programming interfaces. Topics may include: game balance and level design; storytelling and narrative; basic game architecture; sprite-based games and isometric games; representation of scenes; user interaction; architecture of game consoles; development tools for game consoles; interaction with game peripherals. Prerequisite(s): COMP 1005 or COMP 1405. Lectures three hours a week, tutorial one and a half hours a week.</td>
</tr>
</tbody>
</table>
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 B.C.S.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1910 and registration in internship option.

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.
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 and tutorial one and a half hours a week.

COMP 2501 [0.5 credit]
Computer Game Design and Development
Topics may include: user interaction in multiplayer games, representation of animated scenes, tools for game character development, special effects, sound programming, game AI, motion planning and control, collision detection and physics, digital rights management.
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
An introduction to the field of mobile robots and their applications from a computer science perspective. The course will discuss common robot programming architectures and strategies. Students will build various robot configurations and experiment with a variety of sensors using behavior-based programming.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 1006 or COMP 1406 or SYSC 2004 with a minimum grade of C-.
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 or SYSC 2100).
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 or SYSC 2100).
Lectures three hours a week.

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

COMP 3005 [0.5 credit]
Database Management Systems
Introduces students to concepts of database management systems, database design and file structures. Topics include: entity-relationship modeling and object oriented database design, data models (relational, network and object oriented), the relational algebra, SQL, normalization theory, physical data organization, object oriented databases and OQL.
Precludes additional credit for BUSI 3400.
Prerequisite(s): COMP 1805 with a minimum grade of C-, and either COMP 2402 or (SYSC 2004 and SYSC 2100).
Lectures three hours a week.
COMP 3007 [0.5 credit]
Programming Paradigms
An introduction to alternative programming paradigms such as functional, constraint-based, concurrent, and logic programming.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3101.
Prerequisite(s): COMP 1805 with a minimum grade of C-, and either COMP 2402 or (SYSC 2004 and SYSC 2100).
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.
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 or SYSC 2100), MATH 1007, and MATH 1104.
Lectures/lab four hours a week.

COMP 3106 [0.5 credit]
Introduction to Artificial Intelligence
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4106 (no longer offered).
Prerequisite(s): (COMP 2402 or SYSC 2100) and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2804.
Lectures three hours a week.

COMP 3108 [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 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
Mathematical concepts of 3D engines. Topics may include: illumination and visibility determination; quaternions; homogeneous coordinates; transforms; ray tracing; bump mapping; portal systems; polygonal techniques; shadows; and linear and rotational physics.
Prerequisite(s): (COMP 2402 or SYSC 2100) 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.
Prerequisites 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 or SYSC 2100) and either COMP 2804 or (MATH 2007 and MATH 2108).
Lectures three hours a week.

COMP 3805 [0.5 credit]
Discrete Structures and Applications (Honours)
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 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. Includes: Experiential Learning Activity
Prerequisite(s): (COMP 3000 or SYSC 4001) and (COMP 3203 or SYSC 4602).
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).
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.
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 or SYSC 2100) and (COMP 2404 or SYSC 3010 or SYSC 3110) and COMP 2804.
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.
Prerequisite(s): (COMP 2404 or SYSC 3010 or SYSC 3110) and (MATH 1104 or MATH 1107).
Lectures three hours a week.

COMP 4105 [0.5 credit]
Machine Learning
A subset of topics in Artificial Intelligence that emphasize algorithms and statistical models that rely on patterns and inference. Some topics include decision trees, dimension reduction, ensemble methods, Support Vector Machines, some of the fundamental aspects of Neural Networks, and clustering.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3106 and (MATH 1104 or MATH 1107).
Lecture three hours a week.
COMP 4107 [0.5 credit]  
**Neural Networks**  
Theory and application of Neural Networks to problems in machine learning. Topics include explanation of the representation, transformation and compression of data, biological models, Hebbian learning and the Perceptron. Modern neural network architectures, including feed forward, recurrent, convolutional and generative adversarial are introduced.  
Includes: Experiential Learning Activity  
Precludes additional credit for COMP 5206.  
Prerequisite(s): COMP 3106 and (MATH 1104 or MATH 1107).  
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 SYSC 4810.  
Prerequisite(s): (COMP 3000 or SYSC 4001) and COMP 3109.  
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 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.  
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, RFID, and rogue attacks.  
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 advanced facilities of game engines. Such facilities include notions such as physics engines, shadow mapping, lighting with thousands of lights, relief mapping, ambient occlusion, water flow, deferred rendering, occlusion culling, water effects, mirrors, and screen space reflection.  
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.
Includes: Experiential Learning Activity
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 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]
Advanced Topics in Computer Science
Selected 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.