Faculty of Mathematics

About the Faculty of Mathematics

Overview of Faculty
The Faculty of Mathematics consists of the Departments of Applied Mathematics, Combinatorics and Optimization, Pure Mathematics, and Statistics and Actuarial Science, and the David R. Cheriton School of Computer Science. The Faculty offers a four-year honours program leading to the degree Bachelor of Mathematics (BMath) in fields of study corresponding to each of the Departments and the School, as well as in Mathematical Studies, Mathematics/Business, Mathematics/Chartered Professional Accountancy, and Mathematics/Financial Analysis and Risk Management. The Faculty also offers a four-year honours program leading to the degree Bachelor of Computer Science (BCS). In co-operation with the Faculty of Engineering, the Mathematics Faculty offers a program leading to the degree Bachelor of Software Engineering (BSE). In co-operation with the Faculty of Arts, the Mathematics Faculty offers a four-year honours program in Computing and Financial Management (BCFM).

The Faculty also offers graduate programs leading to the following degrees: Master of Mathematics (MMath), Masters of Mathematics for Teachers, and Doctor of Philosophy (PhD). Detailed information is contained in the University of Waterloo Graduate Studies Calendar.

Admission
Admission requirements and procedures for all plans are described in the Admissions section.

Most students are admitted directly from secondary school. However, students who are enrolled in another faculty in the University of Waterloo, or at another university, may apply to transfer to the Faculty of Mathematics. Applicants should have strong academic records. (See Faculty Policies for additional policies concerning transfer students and transfer credits.) In addition, a student who has been away from formal education for more than two years may apply as a mature student. Although the University of Waterloo does not automatically offer admission to mature applicants, the Admissions Committee carefully considers previous academic records, résumés, and other biographical material before determining a candidate's suitability for university studies. Students must be able to demonstrate recent academic proficiency in Mathematics at the senior high school level. For applicants who are lacking the appropriate background, the Centre for Extended Learning offers an online course in Calculus.

Access to Programs, Plans, and Courses

Practical circumstance, such as significant budget shortfalls or the unavailability of qualified personnel, may result in restrictions in the choices available to students as compared with those listed herein or in other University publications. The University reserves the right to limit access to courses or programs/plans, and, at its discretion, to withdraw particular programs, plans/sub plans/options/minors, or courses altogether. In the event that existing resources make it necessary to limit admission to a plan, sub plan, option, or minor, the admission process will be based on competition for the spaces available.

Recognition of Excellence

Alumni Gold Medal

An alumni Gold Medal is presented annually, usually at spring convocation, to recognize the academic excellence of the Math Faculty's most outstanding undergraduate student.

K.D. Fryer Gold Medal

The K.D. Fryer Gold Medal is presented annually, at fall convocation, to a graduating Math student who best exemplifies academic excellence and good student citizenship.

Graduating "With Distinction - Dean's Honours List"

In recognition of outstanding academic records throughout their undergraduate careers, all students who graduate with a Honours Bachelor of Computer Science (BCS) or Bachelor of Mathematics (BMath) degree, have a cumulative average (CAV) of at least 87%, and do not have any INC (Incomplete course work), IP (Course in progress), or UR (Grade under review) grades are eligible to graduate "With Distinction - Dean's Honours List." In addition to having this notation appear on their official University transcripts and diplomas, such students have their names displayed in gold on the walls of the MC corridor 4066.

Graduating "With Distinction"

In recognition of distinguished academic achievement throughout their undergraduate careers, all students who graduate with a Honours BCS or BMath degree, either four-year honours or three-year general, a cumulative average (CAV) of at least 80%, and do not have any INC, IP, or UR grades are eligible to graduate "With Distinction." This notation appears on official University transcripts and diplomas.

Term Dean's Honours List

In recognition of outstanding academic achievement in an academic term, the designation "Term Dean's Honours List" is awarded to undergraduate Math students who satisfy all of the following criteria for the term:

- registered in an honours plan with a term average (TAV) of at least 87%;
- normally enrolled in at least 2.5 units of courses with numeric or letter grades;
- no failed or excluded courses;
- no INC, IP, or UR grades;
- at least 2.5 units of courses without a grade of WD.

J. Alan George Award

The J. Alan George Award is presented annually, at the Math Graduation Ball, to a graduating Math student who best exemplifies student leadership and dedicated involvement in student affairs on campus for the benefit of Math students.

List of Academic Programs/Plans

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
Co-op vs. Regular
Most of the Faculty’s plans are available in both the regular and co-operative systems of study. Plans that are offered only for co-op students are explicitly indicated in the list of plans below.

Honours Bachelor of Mathematics (BMath) Academic Plans
The Faculty offers the following honours plans leading to a BMath degree:

Actuarial Science plans:
- Actuarial Science
- Actuarial Science/Finance Option
- Actuarial Science/Predictive Analytics Option

Applied Mathematics plans:
- Applied Mathematics
- Applied Mathematics/Biology Option
- Applied Mathematics/Earth Sciences Option
- Applied Mathematics/Economics Option
- Applied Mathematics/Physics Option
- Applied Mathematics with Engineering Electives
- Mathematical Physics
- Scientific Computation/Applied Mathematics

Combinatorics and Optimization plans:
- Combinatorics and Optimization
- Mathematical Optimization - Business Specialization
- Mathematical Optimization - Operations Research Specialization

Computer Science BMath plans:
- Computer Science
- Computer Science/Bioinformatics Option
- Computer Science/Business Option
- Computer Science/Computational Fine Art Option
- Computer Science/Digital Hardware Option
- Computer Science/Human-Computer Interaction Option
- Computer Science/Software Engineering Option

Computer Science also offers other plans. See below.

Pure Mathematics plans:
- Pure Mathematics
- Pure Mathematics/Teaching (co-op only)

Statistics plans:
- Data Science
- Statistics
- Statistics for Health

Plan run jointly by Actuarial Science and Pure Mathematics:
- Mathematical Finance

Mathematics and Business plans, administered by a subcommittee of Combinatorics and Optimization, Computer Science, and Statistics and Actuarial Science:
- Information Technology Management
- Mathematical Economics
- Mathematics/Business Administration
- Mathematics/Chartered Professional Accountancy (co-op only)
Mathematics/Chartered Professional Accountancy – Finance Option (co-op only)
Mathematics/Financial Analysis and Risk Management - Professional Risk Management Specialization

Plans administered by the Centre for Education in Mathematics and Computing:

Mathematics/Teaching (co-op only)

Plans administered by the Dean's Office:

Computational Mathematics
Mathematical Studies
Mathematical Studies - Business Specialization

Honours Bachelor of Computer Science (BCS) Academic Plans
Through the David R. Cheriton School of Computer Science, the Faculty offers the following honours plans leading to a BCS degree:

Computer Science
Computer Science/Bioinformatics Option
Computer Science/Business Option
Computer Science/Computational Fine Art Option
Computer Science/Digital Hardware Option
Computer Science/Human-Computer Interaction Option
Computer Science/Software Engineering Option
Data Science

Double Degree Academic Plans
The School of Business and Economics at Wilfrid Laurier University and the Faculty of Mathematics at the University of Waterloo offer the following plan which leads to an Honours Bachelor of Business Administration (BBA) degree from Wilfrid Laurier University and an Honours BMath degree from the University of Waterloo.

Business Administration and Mathematics (co-op only)

The School of Business and Economics at Wilfrid Laurier University and the David R. Cheriton School of Computer Science at the University of Waterloo offer the following plan which leads to an Honours BBA degree from Wilfrid Laurier University and an Honours BCS degree from the University of Waterloo.

Business Administration and Computer Science (co-op only)

Honours Computing and Financial Management
The Bachelor of Computing and Financial Management (BCFM) Steering Committee administers this program which leads to the Bachelor of Computing and Financial Management (BCFM) degree. The committee consists of faculty from the David R. Cheriton School of Computer Science in the Faculty of Mathematics and the School of Accounting and Finance in the Faculty of Arts.

Computing and Financial Management (co-op only)

Honours Software Engineering
The Software Engineering Program Board administers this program, which leads to the Bachelor of Software Engineering (BSE) degree. The board consists of faculty from the David R. Cheriton School of Computer Science in the Faculty of Mathematics and from the Department of Electrical and Computer Engineering in the Faculty of Engineering.

Software Engineering (co-op only)

Computer Science Plans
Computer Science (CS) major plans are:

- All BCS plans
• Computer Science BMath plans
• Any Joint Computer Science plan
• Computing and Financial Management and Software Engineering are considered CS major plans for the purpose of student access to CS courses, but admission and continuation are handled separately.

Admission to Specific Honours Academic Plans

Admission to Specific Honours Academic Plans
Any honours student in good standing before their 3A term may enrol in the plan of their choice, subject to the limitations below. Students in 3A or later may be admitted to specific honours plans at the discretion of the relevant department or other academic unit, as appropriate.

1. The following plans are limited enrolment plans:
   • Actuarial Science (all plans)
   • Business Administration and Computer Science Double Degree
   • Business Administration and Mathematics Double Degree
   • Computer Science
   • Data Science (all plans)
   • Financial Analysis and Risk Management
   • Health Informatics Option
   • Information Technology Management
   • Mathematics/Business Administration
   • Mathematics/Chartered Professional Accountancy (all plans)
   • Mathematics/Teaching
   • Pure Mathematics/Teaching
   • Software Engineering
   • Statistics for Health

2. Students are not admitted to specific honours plans before their 2A term, except for the following plans:
   • Applied Mathematics/Engineering Electives
   • Business Administration and Mathematics Double Degree
   • Computer Science (all major plans)
   • Financial Analysis and Risk Management
   • Information Technology Management
   • Mathematics/Business Administration
   • Mathematics/Chartered Professional Accountancy (all plans)

3. Students are normally admitted to Software Engineering in Year One.

4. Admission to Actuarial Science requires a special major average of at least 70% and no more than one excluded course. A student with no special major average requires a cumulative average of at least 70% on at least ten non-excluded courses, provided they have no failed courses. In addition, a minimum grade of 60% in MTHEL 131 is an admission requirement for the following plans:
   • Honours Actuarial Science
   • Honours Actuarial Science/Finance Option
   • Honours Actuarial Science/Predictive Analytics Option
   • Joint Actuarial Science
   • Actuarial Science Minor

   For Business Administration and Mathematics Double Degree students only, a minimum grade of C- in BUS 121W can be substituted for the MTHEL 131 requirement.

5. Both the Bachelor of Mathematics (Data Science) and Bachelor of Computer Science (Data Science) plans are limited enrolment plans, and students are not normally admitted to either plan before their 2A term. Admission to either plan requires a math major average of at least 65% (calculated over all math and computer science courses) and a CS major average of at least 70%. In addition, students must have completed at least one term in the Faculty of Mathematics with a typical course load for a Computer Science major, have credit for either CS 136 or CS 146, and must otherwise meet all criteria for admission to a Computer Science major plan.
Bachelor of Computer Science and Bachelor of Mathematics Plan Combinations

Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations

Students pursuing a Bachelor of Computer Science (BCS) or Bachelor of Mathematics (BMath) degree may enrol in up to three academic plans, subject to the limitations below. These rules also apply to the set of plans that appear on a student's diploma and convocation program, and they apply to the student's transcript as well, with the exception that notes may be added to the transcript to reflect successful completion of plans beyond the third one.

Note
The rules in this section do not apply to students seeking a Bachelor of Computing and Financial Management (BCFM), Bachelor of Science (BSc), or Bachelor of Software Engineering (BSE) degree.

Eligible Plan Categories (in plan-sequencing priority order – top highest, bottom lowest)

1. “Stand-alone” Math Faculty Honours plans
2. Math Faculty Joint Honours plans
   - BCS Joint can be combined with a BMath Joint Honours
3. Non-Math Joint Honours plans
   - BCS Joint and BMath Joint plans can be combined with a non-Math Joint Honours (acceptable non-Math Joint Honours plans are listed in the non-Math faculty section of the Calendar)
4. Math Faculty minors or options
5. Non-Math minors or options

Plans will be listed on a student's diploma in the above order.

A BCS or BMath student’s plan must include one of the following:
- A stand-alone Math Faculty Honours plan, or
- Two Math Faculty Joint Honours plans, or
- A Joint BCS plan and a non-Math Joint Honours plan (acceptable non-Math Joint Honours plans are listed in the non-Math faculty section of the Calendar)

More plans may be added subject to the other restrictions of this section. The plan listed first on a graduating student’s diploma will dictate the student’s degree: if the first plan is a BCS plan, then the student will graduate with a BCS. If the first plan is a BMath plan, then the student will graduate with a BMath.

Math Faculty Joint Honours Plans

Joint honours academic plans both offered by the Math Faculty, in conjunction with the common degree requirements in Table I, require a total of 40 courses (20 units): the ten mathematics courses in the Faculty core (outlined in Table II) plus the joint requirements of the two departments/school for a minimum of 26 mathematics courses, and at least ten non-math courses (five units). Joint requirements for each department/school can be found in the corresponding department/school description.

Restrictions on Multiple-Plan Combinations

1. A stand-alone BCS plan cannot be combined with any BMath plan (including Joint Honours plans).
3. The BMath (Data Science) and BCS (Data Science) plans cannot be combined with any other Faculty of Mathematics Honours or Joint Honours plan.
4. With the exception of Mathematical Finance, which can be combined with another Actuarial Science and/or Pure Mathematics plan, no student may enrol in or graduate from two plans from the same group in the following list:
   - All plans offered by Actuarial Science
   - All plans offered by Applied Mathematics
   - All plans offered by Combinatorics and Optimization (including all Mathematical Optimization plans)
Specific Invalid Multiple-Plan Combinations

<table>
<thead>
<tr>
<th>Plan</th>
<th>Cannot be Combined With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Business Administration (BBA)/BCS or BBA/BMath with Double Degree plans</td>
<td>Any plan similar to one appearing on the student's Wilfrid Laurier University's academic record transcript</td>
</tr>
<tr>
<td>BCS/Business Option or BMath (Computer Science)/Business Option</td>
<td>A minor or option in Economics, Human Resources Management, or Management Studies</td>
</tr>
<tr>
<td>BCS/Bioinformatics Option or BMath (CS) Bioinformatics</td>
<td>Any plan offered by the Biology Department</td>
</tr>
<tr>
<td>Applied Mathematics/Biology Option</td>
<td>Any plan offered by the Biology Department</td>
</tr>
<tr>
<td>Applied Mathematics/Earth Sciences Option</td>
<td>Any plan offered by the Earth and Environmental Sciences Department</td>
</tr>
<tr>
<td>Applied Mathematics/Economics Option</td>
<td>Any plan offered by the Economics Department</td>
</tr>
<tr>
<td>Applied Mathematics/Physics Option</td>
<td>Any plan offered by the Physics Department</td>
</tr>
<tr>
<td>Mathematical Economics</td>
<td>Any other plan offered by the Economics Department</td>
</tr>
<tr>
<td>Computing Technology Option</td>
<td>Computer Science Minor or Information Technology Management</td>
</tr>
<tr>
<td>Mathematical Physics</td>
<td>Any other plan offered by the Physics Department</td>
</tr>
<tr>
<td>Mathematical Studies (with or without a Business Specialization)</td>
<td>Any other stand-alone or Math Joint plan</td>
</tr>
<tr>
<td>Mathematical Studies/Business Specialization</td>
<td>A Management Studies Option or Minor</td>
</tr>
<tr>
<td>Scientific Computation/Applied Mathematics</td>
<td>Any plan offered by Computational Mathematics</td>
</tr>
</tbody>
</table>

Academic Plans and Requirements

Degree Requirements for all Math students

Degree Requirements for all Math students

- Table I – Degree Requirements
- Communication Skills Requirement
- Table II – Faculty Core Courses
- Responsibility For Meeting Degree Requirements
- Incompatibility of Full-time Study with Full-time Employment
- Honours Fallback Provision

Table I - Degree Requirements

Legend

* The minimum co-op work term course units for the Chartered Accountancy and Teaching plans are 2.0.
** WKRPT courses have a credit weight of 0.13 units. A student needs PD 11 (formerly PD 2) and three WKRPT courses to satisfy the ‘four work report’ requirement.
*** Students in Mathematical Studies plans are permitted up to 4.0 units of failed or excluded courses.
**** This requirement may be waived at the discretion of the student’s academic advisor.
<table>
<thead>
<tr>
<th>Requirements</th>
<th>Four-Year Honours Plans</th>
<th>Double Degree Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Co-op</td>
<td>Regular</td>
</tr>
<tr>
<td>Minimum course units (excluding courses with the subject COOP, PD, and WKRPT)</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Minimum COOP course units</td>
<td>2.5*</td>
<td>0</td>
</tr>
<tr>
<td>Minimum PD course units</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Minimum WKRPT course units</td>
<td>.39**</td>
<td>0</td>
</tr>
<tr>
<td>Minimum non-math units</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Minimum Cumulative Average (CAV)</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Minimum Major Average (MAV)</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>• All AMATH (including Mathematical Physics), C&amp;O (including Mathematical Optimization), PMATH, and STAT plans</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>• Mathematical Finance</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>In addition, a minimum special major average (SMAV) may apply. Please see the more comprehensive table of major averages.</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Maximum failed or excluded course units (excluding courses with the subject COOP, PD, and WKRPT)</td>
<td>2.0***</td>
<td>2.0***</td>
</tr>
<tr>
<td>Maximum unusable course attempts</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Maximum allowed units of course attempts (excluding courses with the subject COOP, PD, and WKRPT)****</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Minimum number of full-time terms</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Communication Skills</td>
<td>All degree candidates must satisfy a Communication Skills requirement. See below.</td>
<td></td>
</tr>
</tbody>
</table>

The terms used in Table I are explained below:
### Term Description

<table>
<thead>
<tr>
<th>Term</th>
<th>Term Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus</td>
<td>Any of the following courses: MATH 116, MATH 117, MATH 127, MATH 137, MATH 147.</td>
</tr>
<tr>
<td>Calculus 2</td>
<td>Any of the following courses: MATH 118, MATH 119, MATH 128, MATH 138, MATH 148.</td>
</tr>
<tr>
<td>Course Attempt</td>
<td>Any course enrolment for which a student is assigned a final grade, including a grade of WD (Withdrew after the drop deadline, no credit granted). Transfer credits from other institutions are also considered to be course attempts.</td>
</tr>
<tr>
<td>Cumulative Average</td>
<td>See 'Averages for Math students' in Faculty Policies.</td>
</tr>
<tr>
<td>Excluded Course</td>
<td>A course taken between fall 2004 and spring 2013 either with a grade below 50, or that a student has voluntarily excluded.</td>
</tr>
<tr>
<td>Full-time Term</td>
<td>A term in which a student is enrolled in at least 1.5 course-attempt units.</td>
</tr>
<tr>
<td>Linear Algebra 1</td>
<td>Any of the following courses: MATH 106, MATH 114, MATH 115, MATH 136, MATH 146.</td>
</tr>
<tr>
<td>Major Average</td>
<td>See 'Major averages for Math students' in Faculty Policies.</td>
</tr>
<tr>
<td>Math Courses</td>
<td>Courses with one of these prefixes: ACTSC, AMATH, CO, CS, MATBUS, MATH, PMATH, and STAT. Any course that is cross-listed with a course having one of these prefixes is also considered a math course, regardless of the label under which it is taken.</td>
</tr>
<tr>
<td>Non-math courses</td>
<td>Courses with the prefix COMM and MTHEL, and those courses offered by other faculties (excluding courses cross-listed with math courses and courses listed above as math courses). COOP, PD, and WKRPT courses do not count as math or non-math courses.</td>
</tr>
<tr>
<td>Unit</td>
<td>The credit value associated with any course. All courses offered in the Faculty of Mathematics have a value of 0.5 units.</td>
</tr>
</tbody>
</table>
| Unusable Course Attempt | A course attempt is counted as unusable if the course is not a COOP, PD or WKRPT course and one of the following conditions holds  
  - a failing grade is assigned (mark < 50, DNW, FTC, NCR, NMR, or WF) (see Grading System for descriptions), or  
  - a CLC is assigned to the course attempt  
  **Note:** Starting in fall 2017, courses with WD grades will not count as unusable. However, if achieved prior to fall 2017, courses with WD grades will continue to count as unusable. |

### Communication Skills Requirement

Since strong communication skills are essential to academic, professional, and personal success, the Faculty places a particular emphasis on their development. With the exception of students in Computing and Financial Management (CFM) and Software Engineering (SE), all students must successfully complete two communications courses:

- Students in Math/Chartered Professional Accountancy (CPA) must take SPCOM 111 (usually taken in term 1B) and AFM 211.
- Students in any Actuarial Science or Statistics plan must take one course chosen from List I (below), and ENGL 378/MTHEL 300. Students are expected to enrol in one of the courses in List I in their first term of study in the Faculty of Mathematics. A grade of at least 60 in a List 1 course is a prerequisite for enrolling in term 2A, and a grade of at least 70 is a prerequisite for ENGL 378/MTHEL 300. ENGL 378/MTHEL 300 is expected to be completed before enrolling in term 4A.
- Students in the Business Administration and Computer Science Double Degree plan or the Business Administration and Mathematics Double Degree plan must take one course chosen from List I (below), and BUS 362W. BUS 362W is expected to be completed before enrolling in term 4A. Students must complete a course from List I with a mark of at least 60 prior to enrolling in term 2A.
- Students in all other plans must take one course chosen from List I, and one course chosen from List II. Students are expected to enrol in one of the courses in List I in their first term of study in the Faculty of Mathematics, and must complete a course from List I with a mark of at least 60 prior to enrolling in term 2A. Students are encouraged to complete the second course by the end of term 2A.

### List I: First Course

The first course must be chosen from one of the following:

- EMLS 101R Oral Communication for Academic Purposes
- EMLS 102R Clear Communication in English Writing
- EMLS 129R/ENGL 129R Written Academic English
ENGL 109 Introduction to Academic Writing  
SPCOM 100 Interpersonal Communication  
SPCOM 223 Public Speaking

This course must be completed with a mark of at least 60% prior to enrolling in a 2A term. Except for some students in the Double Degree plans, students are expected to enrol in one of these courses in their first term of study in the Faculty of Mathematics.

**List II: Second Course**

Any other course listed in the First Course list  
EMLS 103R Effective English Pronunciation  
EMLS 104R Reading and Listening for Academic Purposes  
EMLS 110R Critical Expression in Canadian Academic Contexts  
ENGL 101B Introduction to Rhetorical Studies  
ENGL 108D Digital Lives  
ENGL 119 Communications in Mathematics and Computer Science  
ENGL 209 Advanced Academic Writing  
ENGL 210E Genres of Technical Communication  
ENGL 210F Genres of Business Communication  
ENGL 251A Criticism 1  
ENGL 378/MTHEL 300 Professional Communications in Statistics and Actuarial Science  
SPCOM 225 Interviewing  
SPCOM 227 Leadership  
SPCOM 228 Public Communication

**Notes**

1. Students enrolled in CFM must satisfy the [English Language Proficiency Requirement (ELPR)](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) as set down by the Faculty of Arts.
2. Students enrolled in SE must satisfy the English Language competency requirement as set down by the Faculty of Engineering.
3. SPCOM 111 will qualify as a List 1 course for students who are transferring from AFM and CPA.
4. Transfer credits may be used to satisfy the Communication Skills Requirement.
5. Students who do not complete the first course prior to their 2A term will be restricted to enrolling in a course from the first list and two math courses until the first course requirement is met.

**Table II – Faculty Core Courses**

Some plans do not require all the courses in Table II. Please check your particular plan requirements to see if Table II applies.

One of

- **MATH 106** Applied Linear Algebra 1
- **MATH 136** Linear Algebra 1 for Honours Mathematics
- **MATH 146** Linear Algebra 1 (Advanced Level)

One of

- **MATH 127** Calculus 1 for the Sciences
- **MATH 137** Calculus 1 for Honours Mathematics
- **MATH 147** Calculus 1 (Advanced Level)

One of

- **MATH 128** Calculus 2 for the Sciences
- **MATH 138** Calculus 2 for Honours Mathematics
- **MATH 148** Calculus 2 (Advanced Level)

One of

- **MATH 135** Algebra for Honours Mathematics
- **MATH 145** Algebra (Advanced Level)
One of

- **MATH 235** Linear Algebra 2 for Honours Mathematics
- **MATH 245** Linear Algebra 2 (Advanced Level)

One of

- **STAT 230** Probability
- **STAT 240** Probability (Advanced Level)

One of

- **STAT 231** Statistics
- **STAT 241** Statistics (Advanced Level)

One of

- **CS 115** Introduction to Computer Science 1
- **CS 135** Designing Functional Programs
- **CS 145** Designing Functional Programs (Advanced Level)

One of

- **CS 116** Introduction to Computer Science 2
- **CS 136** Elementary Algorithm Design and Data Abstraction
- **CS 146** Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)
- **MATH 239** Introduction to Combinatorics
- **MATH 249** Introduction to Combinatorics (Advanced Level)

**Note**

CS majors normally start in **CS 135**. Students with strong aptitude may take **CS 145** followed by **CS 146**. Students starting with **CS 115** who wish access to CS major courses must take **CS 136** after **CS 116**.

**Responsibility For Meeting Degree Requirements**

Students are responsible for being aware of all regulations pertaining to their academic plans. This responsibility includes submitting a completed [Intention to Graduate](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) form to the Registrar's Office during their last academic study term.

**Incompatibility of Full-time Study with Full-time Employment**

Students who by choice or necessity work on non-academic activities more than 10 hours per week should, where possible, structure their course/work load so that they can attend fully to their academic obligations. The Standings and Promotions (S&P) Committee will not grant petitions based on time pressure resulting from employment.

**Honours Fallback Provision**

Students who have, at any time, satisfied all of the following conditions may elect to graduate with a three-year BMath General Regular degree:

1. Minimum of 15.0 total units passed
2. Minimum of 5.0 non-math units passed
3. Maximum of 5.0 units of unusable course attempts
4. Maximum of 4.0 units failed or excluded
5. A minimum cumulative average (CAV) of 60%
6. Minimum 8.0 math units including the following courses passed

One of

- **CS 115** Introduction to Computer Science 1
- **CS 135** Designing Functional Programs
CS 145 Designing Functional Programs (Advanced Level)

One of

CS 116 Introduction to Computer Science 2
CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

MATH 106 Applied Linear Algebra 1
MATH 136 Linear Algebra 1 for Honours Mathematics
MATH 146 Linear Algebra 1 (Advanced Level)

One of

MATH 127 Calculus 1 for the Sciences
MATH 137 Calculus 1 for Honours Mathematics
MATH 147 Calculus 1 (Advanced Level)

One of

MATH 128 Calculus 2 for the Sciences
MATH 138 Calculus 2 for Honours Mathematics
MATH 148 Calculus 2 (Advanced Level)

One of

MATH 135 Algebra for Honours Mathematics
MATH 145 Algebra (Advanced Level)

One of

MATH 225 Applied Linear Algebra 2
MATH 235 Linear Algebra 2 for Honours Mathematics
MATH 245 Linear Algebra 2 (Advanced Level)

One of

STAT 220 Probability (Non-Specialist Level)
STAT 230 Probability
STAT 240 Probability (Advanced Level)

One of

STAT 221 Statistics (Non-Specialist Level)
STAT 231 Statistics
STAT 241 Statistics (Advanced Level)

One of

MATH 207 Calculus 3 (Non-Specialist Level)
MATH 237 Calculus 3 for Honours Mathematics
MATH 247 Calculus 3 (Advanced Level)
MATH 229 Introduction to Combinatorics (Non-Specialist Level)
MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

Notes

1. Students are not normally awarded an Honours BMath degree if they already hold a General BMath degree. Petitions for exceptions to this rule will normally be considered only after an absence from the Faculty of several terms.
2. Students choosing the Honours Fallback Provision may not combine this choice with any option, minor, or specialization.

**Actuarial Science**

**Actuarial Science Overview**
The Department of Statistics and Actuarial Science offers courses and plans in Actuarial Science, which is the application of mathematics and statistics to financial problems with particular emphasis on life insurance, casualty insurance, and employee benefit programs. The courses offered provide theoretical preparation for the courses of the Society of Actuaries and the Casualty Actuarial Society, and include studies of such subject areas as Mathematics of Finance, Life Contingencies, Risk Theory, and Casualty Ratemaking. Note: Students in Honours Actuarial Science and Honours Actuarial Science/Finance Option require a major average (MAV) of 70% to remain eligible to continue in their plan.

By carefully selecting their non-math courses, students can also gain valuable background knowledge in economics, finance, administration, and law.

**Actuarial Science**

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

All of

- **AFM 101** Introduction to Financial Accounting
- **ACTSC 231** Introductory Financial Mathematics
- **ACTSC 232** Life Contingencies 1
- **ACTSC 331** Life Contingencies 2
- **ACTSC 371** Introduction to Investments
- **ACTSC 431** Loss Models 1
- **ACTSC 446** Mathematics of Financial Markets
- **AMATH 250** Introduction to Differential Equations
- **ECON 101** Introduction to Microeconomics
- **ECON 102** Introduction to Macroeconomics
- **ENGL 378/MTHEL 300** Professional Communications in Statistics and Actuarial Science
- **MTHEL 131** Introduction to Actuarial Practice
- **STAT 330** Mathematical Statistics
- **STAT 331** Applied Linear Models
- **STAT 333** Applied Probability

One of

- **STAT 340** Computer Simulation of Complex System
- **STAT 341** Computational Statistics and Data Analysis

Three additional 400-level ACTSC courses

Two additional courses chosen from

- Any 300- or 400-level ACTSC course
- **AFM 424** Equity Investments
- **STAT 431** Generalized Linear Models and their Applications
- **STAT 433** Stochastic Processes
- **STAT 441** Statistical Learning – Classification
- **STAT 443** Forecasting

One additional 300-level or 400-level math courses.

**Notes**

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
1. Students currently or previously enrolled in the Business Administration and Mathematics Double Degree plan may substitute:
   - BUS 121W for MTHEL 131.*
   - BUS 127W for AFM 101.
   - BUS 283W for ACTSC 371.
   - BUS 362W for ENGL 378/MTHEL 300.
   - BUS 473W for AFM 424.
   - ECON 120W for ECON 101.
   - ECON 140W for ECON 102.
   * MTHEL 131 is strongly recommended for students with an interest in Actuarial Science.

2. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - AMATH 350 for AMATH 250.
   - STAT 371 for STAT 331.

3. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333, and STAT 373 is not an acceptable substitute for STAT 331.

**Actuarial Science/Finance Option**
This plan has the same course requirements as [Honours Actuarial Science](#) with the following additional requirements:

**One of**

- **AFM 424** Equity Investments
- **ACTSC 471/AFM 476** Advanced Corporate Finance

**One of**

- **AMATH 242/CS 371** Introduction to Computational Mathematics
- **CS 370** Numerical Computation

**All of**

- **AFM 102** Introduction to Managerial Accounting
- **ACTSC 372** Corporate Finance
- **ACTSC 445** Quantitative Enterprise Risk Management
- **CS 476** Numerical Computation for Financial Modeling
- **STAT 340** Computer Simulation of Complex Systems

**Note**
1. Students currently or previously enrolled in the Business Administration and Mathematics Double Degree plan may substitute:
   - BUS 247W for AFM 102.
   - BUS 393W for ACTSC 372.
   - BUS 473W for AFM 424.

**Actuarial Science/Predictive Analytics Option**
This plan has the same course requirements as [Honours Actuarial Science](#) with the following additional requirements:

**All of**

- **CS 330** Management Information Systems
- **STAT 341** Computational Statistics and Data Analysis
- **STAT 431** Generalized Linear Models and their Applications
- **STAT 441** Statistical Learning - Classification
- **STAT 443** Forecasting
One of

- ACTSC 433 Analysis of Survival Data
- STAT 437 Analysis of Longitudinal Data in Health Research

One of

- STAT 440 Computational Inference
- STAT 442 Data Visualization

**Joint Actuarial Science**

See Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations for a description of joint plan requirements. Note that both specialization areas designated in such joint plans must be disciplines within the Faculty of Mathematics.

One of

- MATH 237 Calculus 3 for Honours Mathematics
- MATH 247 Calculus 3 (Advanced Level)

**All of**

- AFM 101 Introduction to Financial Accounting
- ACTSC 231 Introductory Financial Mathematics
- ACTSC 232 Life Contingencies 1
- ACTSC 331 Life Contingencies 2
- ACTSC 431 Loss Models 1
- ACTSC 446 Mathematics of Financial Markets
- ENGL 378/MTHEL 300 Professional Communications in Statistics and Actuarial Science
- MTHEL 131 Introduction to Actuarial Practice
- STAT 330 Mathematical Statistics
- STAT 333 Applied Probability

Three additional courses chosen from

- Any 300- or 400-level ACTSC course
- AFM 424 Equity Investments

**Notes**

1. Students currently or previously enrolled in the Business Administration and Mathematics Double Degree plan may substitute:
   - BUS 121W for MTHEL 131.*
   - BUS 127W for AFM 101.
   - BUS 283W for ACTSC 371.
   - BUS 362W for ENGL 378/MTHEL 300.
   - BUS 393W for ACTSC 372.
   - BUS 473W for AFM 424.
   * MTHEL 131 is strongly recommended for students with an interest in Actuarial Science.

2. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.

3. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333, and STAT 373 is not an acceptable substitute for STAT 331.

**Mathematical Finance**

The Mathematical Finance plan is offered jointly by the Departments of Statistics and Actuarial Science and of Pure Mathematics.

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses and the following specific requirements:
Undergraduate Studies Calendar | University of Waterloo

One of

- **MATH 247** Calculus 3 (Advanced Level)
- **MATH 237** Calculus 3 for Honours Mathematics (requires permission of department)

All of

- **AFM 101** Introduction to Financial Accounting or BUS 127W Introduction to Financial Accounting (see Laurier calendar)
- **AFM 102** Introduction to Managerial Accounting or BUS 247W Managerial Accounting (see Laurier calendar)
- **AFM 131/ARBUS 101** Introduction to Business in North America or BUS 111W Understanding the Business Environment (see Laurier calendar)
- **ACTSC 231** Introductory Financial Mathematics
- **ACTSC 371** Introduction to Investments
- **ACTSC 372** Corporate Finance
- **ACTSC 445** Quantitative Enterprise Risk Management
- **ACTSC 446** Mathematics of Financial Markets
- **AMATH 242/CS 371** Introduction to Computational Mathematics or **CS 335** Computational Methods in Business and Finance
- **AMATH 250** Introduction to Differential Equations or **AMATH 350** Differential Equations for Business and Economics
- **ECON 101** Introduction to Microeconomics or ECON 120W Introduction to Microeconomics (see Laurier calendar)
- **ECON 102** Introduction to Macroeconomics or ECON 140W Introduction to Macroeconomics (see Laurier calendar)
- **ECON 201** Microeconomic Theory for Business and Policy or ECON 260W Intermediate Microeconomic Analysis for Management (see Laurier calendar)
- **PMATH 351** Real Analysis
- **PMATH 450** Lebesgue Integration and Fourier Analysis
- **PMATH 451** Measure and Integration
- **STAT 330** Mathematical Statistics
- **STAT 331** Applied Linear Models
- **STAT 333** Applied Probability
- **STAT 443** Forecasting

One of

- **AMATH 351** Ordinary Differential Equations 2
- **CO 250** Introduction to Optimization
- **PMATH 352** Complex Analysis

One of

- **AMATH 353** Partial Differential Equations 1
- **CO 372** Portfolio Optimization Models
- **CS 476** Numeric Computation for Financial Modeling
- **PMATH 453** Functional Analysis

Notes

1. **MATH 147** and **MATH 148** provide highly desirable background for students in the Mathematical Finance plan.
2. AMATH 350 is an antirequisite of AMATH 351 and AMATH 353, and choosing this course limits selection in the last "One of" list.
3. Students enrolled in the Business Administration and Mathematics Double Degree plan:
   - may substitute BUS 283W for ACTSC 371
   - may substitute BUS 393W for ACTSC 372
   - are exempt from taking STAT 443, but can count it under the "One of AMATH 353, CO 372, CS 476, PMATH 453" if they choose to take it.
4. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis
Actuarial Science Minor
This minor is only open to students within the Faculty of Mathematics. Admission to the minor in Actuarial Science requires an Actuarial Science special major average of at least 70%. A student with no Actuarial Science special major average will be admitted with a cumulative average of at least 70% on at least ten non-excluded courses, provided they have no more than one failed or excluded course.

All of

- MATH 237 Calculus 3 for Honours Mathematics or MATH 247 Calculus 3 (Advanced Level)
- AFM 101 Introduction to Financial Accounting
- ACTSC 231 Introductory Financial Mathematics
- ACTSC 232 Life Contingencies 1
- ACTSC 331 Life Contingencies 2
- ACTSC 431 Loss Models 1
- MTHEL 131 Introduction to Actuarial Practice
- STAT 330 Mathematical Statistics
- STAT 333 Applied Probability

One additional 300- or 400-level ACTSC course.

Notes
1. Students currently or previously enrolled in the Business Administration and Mathematics Double Degree plan may substitute:
   - BUS 121W for MTHEL 131.
   - BUS 127W for AFM 101.
2. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333.

Applied Mathematics

Applied Mathematics Overview
Mathematics and science are intimately connected and advances in one have often stimulated new research areas in the other. Applied mathematics provides a bridge between these two fields through the construction and analysis of mathematical and computational models. Initial efforts in applied mathematics focused primarily on problems in physics and engineering, but applied mathematics approaches are now used widely in many areas of science, health, technology, business, and public policy. Mathematical models generate insight into a wide variety of phenomena and provide a foundation for modern research in a broad range of disciplines.

Our undergraduate plan in Applied Mathematics focuses on the development of a variety of differential equation-based models. These yield mathematical and computational descriptions of dynamic phenomena: from the motion of ocean waves, to the control of aircraft flight, to the volatile price of stock options. The Applied Mathematics plan builds on the fundamental courses in calculus and linear algebra and offers a variety of core courses in ordinary differential equations, partial differential equations, and computational mathematics. These courses, along with an introduction to physics, provide a foundation for modeling across a wide range of domains. This breadth is represented by upper-year Applied Mathematics courses that focus on physics (quantum mechanics, general relativity, fluid dynamics), biology, earth science, and engineering (control theory and signal processing). Additional courses provide a deeper understanding of the mathematical theory on which mathematical and computational models are based, the computational methods used to formulate and investigate models, and the scientific understanding of how we can learn from these models.

As part of their plan, Applied Mathematics students acquire expertise in a chosen application area. The Applied Mathematics plans allow formal recognition of these specializations: the "option" plans are each
composed of a selection of courses in an application area. Students with a strong interest in theoretical physics can pursue our Mathematical Physics plan, offered jointly with the Department of Physics.

**Applied Mathematics**

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- [MATH 237](#) Calculus 3 for Honours Mathematics
- [MATH 247](#) Calculus 3 (Advanced Level)

All of

- [AMATH 231](#) Calculus 4
- [AMATH 242/CS 371](#) Introduction to Computational Mathematics
- [AMATH 251](#) Introduction to Differential Equations (Advanced Level)*
- [AMATH 332/PMATH 332](#) Applied Complex Analysis
- [AMATH 342](#) Computational Methods for Differential Equations
- [AMATH 351](#) Ordinary Differential Equations 2
- [AMATH 353](#) Partial Differential Equations 1
- [PHYS 121](#) Mechanics

*AMATH 250 can be substituted with consent of the department

Three 400-level AMATH courses.

One additional 300- or 400-level AMATH course.

Recommended course

- [AMATH 331/PMATH 331](#) Applied Real Analysis

A subject specialization consisting of four additional courses (2.0 units), all from any one department in the Faculties of Science or Engineering, or the department of Economics. (Alternatively, a set of four courses (2.0 units) from another department may be eligible, subject to approval by the Applied Mathematics undergraduate advisor.)

Five additional math courses: (some suggested courses are listed below)

- [MATH 239](#) Introduction to Combinatorics
- [MATH 249](#) Introduction to Combinatorics (Advanced Level)
- [CO 250](#) Introduction to Optimization
- [CO 255](#) Introduction to Optimization (Advanced Level)
- [CS 475](#) Computational Linear Algebra
- [PMATH 334](#) Introduction to Rings and Fields with Applications
- [PMATH 336](#) Introduction to Group Theory with Applications
- [PMATH 365](#) Differential Geometry
- [STAT 331](#) Applied Linear Models
- [STAT 333](#) Applied Probability

**Joint Applied Mathematics**

See [Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations](#) for a description of joint plan requirements. Note that both specialization areas designated in such joint plans must be disciplines within the Faculty of Mathematics.

One of

- [MATH 237](#) Calculus 3 for Honours Mathematics
- [MATH 247](#) Calculus 3 (Advanced Level)

All of

- [AMATH 231](#) Calculus 4
- [AMATH 242/CS 371](#) Introduction to Computational Mathematics
- [AMATH 251](#) Introduction to Differential Equations (Advanced Level)*
- [AMATH 332/PMATH 332](#) Applied Complex Analysis
AMATH 351 Ordinary Differential Equations 2
AMATH 353 Partial Differential Equations 1
PHYS 121 Mechanics
*AMATH 250 can be substituted with consent of the department

Three 400-level AMATH courses.
A subject specialization consisting of four additional courses (2.0 units) from any one department in the
Faculties of Science or Engineering, or the Department of Economics.
Alternatively, a set of four courses (2.0 units) from departments in other Faculties may be eligible, subject
to approval by the Applied Mathematics undergraduate advisor.

Recommended course

AMATH 331/PMATH 331 Applied Real Analysis

Applied Mathematics/Biology Option
This plan has the same course requirements as Honours Applied Mathematics, with the following
constraints on course selection:
All of

BIOL 130 Introductory Cell Biology
BIOL 239 Genetics

An additional 3.0 units at least 2.0 units of which are at the 300- or 400-level from the following list *:

Any BIOL course
AMATH 382/BIOL 382 Computational Modeling of Cellular Systems
AMATH 383 Introduction to Mathematical Biology

Recommended course

BIOL 364 Mathematical Modeling in Biology

* Courses used to satisfy this requirement cannot be used to satisfy the 300- and 400-level AMATH course
requirements of the Applied Mathematics plan.

Applied Mathematics/Earth Science Option
This plan has the same course requirements as Honours Applied Mathematics with the following constraints
on course selection:
All of

AMATH 271 Introduction to Theoretical Mechanics
EARTH 121 Introductory Earth Sciences
EARTH 122 Introductory Environmental Sciences
PHYS 122 Waves, Electricity and Magnetism

An additional 2.0 units at least 1.5 units of which are at the 300- or 400-level from the following list *:

Any EARTH course
AMATH 361 Continuum Mechanics
AMATH 463 Fluid Mechanics

* Courses used to satisfy this requirement cannot be used to satisfy the 300- and 400-level AMATH course
requirements of the Applied Mathematics plan.

Applied Mathematics/Economics Option
This plan has the same course requirements as Honours Applied Mathematics with the following constraints
on course selection:
One of
CO 250 Introduction to Optimization  
CO 255 Introduction to Optimization (Advanced Level)

All of

ECON 101 Introduction to Microeconomics  
ECON 102 Introduction to Macroeconomics  
ECON 201 Microeconomic Theory for Business and Policy

One of

ECON 206 Money and Banking 1  
ECON 207 Economic Growth and Development 1

An additional 1.5 units of 300- or 400-level ECON courses.

**Applied Mathematics/Physics Option**

This plan has the same course requirements as Honours Applied Mathematics with the following additional constraints on course selection:

All of

AMATH 271 Introduction to Theoretical Mechanics  
ECE 403 Thermal Physics or PHYS 358 Thermal Physics  
PHYS 122 Waves, Electricity and Magnetism  
PHYS 234 Quantum Physics 1  
PHYS 242 Electricity and Magnetism 1  
PHYS 358 Thermal Physics or ECE 403 Thermal Physics  
PHYS 359 Statistical Mechanics

An additional 1.0 units from the following list:

Any 300- or 400- PHYS courses  
AMATH 361 Continuum Mechanics  
AMATH 373 Quantum Theory 1  
AMATH 463 Fluid Mechanics  
AMATH 473 Quantum Theory 2  
AMATH 475/PHYS 476 Introduction to General Relativity

* Courses used to satisfy this requirement cannot be used to satisfy the 300- and 400-level AMATH course requirements of the Applied Mathematics plan.

**Applied Mathematics with Engineering Electives**

*Enrolment in this plan is limited; a cumulative average of 70% or higher is strongly recommended.*  
*Students must choose one of two specializations in this option.*

Both options have the same requirements as Honours Applied Mathematics, with the following constraints on course selection:

**Fluids and Heat**

All of

AMATH 271 Introduction to Theoretical Mechanics  
AMATH 361 Continuum Mechanics*  
AMATH 463 Fluid Mechanics*  
PHYS 122 Waves, Electricity and Magnetism

One of

CO 250 Introduction to Optimization  
CO 255 Introduction to Optimization (Advanced Level)  
STAT 331 Applied Linear Models  
STAT 340 Computer Simulation of Complex Systems

All of
GENE 123 Electrical Circuits and Instrumentation  
ME 219 Mechanics of Deformable Solids 1  
ME 250 Thermodynamics 1  
ME 353 Heat Transfer 1  
ME 354 Thermodynamics 2  
ME 456 Heat Transfer 2

One of  

ME 557 Combustion 1  
ME 564 Aerodynamics  
ME 571 Air Pollution

* This course can be used to satisfy the 300- and 400-level AMATH course requirements of the Applied Mathematics plan.

Communication and Control  
All of  

AMATH 455 Control Theory*  
PHYS 122 Waves, Electricity and Magnetism

One of  

CO 250 Introduction to Optimization  
CO 255 Introduction to Optimization (Advanced Level)  
CS 475 Computational Linear Algebra  
STAT 331 Applied Linear Models  
STAT 340 Computer Simulation of Complex Systems

All of  

GENE 123 Electrical Circuits and Instrumentation  
ECE 207 Signals and Systems  
ECE 240 Electronic Circuits 1  
ECE 318 Analog and Digital Communications  
ECE 380 Analog Control Systems

Two of  

ECE 413 Digital Signal Processing  
ECE 484 Digital Control Applications  
ECE 486 Robot Dynamics and Control  
SYDE 372 Introduction to Pattern Recognition  
SYDE 544 Biomedical Measurement and Signal Processing

* This course can be used to satisfy the 300- and 400-level AMATH course requirements of the Applied Mathematics plan.

Mathematical Physics  
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 20 math courses, and the following specific requirements:

One of  

MATH 237 Calculus 3 for Honours Mathematics  
MATH 247 Calculus 3 (Advanced Level)

All of  

AMATH 231 Calculus 4  
AMATH 242/CS 371 Introduction to Computational Mathematics  
AMATH 251 Introduction to Differential Equations (Advanced Level)*  
AMATH 271 Introduction to Theoretical Mechanics  
AMATH 331/PMATH 331 Applied Real Analysis
AMATH 332/PMATH 332  Applied Complex Analysis  
AMATH 351  Ordinary Differential Equations 2  
AMATH 353  Partial Differential Equations 1  
AMATH 361  Continuum Mechanics  
AMATH 373  Quantum Theory 1  
AMATH 473/PHYS 454  Quantum Theory 2  
AMATH 475/PHYS 476  Introduction to General Relativity  
PHYS 121  Mechanics  
PHYS 122  Waves, Electricity and Magnetism  
PHYS 234  Quantum Physics 1  
PHYS 242  Electricity and Magnetism 1  
PHYS 342  Electricity and Magnetism 2  
PHYS 358  Thermal Physics or ECE 403  Thermal Physics  
PHYS 359  Statistical Mechanics  
PHYS 363  Intermediate Classical Mechanics  
*AMATH 250 can be substituted with consent of the department

2.5 units of AMATH/PHYS electives. We strongly suggest that at least 1.0 units should be chosen from the list of sensible course streams available on the department website and from the Applied Mathematics undergraduate advisor.

Scientific Computation/Applied Mathematics

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

MATH 237  Calculus 3 for Honours Mathematics  
MATH 247  Calculus 3 (Advanced Level)

All of

AMATH 231  Calculus 4  
AMATH 242/CS 371  Introduction to Computational Mathematics  
AMATH 251  Introduction to Differential Equations (Advanced Level)  Note: AMATH 250 can be substituted with consent of the department.  
AMATH 342  Computational Methods for Differential Equations  
AMATH 351  Ordinary Differential Equations 2  
AMATH 353  Partial Differential Equations 1  
CS 230  Introduction to Computers and Computer Systems  
CS 234  Data Types and Structures  
CS 475  Computational Linear Algebra  
STAT 331  Applied Linear Models

One of

AMATH 331/PMATH 331  Applied Real Analysis  
AMATH 332/PMATH 332  Applied Complex Analysis

One of

CO 250  Introduction to Optimization  
CO 255  Introduction to Optimization (Advanced Level)

Two of

AMATH 442  Computational Methods for Partial Differential Equations  
AMATH 453  Partial Differential Equations 2  
AMATH 455  Control Theory  
AMATH 456  Calculus of Variations  
AMATH 463  Fluid Mechanics  
AMATH 473/PHYS 454  Quantum Theory 2  
CO 453  Network Design  
CO 459  Topics in Optimization
CO 463  Convex Optimization and Analysis
CO 466  Continuous Optimization
CS 487  Introduction to Symbolic Computation
STAT 440  Computational Inference
STAT 444  Statistical Learning - Classification

Note: Many of the courses on this list have prerequisites that are not plan requirements.

A subject specialization consisting of four additional courses (2.0 units) from any one department in the Faculties of Science or Engineering, or the Department of Economics. Alternatively, a set of four courses (2.0 units) from departments in other Faculties may be eligible, subject to approval by the Applied Mathematics undergraduate advisor.

**Applied Mathematics Minor**
This minor is only open to students within the Faculty of Mathematics.

All of

- MATH 237  Calculus 3 for Honours Mathematics or MATH 247  Calculus 3 (Advanced Level)
- AMATH 231  Calculus 4
- AMATH 251  Introduction to Differential Equations (Advanced Level) Note: AMATH 250 can be substituted with consent of the department.
- AMATH 351  Ordinary Differential Equations 2
- AMATH 353  Partial Differential Equations 1

Three additional 300- or 400-level AMATH courses.

**Combinatorics and Optimization including Mathematical Optimization**

**Combinatorics and Optimization Overview**
Combinatorics is the study of discrete structures and their properties. It includes coding theory, combinatorial design, enumeration theory, graph theory, and polyhedral theory. Many modern scientific advances have employed combinatorial structures to model the physical world, and recent advances in computational technology have made such investigations feasible. In particular, since computers process discrete data, combinatorics has become indispensable to computer science.

Optimization, or mathematical programming, is the study of maximizing and minimizing functions subject to specified boundary conditions or constraints. The functions to be optimized arise in engineering, the physical and management sciences, and in various branches of mathematics. With the emergence of computers, optimization experienced a dramatic growth as a mathematical theory, enhancing both combinatorics and classical analysis. In its applications to engineering and management sciences, optimization forms an important part of the discipline of operations research.

Both combinatorics and optimization have long been special interests of Canadian mathematicians. Indeed, Waterloo was the first university in the world to have a Department of Combinatorics and Optimization, and it continues to be a leading centre for teaching and research in the theories and applications of these disciplines.

**Combinatorics and Optimization**
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- MATH 239  Introduction to Combinatorics
- MATH 249  Introduction to Combinatorics (Advanced Level)

One of

- CO 250  Introduction to Optimization
- CO 255  Introduction to Optimization (Advanced Level)

One of

- CO 330  Combinatorial Enumeration
- CO 342  Introduction to Graph Theory
One of

CO 351 Network Flow Theory
CO 353 Computational Discrete Optimization
CO 367 Nonlinear Optimization
(If CO 255 is taken, this requirement can be satisfied by taking one of CO 450 to CO 471.)

Three additional courses chosen from

CO 330 Combinatorial Enumeration
CO 331 Coding Theory
CO 342 Introduction to Graph Theory
CO 351 Network Flow Theory
CO 353 Computational Discrete Optimization
CO 367 Nonlinear Optimization
CO 430 to CO 487, excluding CO 480

All of

PMATH 336 Introduction to Group Theory with Applications or PMATH 347 Groups and Rings

Three of

MATH 237 Calculus 3 for Honours Mathematics or MATH 247 Calculus 3 (Advanced Level)
AMATH 331/PMATH 331 Applied Real Analysis
AMATH 332/PMATH 332 Applied Complex Analysis
CS 462 Formal Languages and Parsing
CS 466 Algorithm Design and Analysis
CS 487 Introduction to Symbolic Computation
PMATH 334 Introduction to Rings and Fields with Applications or PMATH 348 Fields and Galois Theory
PMATH 340 Elementary Number Theory

Note: These fourth-year CS courses are open only to CS majors.

Two additional 300- or 400-level math courses with a course prefix other than CO.
One additional 300- or 400-level math course.
Three additional math courses.

Joint Combinatorics and Optimization
See Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations for a description of joint plan requirements. Note that both specialization areas designated in such joint plans must be disciplines within the Faculty of Mathematics.

One of

MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

One of

CO 250 Introduction to Optimization
CO 255 Introduction to Optimization (Advanced Level)

Four additional courses chosen from

CO 330 Combinatorial Enumeration
CO 331 Coding Theory
CO 342 Introduction to Graph Theory
CO 351 Network Flow Theory
CO 353 Computational Discrete Optimization
CO 367 Nonlinear Optimization
CO 430 to CO 487, excluding CO 480
All of

PMATH 336 Introduction to Group Theory with Applications or PMATH 347 Groups and Rings

Three of

MATH 237 Calculus 3 for Honours Mathematics or MATH 247 Calculus 3 (Advanced Level)
AMATH 331/PMATH 331 Applied Real Analysis
AMATH 332/PMATH 332 Applied Complex Analysis
CS 341 Algorithms
CS 360 Introduction to the Theory of Computing
CS 466 Algorithm Design and Analysis
PMATH 334 Introduction to Rings and Fields with Applications or PMATH 348 Fields and Galois Theory
PMATH 340 Elementary Number Theory
Note: CS 466 is open only to CS joint majors.

Combinatorics and Optimization Minor

One of

MATH 103 Introductory Algebra for Arts and Social Science
MATH 106 Applied Linear Algebra 1
MATH 114 Linear Algebra for Science
MATH 115 Linear Algebra for Engineering
MATH 136 Linear Algebra 1 for Honours Mathematics
MATH 146 Linear Algebra 1 for Honours Mathematics (Advanced Level)

One of

MATH 135 Algebra for Honours Mathematics
MATH 145 Algebra (Advanced Level)
ECE 103 Discrete Mathematics
PMATH 340 Elementary Number Theory

One of

MATH 104 Introductory Calculus for Arts and Social Science
MATH 116 Calculus 1 for Engineering
MATH 117 Calculus 1 for Engineering
MATH 127 Calculus 1 for the Sciences
MATH 137 Calculus 1 for Honours Mathematics
MATH 147 Calculus 1 for Honours Mathematics (Advanced Level)

All of

MATH 239 Introduction to Combinatorics or MATH 249 Introduction to Combinatorics (Advanced Level)
CO 250 Introduction to Optimization or CO 255 Introduction to Optimization (Advanced Level)

Three of

CO 330 Combinatorial Enumeration
CO 331 Coding Theory
CO 342 Introduction to Graph Theory
CO 351 Network Flow Theory
CO 353 Computational Discrete Optimization
CO 367 Nonlinear Optimization
CO 370 Deterministic OR Models
CO 372 Portfolio Optimization Models
CO 430 to CO 487, excluding CO 480

Notes
1. The Combinatorics and Optimization minor designation is not available to students outside the Faculty pursuing a Joint Honours Academic Plans with Mathematics or a Mathematics Minor.
2. Other Linear Algebra and Calculus courses than those listed above may be used to satisfy the "One of" requirements above, with approval of the Combinatorics and Optimization advisor.

**Mathematical Optimization - Overview**
Mathematical Optimization (MO) is a branch of mathematics that develops and studies analytic tools to model and solve complex optimization problems arising in real world applications. It focuses on decision problems where scarce resources need to be allocated effectively, in complex, dynamic, and uncertain conditions.

Practical examples for MO applications include enhanced scheduling for airline crews and sports games, improved production and distribution efficiency for manufacturing companies, increased service quality and efficiency in healthcare administration, and development of sophisticated tools for finance and investments.

The honours plan in MO combines a solid foundation in mathematics with special sequences of courses in economics, business, and management science. The mathematics portion of the plan includes combinatorics, linear optimization, modeling, scheduling, forecasting, decision theory, and computer simulation. Students in MO must choose from one of two specializations: Operations Research Specialization or the Business Specialization.

**Mathematical Optimization**
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

One of

- **MATH 239** Introduction to Combinatorics
- **MATH 249** Introduction to Combinatorics (Advanced Level)

One of

- **CO 250** Introduction to Optimization
- **CO 255** Introduction to Optimization (Advanced Level)

One of

- **CS 330** Management Information Systems
- **CS 490** Information Systems Management

One of

- **AMATH 242/CS 371** Introduction to Computational Mathematics
- **CS 370** Numerical Computation

All of

- **CO 370** Deterministic OR Models
- **STAT 340** Computer Simulation of Complex Systems

All of

- **AFM 101** Introduction to Financial Accounting
- **ECON 101** Introduction to Microeconomics
- **MSCI 211** Organizational Behaviour
Three additional courses chosen from

- **CO 342** Introduction to Graph Theory
- **CO 351** Network Flow Theory
- **CO 353** Computational Discrete Optimization
- **CO 367** Nonlinear Optimization
- **CO 372** Portfolio Optimization Models
- **CO 450** Combinatorial Optimization
- **CO 452** Integer Programming
- **CO 453** Network Design
- **CO 454** Scheduling
- **CO 456** Introduction to Game Theory
- **CO 463** Convex Optimization and Analysis
- **CO 466** Continuous Optimization
- **CO 471** Semidefinite Optimization

In addition to the above, students must complete the requirements for one of the specializations below.

**Note**
No course that is used to satisfy the requirements above can be used to satisfy any of the requirements for a specialization below.

**Operations Research Specialization**
One of

- **CO 351** Network Flow Theory
- **CO 353** Computational Discrete Optimization
  (if CO 255 is taken, this requirement may be replaced by one of CO 450 to CO 471)

All of

- **CS 234** Data Types and Structures
- **STAT 331** Applied Linear Models
- **STAT 333** Applied Probability

Two of

- **AFM 102** Introduction to Managerial Accounting
- **ECON 102** Introduction to Macroeconomics
- **MSCI 311** Organizational Design and Technology
- **MSCI 432** Production and Service Operations Management

One additional course chosen from

- **AMATH 250** Introduction to Differential Equations
- **CO 487** Applied Cryptography
- **CS 338** Computer Applications in Business: Databases
- **CS 430** Applications Software Engineering
- **STAT 332** Sampling and Experimental Design
- **STAT 433** Statistical Methods for Process Improvements
- **STAT 443** Forecasting

Two additional math courses.

**Business Specialization**
All of

- **ACTSC 371** Introduction to Investments
- **AFM 102** Introduction to Managerial Accounting
- **BUS 111W** Understanding the Business Environment (see Laurier calendar)
- **BUS 121W** Functional Areas of the Organization (see Laurier calendar)
- **BUS 352W** Introduction to Marketing Management (see Laurier calendar)
- **BUS 481W** Business Policy I (see Laurier calendar)
CS 338 Computer Applications in Business: Databases
ECON 102 Introduction to Macroeconomics
MSCI 432 Production and Service Operations Management
STAT 371 Applied Linear Models and Process Improvement for Business
STAT 372 Survey Sampling and Experimental Design Techniques for Business

Two additional courses chosen from

AMATH 350 Differential Equations for Business and Economics
BUS 435W Supply Chain Management (see Laurier calendar)
BUS 445W Information Systems for Supply Chain Management (see Laurier calendar)
BUS 455W Transportation and Facilities Management (see Laurier calendar)
BUS 485W Environmental Management for Operations (see Laurier calendar)
CS 230 Introduction to Computers and Computer Systems
CS 234 Data Types and Structures
MSCI 311 Organizational Design and Technology
MSCI 421 Strategic Management of Technology
MSCI 423 Managing New Product and Process Innovation
MSCI 436 Decision Support Systems
STAT 440 Computational Inference
STAT 442 Data Visualization
STAT 444 Statistical Learning - Function Estimation

Notes

1. The Mathematical Optimization – Business Specialization cannot be combined with any other Business or Accounting plan.
2. Students may replace the Computer Science courses listed above with the corresponding courses available to Honours Computer Science major students.
3. Students in the Bachelor of Business Administration/Bachelor of Mathematics (BBA/BMath) or Bachelor of Business Administration/Bachelor of Computer Science (BBA/BCS) Double Degree plan may make the following course substitutions towards the Mathematical Optimization – Operations Research Specialization:
   - BUS 127W/BUS 227W for AFM 101
   - BUS 247W for AFM 102
   - ECON 120W for ECON 101
   - ECON 140W for ECON 102
   - BUS 288W for MSCI 211
   - STAT 371 and 372 for STAT 331 and STAT 332

Computational Mathematics

Computational Mathematics Overview
Mathematical models arise in a wide variety of fields: business, economics, engineering, finance, medicine, science, and many others. The application of computer methods to simulate such models was traditionally called "scientific computation," though the practice has spread far beyond its roots in science to encompass problems arising in all areas of society. The results of such simulations are numerical answers, formulae, data sets, plots, charts, and images that help us to understand the nature of the world around us, and allow us to predict and influence the future. Developing and analyzing such models involves a blend of mathematics and computer science. It includes issues such as the implications of finite precision arithmetic, the efficiency, accuracy, and stability of numerical computations, the development and maintenance of mathematical software, and the effects of modern developments in computer architectures and networks. Graduates of Computational Mathematics will be able to deploy effectively a wide range of mathematical and computational techniques in areas of application.

Computational Mathematics
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of
MATH 237 Calculus 3 for Honours Mathematics
MATH 247 Calculus 3 (Advanced Level)

One of
MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

All of
AMATH 242/CS 371 Introduction to Computational Mathematics

One of
CS 230 Introduction to Computers and Computer Systems
CS 241 Foundations of Sequential Programs

One of
CS 234 Data Types and Structures
CS 240 Data Structures and Data Management

Notes:
CS 240 requires CS 245 and CS 246 as prerequisites, CS 241 requires CS 246 as a prerequisite.
CS 240 and CS 241 have restricted access for non-CS majors.

Four of the following "core" courses
AMATH 342 Computational Methods for Differential Equations
CO 250 Introduction to Optimization or CO 255 Introduction to Optimization (Advanced Level)
CS 245 Logic and Computation
CS 246 Object-Oriented Software Development
CS 475 Computational Linear Algebra
STAT 340 Computer Simulation of Complex Systems or STAT 341 Computational Statistics and Data Analysis
Note: CS 245 and CS 246 require CS 136 as a prerequisite.

Four additional courses
AMATH 382/BIOL 382 Computational Modeling of Cellular Systems
AMATH 442 Computational Methods for Partial Differential Equations
CO 353 Computational Discrete Optimization
CO 367 Nonlinear Optimization
CO 370 Deterministic OR Models
CO 372 Portfolio Optimization Models
CO 450 Combinatorial Optimization
CO 452 Integer Programming
CO 454 Scheduling
CO 456 Introduction to Game Theory
CO 485 The Mathematics of Public-Key Cryptography
CO 487 Applied Cryptography
CS 341 Algorithms
CS 451 Data-Intensive Distributed Computing
CS 466 Algorithm Design and Analysis
CS 476 Numerical Computation for Financial Modeling
CS 482 Computational Techniques in Biological Sequence Analysis
CS 487 Introduction to Symbolic Computation
PMATH 370 Chaos and Fractals
STAT 440 Computational Inference
STAT 441 Statistical Learning - Classification
STAT 442 Data Visualization
STAT 444 Statistical Learning - Function Estimation
Note: CS 341, CS 451, and CS 466 have restricted access for non-CS majors.
Three (1.5 units) non-math courses from one of the following departments:

- Economics
- any one Science department
- any one Engineering department

**Note:** Engineering courses may not be open to Mathematics students or may not easily fit schedules.

At least one of these three courses must be at the 200-, 300-, or 400-level. Other course concentrations may be eligible subject to approval by a Computational Mathematics advisor.

### Computational Mathematics Minor

This minor is only available to students within the Faculty of Mathematics.

One of

- **AMATH 242/CS 371** Introduction to Computational Mathematics
- **CS 370** Numerical Computation

Three of

- **AMATH 342** Computational Methods for Differential Equations
- **CO 250** Introduction to Optimization
- **CS 245** Logic and Computation
- **CS 246** Object-Oriented Software Development
- **CS 475** Computational Linear Algebra
- **STAT 340** Computer Simulation of Complex Systems or **STAT 341** Computational Statistics and Data Analysis

Three additional courses

- **AMATH 382/BIOL 382** Computational Modeling of Cellular Systems
- **AMATH 442** Computational Methods for Partial Differential Equations
- **CO 353** Computational Discrete Optimization
- **CO 367** Nonlinear Optimization
- **CO 370** Deterministic OR Models
- **CO 372** Portfolio Optimization Models
- **CO 450** Combinatorial Optimization
- **CO 452** Integer Programming
- **CO 454** Scheduling
- **CO 456** Introduction to Game Theory
- **CO 485** The Mathematics of Public-Key Cryptography
- **CO 487** Applied Cryptography
- **CS 341** Algorithms
- **CS 466** Algorithm Design and Analysis
- **CS 476** Numerical Computation for Financial Modeling
- **CS 482** Computational Techniques in Biological Sequence Analysis
- **CS 487** Introduction to Symbolic Computation
- **PMATH 370** Chaos and Fractals
- **STAT 440** Computational Inference
- **STAT 441** Statistical Learning - Classification
- **STAT 442** Data Visualization
- **STAT 444** Statistical Learning - Function Estimation

At most three of these seven courses may also be used to satisfy an explicit choice list course requirement of the student’s major. For CS majors, at most three of the seven can have (or be cross-listed with courses having) a CS label.

### Computer Science

**Overview**

Computer scientists study the nature and properties of information, its structure and classification, its storage and retrieval, and the various types of processing to which it can be subjected.
The David R. Cheriton School of Computer Science is the largest centre of research and teaching in computer science in Canada. Our students and faculty work across the breadth of the field in areas such as algorithms and complexity; artificial intelligence; bioinformatics; computer algebra and symbolic computation; computer graphics; cryptography, security and privacy; database systems; formal methods; health informatics; human computer interaction; information retrieval; machine learning; programming languages; quantum computing; scientific computation; software engineering; and systems and networking.

The following regular and co-operative plans are accredited by the Computer Science Accreditation Council, which is sponsored by the Canadian Information Processing Society.

- Bachelor of Mathematics (BMath) Honours Computer Science
- Bachelor of Mathematics (BMath) Honours Computer Science/Business Option
- Bachelor of Mathematics (BMath) Honours Computer Science/Digital Hardware Option
- Honours Bachelor of Computer Science
- Honours Bachelor of Computer Science/Business Option
- Honours Bachelor of Computer Science/Digital Hardware Option
- Honours Bachelor of Computer Science/Software Engineering Option
- Any double Honours plan involving an accredited Computer Science plan
- Any accredited Computer Science plan with a minor

Plans involving the Software Engineering Option are also accredited under the Software Engineering criteria.

This accreditation recognizes that the quality of these plans meets published, generally accepted criteria for sound education in the discipline. A student who graduates from an accredited plan is eligible to be designated as an Information Systems Professional after two years of professional level experience.

Accreditation for Joint Honours Computer Science has not been sought.

**Admissions**

Admission to Computer Science major plans will normally occur when a student first applies to the Faculty of Mathematics.

Students from within the Faculty of Mathematics with advanced standing may apply for admission to a Computer Science major plan if they:

- have completed at least one term in the Faculty of Mathematics with a typical course load for a Computer Science major. For students taking a first-year CS course, a typical load includes one CS course, two math courses, and two non-math electives. For students taking second-year CS courses, a typical load includes two CS courses, two math courses, and one non-math elective.
- have credit for CS 136 or CS 146
- have a math major average of at least 65% (calculated over all math and computer science courses) and a CS major average of at least 70%

Computer Science major plans are limited-enrolment plans and successful completion of the above conditions will not guarantee admission; applicants without some of these conditions will be considered on an individual basis. Students are normally not considered for admission beyond the 2B level.

**Plan Requirements**

**Bachelor of Computer Science**

Students in this plan must fulfill all the requirements in Table I and the following:

One of

- CS 115 Introduction to Computer Science 1
- CS 135 Designing Functional Programs
- CS 145 Designing Functional Programs (Advanced Level)

One of

- CS 136 Elementary Algorithm Design and Data Abstraction
- CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
MATH 127 Calculus 1 for the Sciences  
MATH 137 Calculus 1 for Honours Mathematics  
MATH 147 Calculus 1 (Advanced Level)

One of  
MATH 128 Calculus 2 for the Sciences  
MATH 138 Calculus 2 for Honours Mathematics  
MATH 148 Calculus 2 (Advanced Level)

One of  
MATH 135 Algebra for Honours Mathematics  
MATH 145 Algebra (Advanced Level)

One of  
MATH 136 Linear Algebra 1 for Honours Mathematics  
MATH 146 Linear Algebra 1 (Advanced Level)

One of  
MATH 239 Introduction to Combinatorics  
MATH 249 Introduction to Combinatorics (Advanced Level)

One of  
STAT 230 Probability  
STAT 240 Probability (Advanced Level)

One of  
STAT 231 Statistics  
STAT 241 Statistics (Advanced Level)

All of  
CS 240 Data Structures and Data Management  
CS 241 Foundations of Sequential Programs  
CS 245 Logic and Computation  
CS 246 Object-Oriented Software Development  
CS 251 Computer Organization and Design  
CS 341 Algorithms  
CS 350 Operating Systems

Three additional CS courses chosen from CS 340-CS 398, CS 440-CS 489.  
Two additional CS courses chosen from CS 440-CS 489.  
One additional course chosen from

CO 487 Applied Cryptography  
CS 440 - CS 498  
CS 499T Honours Thesis  
STAT 440 Computational Inference  
CS 600- or 700-level courses  
(CS 600- or 700-level courses may be taken only if an equivalent 400-level course does not exist and special permission is obtained from the instructor and a CS undergraduate advisor. Courses in this list may be counted as CS 0.5 units.)

The 5.0 non-math units must satisfy the following elective breadth and depth requirements. *(Alternate plans must be approved by a CS advisor.)*  
Elective breadth requirements

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
1.0 units from the humanities (subjects from ARTS, CHINA, CLAS, CMW, CROAT, DACE, DRAMA, DUTCH, EASIA, ENGL, FINE, FR, GER, GRK, HIST, HUMSC, ITAL, ITALST, JAPAN, JS, KOREA, LAT, MEDVL, MUSIC, PHIL, POLSH, PORT, REES, RS, RUSS, SI, SPAN, SPCOM, VCULT)
1.0 units from the social sciences (subjects from AFM, ANTH, APPLS, ARBUS, BET, BUS, COMM, ECON, ENBUS, GEOG, HRM, INDEV, INTST, INTTS, ISS, LS, MSCI, NATST, PACS, PSCI, PSYCH, REC, SDS, SMF, SOC, SOCWK, STV, WS)
0.5 units from the pure sciences (subjects from BIOL, CHEM, EARTH, PHYS, SCI)
0.5 units from the pure and applied sciences (subjects from pure sciences plus ARCH, BME, CHEM, CIVE, ECE, ENVE, ENVS, ERS, GERO, HLTH, KIN, ME, MNS, MTE, NE, PLAN, SYDE)

**Elective depth requirements**

1.5 units with the same subject, including at least 0.5 units at third-year level or higher
or
1.5 units with the same subject forming a prerequisite chain of length three

**Notes**

1. No course can satisfy more than one of the breadth requirements.
2. Courses with substantial math or computer science content, regardless of subject, do not satisfy the elective breadth or depth requirement. Students may wish to consult with the CS advisors about specific courses.
3. Courses from the "First Course" list for the Math Faculty Communication Skills Requirement do not satisfy the humanities breadth requirement. Courses only found in the "Second Course" list can satisfy both the humanities breadth requirement and the Communication Skills Requirement.

**Bachelor of Computer Science (Data Science)**

Data Science is the study of methods to obtain insight from available data in order to understand, predict, and improve business strategy, products and services, marketing campaigns, medicine, public health and safety, and many other pursuits. Such methods involve elements of both Statistics and Computer Science, with a focus on three foundational components: (i) Database Management, (ii) Statistics and Machine Learning, and (iii) Distributed and Parallel Systems.

The Data Science plan is guided by a joint curriculum committee. This committee is chaired by a Director of Data Science, normally a faculty member chosen from either academic unit with the agreement of both. Along with the Director, the committee includes four Faculty representatives, two appointed by each unit. In addition, the Associate Chair of Undergraduate Studies for Statistics and Actuarial Science and the Director of Undergraduate Studies for Computer Science serve ex officio on the committee. Curriculum changes introduced by the committee must receive approval from both units before being approved at the Faculty level. In addition to chairing the curriculum committee, the Director has responsibility for promoting the plan, both internally and externally, and for overall coordination.

The Faculty of Mathematics offers two Honours plans in Data Science, a BMath (Data Science) and a BCS (Data Science). The Data Science plans are offered jointly by the Department of Statistics and Actuarial Science and by the David R. Cheriton School of Computer Science. Students in the two plans graduate with a background in both computer science and statistics, taking a combination of required and elective courses that together provide a solid foundation in this emerging area.

Students in this plan must satisfy all requirements for the Bachelor of Computer Science and must satisfy the following additional constraints on course selection:

One of

- **MATH 235** Linear Algebra 2 for Honours Mathematics
- **MATH 245** Linear Algebra 2 (Advanced Level)

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

All of

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
One of

- **CS 485** Machine Learning: Statistical and Computational Foundations
- **CS 486** Introduction to Artificial Intelligence

One additional course from the following list

- **CS 448** Database System Implementation
- **CS 454** Distributed Systems
- **CS 485** Machine Learning: Statistical and Computational Foundations
- **CS 486** Introduction to Artificial Intelligence

Two of

- **STAT 431** Generalized Linear Models and their Applications
- **STAT 440** Computational Inference
- **STAT 441** Statistical Learning - Classification
- **STAT 442** Data Visualization
- **STAT 443** Forecasting
- **STAT 444** Statistical Learning - Function Estimation

**Bachelor of Mathematics (Computer Science)**

Students in this plan must fulfill all the requirements in **Table I** and **Table II**. This must include at least 27 math courses and the following specific requirements:

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

One of

- **MATH 239** Introduction to Combinatorics
- **MATH 249** Introduction to Combinatorics (Advanced Level)

All of

- **CS 240** Data Structures and Data Management
- **CS 241** Foundations of Sequential Programs
- **CS 245** Logic and Computation
- **CS 246** Object-Oriented Software Development
- **CS 251** Computer Organization and Design
- **CS 341** Algorithms
- **CS 350** Operating Systems

One of

- **AMATH 242/CS 371** Introduction to Computational Mathematics
- **CS 370** Numerical Computation

One of

- **CS 360** Introduction to the Theory of Computing
- **CS 365** Models of Computation

One additional CS course chosen from CS 340-398, 440-489.

Two additional CS courses chosen from CS 440-489.
One additional course chosen from

- **CO 487** Applied Cryptography
- **CS 440-CS 498**
- **CS 499T** Honours Thesis
- **STAT 440** Computational Inference
- CS 600- or 700-level courses
  (CS 600- or 700-level courses may be taken only if an equivalent 400-level course does not exist and special permission is obtained from the instructor and a [CS undergraduate advisor](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117). Courses in this list may be counted as CS 0.5 units.)

Three additional courses labelled ACTSC, AMATH, CO, PMATH, STAT, excluding the following:

- Courses with requisites normally excluding Honours CS students
- Courses cross-listed with a CS course
- Courses explicitly listed in CS major plans as alternatives to CS courses
- Readings and Topics courses
- **ACTSC 221, CO 353, CS 380, CS 480**

The 5.0 non-math units must satisfy the same restrictions as specified for the [Bachelor of Computer Science](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117).

### Business Administration & Computer Science Double Degree

#### Overview

Students can earn both a computer science and business degree in five years by enrolling in this double degree program. Students receive an Honours Bachelor of Computer Science (BCS) from Waterloo and an Honours Bachelor of Business Administration (BBA) from Wilfrid Laurier University (Laurier) and are invited to both universities' convocation ceremonies for graduation.

- At the David R. Cheriton School of Computer Science, students gain an understanding of software, algorithms, programming, and their mathematical foundations.
- At the School of Business and Economics, students develop an understanding of a variety of areas of business, such as brand communication, accounting, human resource management, marketing, and finance. Students can specialize in these and other areas to focus their studies.

Enrolment in this double-degree program is restricted and students are normally admitted for the fall term of their first year.

Students may apply to Waterloo, Laurier, or both. Students select their "home school" by accepting an admissions offer from one of the two universities. The home school provides most student support services, such as co-op, scholarships, and housing. The choice of home school also identifies the university from which students receive the co-op designation on their degree. Students usually cannot change their home school without leaving the double degree program.

The double degree program cannot be combined with any other major, minor, or option except as described in the notes below. The program requires the following:

- Nine or more full-time academic study terms.
- Successful completion of a minimum of 52 one-term courses (26 units). Students take 24 specified courses (12 units) at Waterloo and 24 specified courses (12 units) at Laurier, and four elective courses (two units), which may be taken at either university.
- Students whose home school is Waterloo: Completion of four or five co-op work terms intermixed with study terms. The first work term occurs during the spring term of Year One. The co-op sequence for these students is listed in the [Study/Work Sequence section](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) of this Calendar. Students in this program will be required to pay six co-op fees, which are usually assessed in the first three years of study.
- Students whose home school is Laurier: Completion of three or four co-op work terms intermixed with study terms. The first work term occurs during the winter term of Year Two. After this term, Laurier and Waterloo students have co-op terms at the same time.
Students can only change their co-op term sequences in their first three years if they have especially mitigating circumstances, and with the approval of both universities. This type of change may delay graduation.

All double degree students must follow the policies, procedures, regulations, and requirements of both Waterloo and Laurier in regards to course selection, academic performance, and academic conduct. Students who fail to do so are normally Required to Withdraw from the double degree program. These students may be able to enrol in a (single degree) program at Laurier (BBA) or Waterloo (Bachelor of Mathematics (BMath) or BCS) depending upon their individual circumstances. Such students may not be eligible to continue in co-op in their new plan.

**Degree Requirements**

Students in this plan must fulfill all the requirements in Table 1 and the following:

**From the University of Waterloo (Waterloo)**

One of

- CS 115 Introduction to Computer Science 1
- CS 135 Designing Functional Programs
- CS 145 Designing Functional Programs (Advanced Level)

One of

- CS 136 Elementary Algorithm Design and Data Abstraction
- CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

- MATH 127 Calculus 1 for the Sciences
- MATH 137 Calculus 1 for Honours Mathematics
- MATH 147 Calculus 1 (Advanced Level)

One of

- MATH 128 Calculus 2 for the Sciences
- MATH 138 Calculus 2 for Honours Mathematics
- MATH 148 Calculus 2 (Advanced Level)

One of

- MATH 135 Algebra for Honours Mathematics
- MATH 145 Algebra (Advanced Level)

One of

- MATH 136 Linear Algebra 1 for Honours Mathematics
- MATH 146 Linear Algebra 1 (Advanced Level)

One of

- MATH 239 Introduction to Combinatorics
- MATH 249 Introduction to Combinatorics (Advanced Level)

One of

- STAT 230 Probability
- STAT 240 Probability (Advanced Level)

One of
STAT 231 Statistics  
STAT 241 Statistics (Advanced Level)

All of

CO 250 Introduction to Optimization  
CS 240 Data Structures and Data Management  
CS 241 Foundations of Sequential Programs  
CS 245 Logic and Computation  
CS 246 Object-Oriented Software Development  
CS 251 Computer Organization and Design  
CS 341 Algorithms  
CS 350 Operating Systems  
CS 490 Information Systems Management  
CS 492 The Social Implications of Computing

Four additional CS courses chosen from CS 340-CS 398, CS 440-CS 489, with at least two chosen from CS 440-CS 489.

From Wilfrid Laurier University (Laurier)

All of

BUS 111W Understanding the Business Environment  
BUS 121W Functional Areas of the Organization  
BUS 127W Introduction to Financial Accounting  
BUS 231W Business Law  
BUS 247W Managerial Accounting  
BUS 283W Financial Management I  
BUS 288W Organizational Behaviour I  
BUS 352W Introduction to Marketing Management  
BUS 354W Human Resources Management  
BUS 362W Building and Managing Products, Services and Brands  
BUS 375W Operations Management  
BUS 393W Financial Management II  
BUS 398W Organizational Behaviour II  
BUS 481W Business Policy I  
BUS 491W Business Policy II  
ECON 120W Introduction to Microeconomics  
ECON 140W Introduction to Macroeconomics

Note: See Laurier calendar for above list of courses.

One of

ECON 250W Intermediate Macroeconomic Analysis for Management  
ECON 260W Intermediate Microeconomic Analysis for Management

Note: See Laurier calendar for above list of courses.

Six additional 300- or 400- level BUS or ENTR elective courses (3.0 units) taken in third, fourth, or fifth year.

From Waterloo or Laurier

Four additional elective courses (2.0 units) are required. Students are free to choose their elective courses from either university.

Notes

1. For details about the various Laurier Honours Bachelor of Business Administration (BBA) policies, procedures, regulations, and requirements that apply to this double degree plan, please consult the Laurier calendar and/or one of the plan's academic advisors at Laurier.

2. Students may be allowed to have additional designations (e.g., minors or options) on their Waterloo diploma and transcript. Such designations must be approved by the academic unit offering the minor or option and the double degree advisors from both Waterloo and Laurier. The designations must not be similar to any designations on the student's Laurier academic record and must be in disciplines offered outside of the School of Business & Economics at Laurier.

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
3. Students may elect to replace the Computer Science (BCS) with one of the following degree plans if they satisfy all the degree requirements for both the alternate degree and the double degree.

- a BCS Data Science plan,
- a BMath CS plan, or
- a BMath Data Science plan.

Note: The alternate degree must be approved by the double degree advisors from both Waterloo and Laurier.

**Joint Computer Science (Bachelor of Mathematics)**

See [Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) for a description of joint plan requirements. Note that both specialization areas designated in joint plans must be disciplines within the Faculty of Mathematics. The joint requirements for Joint Computer Science (Bachelor of Mathematics) are identical to those for the [Joint Bachelor of Computer Science](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117).

**Joint Bachelor of Computer Science**

Students in this plan must satisfy all the requirements of [Table I](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117), and the requirements below.

One of

- CS 115 Introduction to Computer Science 1
- CS 135 Designing Functional Programs
- CS 145 Designing Functional Programs (Advanced Level)

One of

- CS 136 Elementary Algorithm Design and Data Abstraction
- CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

- MATH 127 Calculus 1 for the Sciences
- MATH 137 Calculus 1 for Honours Mathematics
- MATH 147 Calculus 1 (Advanced Level)

One of

- MATH 128 Calculus 2 for the Sciences
- MATH 138 Calculus 2 for Honours Mathematics
- MATH 148 Calculus 2 (Advanced Level)

One of

- MATH 135 Algebra for Honours Mathematics
- MATH 145 Algebra (Advanced Level)

One of

- MATH 136 Linear Algebra 1 for Honours Mathematics
- MATH 146 Linear Algebra 1 (Advanced Level)

One of

- MATH 239 Introduction to Combinatorics
- MATH 249 Introduction to Combinatorics (Advanced Level)

One of

- STAT 230 Probability
- STAT 240 Probability (Advanced Level)

One of
STAT 231  Statistics  
STAT 241  Statistics (Advanced Level)  

All of  
  
CS 240  Data Structures and Data Management  
CS 241  Foundations of Sequential Programs  
CS 245  Logic and Computation  
CS 246  Object-Oriented Software Development  
CS 251  Computer Organization and Design  
CS 341  Algorithms  
CS 350  Operating Systems  

One additional course chosen from CS 340-CS 398, CS 440-CS 489.  
Two additional courses chosen from CS 440-CS 489, CS 499T.  
Ten non-math courses satisfying the same restrictions as specified for the Bachelor of Computer Science.  

Options  

Bioinformatics Option  
The Bioinformatics Option is available for both the Bachelor of Computer Science (BCS) and the Bachelor of Mathematics (BMath) (Computer Science) plans. The requirements are the same as for the BCS and BMath (CS) plans except that  

1. elective breadth and depth requirements are waived, and  
2. both plans include the following additional constraints on course selection.  

All of  
  
BIOL 130  Introductory Cell Biology  
BIOL 130L  Cell Biology Laboratory  
BIOL 239  Genetics  
BIOL 240  Fundamentals of Microbiology  
BIOL 240L  Microbiology Laboratory  
BIOL 309  Analytical Methods in Molecular Biology  
BIOL 365  Methods in Bioinformatics  
BIOL 465  Structural Bioinformatics  
CHEM 120  Physical and Chemical Properties of Matter  
CHEM 120L  Chemical Reaction Laboratory 1  
CHEM 123  Chemical Reactions, Equilibria and Kinetics  
CHEM 123L  Chemical Reaction Laboratory 2  
CS 482  Computational Techniques in Biological Sequence Analysis  

Business Option  
The Business Option is available for both the Bachelor of Computer Science (BCS) and the Bachelor of Mathematics (BMath) (Computer Science) plans. The requirements are the same as for the BCS and BMath (CS) plans except that  

1. elective breadth and depth requirements are waived, and  
2. both plans include the following additional constraints on course selection.  

Two of  
  
CS 348  Introduction to Database Management  
CS 454  Distributed Systems  
CS 490  Information Systems Management  

Six of (business courses)  
  
ACTSC 231  Introductory Financial Mathematics  
ACTSC 371  Introduction to Investments  
ACTSC 372  Corporate Finance
AFM 101 Introduction to Financial Accounting or AFM 123/ARBUS 102 Accounting Information for Managers
AFM 102 Introduction to Managerial Accounting
AFM 131/ARBUS 101 Introduction to Business in North America or BUS 111W Understanding the Business Environment (see Laurier calendar)
ARBUS 302/ECON 344 Marketing I: Principles of Marketing and Consumer Economics
BUS 121W Functional Areas of the Organization (see Laurier calendar)
BUS 362W Building and Managing Products, Services and Brands (see Laurier calendar)
BUS 481W Business Policy I (see Laurier calendar)
BUS 491W Business Policy II (see Laurier calendar)
COMM 400 Entrepreneurship, Technology and the Emerging Information Economy
ECON 101 Introduction to Microeconomics
ECON 102 Introduction to Macroeconomics
ECON 220 Entrepreneurship Principles and Practices
HRM 200 Basic Human Resources Management
MSCI 211 Organizational Behaviour or PSYCH 238 Organizational Psychology
MSCI 311 Organizational Design and Technology
MSCI 452 Decision Making Under Uncertainty

Note: Courses labelled BUS are offered by the School of Business and Economics at Wilfrid Laurier University and are designated as BU in the Laurier calendar. Non-math courses may have enrolment limits or may not easily fit schedules.

Computational Fine Arts Option
This option is available for the Bachelor of Computer Science (BCS) and Bachelor of Mathematics (BMath) (Computer Science) plans. The Computational Fine Art Option gives Computer Science students an opportunity to develop creativity and critical thinking, ultimately applying their computer science skills to create works of art. These works might, for example, explore new ways to visualize high dimensional data, develop non-photorealistic rendering, or simply create new computer-mediated experiences. The option provides a basic foundation in art studio practice, art history, and art theory to prepare students for focused studio courses combining computers and art. The option culminates in a specially designed studio course (CS 383/FINE 383) taken together with Fine Arts students who have a foundation in computer programming. The course requirements are the same as for the BCS or BMath (Computer Science) with the following additional requirements:

All of

- CS 349 User Interfaces
- CS 488 Introduction to Computer Graphics
- CS 383/FINE 383 Computational Digital Art Studio
- FINE 100 Studio Fundamentals
- FINE 101/VCULT 101 Art History and Visual Culture
- FINE 229/GBDA 229 Hybrid Digital Media
- FINE 257 Video, New Media & the Digital Turn

Computing Technology Option
A Computing Technology option is available to all students, except those enrolled in Software Engineering, Computing and Financial Management, and other plans involving Computer Science. Certain plans already including substantial computer science content may also be excluded. See the Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations page for more details about excluded plans.

One of

- CS 115 Introduction to Computer Science 1
- CS 135 Designing Functional Programs
- CS 145 Designing Functional Programs (Advanced Level)

One of
CS 116 Introduction to Computer Science 2  
CS 136 Elementary Algorithm Design and Data Abstraction  
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One additional CS course from CS 100-146, CS 200-299, CS 300-398, CS 400-498.

Four additional courses from CS 200-299, CS 300-398, CS 400-498, COMM 432

One additional course from CS 300-398, CS 400-498

The average of all CS courses on the student’s record (including repeated courses) must be at least 60%.

Notes

1. Most courses in the range CS 240-299, CS 340-398, CS 440-498 are only available to CS majors, so upper-year CS courses taken toward this option will usually be in the range CS 200-239, CS 300-339, CS 400-439.
2. A common route into upper-year CS courses is to take all of CS 115, CS 116 and CS 136. All three of these courses may count toward this option.
3. Students cannot obtain both the CS minor and the Computing Technology option.

Digital Hardware Option

Students must apply for entry during 1A and have a cumulative average of 75% or higher. Enrolment in this plan is limited. Graduates of this option do not qualify for the professional engineering designation.

The "Digital Hardware Option" is available for both the Bachelor of Computer Science and the Bachelor of Mathematics (Computer Science). In each case, the requirements are the same except that ECE 222 replaces CS 251 and the following additional constraints apply to course selection:

Two of

- CS 452 Real-Time Programming
- CS 454 Distributed Systems
- CS 456 Computer Networks
- CS 457 System Performance Evaluation

One of

- ECE 224 Embedded Microprocessor Systems
- MTE 325 Microprocessor Systems and Interfacing for Mechatronics Engineering

One of

- ECE 429 Computer Architecture
- CS 450 Computer Architecture

Note: Students taking ECE 429 instead of CS 450 will count this as 0.5 math units in the range CS 440-498, and not 0.5 non-math units.

One of

- GENE 123 Electrical Circuits and Instrumentation
- MTE 120 Circuits

All of

- ECE 124 Digital Circuits and Systems
- ECE 327 Digital Hardware Systems
- ECE 423 Embedded Computer Systems

Recommended courses

- ECE 455 Embedded Software
- PHYS 121 Mechanics
Human-Computer Interaction Option

Human-Computer Interaction (HCI) is concerned with the study of how people interact with computers and computational systems, as well as, the design and implementation of such systems. The HCI Option is available for the Bachelor of Computer Science (BCS) and Bachelor of Mathematics (Computer Science (BMath) plans. The course requirements are the same as for the BCS or BMath with the following additional requirements:

All of

- CS 349 User Interfaces
- CS 449 Human-Computer Interaction
- CS 492 The Social Implications of Computing

Two of

- CS 445/ECE 451 Software Requirements Specification and Analysis
- CS 446/ECE 452 Software Design and Architectures
- CS 447/ECE 453 Software Testing, Quality Assurance and Maintenance
- CS 454 Distributed Systems
- CS 458 Computer Security and Privacy
- CS 484 Computational Vision
- CS 485 Machine Learning: Statistical and Computational Foundation
- CS 488 Introduction to Computer Graphics

Two of

- ENGL 108D Digital Lives
- ENGL 293 Introduction to Digital Media Studies
- ENGL 295 Social Media
- FINE 150 Appreciation and Expression
- FINE 257 Video, New Media & the Digital Turn
- INTEG 251 Creative Thinking
- KIN 320 Task Analysis
- PSYCH 207 Cognitive Processes
- PSYCH 261 Physiological Psychology
- STAT 332 Sampling and Experimental Design
- STAT 430 Experimental Design

Software Engineering Option

The Software Engineering Option is available for both the Bachelor of Computer Science (BCS) and the Bachelor of Mathematics (Computer Science) (BMath) plans. This option is offered jointly by the David R. Cheriton School of Computer Science and the Department of Electrical and Computer Engineering. The rationale for the plan is described in the engineering section of Faculty Options. Given that the option involves two faculties, it has slightly different realizations in those faculties. Students who complete this option do not qualify for the professional engineering designation. The course requirements are the same as for the BCS and BMath with the following constraints on upper-year CS courses:

Foundations

All of

- CS 445/ECE 451 Software Requirements Specification and Analysis
- CS 446/ECE 452 Software Design and Architectures
- CS 447/ECE 453 Software Testing, Quality Assurance and Maintenance
- CS 492 The Social Implications of Computing

Applications

Two of
CS 343 Concurrent and Parallel Programming
CS 348 Introduction to Database Management
CS 349 User Interfaces

Two of

CS 444 Compiler Construction
CS 448 Database Systems Implementation
CS 449 Human-Computer Interaction
CS 450 Computer Architecture
CS 452 Real-time Programming
CS 454 Distributed Systems
CS 456 Computer Networks
CS 457 System Performance Evaluation
CS 458 Computer Security and Privacy
CS 484 Computational Vision
CS 485 Machine Learning: Statistical and Computational Foundations
CS 486 Introduction to Artificial Intelligence
CS 488 Introduction to Computer Graphics

Computer Science Minor
A "Computer Science minor" is available to all Honours students except in combination with Computer Science plans. Excluded plans include Software Engineering, Computing and Financial Management, and joint plans involving Computer Science.

The Computer Science minor is generally not available to students outside the Faculty of Mathematics because it includes several restricted courses. Students inside the Faculty of Mathematics may need to register as a Computer Science major for one or more terms to complete the Computer Science minor.

Students are encouraged to consider the Computing Technology Option as an alternative to the Computer Science Minor. Students may not complete both the Computer Science Minor and the Computing Technology Option.

One of

MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

A minimum of eight CS courses including:

One of

CS 115 Introduction to Computer Science 1
CS 135 Designing Functional Programs
CS 145 Designing Functional Programs (Advanced Level)

One of

CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One additional course from CS 340-398, CS 440-498.

Five additional courses from CS 240-299, CS 340-398, CS 440-498.

The average of all CS courses on the student’s record (including repeated courses) must be at least 60%.

Notes

1. Some CS courses are not available to students pursuing a CS minor. Consult individual course requisites for details.
2. Students who are not eligible for the CS minor are encouraged to consider the Computing Technology Option.

Accelerated Master's
Undergraduate students in the Bachelor of Mathematics (CS) and Bachelor of Computer Science plans can, under some circumstances, take graduate courses in their fourth year that will count towards a Master of Mathematics (MMath) degree. Such students must have high marks and enough room in their schedule to take such courses without counting them toward the undergraduate degree.

Students interested in this opportunity should contact the Coordinator of Graduate Studies for Computer Science or consult the Graduate Studies Academic Calendar.

Computing and Financial Management

Computing and Financial Management Overview and Degree Requirements
The objective of the Computing and Financial Management (CFM) program is to provide students with a strong core background in computer science and financial management. Careful selection of optional courses should permit graduates to go on to graduate studies in these disciplines, with a small number of supplemental courses.

The CFM program is offered jointly by the David R. Cheriton School of Computer Science and the School of Accounting and Finance. Students will be members of both the Faculty of Arts and the Faculty of Mathematics, although, for administrative purposes, they will be registered in a separate unit. The Honours Computing and Financial Management program leads to a Bachelor of Computing and Financial Management degree.

The course requirements for CFM reflect the interdisciplinary nature of this program, with eighteen courses from the Faculty of Mathematics, eighteen courses from the Faculty of Arts, and four general electives, for a total of forty courses.

Students in CFM must fulfil all the requirements of Table I, except the Communication Skills Requirement; instead, students in CFM must satisfy the English Language Proficiency Requirement as specified by the Faculty of Arts. A student’s standing in the program will be determined according to policies used in the Faculty of Mathematics. The Honours Computing and Financial Management program is also considered an Honours Computer Science plan for purposes of student access to math courses.

One of

- **CS 115** Introduction to Computer Science 1
- **CS 135** Designing Functional Programs
- **CS 145** Designing Functional Programs (Advanced Level)

**Note:** CFM students normally start in CS 135. Students with strong aptitude may take CS 145 and CS 146. Students who start in CS 115 must take CS 116 as an extra course before taking CS 136.

One of

- **CS 136** Elementary Algorithm Design and Data Abstraction
- **CS 146** Elementary Algorithm Design and Data Abstraction (Advanced Level)

All of

- **AFM 101** Introduction to Financial Accounting
- **AFM 102** Introduction to Managerial Accounting
- **AFM 121** Introduction to Global Financial Markets
- **AFM 131** Introduction to Business in North America
- **AFM 231** Business Law
- **AFM 272/ACTSC 291** Corporate Finance 1
- **AFM 322** Derivative Securities
- **AFM 372/ACTSC 391** Corporate Finance 2
- **AFM 424** Equity Investments
- **AFM 425** Fixed Income Securities
- **CS 240** Data Structures and Data Management
- **CS 241** Foundations of Sequential Programs
- **CS 245** Logic and Computation
- **CS 246** Object-Oriented Software Development
- **CS 341** Algorithms
- **ECON 101** Introduction to Microeconomics
**ECON 102** Introduction to Macroeconomics

**STAT 373** Regression and Forecasting Methods in Finance

One of

**MATH 135** Algebra for Honours Mathematics

**MATH 145** Algebra (Advanced Level)

One of

**MATH 136** Linear Algebra 1 for Honours Mathematics

**MATH 146** Linear Algebra 1 (Advanced Level)

One of

**MATH 127** Calculus 1 for the Sciences

**MATH 137** Calculus 1 for Honours Mathematics

**MATH 147** Calculus 1 (Advanced Level)

One of

**MATH 128** Calculus 2 for the Sciences

**MATH 138** Calculus 2 for Honours Mathematics

**MATH 148** Calculus 2 (Advanced Level)

One of

**MATH 239** Introduction to Combinatorics

**MATH 249** Introduction to Combinatorics (Advanced Level)

One of

**STAT 230** Probability

**STAT 240** Probability (Advanced Level)

One of

**STAT 231** Statistics

**STAT 241** Statistics (Advanced Level)

Three of

**AFM 291** Intermediate Financial Accounting 1

Any AFM course at the 300- or 400-level not listed above.

**ECON 201** Microeconomic Theory for Business and Policy

**ECON 206** Money and Banking 1

**ECON 207** Economic Growth and Development 1

**ECON 231** Introduction to International Economics

**ECON 332** International Finance

**ECON 344** Marketing 1: Principles of Marketing and Consumer Economics

**PHIL 215** Professional and Business Ethics

**SPCOM 223** Public Speaking

Two additional AFM courses (1.0 units) at the 300- or 400-level not listed above.

One additional course from CS 440-498, **CO 487**.

Two additional courses from CS 340-398, CS 440-498, **CO 487**.

One of

**ENGL 119** Communications in Mathematics & Computer Science

**ENGL 210F** Genres of Business Communication

Four additional courses (2.0 units).
Notes

1. The Computing and Financial Management program's academic curriculum is a combination of the curricula in Computer Science and Accounting and Financial Management, and therefore, cannot be combined with any plan, minor, or option offered by the David R. Cheriton School of Computer Science or the School of Accounting and Finance. Other plan combinations, minors, or options may be possible, but may require more than 40 courses (20.0 units) and/or more than the customary eight study terms to satisfy all of the various requirements. Plan combinations, minors or options should not be considered without careful consultation with a Bachelor of Computing and Financial Management (BCFM) advisor.

2. BCFM students have a major average (MAV) based on all math courses and a special average (SMAV) based on all courses taken from the Faculty of Arts. To graduate with a BCFM degree, a student must have a MAV of at least 60% and a SMAV of at least 70%.

3. To continue in the BCFM program a student must normally meet the average requirements specified in the preceding note at the end of each term. The averages, however, are not computed until there are at least three courses available for the average. A student who does not meet the MAV or SMAV requirement at the end of a term, may, at the discretion of a BCFM advisor, be allowed to continue for an additional term in an attempt to raise the average(s) to the required standard.

4. The Bachelor of Computing and Financial Management (see the co-op Study/Work Sequence section) follows Sequence A. Deviations from this sequence can cause a delay in graduation of as much as one calendar year; therefore, alterations should not be considered without careful consultation with a BCFM advisor.

Admissions

The Bachelor of Computing and Financial Management (BCFM) Steering Committee, in consultation with the Faculties of Arts and Mathematics, and their admission committees, determines admission requirements for the BCFM program.

Minimum admission requirements are those of the Faculty of Mathematics, with admissions to the BCFM program handled by the Mathematics Admissions committee, following policies set by the BCFM Steering committee.

English language proficiency requirements are those of the Faculty of Arts. Students will be required to have a minimum of 75% in English 4 U (grade 12 university level) or equivalent.

Recognition of Excellence

Term Dean's Honours List

The designation "Dean's Honours List" is awarded to any Bachelor of Computing and Financial Management (BCFM) student who satisfies either of the following criteria:

1. Completed a minimum of 5.0 units which count in the cumulative average, with a cumulative average of at least 83%.
2. Completed a minimum of 2.5 units in that term with numeric or letter grades, with no excluded courses, no grades of INC, IP, or UR (see Grading System for full grade descriptions), and a term average of at least 87%.

The Dean's Honours List designation will appear on the student's official University transcript.

Graduation Dean's Honours List

A BCFM student who satisfies either of the following criteria will graduate on the Dean's Honours List.

1. A cumulative overall average of 83% with no INC, IP, or UR grades (see Grading System for full grade descriptions)
2. A cumulative overall average of 87% with no INC, IP, or UR grades (see Grading System for full grade descriptions). Any student who satisfies this criterion will have their name displayed on the walls of the MC corridor 1108.

The Dean's Honours List designation will appear on the student's official University transcript and diploma.

Health Informatics Option

Health Informatics Option

The "Health Informatics Option" is a restricted-enrolment plan which is available for honours students in the Faculty of Mathematics. This option requires completion of the following courses:
All of

- HLTH 101 Introduction to Health 1
- HLTH 102 Introduction to Health 2
- HLTH 230 Introduction to Health Informatics

One of

- HLTH 333 Principles of Epidemiology
- HLTH 344 Qualitative Methods for Health Research

One of

- AFM 131/ARBUS 101 Introduction to Business in North America
  BUS 111W Introduction to Business Organization (see Laurier calendar)

One of

- CS 330 Management Information Systems
- CS 490 Information Systems Management

One of

- CS 432 Business Systems Analysis
  Any course from CS 440-489

**Mathematics/Business**

**Business Administration and Mathematics Double Degree**

**Overview**

This double degree academic plan is administered jointly by the Faculty of Mathematics at the University of Waterloo (Waterloo) and the School of Business and Economics at Wilfrid Laurier University (Laurier). It is a restricted-enrolment plan with admission normally limited to Year One in fall term.

Students who successfully complete this plan will be eligible to attend both universities' convocation ceremonies and be awarded a Waterloo Honours Bachelor of Mathematics (BMath) degree and a Laurier Honours Bachelor of Business Administration (BBA) degree at the respective convocations. Students may register for this plan at either university. The academic component is the same, regardless of where students are formally registered, but students participate in the co-op process at their home institution. Thus, the degree attached to each student's registered university is a co-op degree, with the other university's degree being a regular one.

This academic plan cannot be combined with any other major, minor, or option designation except as described in the notes below. It requires a minimum of nine full-time academic study terms and successful completion of a minimum of 52 one-term courses (26 units). These 52 courses (26 units) must include 24 (12 units) specified mathematics and computer science courses taken at Waterloo and 24 (12 units) specified business-related courses at Laurier. The remaining four (two units) elective courses may be taken at either university.

For Waterloo-registered students, the co-op process involves four (or five at a student's discretion) co-op work terms intermixed with study terms. The first of these work terms occurs during the spring (May to August period) between the second and third study terms. The complete sequencing of terms for Waterloo-registered students is listed in the Study/Work Sequence section. Students in this plan will be required to pay six co-op fees, which are usually assessed in the first three years of study.

For Laurier-registered students, the co-op process involves three (or four at a student's discretion) co-op work terms intermixed with the ten study terms. The first of these work terms occurs during the January to April period between the third and fourth study terms. The earlier spring (May to August period) between the second and third study terms is an "off" term (where students are on their own for the term, similar to regular students). With the exception of this first May to August term being an "off" term rather than a co-op work term, the term sequencing for Laurier-registered students is identical to the one for Waterloo-registered students.

With the sequencing of study terms and work terms indicated above, the normal duration for this plan is four and two-thirds calendar years (or five calendar years at a student's discretion). Only under especially
mitigating circumstances, and with the approval of both universities, can the term sequencing attached to
the double degree plan be altered, and such instances will usually result in a delay (possibly as much as
one calendar year) of graduation date.

All double degree plan students, regardless of their home university affiliation, are required to satisfy all
term-by-term progression requirements of both Waterloo's Faculty of Mathematics and the School of
Business and Economics at Wilfrid Laurier University to remain eligible to continue in the plan, and to meet
all graduation requirements of both institutions to be eligible for the two degrees. More specifically,
students must ensure that their course selection each term, their academic performance level, and their
academic conduct in general, comply with all the policies, procedures, regulations, and requirements of
both universities. Failure to do so will normally result in students being Required to Withdraw from the
double degree plan. Such students may remain eligible to enrol in the (single-degree) Laurier BBA program
(although not necessarily in co-op) or to enrol in another appropriate (single-degree) Waterloo BMath plan
respectively, depending upon their individual circumstances.

Degree Requirements
Students in this plan must fulfill all the requirements in Table I and Table II. This must include the following
specific requirements:

From the University of Waterloo (Waterloo)
One of

CO 250 Introduction to Optimization
CO 255 Introduction to Optimization (Advanced Level)

All of

ACTSC 231 Introductory Financial Mathematics
CO 370 Deterministic OR Models
CS 330 Management Information Systems
STAT 371 Applied Linear Models and Process Improvement for Business
STAT 372 Survey Sampling and Experimental Design Techniques for Business

Seven additional 200- or 300- or 400-level math courses.

From Wilfrid Laurier University (Laurier)
All of

BUS 111W Understanding the Business Environment
BUS 121W Functional Areas of the Organization
BUS 127W Introduction to Financial Accounting
BUS 231W Business Law
BUS 247W Managerial Accounting
BUS 283W Financial Management I
BUS 288W Organizational Behaviour I
BUS 352W Introduction to Marketing Management
BUS 354W Human Resources Management
BUS 362W Building and Managing Products, Services and Brands
BUS 375W Operations Management
BUS 393W Financial Management II
BUS 398W Organizational Behaviour II
BUS 481W Business Policy I
BUS 491W Business Policy II
ECON 120W Introduction to Microeconomics
ECON 140W Introduction to Macroeconomics

Note: See Laurier calendar for above list of courses.

One of

ECON 250W Intermediate Macroeconomic Analysis for Management
ECON 260W Intermediate Microeconomic Analysis for Management

Note: See Laurier calendar for above list of courses.
Six additional 300- or 400-level BUS or ENTR elective courses (3.0 units) taken in third, fourth or fifth year.

**From Waterloo or Laurier**

Four additional elective courses (2.0 units) are required. Students are free to choose their elective courses from either university.

**Notes**

1. For details about the various Laurier Honours Bachelor of Business Administration (BBA) policies, procedures, regulations, and requirements that apply to this double degree plan, please consult the Laurier calendar and/or one of the plan's academic advisors at Laurier.
2. The abbreviations "BU" and "EC" are used in the Laurier calendar for Business and Economics courses respectively.
3. Waterloo-registered students who meet all the academic graduation requirements for this plan, but who do not meet the minimum requirements for a co-op degree may, in exceptional circumstances and at the discretion of the Standing and Promotions (S&P) Committee, be awarded a Regular Honours BMath/Business Administration and Mathematics degree.
4. Students may, in certain circumstances, be permitted to have a minor and/or option designation on their Waterloo Bachelor of Mathematics (BMath) diploma and transcript. Such a designation must be in a Waterloo discipline outside the areas of study offered by the Department of Business at Wilfrid Laurier University, and it cannot duplicate a similar designation on the student's Laurier academic record. In addition to the approval of the academic unit offering the minor or option, students require the approval of a double degree academic advisor from both Waterloo and Laurier to enrol for such a minor or option designation on their Waterloo academic record. Students wishing to have a minor, option, or specialization designation on their Laurier academic record should consult the Laurier calendar for details and discuss their situation with an academic advisor from the School of Business and Economics at Wilfrid Laurier University. Electing to have a separate major, minor, option, or specialization designation is not required for students in the double degree plan, and in some cases, satisfying the combined requirements for both the double degree plan and those for an extra designation may require successful completion of more than 52 courses.

**Information Technology Management**

**Overview**

The effective management of information technology is now a mission-critical component of virtually every enterprise. This plan is designed to equip graduates with the skills necessary to apply modern technology solutions to business processes.

Combining technical courses in computer science, business statistics, optimization, and finance with business courses in marketing, project management, electronic business and strategic management of technology, students will be well prepared for exciting careers in business.

Information Technology Management is a restricted-enrolment plan. Students are normally admitted at the Year One level into the Mathematics/Business Administration admission category. In Year Two, provided they remain eligible for an honours program, such students may select the Information Technology Management plan.

Students admitted to the Faculty in other admission categories may subsequently apply for transfer into Information Technology Management at a later date. However, to be admitted, such applicants will normally be required to have a “Good” or “Excellent” academic standing with a minimum 70.0 cumulative overall average (CAV) based on at least 5.0 units of non-excluded courses.

**Degree Requirements**

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 20 math courses, and the following specific requirements:

One of

- MATH 239 Introduction to Combinatorics
- MATH 249 Introduction to Combinatorics (Advanced Level)
One of

- CO 250 Introduction to Optimization
- CO 255 Introduction to Optimization (Advanced Level)

All of

- ACTSC 371 Introduction to Investments
- CS 230 Introduction to Computers and Computer Systems
- CS 330 Management Information Systems
- CS 338 Computer Applications in Business: Databases
- CS 430 Applications Software Engineering
- CS 432 Business Systems Analysis
- CS 436 Networks and Distributed Computer Systems
- STAT 371 Applied Linear Models and Process Improvement for Business
- STAT 372 Survey Sampling and Experimental Design Techniques for Business

All of

- AFM 101 Introduction to Financial Accounting
- AFM 102 Introduction to Managerial Accounting
- BUS 111W Understanding the Business Environment (see Laurier calendar)
- BUS 121W Functional Areas of the Organization (see Laurier calendar)
- BUS 352W Introduction to Marketing Management (see Laurier calendar)
- BUS 481W Business Policy I (see Laurier calendar)
- COMM 231 Commercial and Business Law for Mathematics Students
- COMM 431 Project Management
- COMM 432 Electronic Business
- ECON 101 Introduction to Microeconomics
- ECON 102 Introduction to Macroeconomics
- MSCI 211 Organizational Behaviour
- MSCI 311 Organizational Design and Technology
- STV 202 Design and Society

One of

- MSCI 421 Strategic Management of Technology
- Any 300- or 400-level STV course

Three additional courses (1.5 units).

**Mathematical Economics**

**Overview**

Economics and Mathematics are complementary disciplines. Indeed, much of current economic theory is expressed in terms of mathematical models, and most branches of economics use mathematical, statistical, and computational concepts extensively. Also, many advances in mathematics have been motivated by problems from economics.

The Faculty of Mathematics and the Faculty of Arts are proud to offer this collaborative plan. In addition to this Mathematical Economics plan offered by the Faculty of Mathematics, the Faculty of Arts also offers an Honours Mathematical Economics plan which leads to a Bachelor of Arts (BA) degree. Since the junior-level courses are common to both degrees, the structure of the plan makes it easier for students to switch between the two plans. Students contemplating an application to transfer Faculties should consult an advisor regarding important effects of such a change (such applications are not automatically granted).

**Degree Requirements**

**Legend**

*Students must choose one of ACTSC 371 or ECON 371. If a student chooses ACTSC 371, it will count as one of the mathematics group choices. If a student chooses ECON 371, it will count as one of the economics group choices.*
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 22 math courses, and the following specific requirements:

All of

- **ECON 101** Introduction to Microeconomics
- **ECON 102** Introduction to Macroeconomics
- **ECON 290** Models of Choice in Competitive Markets
- **ECON 306** Macroeconomics
- **ECON 391** Equilibrium in Market Economies
- **ECON 393** Market Failures
- **ECON 472** Senior Honours Essay
- **ECON 491** Advanced Microeconomics
- **ECON 496** Advanced Macroeconomics

One of

- **ECON 406** Money and Banking 2
- **ECON 407** Economic Growth and Development 2
- **ECON 408** Business Cycles
- **ECON 409** Workers, Jobs, and Wages

**Economics group**
Four (2.0 units) additional 300- or 400-level ECON courses*.

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

One of

- **CO 250** Introduction to Optimization
- **CO 255** Introduction to Optimization (Advanced Level)

All of

- **AMATH 331/PMATH 331** Applied Real Analysis
- **AMATH 350** Differential Equations for Business and Economics
- **STAT 331** Applied Linear Models
- **STAT 443** Forecasting

**Mathematics group**
Seven additional math courses*.

Two additional courses (1.0 units).

**Note**

1. For graduation and progression purposes, a student’s averages will be calculated according to the practices of the Faculty in which the student is formally registered. Should a student transfer from the Mathematics Faculty to the Arts Faculty (or vice versa), the student’s average calculations may be revised to reflect the differing average calculation rules.

**Mathematics/Business Administration**

**Overview**

The Faculty of Mathematics, in co-operation with various academic units from other faculties at the University of Waterloo (Waterloo) and the School of Business and Economics at Wilfrid Laurier University (Laurier), offers the Honours Mathematics/Business Administration plan.

The Mathematics/Business Administration plan provides an opportunity to combine courses in actuarial science, computer science, optimization, and statistics with courses in accounting, business, economics, human resource management, and management sciences. Graduates are well prepared to use
sophisticated analytical techniques in the solution of business-related problems and adapt to the rapidly changing modern business environment.

Honours Mathematics/Business Administration is a restricted-enrolment plan. Most of the students enrolled in this plan are admitted at the Year One level directly into the Mathematics/Business Administration admission category.

Students admitted to the Faculty of Mathematics in other admission categories may subsequently apply for transfer to Mathematics/Business Administration at a later date. However, to be admitted, such applicants will normally be required to have a "Good" or "Excellent" academic standing with a minimum 70.0 cumulative overall average (CAV) based on at least 5.0 units of non-excluded courses. Applicants "in good standing" with less than a 70.0 CAV will also be considered on an individual basis if resources available at the time of their application should permit enrolling additional students in the plan.

**Required BUS Courses At Laurier**

In the plan requirements, courses with the prefix BUS are offered by the School of Business and Economics at Wilfrid Laurier University.

**Degree Requirements**

Students in this plan must fulfill all the requirements in [Table I](#) and [Table II](#). This must include at least 21 math courses, and the following specific requirements:

One of

- MATH 237 Calculus 3 for Honours Mathematics
- MATH 247 Calculus 3 (Advanced Level)

One of

- CO 250 Introduction to Optimization
- CO 255 Introduction to Optimization (Advanced Level)

All of

- ACTSC 371 Introduction to Investments
- ACTSC 372 Corporate Finance
- AMATH 350 Differential Equations for Business and Economics
- CO 370 Deterministic OR Models
- CS 330 Management Information Systems
- CS 338 Computer Applications in Business: Databases
- STAT 371 Applied Linear Models and Process Improvement for Business
- STAT 372 Survey Sampling and Experimental Design Techniques for Business

Two additional math courses.

All of

- AFM 102 Introduction to Managerial Accounting
- BUS 111W Understanding the Business Environment (see Laurier calendar)
- BUS 121W Functional Areas of the Organization (see Laurier calendar)
- BUS 352W Introduction to Marketing Management (see Laurier calendar)
- BUS 481W Business Policy I (see Laurier calendar)
- COMM 231 Commercial and Business Law for Mathematics Students
- ECON 101 Introduction to Microeconomics
- ECON 102 Introduction to Macroeconomics
- HRM 200 Basic Human Resources Management

One of

- AFM 101 Introduction to Financial Accounting
- BUS 227W Introduction to Financial Accounting (see Laurier calendar)

One of

- MSCI 211 Organizational Behaviour
- PSYCH 238 Organizational Psychology
One additional 300- or 400- level COMM course.
One additional 300- or 400- level BUS or COMM course.
One additional course (0.5 unit) chosen from

- **ARBUS 202/PHIL 215** Professional and Business Ethics
- **COMM 400** Entrepreneurship, Technology and the Emerging Information Economy
- **LS 271/PACS 202** Conflict Resolution
- **LS 319/PACS 323** Negotiation: Theories and Strategies
- **PSYCH 339** Personnel Psychology

Any AFM, BUS (see Laurier calendar), COMM, ECON, HRM, MSCI, PSCI, or STV course

Three additional courses (1.5 units).

**Mathematics/Chartered Professional Accountancy (co-op only)**

**Overview**
The Faculty of Mathematics, in co-operation with the School of Accounting and Finance, offers the Honours Mathematics/Chartered Professional Accountancy (CPA) plan which combines mathematics with accounting and business-related disciplines.

In addition to providing excellent background preparation for careers in industry, this plan can lead to postgraduate studies in business-oriented disciplines. In particular, the Mathematics/CPA plan is specifically designed to be a prelude to Waterloo's two-term Master of Accounting (MAcc) graduate degree plan in the Faculty of Arts.

The Honours Mathematics/CPA plan provides an opportunity for studies in areas of mathematics including Actuarial Science, Computer Science, Optimization, and Statistics combined with an extensive professionally-oriented sequence of accounting courses. Graduates are well prepared to play a leading role in the increasingly important development and utilization of computer-based accounting information systems, the analysis of the information provided by such systems and the subsequent decision-making processes, and allocation of resources so crucial to an organization's success in the modern business world.

This plan involves four co-op work terms, the first of which occurs in the winter term immediately following the fall 2A academic term (see Study/Work Sequence). Students are exempted from paying co-op fees for their 1A and 1B terms.

**Admissions**
Students normally apply for direct admission from high school into the first year of the Mathematics/CPA plan. Upon successful completion of a provisional first year, students will formally proceed into the Mathematics/CPA plan in second year. Successful completion of the provisional year requires all of the following:

- Successful completion of at least 5.0 units including the following courses: **AFM 101**, **AFM 102**, **AFM 131**; **COMM 103/ECON 100** or (one of **ECON 101**, **ECON 102**); one of **CS 115**, **CS 135**, **CS 145**; **MATH 135/MATH 145**; **MATH 136/MATH 146**; **MATH 137/MATH 147**; **MATH 138/MATH 148**; **SPCOM 111**.

  These courses must be completed within 12 months of admission into the provisional year.

- A minimum average of 60% in all math courses taken to date.
- A minimum average of 70% in all AFM, COMM, or ECON courses taken to date.
- "Good standing" or "Excellent standing" in the Faculty of Mathematics.

Mathematics/CPA is a restricted-enrolment plan, and admission into the plan for students not currently enrolled in the provisional year is not normally granted.

**Degree Requirements**
Students in this plan must fulfill all the requirements in Table 1. This must include at least 18 math courses, and the following specific requirements:

One of

- **CS 115** Introduction to Computer Science 1
- **CS 135** Designing Functional Programs
- **CS 145** Designing Functional Programs (Advanced Level)

One of

- **CS 116** Introduction to Computer Science 2
- **CS 136** Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

MATH 127 Calculus 1 for the Sciences
MATH 137 Calculus 1 for Honours Mathematics
MATH 147 Calculus 1 (Advanced Level)

One of

MATH 128 Calculus 2 for the Sciences
MATH 138 Calculus 2 for Honours Mathematics
MATH 148 Calculus 2 (Advanced Level)

One of

MATH 135 Algebra for Honours Mathematics
MATH 145 Algebra (Advanced Level)

One of

MATH 136 Linear Algebra 1 for Honours Mathematics
MATH 146 Linear Algebra 1 (Advanced Level)

One of

STAT 230 Probability
STAT 240 Probability (Advanced Level)

One of

STAT 231 Statistics
STAT 241 Statistics (Advanced Level)

All of

AFM 272/ACTSC 291 Corporate Finance 1
AFM 372/ACTSC 391 Corporate Finance 2
AFM 476/ACTSC 471 Advanced Corporate Finance
STAT 373 Regression and Forecasting Models in Finance

One of

AFM 231/LS 283 Business Law
COMM 231 Commercial and Business Law for Mathematics Students

All of

AFM 101 Introduction to Financial Accounting
AFM 102 Introduction to Managerial Accounting
AFM 131/ARBUS 101 Introduction to Business in North America
AFM 202 Introduction to Public Practice
AFM 211 Connections to Business Context
AFM 291 Intermediate Financial Accounting 1
AFM 311 Connections to Ethical Context
AFM 341 Accounting Information Systems
AFM 351 Audit Strategy
AFM 362 Taxation 1 - Foundations
AFM 363 Taxation 2 - Integration
AFM 391 Intermediate Financial Accounting 2
AFM 401 Accounting Theory
AFM 433 Business Strategy
AFM 462 Taxation 3 - Tax Planning Topics
AFM 479 Cases and Applications in Finance II
AFM 481 Cost Management Systems
AFM 482 Performance Measurement and Organization Control
AFM 491 Advanced Financial Accounting
COMM 103/ECON 100 Principles of Economics or (ECON 101 Introduction to Microeconomics and ECON 102 Introduction to Macroeconomics)
SPCOM 111 Leadership Communication, and Collaboration

Six additional math courses (3.0 units).
One additional AFM, COMM, ECON, MSCI, or math course (0.5 units).

Notes

1. There is very little flexibility for altering the academic/work-term sequence prescribed for the Mathematics/Chartered Professional Accountancy (Math/CPA) plan (see "Study/Work Sequence") because of limited term offerings and structured prerequisites for most AFM courses. Since deviations from this sequence can cause a delay in graduation of as much as one calendar year, alterations should not be considered without careful consultation with the appropriate faculty advisor.
2. The order in which required non-math courses in this plan are taken is very important, and there is little room for flexibility (for the same reasons in Note 1 above). During the class enrolment period each term, students should be sure to consult with the appropriate faculty advisor.
3. Students may not repeat an AFM course in which they have obtained a grade of 60% or higher. AFM courses completed with a grade in the range 50 - 59% may be repeated, but only once, and then only with approval from the School of Accounting and Finance.
4. Students who have attempted, to the satisfaction of the Standings and Promotions (S&P) Committee and Co-operative Education and Career Action, to gain employment for all four available work terms, but are successful in so doing for only three work terms, will be eligible for a co-op degree, provided they have received credit for all three of their work terms and all three of their work reports, and they have successfully completed all academic graduation requirements. Students who are successful in gaining acceptable employment for four work terms will be required to have credit for all four work terms and all four work reports in order to qualify for a co-op degree.
5. Students who meet all the academic graduation requirements for this plan, but who do not meet the minimum requirements for a co-op degree (see preceding Note 4) may, in exceptional circumstances and at the discretion of the S&P Committee, be awarded a regular Honours Mathematics/Chartered Professional Accountancy degree.
6. In order to meet the requirements of both the Faculty of Mathematics and the School of Accounting and Finance, the Math/CPA plan requires the successful completion of 41 courses.

Tuition
This is a cost-recovery plan as defined by the Ministry of Training, Colleges, and Universities. As such, tuition higher than the normal University of Waterloo tuition is required.

Eligibility for Waterloo's Master of Accounting (MAcc) Academic Plan
The Math/CPA plan is designed to lead to the University of Waterloo Master in Accounting (MAcc) degree. Students should consult the MAcc website to ascertain specific MAcc admission criteria for Math/CPA graduates.

Finance Option (co-op only)
Students in this option must fulfill all the requirements in Table I. This must include at least 18 math courses, and the following specific requirements:

One of

CS 115 Introduction to Computer Science 1
CS 135 Designing Functional Programs
CS 145 Designing Functional Programs (Advanced Level)

One of

CS 116 Introduction to Computer Science 2
CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of
MATH 127 Calculus 1 for the Sciences  
MATH 137 Calculus 1 for Honours Mathematics  
MATH 147 Calculus 1 (Advanced Level)

One of  
MATH 128 Calculus 2 for the Sciences  
MATH 138 Calculus 2 for Honours Mathematics  
MATH 148 Calculus 2 (Advanced Level)

One of  
MATH 135 Algebra for Honours Mathematics  
MATH 145 Algebra (Advanced Level)

One of  
MATH 136 Linear Algebra 1 for Honours Mathematics  
MATH 146 Linear Algebra 1 (Advanced Level)

One of  
MATH 237 Calculus 3 for Honours Mathematics  
MATH 247 Calculus 3 (Advanced Level)

One of  
STAT 230 Probability  
STAT 240 Probability (Advanced Level)

One of  
STAT 231 Statistics  
STAT 241 Statistics (Advanced Level)

All of  
ACTSC 231 Introductory Financial Mathematics  
AFM 272/ACTSC 291 Corporate Finance 1  
AFM 372/ACTSC 391 Corporate Finance 2  
AFM 476/ACTSC 471 Advanced Corporate Finance  
STAT 373 Regression and Forecasting Models in Finance

One of  
AFM 231/LS 283 Business Law  
COMM 231 Commercial and Business Law for Mathematics Students

All of  
AFM 101 Introduction to Financial Accounting  
AFM 102 Introduction to Managerial Accounting  
AFM 131/ARBUS 101 Introduction to Business in North America  
AFM 202 Introduction to Public Practice  
AFM 211 Connections to Business Context  
AFM 291 Intermediate Financial Accounting 1  
AFM 311 Connections to Ethical Context  
AFM 341 Accounting Information Systems  
AFM 351 Audit Strategy  
AFM 362 Taxation 1 - Foundations  
AFM 363 Taxation 2 – Integration  
AFM 391 Intermediate Financial Accounting 2  
AFM 401 Accounting Theory
AFM 433 Business Strategy
AFM 462 Taxation 3 - Tax Planning Topics
AFM 479 Cases and Applications in Finance II
AFM 481 Cost Management Systems
AFM 482 Performance Measurement and Organization Control
AFM 491 Advanced Financial Accounting
COMM 103/ECON 100 Principles of Economics or (ECON 101 Introduction to Microeconomics and ECON 102 Introduction to Macroeconomics)
SPCOM 111 Leadership Communication, and Collaboration

Two of

ACTSC 371 Introduction to Investments
CS 335 Computational Methods in Business and Finance
MATBUS 471 Fixed Income Securities
MATBUS 472 Risk Management
STAT 334 Probability Models for Business and Accounting

Two of

AFM 321 Personal Financial Planning
AFM 322 Derivative Securities
AFM 328 and AFM 329, or AFM 328 and AFM 428, or AFM 329 and AFM 429 Investment Management (0.25 units each)
AFM 415 Special Topics or AFM 416 Special Topics in Finance
AFM 423 Topics in Financial Econometrics
AFM 434 Governance and Enterprise Risk Management for Global Organizations
AFM 477 Mergers and Acquisitions
AFM 478 International Financial Management
AFM 492 Financial Statement Analysis

Two additional math courses (1.0 units).

Notes

1. AFM 363, AFM 401, AFM 462, AFM 482, AFM 491 may be substituted with an acceptable 300/400 level AFM elective, with the understanding that any such substitution would forfeit MAcc admission eligibility and will impact the path to a CPA designation pursued through CPA Ontario.
2. Students in this option may take AFM 322 and AFM 424 to replace the AFM 479 degree requirement. If so, students need only take one of the remaining AFM courses in the above "Two of" list of AFM courses.
3. There is very little flexibility for altering the academic/work-term sequence prescribed for the Mathematics/Chartered Professional Accountancy (Math/CPA) - Finance option (see "Study/Work Sequence") because of limited term offerings and structured prerequisites for most AFM courses. Since deviations from this sequence can cause a delay in graduation of as much as one calendar year, alterations should not be considered without careful consultation with the appropriate faculty advisor.
4. The order in which required non-math courses in this plan are taken is very important, and there is little room for flexibility (for the same reasons in Note 3 above). During the class enrolment period each term, students should be sure to consult with the appropriate faculty advisor.
5. Students may not repeat an AFM course in which they have obtained a grade of 60% or higher. AFM courses completed with a grade in the range 50 - 59% may be repeated, but only once, and then only with approval from the School of Accounting and Finance.
6. Students who have attempted, to the satisfaction of the Standings and Promotions (S&P) Committee and Co-operative Education and Career Action, to gain employment for all four available work terms, but are successful in so doing for only three work terms, will be eligible for a co-op degree, provided they have received credit for all three of their work terms and all three of their work reports, and they have successfully completed all academic graduation requirements. (Students who are successful in gaining acceptable employment for four work terms will be required to have credit for all four work terms and all four work reports in order to qualify for a co-op degree.)
7. Students who meet all the academic graduation requirements for this option, but who do not meet the minimum requirements for a co-op degree (see preceding Note 6) may, in exceptional circumstances and at the discretion of the S&P Committee, be awarded a regular Honours Mathematics/Chartered Professional Accountancy degree.

8. In order to meet the requirements of both the Faculty of Mathematics and the School of Accounting and Finance, the Math/CPA - Finance option requires the successful completion of 42 courses.

Tuition
This is a cost-recovery plan as defined by the Ministry of Training, Colleges, and Universities. As such, tuition higher than the normal University of Waterloo tuition is required.

Eligibility for Waterloo's Master of Accounting (MAcc) Academic Plan
The Math/CPA plan is designed to lead to the University of Waterloo Master in Accounting (MAcc) degree. Students should consult the MAcc website to ascertain specific MAcc admission criteria for Math/CPA graduates.

Mathematics/Financial Analysis and Risk Management
Overview
A strong quantitative background is essential for success in the financial analysis and risk management areas. The escalating use of financial derivatives for both hedging and speculation, new governance and banking regulations, and more complex reporting requirements are increasing the demand for professionals with the mathematical background necessary to understand the broad impact these issues can have.

The Faculty of Mathematics is proud to offer this plan, which is designed for students who are interested in working in finance, banking, insurance, or industrial firms in financial analysis or risk management. The two specializations available, Chartered Financial Analyst (CFA) and Professional Risk Management (PRM), provide excellent preparation for the required professional examinations necessary for those designations.

Both the Mathematics/CFA and Mathematics/PRM specialization plans are restricted-enrolment plans. Most of the students enrolled in these plans are admitted at the Year One level directly into the Mathematics/Financial Analysis and Risk Management admission category. In 3A, students must select the specific specialization of their choice.

Degree Requirements
Students in this plan must fulfill all the requirements in Table I and Table II and the following specific requirements along with four academic milestones which must be completed at or before specified times:

One of
- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

All of
- **ACTSC 231** Introductory Financial Mathematics
- **ACTSC 371** Introduction to Investments
- **ACTSC 372** Corporate Finance
- **AMATH 350** Differential Equations for Business and Economics
- **CS 330** Management Information Systems
- **STAT 334** Probability Models for Business and Accounting or (**STAT 330** Mathematical Statistics and **STAT 333** Applied Probability)
- **STAT 371** Applied Linear Models and Process Improvement for Business
- **STAT 372** Survey Sampling and Experimental Design Techniques for Business

One of
- **ACTSC 446** Mathematics of Financial Markets
- **MATBUS 470** Derivatives
One of

- **CO 250** Introduction to Optimization
- **CO 255** Introduction to Optimization (Advanced Level)

One of

- **CS 335** Computational Methods in Business and Finance
- **CS 476** Numeric Computation for Financial Modeling (Note: CS 476 may require additional courses as prerequisites.)

All of

- **AFM 101** Introduction to Financial Accounting
- **AFM 102** Introduction to Managerial Accounting
- **BUS 111W** Understanding the Business Environment (see Laurier calendar)
- **BUS 121W** Functional Areas of the Organization (see Laurier calendar)
- **COMM 231** Commercial and Business Law for Mathematics Students
- **ECON 101** Introduction to Microeconomics
- **ECON 102** Introduction to Macroeconomics

All of the courses required for one of the two specialization choices below.

**Chartered Financial Analyst Specialization**

All of

- **CO 372** Portfolio Optimization Models
- **MATBUS 471** Fixed Income Securities

All of

- **BUS 352W** Introduction to Marketing Management (see Laurier calendar)
- **COMM 321** Intermediate Accounting for Finance
- **COMM 421** Financial Statement Analysis
- **COMM 433** Income Tax for Finance students

One of

- **ECON 206** Money and Banking I
- **ECON 207** Economic Growth and Development I
- **ECON 290** Models of Choice in Competitive Markets

One of

- **HRM 200** Basic Human Resources Management
- **MSCI 211** Organizational Behaviour
- **PSYCH 238** Organizational Psychology

**Professional Risk Management Specialization**

All of

- **AMATH 331/PMATH 331** Applied Real Analysis
- **CS 338** Computer Applications in Business: Databases
- **MATBUS 471** Fixed Income Securities

One of

- **ACTSC 445** Quantitative Enterprise Risk Management
- **MATBUS 472** Risk Management

One of
One of

**STAT 340** Computer Simulation of Complex Systems

**STAT 341** Computational Statistics and Data Analysis

One of

**CO 370** Deterministic OR Models

**CO 372** Portfolio Optimization Models

One additional course (.50 units) labelled BUS, COMM, ECON, HRM, or MSCI.

Two additional non-math courses (1.0 units).

**Note**

1. Any Financial Analysis and Risk Management (FARM) student who meets all the course requirements for one of the two specializations, but who does not meet the special major average (SMAV) requirements, will be eligible to graduate in the Mathematics/Business Administration plan, either regular or co-op, as appropriate.

**Mathematical Studies**

**Mathematical Studies Overview**

The Mathematical Studies plan is meant for students whose mathematical interests are broadly based. Its high degree of flexibility makes it suitable for those who wish to design a course of study that suits their individual tastes. Under this plan, there is ample scope for students to obtain a minor in an area of mathematics or a minor from another faculty. With judicious course selections, graduates of Mathematical Studies can confidently pursue careers in business, teaching, or public service.

**Mathematical Studies**

Students in this plan must fulfill all the requirements in Table 1. This must include at least 26 math courses (see note 1 below), and the following specific requirements:

One of

**MATH 127** Calculus 1 for the Sciences

**MATH 137** Calculus 1 for Honours Mathematics

**MATH 147** Calculus 1 (Advanced Level)

One of

**MATH 128** Calculus 2 for the Sciences

**MATH 138** Calculus 2 for Honours Mathematics

**MATH 148** Calculus 2 (Advanced Level)

One of

**MATH 135** Algebra for Honours Mathematics

**MATH 145** Algebra (Advanced Level)

One of

**MATH 106** Applied Linear Algebra 1

**MATH 136** Linear Algebra 1 for Honours Mathematics

**MATH 146** Linear Algebra 1 (Advanced Level)

One of

**MATH 225** Applied Linear Algebra 2

**MATH 235** Linear Algebra 2 for Honours Mathematics

**MATH 245** Linear Algebra 2 (Advanced Level)

One of

**STAT 220** Probability (Non-Specialist Level)

**STAT 230** Probability
STAT 240 Probability (Advanced Level)

One of

STAT 221 Statistics (Non-Specialist Level)
STAT 231 Statistics
STAT 241 Statistics (Advanced Level)

One of

CS 115 Introduction to Computer Science 1
CS 135 Designing Function Programs
CS 145 Designing Function Programs (Advanced Level)

One of

CS 116 Introduction to Computer Science 2
CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

One of

MATH 207 Calculus 3 (Non-Specialist Level)
MATH 237 Calculus 3 for Honours Mathematics
MATH 247 Calculus 3 (Advanced Level)
MATH 229 Introduction to Combinatorics (Non-Specialist Level)
MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

Ten 300- or 400-level math courses.

Note

1. Students in Mathematical Studies who complete a minor or joint honours plan in a discipline outside the Faculty of Mathematics are only required to complete 24 math courses.

Mathematical Studies - Business Specialization
Students in this plan must fulfill all the requirements in Table 1. This must include at least 24 math courses, and the following specific requirements:

One of

MATH 127 Calculus 1 for the Sciences
MATH 137 Calculus 1 for Honours Mathematics
MATH 147 Calculus 1 (Advanced Level)

One of

MATH 128 Calculus 2 for the Sciences
MATH 138 Calculus 2 for Honours Mathematics
MATH 148 Calculus 2 (Advanced Level)

One of

MATH 135 Algebra for Honours Mathematics
MATH 145 Algebra (Advanced Level)

One of

MATH 106 Applied Linear Algebra 1
MATH 136 Linear Algebra 1 for Honours Mathematics
MATH 146 Linear Algebra 1 (Advanced Level)

One of
MATH 225  Applied Linear Algebra 2  
MATH 235  Linear Algebra 2 for Honours Mathematics  
MATH 245  Linear Algebra 2 (Advanced Level)  

One of  
STAT 220  Probability (Non-Specialist Level)  
STAT 230  Probability  
STAT 240  Probability (Advanced Level)  

One of  
STAT 221  Statistics (Non-Specialist Level)  
STAT 231  Statistics  
STAT 241  Statistics (Advanced Level)  

One of  
CS 115  Introduction to Computer Science 1  
CS 135  Designing Functional Programs  
CS 145  Designing Functional Programs (Advanced Level)  

One of  
CS 116  Introduction to Computer Science 2  
CS 136  Elementary Algorithm Design and Data Abstraction  
CS 146  Elementary Algorithm Design and Data Abstraction (Advanced Level)  

One of  
MATH 207  Calculus 3 (Non-Specialist Level)  
MATH 229  Introduction to Combinatorics (Non-Specialist Level)  
MATH 237  Calculus 3 for Honours Mathematics  
MATH 247  Calculus 3 (Advanced Level)  
MATH 239  Introduction to Combinatorics  
MATH 249  Introduction to Combinatorics (Advanced Level)  

All of  
AFM 101  Introduction to Financial Accounting  
AFM 102  Introduction to Managerial Accounting  
BUS 121W Functional Areas of the Organization (see Laurier calendar)  
ECON 101  Introduction to Microeconomics  
ECON 102  Introduction to Macroeconomics  

One of  
AFM 131/ARBUS 101  Introduction to Business in North America  
BUS 111W Understanding the Business Environment (see Laurier calendar)  

One of  
ARBUS 302/ECON 344  Marketing 1: Principles of Marketing and Consumer Economics  
BUS 352W Introduction to Marketing Management (see Laurier calendar)  

Three additional courses chosen from  
LS 271/PACS 202  Conflict Resolution  
LS 319/PACS 323  Negotiation: Theories and Strategies  
Any AFM, BUS (see Laurier calendar), COMM, ECON, HRM, MSCI, STV courses  

One of
CO 227  Introduction to Optimization (Non-Specialist Level)
CO 250  Introduction to Optimization
CO 255  Introduction to Optimization (Advanced Level)

One of

CO 327  Deterministic OR Models (Non-Specialist Level)
CO 370  Deterministic OR Models

All of

CS 330  Management Information Systems

One of

AFM 272/ACTS291  Corporate Finance 1
ACTSC 221  Introductory Financial Mathematics (Non-Specialist Level)
ACTSC 231  Introductory Financial Mathematics
ACTSC 371  Introduction to Investments

Two of

CS 200  Concepts for Advanced Computer Usage; Note: students wishing to take CS 200 must do so prior to taking any other 200-level or higher CS courses
CS 338  Computer Applications in Business: Databases
CS 430  Applications Software Engineering
CS 432  Business Systems Analysis
STAT 340  Computer Simulation of Complex Systems

One of

STAT 321  Regression and Forecasting (Non-Specialist Level)
STAT 322  Sampling and Experimental Design (Non-Specialist Level)

Seven additional math courses (3.5 units).
A minimum of ten 300- or 400-level math courses, including any taken to satisfy the requirements above.

# Mathematics/Teaching

## Mathematics/Teaching Overview

The co-operative Mathematics Teaching plan combines academic studies in mathematics, teaching experience in secondary schools, professional training, and other work experience.

Students interested in this restricted-enrolment plan should enrol in the Honours Mathematics co-operative plan in Year One, and will be considered for admission to Teaching in Year Two on the basis of an interview, satisfactory academic standing, and good standing in co-op.

Work-term arrangements in this option differ from other co-operative plans offered in the Faculty (see the Study/Work Sequence section). Details concerning this are available from the academic advisors or the co-ordinator for this plan.

### Mathematics/Teaching (co-op only)

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 24 math courses, and the following specific requirements:

One of

MATH 237  Calculus 3 for Honours Mathematics
MATH 247  Calculus 3 (Advanced Level)

One of

MATH 239  Introduction to Combinatorics
MATH 249  Introduction to Combinatorics (Advanced Level)
All of

ACTSC 221 Introductory Financial Mathematics (Non-Specialist Level)
CO 250 Introduction to Optimization
CS 234 Data Types and Structures

One of

AMATH 250 Introduction to Differential Equations
AMATH 343 Discrete Models in Applied Mathematics

One of

AMATH 331/PMATH 331 Applied Real Analysis
AMATH 332/PMATH 332 Applied Complex Analysis

One of

CO 380 Mathematical Discovery and Invention
CO 480 History of Mathematics

One of

CS 230 Introduction to Computers and Computer Systems
CS 330 Management Information Systems
CS 338 Computer Applications in Business: Databases
CS 370 Numerical Computation
CS 430 Applications Software Engineering
CS 436 Networks and Distributed Computer Systems

One of

PMATH 334 Introduction to Rings and Fields with Applications
PMATH 336 Introduction to Group Theory with Applications
PMATH 347 Groups and Rings

One of

PMATH 330 Introduction to Mathematical Logic
PMATH 340 Elementary Number Theory
PMATH 360 Geometry

One of

STAT 331 Applied Linear Models
STAT 332 Sampling and Experimental Design
STAT 333 Applied Probability

All of

MTHEL 206A Introduction to Mathematics Education
PSYCH 101/PSYCH 101R Introductory Psychology

One of

PSYCH 211 Developmental Psychology
PSYCH 212/PSYCH 212R Educational Psychology

Eight 300- or 400-level math courses, including any taken to satisfy the above requirements.
Recommended non-math course

SOC 207/SOC 207R Sociology of Education

Notes
1. Successful completion of the academic requirements for any of the departmental honours plans "X" in the Faculty of Mathematics, leading to a Bachelor of Mathematics (BMath) degree, will be accepted as a replacement for the math course requirements listed above provided that "X" is not a Mathematical Studies plan. All requirements specified in Table II must be completed, however, even if the departmental honours plan provides exemptions from any of those requirements. Students who elect this option will be designated by a plan label such as "Honours 'X'/Teaching" rather than "Honours Mathematics/Teaching".

2. The selection of courses required for BMath/Teaching must include a second teaching subject. Options for the second teaching subject are chosen from the subjects available at Ontario Faculties of Education in consultation with the Math/Teaching plan academic advisors.

Plans for Students outside the Mathematics Faculty

Joint Bachelor of Computer Science

Joint Bachelor of Computer Science plan requirements.

Joint Honours Academic Plans with Mathematics

The requirements listed below apply for all students admitted to the Mathematics portion of such joint honours plans for the fall 2004 term or thereafter.

Course requirements for admission

Joint Honours Mathematics is only open to non-math students enrolled in an Honours program. To be admitted to Joint Honours Mathematics a student must have, at most, 3.0 units of failed courses and must have completed the following requirements:

One of

- MATH 106 Applied Linear Algebra 1 with at least 70%
- MATH 136 Algebra for Honours Mathematics with at least 60%
- MATH 146 Algebra for Honours Mathematics (Advanced Level)

One of

- MATH 127 Calculus 1 for the Sciences with at least 70%
- MATH 137 Calculus 1 for Honours Mathematics with at least 60%
- MATH 147 Calculus 1 for Honours Mathematics (Advanced Level)

One of

- MATH 128 Calculus 2 for the Sciences with at least 70%
- MATH 138 Calculus 2 for Honours Mathematics with at least 60%
- MATH 148 Calculus 2 for Honours Mathematics (Advanced Level)

One of

- MATH 225 Applied Linear Algebra 2 with at least 70%
- MATH 235 Linear Algebra 2 for Honours Mathematics with at least 60%
- MATH 245 Linear Algebra 2 for Honours Mathematics (Advanced Level)

One of

- CS 115 Introduction to Computer Science 1 with at least 70%
- CS 135 Designing Functional Programs with at least 60%
- CS 145 Designing Functional Programs (Advanced Level)

One of

- CS 116 Introduction to Computer Science 2 with at least 70%
- CS 136 Elementary Algorithm Design and Data Abstraction with at least 60%
- CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

Additional course requirements

One of
**MATH 135** Algebra for Honours Mathematics  
**MATH 145** Algebra (Advanced Level)

One of  
**STAT 220** Probability (Non-Specialist Level)  
**STAT 230** Probability  
**STAT 240** Probability (Advanced Level)

One of  
**STAT 221** Statistics (Non-Specialist Level)  
**STAT 231** Statistics  
**STAT 241** Statistics (Advanced Level)

One of  
**MATH 207** Calculus 3 (Non-Specialist Level)  
**MATH 229** Introduction to Combinatorics (Non-Specialist Level)  
**MATH 237** Calculus 3 for Honours Mathematics  
**MATH 239** Introduction to Combinatorics  
**MATH 247** Calculus 3 (Advanced Level)  
**MATH 249** Introduction to Combinatorics (Advanced Level)

Four additional math courses that qualify for Honours Bachelor of Mathematics (BMath) degree credit.

**Maximum Failure Requirement**  
The maximum number of failures allowed for a Joint Mathematics academic plan is 3.0 units.

**Graduation Average Requirement**  
To graduate in a Joint Honours Mathematics plan, a student requires a minimum average of 60 over all math courses.

**Notes**

1. A Joint Honours cannot be combined with the Mathematical Economics plan offered in the Faculty of Arts.
2. A Joint Honours cannot be combined with the Mathematical Physics plan offered in the Science Faculty.

**Combinatorics and Optimization Minor**  
[Combinatorics and Optimization](#) minor requirements

**Computing Technology Option**  
A Computing Technology Option is available to all students, except those enrolled in Software Engineering, Computing and Financial Management, and other joint plans involving Computer Science. Certain plans already including substantial computer science content may also be excluded (see [academic plan combinations](#)).

One of  
**CS 115** Introduction to Computer Science 1  
**CS 135** Designing Functional Programs  
**CS 145** Designing Functional Programs (Advanced Level)

One of  
**CS 116** Introduction to Computer Science 2  
**CS 136** Elementary Algorithm Design and Data Abstraction  
**CS 146** Elementary Algorithm Design and Data Abstraction (Advanced Level)

One additional CS course from CS 100-146, CS 200-299, CS 300-398, CS 400-498.
Four additional courses from CS 200-299, CS 300-398, CS 400-498, CS COMM 432

One additional course from CS 300-398, CS 400-498

The average of all CS courses on the student’s record (including repeated courses) must be at least 60%. Students may not complete both the Computer Science minor and the Computing Technology option.

Notes

1. Most courses in the range CS 240-299, CS 340-398, CS 440-498 are only available to CS majors, so upper-year CS courses taken toward this option will usually be in the range CS 200-239, CS 300-339, CS 400-439.
2. A common route into upper-year CS courses is to take all of CS 115, 116 and 136. All three of these courses may count toward this option.
3. Students cannot obtain both the CS minor and the Computing Technology option.

Mathematics Minor
A Mathematics Minor is available for Honours or Four-Year General students in other Faculties. This minor requires a total of ten math courses which must include the following specific courses:

One of

MATH 106 Applied Linear Algebra 1
MATH 114 Linear Algebra for Science
MATH 115 Linear Algebra for Engineering

One of

MATH 116 Calculus 1 for Engineering
MATH 117 Calculus 1 for Engineering
MATH 127 Calculus 1 for the Sciences

One of

MATH 118 Calculus 2 for Engineering
MATH 119 Calculus 2 for Engineering
MATH 128 Calculus 2 for the Sciences

Two of

STAT 220 Probability (Non-Specialist Level)
STAT 221 Statistics (Non-Specialist Level)
STAT 321 Regression and Forecasting (Non-Specialist Level)
STAT 322 Sampling and Experimental Design (Non-Specialist Level)

One of

CS 115 Introduction to Computer Science 1
CS 135 Designing Functional Programs
CS 145 Designing Functional Programs (Advanced Level)

One of

CS 116 Introduction to Computer Science 2
CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

Three additional math courses which qualify for Bachelor of Mathematics (BMath) degree credit.

The average of all math courses must be at least 60%, and at most two math courses may have failing grades.
Notes

1. The Mathematics minor designation is not available to students pursuing a Joint Honours with Mathematics.
2. A student who obtains a Mathematics minor may not also obtain another minor offered by the Faculty of Mathematics.
3. A Mathematics minor cannot be combined with the Mathematical Economics plan offered in the Faculty of Arts.
4. A Mathematics minor cannot be combined with the Mathematical Physics plan offered in the Science Faculty.
5. The MATH courses listed above may be replaced by more advanced courses for Honours Mathematics students. For example, instead of MATH 116 or MATH 117 or MATH 127, a student may take MATH 137 or MATH 147.

Pure Mathematics Minor

Pure Mathematics minor requirements

Pure Mathematics

Pure Mathematics Overview

Mathematics is both an art and a science, and Pure Mathematics lies at its heart. Many study Pure Mathematics to pursue knowledge for its own sake and because of its beauty. Others want a strong foundation for graduate work or have a desire to apply their knowledge. Pure Mathematics courses explore the boundary of Mathematics and pure reason; they stimulate the mind, promise intellectual growth, and are an asset to any plan. We hope to impart to our students a love for learning, and to develop their abilities to work independently, and to think critically and creatively. This is achieved with a supportive atmosphere in which all students are challenged to fulfill their academic potential.

Pure Mathematics graduates have been successful in a wide variety of careers. Many go on to graduate school in a wide variety of disciplines. Others go into industry, as the skills they have acquired are recognized by employers as being valuable and transferable.

Pure Mathematics comprises a broad spectrum of Mathematics. Interests of the Department include algebra, number theory, analysis, geometry, topology, and logic, and range from the very classical to the most modern. The Department offers several honours plans including Honours Pure Mathematics, Honours Pure Mathematics/Teaching and Honours Mathematical Finance. It is also possible to do a minor in Pure Mathematics. All, except the Pure Mathematics/Teaching plan (which is co-op only), are available to both co-op and regular students. Co-operative students should consult the schedule of classes plan and their co-op sequence accordingly.

Many students have found it rewarding to combine Pure Mathematics or Mathematical Finance with another mathematical discipline or with each other. For such students double honours plans are available. A joint honours plan is available for Pure Mathematics. Students from other departments, especially those considering pursuing graduate work (in any area of Mathematics), are encouraged to speak with a Pure Mathematics advisor about which Pure Mathematics courses would be particularly important, interesting, and beneficial for them.

Students who have enjoyed their core mathematics courses and would like to obtain a broad base in mathematics, at a less intensive level than the traditional Honours Pure Mathematics plans, may be interested in pursuing an Honours Mathematical Studies with a minor in Pure Mathematics. Interested students should consult a Pure Mathematics advisor.

A more detailed description of the Department and its plans may be found on the Pure Mathematics website.

Pure Mathematics

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- MATH 237 Calculus 3 for Honours Mathematics
- MATH 247 Calculus 3 (Advanced Level)

One of
MATH 239 Introduction to Combinatorics  
MATH 249 Introduction to Combinatorics (Advanced Level)

All of  

PMATH 347 Groups and Rings  
PMATH 348 Fields and Galois Theory  
PMATH 351 Real Analysis  
PMATH 352 Complex Analysis  
PMATH 365 Differential Geometry  
PMATH 450 Lebesgue Integration and Fourier Analysis

Three additional 400-level PMATH courses.  
Two additional 400-level math courses.

**Joint Pure Mathematics**

See [Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) for a description of joint plan requirements. Note that both specialization areas designated in such joint plans must be disciplines within the Faculty of Mathematics.

One of  

MATH 237 Calculus 3 for Honours Mathematics  
MATH 247 Calculus 3 (Advanced Level)

One of  

AMATH 331/PMATH 331 Applied Real Analysis  
PMATH 333 Introduction to Real Analysis  
PMATH 351 Real Analysis

One of  

AMATH 332/PMATH 332 Applied Complex Analysis  
PMATH 352 Complex Analysis

Two of  

PMATH 334 Introduction to Rings and Fields with Applications  
PMATH 336 Introduction to Group Theory with Applications  
PMATH 347 Groups and Rings  
PMATH 348 Fields and Galois Theory

One of  

MATH 239 Introduction to Combinatorics  
MATH 249 Introduction to Combinatorics (Advanced Level)

An additional PMATH course

Three additional PMATH courses.

**Pure Mathematics/Teaching (co-op only)**

*Students must be accepted into Math/Teaching to be eligible for this plan.*

Students in this plan must fulfill all the requirements in [Table I](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) and [Table II](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117). This must include at least 24 math courses, and the following specific requirements:

One of  

MATH 237 Calculus 3 for Honours Mathematics  
MATH 247 Calculus 3 (Advanced Level)

One of  

MATH 239 Introduction to Combinatorics  
MATH 249 Introduction to Combinatorics (Advanced Level)
All of

**AMATH 231** Calculus 4
**AMATH 242/CS 371** Introduction to Computational Mathematics
**AMATH 250** Introduction to Differential Equations
**PMATH 360** Geometry

One of

**AMATH 331/PMATH 331** Applied Real Analysis
**PMATH 351** Real Analysis

One of

**PMATH 334** Introduction to Rings and Fields with Applications
**PMATH 347** Groups and Rings

Two additional courses of

**AMATH 332/PMATH 332** Applied Complex Analysis or **PMATH 352** Complex Analysis
**PMATH 330** Introduction to Mathematical Logic
**PMATH 336** Introduction to Group Theory with Applications or **PMATH 347** Groups and Rings or **PMATH 348** Fields and Galois Theory
**PMATH 340** Elementary Number Theory

One additional PMATH course.

One of

**CO 380** Mathematical Discovery and Invention
**CO 480** History of Mathematics

Three additional 300- or 400-level math courses.

All of

**MTHEL 206A** Introduction to Mathematics Education
**PSYCH 101/PSYCH 101R** Introductory Psychology

One of

**PSYCH 211** Developmental Psychology
**PSYCH 212/PSYCH 212R** Educational Psychology

**Note**

1. See notes under [Math/Teaching](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117).

**Mathematical Finance**

The Mathematical Finance plan is offered jointly by the Departments of Statistics and Actuarial Science and of Pure Mathematics.

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses and the following specific requirements:

One of

**MATH 247** Calculus 3 (Advanced Level)
**MATH 237** Calculus 3 for Honours Mathematics (requires permission of department)

All of

**AFM 101** Introduction to Financial Accounting or BUS 127W Introduction to Financial Accounting (see Laurier calendar)
**AFM 102** Introduction to Managerial Accounting or BUS 247W Managerial Accounting (see Laurier calendar)
AFM 131/ARBUS 101 Introduction to Business in North America or BUS 111W Understanding the Business Environment (see Laurier calendar)
ACTSC 231 Introductory Financial Mathematics
ACTSC 371 Introduction to Investments
ACTSC 372 Corporate Finance
ACTSC 445 Quantitative Enterprise Risk Management
ACTSC 446 Mathematics of Financial Markets
AMATH 242/CS 371 Introduction to Computational Mathematics or CS 335 Computational Methods in Business and Finance
AMATH 250 Introduction to Differential Equations or AMATH 350 Differential Equations for Business and Economics
ECON 101 Introduction to Microeconomics or ECON 120W Introduction to Microeconomics (see Laurier calendar)
ECON 102 Introduction to Macroeconomics or ECON 140W Introduction to Macroeconomics (see Laurier calendar)
ECON 201 Microeconomic Theory for Business and Policy or ECON 260W Intermediate Microeconomic Analysis for Management (see Laurier calendar)
PMATH 351 Real Analysis
PMATH 450 Lebesgue Integration and Fourier Analysis
PMATH 451 Measure and Integration
STAT 330 Mathematical Statistics
STAT 331 Applied Linear Models
STAT 333 Applied Probability
STAT 443 Forecasting

One of

AMATH 351 Ordinary Differential Equations 2
CO 250 Introduction to Optimization
PMATH 352 Complex Analysis

One of

AMATH 353 Partial Differential Equations 1
CO 372 Portfolio Optimization Models
CS 476 Numeric Computation for Financial Modeling
PMATH 453 Functional Analysis

Notes:

1. MATH 147 and MATH 148 provide highly desirable background for students in the Mathematical Finance plan.
2. AMATH 350 is an antirequisite of AMATH 351 and AMATH 353, and choosing this course limits selection in the last "One of" list.
3. Students enrolled in the Business Administration and Mathematics Double Degree plan:
   - may substitute BUS 283W for ACTSC 371
   - may substitute BUS 393W for ACTSC 372
   - are exempt from taking STAT 443, but can count it under the "One of AMATH 353, CO 372, CS 476, PMATH 453" if they choose to take it.
4. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.

Pure Mathematics Minor
One of

MATH 103 Introductory Algebra for Arts and Social Science
MATH 106 Applied Linear Algebra 1
MATH 114 Linear Algebra for Science
MATH 115 Linear Algebra for Engineering
MATH 136 Linear Algebra 1 for Honours Mathematics
MATH 146 Linear Algebra 1 for Honours Mathematics (Advanced Level)

One of

MATH 104 Introductory Calculus for Arts and Social Science
MATH 116 Calculus 1 for Engineering
MATH 117 Calculus 1 for Engineering
MATH 127 Calculus 1 for the Sciences
MATH 137 Calculus 1 for Honours Mathematics
MATH 147 Calculus 1 for Honours Mathematics (Advanced Level)

One of

MATH 118 Calculus 2 for Engineering
MATH 119 Calculus 2 for Engineering
MATH 128 Calculus 2 for the Sciences
MATH 138 Calculus 2 for Honours Mathematics
MATH 148 Calculus 2 for Honours Mathematics (Advanced Level)

Six PMATH courses. MATH 212/ECE 206, MATH 217, MATH 227, MATH 237 or MATH 247 may be substituted for one of the six.

Notes

1. The Pure Mathematics Minor designation is not available to students outside the faculty pursuing a Joint Honours Academic Plans with Mathematics or a Mathematics Minor.
2. Other Linear Algebra and Calculus courses than those listed above may be used to satisfy the "One of" requirements above, with approval of the Pure Math advisor.

Software Engineering

Software Engineering
Over the last few decades there has been a tremendous growth in information technology and its impact on everyday life. Complex software systems have become critical to the operation of many systems in areas such as banking, communications, manufacturing, power generation, and transportation. Progress in computer science and accumulated experience with industrial production of software have led to the emergence of software engineering as a separate discipline. The software engineering discipline has been defined as "the application of systematic, disciplined, quantifiable approaches to the development, operation, and maintenance of software"; that is, the application of engineering to software. The software engineer must apply well-defined techniques, methods, and tools to ensure the correctness, reliability, performance, maintainability, and usability of the software systems being developed.

The technical requirements of these software engineers include a strong foundation in mathematics, natural sciences, and computer science; a broad education in software engineering and design; an understanding of computers and networks; a better appreciation for all aspects of the software engineering life cycle; and the use of methodologies and tools.

The curriculum requirements are not all technical. Industry is also asking for graduates who have facility across several disciplines. Software engineering graduates need to have substantial communications, business, and reasoning skills. Graduates should be able to work in groups; make presentations to technical and non-technical audiences; write coherent well-reasoned reports; and assess the social, technical, legal, and commercial implications of the technology they help to create.

The Honours Software Engineering program leads to a Bachelor of Software Engineering (BSE) degree. The program is accredited by both the Canadian Engineering Accreditation Board and the Computer Science Accreditation Council.

Administrative Structure

Leadership for the Software Engineering program is provided by a Software Engineering Program Director, normally a faculty member chosen from either Computer Science or Electrical and Computer Engineering with a joint or cross appointment. The Program Director is responsible for the academic issues associated with the program's operations, including student liaison and advisement. The Associate Director of
Software Engineering assists the Director in managing the program’s day-to-day operations and in advising students.

The Software Engineering Program Board oversees the program’s operation and evolution. This inter-faculty Board consults with the two home departments and reports to the two Faculty Councils. The Chair of the Board alternates between the Dean of the Faculty of Engineering and the Dean of Mathematics. Ex-officio members of the board include the

- Dean of Engineering
- Dean of Mathematics
- Director of the David R. Cheriton School of Computer Science
- Chair of Electrical and Computer Engineering
- Director (or Associate Director) of Undergraduate Studies (Computer Science)
- Associate Chair of Undergraduate Studies (Electrical and Computer Engineering)
- Software Engineering Program Director

In addition, the board includes four faculty members, two from Computer Science and two from Electrical and Computer Engineering; and one student from the Software Engineering program. Faculty members are appointed for two-year, renewable terms; the student member typically serves a two-term appointment.

The Software Engineering Curriculum Committee is responsible for the maintenance and evolution of the program curriculum and is chaired by the Software Engineering Program Director. The committee consists of the Director and Associate Director of the Software Engineering Program, six other faculty members (three from Computer Science and three from Electrical and Computer Engineering, including the Electrical and Computer Engineering Associate Chair of Undergraduate Studies and the Computer Science Director of Undergraduate Studies) and one student from the Software Engineering Program. The membership may be drawn from outside of the Board and must include a majority of licensed professional engineers. The Software Engineering Curriculum Committee reports to the Software Engineering Program Board and consults with both the Computer Science Undergraduate Academic Plans Committee and the Electrical and Computer Engineering Program Committee.

**Admissions**

The Software Engineering Program Board, in consultation with the Faculties of Engineering and Mathematics and their Admissions Committees, determines the admission requirements for the Software Engineering program.

For details on admission information, see the Admissions section of this Calendar.

**Options, Minors, and Joint Honours**

Software Engineering students are considered to be both Mathematics and Engineering students, and can thus take advantage of degree enhancements available to students from either Faculty. These enhancements take the form of additional plans such as Options, Minors, and Joint Honours, and include:

- **Business Option** (from Computer Science)
- **Cognitive Science Minor** (a university-wide minor)
- **Computational Fine Arts Option** (from Computer Science)
- **Human Computer Interaction Option** (from Computer Science)
- **Option in Entrepreneurship** (from Engineering)
- **Option in Management Sciences** (from Engineering)

The following Joint Honours Mathematics plans are also approved as additional plans for BSE students:

- **Joint Applied Mathematics**
- **Joint Combinatorics and Optimization**
- **Joint Pure Mathematics**, and
- **Joint Statistics**

BSE students are not eligible to add Joint Computer Science (Bachelor of Mathematics) or Joint Bachelor of Computer Science plans. BSE students may be eligible to add other Options or Minors in the Mathematics, Engineering or other Faculties, subject to the approval of the Software Engineering Associate Director. Students should be aware that adding plans will constrain their choice of elective courses and may require additional courses. Thus, it is advisable to start planning for additional plans in the first and second years. Students should also consider the benefits of not adding plans, in that they are better able to personalize their curriculum if they have more flexibility in choosing their electives.

**Software Engineering Awards**

**Term Dean's Honours List**
In recognition of outstanding academic achievement in an academic term, the designation "Dean's Honours List" is awarded to any BSE student who satisfies either of the following criteria:

1.1. The student is unconditionally promoted at the end of that term, and their term average minus their percentile rank from the top for that academic term is at least 80%.
1.2. The student completes the academic term with a term average of at least 87% based upon a course load which includes a minimum of 2.5 units with numeric or letter grades and which does not include any failing grades or any INC, IP, or UR grades (see Grading System for description).

This designation will be reflected on the official university transcript.

**Graduation "With Distinction - Dean's Honours List"**

In recognition of outstanding academic achievement throughout undergraduate studies, the designation Graduation "With Distinction - Dean's Honours List" is awarded to any BSE graduate who satisfies either of the following criteria:

1.1. The student has satisfied criterion "1" of the term Dean's Honours List for at least two of the six academic terms preceding graduation, and has a cumulative average over these last six academic terms of at least 80.
1.2. The student has a cumulative average (as specified in Mathematics Faculty Policy #1) of at least 87% with no record of INC, IP, or UR grades (see Grading System for description). Any student who satisfies this criterion will have their name displayed in gold on the walls of the Math & Computer (MC) corridor (1108).

This designation will appear on the student's official University transcript and diploma.

Some of the upper-year awards offered by the Faculties of Engineering and Mathematics are open to Software Engineering students. If such an Engineering or Mathematics award specifies that the recipient achieve term “Dean's Honours List” or “Graduating 'With Distinction - Dean's Honours List,'” then a Software Engineering student must satisfy the appropriate Faculty's Dean's Honours List criteria in order to be eligible for the award.

**Honours Software Engineering (Co-operative 8-stream only)**

The Software Engineering program is offered jointly by the David R. Cheriton School of Computer Science and the Department of Electrical and Computer Engineering.

Its curriculum prepares graduates for entry into the software engineering profession. It covers the scientific and mathematical foundations of the discipline, engineering science and engineering design appropriate to the discipline, and exposes students to the ethical and societal issues associated with the discipline. Graduates will be able to apply their knowledge to produce software solutions to specific problems.

Students will be considered members of both the Faculty of Engineering and the Faculty of Mathematics, although for administrative purposes they will be registered officially in a separate unit. Students will be promoted based on the Examination and Promotion rules used in the Faculty of Engineering (see Examinations and Promotions). A non-voting representative from the Faculty of Mathematics will sit on the Engineering Examinations and Promotion Committee, to provide insight into the policies, philosophies, culture, and requirements that pertain to Math students. The Software Engineering program is also considered an Honours Mathematics plan for purposes of student access to math courses. The Software Engineering Advisor will advise students on how to achieve their academic goals. Students will graduate with a Bachelor of Software Engineering (BSE).

**Academic Curriculum**

**Key for next table:**
**Abbreviation/ Symbol** | **Description**
--- | ---
* | Alternate weeks
** | One hour seminar per week
*** | Laboratory is not scheduled and students are expected to find time in open hours to complete their work
+ | Number of contact hours for the tutorial or laboratory are unknown; there may be more components than the class (LEC) section
Cls | Class
Tut | Tutorial
Lab | Laboratory
0 - 9 | Number of hours for Class, Tutorial, Laboratory

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
The term by term academic component of the program is as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Course and Title</th>
<th>Cls</th>
<th>Tut</th>
<th>Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A Fall</td>
<td><strong>CS 137</strong> Programming Principles</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>ECE 105</strong> Classical Mechanics</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td><strong>MATH 115</strong> Linear Algebra for Engineering</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>MATH 117</strong> Calculus 1 for Engineering</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>MATH 135</strong> Algebra for Honours Mathematics</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>SE 101</strong> Introduction to Methods of Software Engineering**</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1B Winter</td>
<td><strong>SE 102</strong> Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>CS 138</strong> Introduction to Data Abstraction and Implementation</td>
<td>3</td>
<td>1</td>
<td>2</td>
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<tr>
<td></td>
<td><strong>ECE 106</strong> Electricity and Magnetism</td>
<td>3</td>
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<td>1.5</td>
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<tr>
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<td><strong>ECE 124</strong> Digital Circuits and Systems</td>
<td>3</td>
<td>1</td>
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<td></td>
<td><strong>ECE 140</strong> Linear Circuits</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<td></td>
<td><strong>MATH 119</strong> Calculus 2 for Engineering</td>
<td>3</td>
<td>2</td>
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<tr>
<td>2A Fall</td>
<td><strong>SE 201</strong> Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>CHE 102</strong> Chemistry for Engineers</td>
<td>3</td>
<td>2</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>CS 241</strong> Foundations of Sequential Programs</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>ECE 222</strong> Digital Computers</td>
<td>3</td>
<td>1</td>
<td>3*</td>
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<tr>
<td></td>
<td><strong>SE 212</strong> Logic and Computation</td>
<td>3</td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>STAT 206</strong> Statistics for Software Engineering (see note 5)</td>
<td>3</td>
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</tr>
<tr>
<td></td>
<td>Communication Elective (see note 6)</td>
<td>3</td>
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<td>+</td>
</tr>
<tr>
<td>2B Spring</td>
<td><strong>SE 202</strong> Seminar</td>
<td>1</td>
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<tr>
<td></td>
<td><strong>CS 240</strong> Data Structures and Data Management</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>CS 247</strong> Software Engineering Principles ***</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>MSCI 261</strong> Engineering Economics: Financial Management for Engineers</td>
<td>3</td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>MATH 213</strong> Advanced Mathematics for Software Engineers</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>MATH 239</strong> Introduction to Combinatorics</td>
<td>3</td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td>Elective (see note 1)</td>
<td>3</td>
<td>+</td>
<td>+</td>
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<td><strong>WKRPT 200</strong> Work-term Report</td>
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<td><strong>TPM 000</strong> CR/NCR</td>
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<td>3A Winter</td>
<td><strong>SE 301</strong> Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>CS 341</strong> Algorithms</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>CS 349</strong> User Interfaces ***</td>
<td>3</td>
<td>0</td>
<td>1</td>
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<td></td>
<td><strong>SE 350</strong> Operating Systems</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
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<tr>
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<td><strong>SE 465</strong> Software Testing and Quality Assurance ***</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>Elective (see note 1)</td>
<td>3</td>
<td>+</td>
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<td>3B Fall</td>
<td><strong>SE 302</strong> Seminar</td>
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<td><strong>CS 343</strong> Concurrent and Parallel Programming</td>
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<td></td>
<td><strong>CS 348</strong> Introduction to Database Management</td>
<td>3</td>
<td>0</td>
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<tr>
<td></td>
<td><strong>SE 380</strong> Introduction to Feedback Control</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
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<tr>
<td></td>
<td><strong>SE 390</strong> Design Project Planning ***</td>
<td>2</td>
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<tr>
<td></td>
<td><strong>SE 464</strong> Software Design and Architectures ***</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Elective (see note 1)</td>
<td>3</td>
<td>+</td>
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<td><strong>WKRPT 300</strong> Work-term Report</td>
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<td>4A Spring</td>
<td><strong>SE 401</strong> Seminar</td>
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<tr>
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<td><strong>ECE 358</strong> Computer Networks</td>
<td>3</td>
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<td><strong>SE 463</strong> Software Requirements Specification and Analysis ***</td>
<td>3</td>
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<td><strong>SE 490</strong> Design Project 1 ***</td>
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<td>9</td>
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<td>Two Electives (see notes 1 and 2)</td>
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<td></td>
<td><strong>WKRPT 400</strong> Work-term Report</td>
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<tr>
<td>4B Winter</td>
<td><strong>SE 402</strong> Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>SE 491</strong> Design Project 2 ***</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Five Electives (see notes 1 and 2)</td>
<td>3</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Three Advanced Technical Electives (ATE):
The advanced technical electives comprise fourth-year course offerings in CS or ECE. Students are advised to plan ahead when selecting ATEs. Most ATEs are not offered every term, and some ATEs have other ATEs as prerequisites. Other courses may be approved by the Program Director.

One of the following CS courses (CS List):

- **CS 442** Principles of Programming Languages
- **CS 444** Compiler Construction
- **CS 448** Database Systems Implementation
- **CS 449** Human-Computer Interaction
- **CS 450** Computer Architecture
- **CS 452** Real-time Programming
- **CS 454** Distributed Systems
- **CS 457** System Performance Evaluation
- **CS 458** Computer Security and Privacy
- **CS 462** Formal Languages and Parsing
- **CS 466** Algorithm Design and Analysis
- **CS 484** Computational Vision
- **CS 485** Machine Learning: Statistical and Computational Foundations
- **CS 486** Introduction to Artificial Intelligence
- **CS 487** Introduction to Symbolic Computation
- **CS 488** Introduction to Computer Graphics

One of the following ECE courses (ECE list):

- **ECE 409** Cryptography and System Security
- **ECE 416** Higher Level Network Protocols
- **ECE 418** Communications Networks
- **ECE 423** Embedded Computer Systems
- **ECE 429** Computer Architecture
- **ECE 454** Distributed Computing
- **ECE 455** Embedded Software
- **ECE 457A** Cooperative and Adaptive Algorithms
- **ECE 457B** Fundamentals of Computational Intelligence
- **ECE 458** Computer Security
- **ECE 459** Programming for Performance
- **ECE 481** Digital Control Systems
- **ECE 486** Robot Dynamics and Control
- **ECE 488** Multivariable Control Systems

One additional course from the CS and ECE lists above

Two Science Electives (SCE)
Normally these courses are in the natural sciences, chosen from the list below. Alternate courses may be chosen in consultation with the SE Program Advisors.

**Science Elective Courses:**


Three Linkage Electives (LE)
At least one from each of the areas of Societal Issues, Humanities and Social Sciences, and Communications, as specified below. Students should be aware that these courses may have enrolment limits, or may not fit their schedules.

**One course on Societal Issues:**
**CS 492**, **Complementary Studies Elective** List A

**One course on Communication:**
**ENGL 109**, **ENGL 129R/EMLS 129R**, **EMLS 101R**, **EMLS 102R**, **SPCOM 100**, **SPCOM 223**

**One additional course on Humanities and Social Sciences:**
**Complementary Studies Elective** List C

Notes
1. There are eleven electives. As detailed above, these electives must include three advanced technical electives, two science electives, and three linkage electives. For their remaining three electives, students may choose to take additional courses from the elective lists above or any other 0.5 credit course(s) for which they meet the requisites. Advanced Technical Electives may not be taken before the 3A term.

2. Students may choose to take three electives in 4A and four electives in 4B, instead of two in 4A and five in 4B.

3. Students enrolled in Software Engineering will only be permitted to use the WD and WF (see Grading System for descriptions) provisions used in the Faculty of Mathematics to withdraw from extra courses taken above and beyond the degree requirements.

4. With the permission of the Program Advisor, ECE 358 may be taken in 3A or 3B and replaced with a technical elective in 4A if required as a prerequisite for an ATE.

5. Students may replace STAT 206 and one of their unrestricted electives with the combination of STAT 230 and STAT 231.

6. The Linkage elective on Communication is normally taken in the 2A term. It must be completed with a grade of at least 60% prior to enrolling in the 3A term.

Communication Skills Requirement

Strong communication skills are essential to academic, professional, and personal success. As such, Software Engineering students must take a course from the Linkage Elective Communication List in the 2A term. This elective list parallels the Math Communication Skills Requirements List 1. In addition to the communication elective, Software Engineering students must satisfy the Technical Presentation Milestone (described below) in the 2B term. Communication skills are further developed and evaluated in three work-term reports (described below) and in SE 101, SE 390, SE 490, and SE 491.

Three Work-term Reports (WKRPT)

Work-term reports are listed as part of the Software Engineering curriculum; they are treated as courses that a BSE student must successfully complete to satisfy the program requirements. They appear on all grade reports and transcripts, but they are not used in calculating term averages.

Each work-term report requirement is satisfied by earning a grade of satisfactory or better on a work-term report related to the previous term's co-op employment. Each work-term report must be submitted at the beginning of the academic term in which it is listed as a course; it is due seven days after the first official day of lectures. Reports submitted after the due date will receive a failing grade and will be evaluated the following academic term.

Failed work-term reports contribute to a student's accumulated failed-course count. They also appear on a student's transcripts. Once a failure has cleared, the original grade will still be listed on transcripts but will be annotated with a credit (CR) in the "sup" field.

Technical Presentation Milestone (TPM)

Each student registered in Software Engineering is required to satisfy the Technical Presentation Milestone (TPM) during their 2B term. If admitted to the Software Engineering program after 2B, then the student must satisfy this requirement before the end of the student's first academic term in the program. The details of the TPM requirement are provided during the student's 2A term, so that the student can plan appropriately for the presentation during the work term preceding 2B. A student who is interested in formal instruction on how to develop and deliver an oral presentation should consider taking SPCOM 223.

Five Professional Development (PD) Courses

Five professional development courses are required as described in the BASc and BSE Specific Degree Requirements section on Work Terms. Two core PD courses are specified for all engineering students: PD 20 and PD 21. Due to the importance of understanding the legal and ethical ramifications of software development, Software Engineering students are also required to take PD 10. This course replaces one of the PD electives, such that Software Engineering students have three core PD courses (PD 20, PD 21, and PD 10) and two PD elective courses. Software Engineering students are automatically enrolled in PD 20, PD 21, and PD 10 but must enrol in the elective PD courses using the normal Quest enrolment process.

Statistics

Statistics Overview

Statistics deals with the collection and analysis of data. Statistical methods are extensively used in biology, medicine, health sciences, agriculture, business, finance, economics, engineering, and many other fields. Claims based on statistical arguments appear daily in the press, and it is difficult to assess these claims intelligently without knowledge of statistical methods.
The statistician’s first job is to determine what data to collect, and how to collect it so that it will be without bias or distortion. These problems are discussed in the Design of Experiments and Sample Surveys. Statistical Inference is concerned with inferring what the population is like on the basis of a small amount of data (the sample). The link between population and sample is provided by Probability Theory, which forms an important part of the statistics curriculum. Developing and assessing statistical models to describe the variation in some response in terms of other explanatory variables, and applications of these models is discussed throughout the statistics curriculum.

Other areas of pure and applied mathematics find applications in statistics. Calculus and linear algebra are used in the undergraduate program; abstract algebra, combinatorics, difference and differential equations, analysis, and measure theory are required in more advanced work. Many statistical analyses involve the computer, so a good background in computing is highly desirable.

**Statistics**

Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 26 math courses, and the following specific requirements:

One of

- MATH 237 Calculus 3 for Honours Mathematics
- MATH 247 Calculus 3 (Advanced Level)

All of

- ENGL 378/MTHEL 300 Professional Communications in Statistics and Actuarial Science
- STAT 330 Mathematical Statistics
- STAT 331 Applied Linear Models
- STAT 332 Sampling and Experimental Design
- STAT 333 Applied Probability

One of

- MATH 239 Introduction to Combinatorics
- MATH 249 Introduction to Combinatorics (Advanced Level)
- AMATH 231 Calculus 4
- AMATH 242/CS 371 Introduction to Computational Mathematics
- AMATH 250 Introduction to Differential Equations

Two 400-level STAT courses.

One additional 300- or 400-level STAT course.

One of

- One additional 400-level STAT course
- CS 457 System Performance Evaluation
- CS 485 Machine Learning: Statistical and Computational Foundations
- CS 486 Introduction to Artificial Intelligence

**Note:** CS 457, CS 485, and CS 486 are open only to those with a major in CS.

Four additional 300- or 400-level math courses.

At least three additional math courses for a minimum of 26 math courses.

**Notes**

1. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.
   - STAT 372 for STAT 332.
   - AMATH 350 for AMATH 250.
2. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333; STAT 373 is not an acceptable substitute for STAT 331.
3. Business Administration and Mathematics Double Degree students may substitute BUS 362W for ENGL 378/MTHEL 300.

**Joint Statistics**

See [Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) for a description of joint plan requirements. Note that both specializations designated in such joint plans must be disciplines within the Faculty of Mathematics.

One of

- **MATH 237** Calculus 3 for Honours Mathematics
- **MATH 247** Calculus 3 (Advanced Level)

All of

- **ENGL 378/MTHEL 300** Professional Communications in Statistics and Actuarial Science
- **STAT 330** Mathematical Statistics
- **STAT 331** Applied Linear Models
- **STAT 333** Applied Probability

Two 400-level STAT courses.

One additional 300- or 400-level STAT course.

**Notes**

1. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.
2. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333; STAT 373 is not an acceptable substitute for STAT 331.
3. Business Administration and Mathematics Double Degree students may substitute BUS 362W for ENGL 378/MTHEL 300.

**Data Science**

Data Science is the study of methods to obtain insight from available data in order to understand, predict, and improve business strategy, products and services, marketing campaigns, medicine, public health and safety, and many other pursuits. Such methods involve elements of both Statistics and Computer Science, with a focus on three foundational components: (i) Database Management, (ii) Statistics and Machine Learning, and (iii) Distributed and Parallel Systems.

The Data Science plan is guided by a joint curriculum committee. This committee is chaired by a Director of Data Science, normally a faculty member chosen from either academic unit with the agreement of both. Along with the Director, the committee includes four faculty representatives, two appointed by each unit. In addition, the Associate Chair of Undergraduate Studies for Statistics and Actuarial Science and the Director of Undergraduate Studies for Computer Science serve ex officio on the committee. Curriculum changes introduced by the committee must receive approval from both units before being approved at the Faculty level. In addition to chairing the curriculum committee, the Director has responsibility for promoting the plan, both internally and externally, and for overall coordination.

The Faculty of Mathematics offers two Honours plans in Data Science, a BMath (Data Science) and a BCS (Data Science). The Data Science plans are offered jointly by the Department of Statistics and Actuarial Science and by the David R. Cheriton School of Computer Science. Students in the two plans graduate with a background in both Computer Science and Statistics, taking a combination of required and elective courses that together provide a solid foundation in this emerging area. Students in this plan must satisfy all requirements for [Honours Statistics](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) and must satisfy the following additional constraints on course selection:

One of
MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)

One of

CS 136 Elementary Algorithm Design and Data Abstraction
CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

All of

CS 240 Data Structures and Data Management
CS 241 Foundations of Sequential Programs
CS 245 Logic and Computation
CS 246 Object-Oriented Software Development
CS 252 Computer Organization and Design
CS 341 Algorithms
CS 348 Introduction to Database Management
CS 350 Operating Systems
CS 451 Data-Intensive Distributed Computing
STAT 341 Computational Statistics and Data Analysis

One of

CS 485 Machine Learning: Statistical and Computational Foundations
CS 486 Introduction to Artificial Intelligence
STAT 441 Statistical Learning - Classification

Two additional courses from the following list

CS 485 Machine Learning: Statistical and Computational Foundations
CS 486 Introduction to Artificial Intelligence
STAT 431 Generalized Linear Models and their Applications
STAT 440 Computational Inference
STAT 441 Statistical Learning - Classification
STAT 442 Data Visualization
STAT 443 Forecasting
STAT 444 Statistical Learning - Function Estimation

Statistics for Health
Students in this plan must fulfill all the requirements in Table I and Table II. This must include at least 24 math courses, and the following specific requirements:

One of

MATH 237 Calculus 3 for Honours Mathematics
MATH 247 Calculus 3 (Advanced Level)

All of

STAT 330 Mathematical Statistics
STAT 331 Applied Linear Models
STAT 332 Sampling and Experimental Design
STAT 333 Applied Probability
STAT 337 Introduction to Medical Statistics
STAT 431 Generalized Linear Models and their Applications
STAT 436 Introduction to the Analysis of Spatial Data in Health Research
STAT 437 Analysis of Longitudinal Data in Health Research

One of

MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)
AMATH 231 Calculus 4
AMATH 242/CS 371 Introduction to Computational Mathematics
AMATH 250 Introduction to Differential Equations

Two additional 300- or 400-level math courses.

All of

CS 330 Management Information Systems
CS 338 Computer Applications to Business: Databases
CS 432 Business Systems Analysis
ENGL 378/MTHEL 300 Professional Communications in Statistics and Actuarial Science
GERON 245/HLTH 245 Canadian Health Systems
HLTH 101 Introduction to Health 1

Two of

AFM 101 Introduction to Financial Accounting
AFM 102 Introduction to Managerial Accounting
BIOL 239 Genetics
ECON 101 Introduction to Microeconomics
ECON 102 Introduction to Macroeconomics
HLTH 102 Introduction to Health 2
HIST 209 Smallpox to Medicare: Canadian Medical History

Notes

1. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.
   - STAT 372 for STAT 332.
   - AMATH 350 for AMATH 250.

2. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333; STAT 373 is not an acceptable substitute for STAT 331.

Statistics Minor
This minor is only open to students within the Faculty of Mathematics.

All of

MATH 237 Calculus 3 for Honours Mathematics or MATH 247 Calculus 3 (Advanced Level)

Three of

STAT 330 Mathematical Statistics
STAT 331 Applied Linear Models
STAT 332 Sampling and Experimental Design
STAT 333 Applied Probability

Two additional 300- or 400-level STAT courses.

Notes

1. Students currently or previously enrolled in the following plans: Business Administration and Mathematics Double Degree, Mathematics/Business Administration, Mathematics/Financial Analysis and Risk Management, Information Technology Management, and Mathematical Optimization – Business Specialization may substitute:
   - STAT 371 for STAT 331.
   - STAT 372 for STAT 332.

2. STAT 334 is not an acceptable substitute for STAT 330 or STAT 333; STAT 373 is not an acceptable substitute for STAT 331.
Faculty Policies

Degree requirements and policies that apply to students enrolled in the Bachelor of Software Engineering (BSE) degree program are included in the Software Engineering program description. Also see Degree Requirements for definitions of the basic terms used in this section.

- Academic Enrolment Blocks (Holds)
- Academic Standing within the Faculty
- Averages for Math Students
- Major Averages for Math Students
- Co-op Regulations
- Course Load
- Discretion in the Application of Policies
- Exceptions
- Extended Absences and Withdrawals
- Grades
- Other Course Rules
- Residency Requirement

Academic Enrolment Blocks (Holds)
In some instances a student will be blocked from enrolling in classes. Any student with an enrolment block (hold) should speak to their academic advisor concerning their situation. A student will be blocked, regardless of their academic standing for the term, in the following circumstances:

- after the term in which a student reaches 1.5 failed or excluded units; or
- after the term in which a student enrolled in Mathematical Studies reaches 3.0 failed or excluded units; or
- after the first term in which a student reaches or exceeds 4.0 units of unusable course attempts; or
- when the "First Course" of the Communication Skills requirement is not completed before enrolling in 2A.

Students may be blocked from enrolling in courses for reasons other than those listed here.

Academic Standing within the Faculty
This section specifies the rules that determine a student’s academic standing. A student’s standing determines whether a student is able to proceed in the Faculty or in their chosen plan, how many courses they are able to take in the next term, etc.
**Conditions**

<table>
<thead>
<tr>
<th>Any of the following:</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The student has more than 4.0 units of failed or excluded courses, or</td>
<td>Required to withdraw – may not continue in Faculty</td>
</tr>
<tr>
<td>• The student’s total unit value of unusable course attempts exceeds 5.0 units, or</td>
<td></td>
</tr>
<tr>
<td>• The student did not pass at least two courses in their first full-time 1A term, unless the one course passed is a math course with a grade of at least 60% and</td>
<td></td>
</tr>
<tr>
<td>the Standings and Promotions (S&amp;P) Committee has approved the student to continue with their studies, or</td>
<td></td>
</tr>
<tr>
<td>• The student cannot earn a degree within the permitted maximum number of course attempts (this requirement may be waived at the discretion of the student’s academic advisor) (see Table 1), or</td>
<td></td>
</tr>
<tr>
<td>• In the opinion of S&amp;P, the student is unlikely to profit from further study in the Faculty or is not making satisfactory progress toward fulfilling degree</td>
<td></td>
</tr>
<tr>
<td>requirements</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and all of the following:</td>
<td>Must change to Mathematical Studies; CAV low</td>
</tr>
<tr>
<td>• The student’s cumulative average (CAV) is lower than 60%, and</td>
<td></td>
</tr>
<tr>
<td>• The student has more than 2.0 units and less than or equal to 4.0 units of failed or excluded courses.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and all of the following:</td>
<td>Must change to Mathematical Studies; MAV low</td>
</tr>
<tr>
<td>• The student’s major average (MAV) is lower than 60%, and</td>
<td></td>
</tr>
<tr>
<td>• The student has more than 2.0 units and less than or equal to 4.0 units of failed or excluded courses.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and all of the following:</td>
<td>Must change to Mathematical Studies; CAV and MAV low</td>
</tr>
<tr>
<td>• The student’s CAV is lower than 60%, and</td>
<td></td>
</tr>
<tr>
<td>• The MAV is between the required minimum and 5% lower than that, and</td>
<td></td>
</tr>
<tr>
<td>• The student has more than 2.0 units and less than or equal to 4.0 units of failed or excluded courses.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies and the student has more than 2.0 units and less than or equal to 4.0 units of failed or excluded courses.</td>
<td>Must change to Mathematical Studies</td>
</tr>
<tr>
<td>No standing above applies, and any of the following:</td>
<td>Must change academic plan - plan average(s) too low</td>
</tr>
<tr>
<td>• Standing from the previous full-time term or equivalent is Conditional or Probation/Conditional and any MAV is below the required minimum, or</td>
<td></td>
</tr>
<tr>
<td>• Any MAV is below the required minimum and the plan’s administrators do not give permission for the student to continue, or</td>
<td></td>
</tr>
<tr>
<td>• Any MAV is more than 5% lower than the required minimum, or</td>
<td></td>
</tr>
<tr>
<td>• The student is in an Actuarial Science plan and special major average (SMAV) is below the required minimum.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and all of the following:</td>
<td>Probation/Conditional - Must raise averages</td>
</tr>
<tr>
<td>• The student’s CAV is lower than 60%, and</td>
<td></td>
</tr>
<tr>
<td>• At least one MAV is between the required minimum and 5% lower than that, and</td>
<td></td>
</tr>
<tr>
<td>• The plan’s administrators have given permission for the student to continue.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and the student’s CAV is lower than 60%.</td>
<td>Probation - Must raise overall program average</td>
</tr>
<tr>
<td>No standing above applies, at least one MAV is between the required minimum and 5% lower than that, and the plan’s administrators have given</td>
<td>Conditional - Must raise plan average(s)</td>
</tr>
<tr>
<td>permission for the student to continue.</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and the student’s CAV is lower than 80%.</td>
<td>Good</td>
</tr>
<tr>
<td>No standing above applies, and the student’s CAV is at least 80%.</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

The following table describes the implications of the standings listed above.
### Implications of Undergraduate Studies Standing

<table>
<thead>
<tr>
<th>Standing</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required to withdraw – may not continue in Faculty</td>
<td>The student is no longer eligible to study as a Faculty of Mathematics student. This standing normally means that a student is no longer eligible for any subsequent degree studies in the Faculty of Mathematics. Students who are unable to satisfy the major average admission or continuation standard for any honours plan will be required to withdraw from the Math Faculty. However, a student may submit a petition to S&amp;P to enrol in one final term of non-degree studies. Such petitions are likely to be granted only if the student is requesting a non-degree term of courses selected to enhance the chances for admission to a program of study outside the Faculty, either at the University of Waterloo or at some other post-secondary institution. A student who is required to withdraw may graduate with a general degree under the Honours Fallback Provision if they meet the requirements when they are required to withdraw.</td>
</tr>
<tr>
<td>Must change to Mathematical Studies; CAV low</td>
<td>The student is no longer eligible to continue in their current Honours plan and their plan/major has been changed to Mathematical Studies. Also, the student is not currently meeting the Faculty’s CAV standards. If enrolled in a co-op plan, the student will normally be suspended from the Co-operative Education and Career Action (CECA) employment process during their next academic term.</td>
</tr>
<tr>
<td>Must change to Mathematical Studies; MAV low</td>
<td>The student is no longer eligible to continue in their current Honours plan and their plan/major has been changed to Mathematical Studies. Also, the student is not currently meeting the Faculty’s MAV standards. If enrolled in a co-op plan, the student will normally be suspended from the CECA employment process during their next academic term.</td>
</tr>
<tr>
<td>Must change to Mathematical Studies; CAV/MAV low</td>
<td>The student is no longer eligible to continue in their current Honours plan and their plan/major has been changed to Mathematical Studies. Also, the student is not currently meeting the Faculty’s CAV and MAV standards. If enrolled in a co-op plan, the student will normally be suspended from the CECA employment process during their next academic term.</td>
</tr>
<tr>
<td>Must change to Mathematical Studies</td>
<td>The student is no longer eligible to continue in their current Honours plan and their plan/major has been changed to Mathematical Studies.</td>
</tr>
<tr>
<td>Must change academic plan - plan average(s) too low</td>
<td>The student must change to a different plan/major.</td>
</tr>
<tr>
<td>Probation/Conditional - Must raise averages</td>
<td>The implications of both Probationary standing and Conditional standing apply.</td>
</tr>
<tr>
<td>Probation - Must raise overall program average</td>
<td>The student is not currently meeting the Faculty’s standards. If enrolled in a co-op plan, the student will normally be suspended from the CECA employment process during their next academic term.</td>
</tr>
<tr>
<td>Conditional - Must raise plan average(s)</td>
<td>The student is not currently meeting their plan’s standards. If the student’s standing does not improve (e.g., by raising their MAV(s) to meet the minimum requirements), they will be required to change their plan.</td>
</tr>
<tr>
<td>Good</td>
<td>The student may continue with their studies.</td>
</tr>
<tr>
<td>Excellent</td>
<td>The student may continue with their studies, and their maximum course load is increased to 3.0 units.</td>
</tr>
</tbody>
</table>

### Averages for Math Students
The Faculty of Mathematics computes several averages that are used to determine a student’s “standing” within the Faculty. The averages are:

- **Cumulative Average (CAV):** The average mark of all courses taken by a student that meet the following criteria:
  - was taken while the student was enrolled at the University of Waterloo,
• is not a specifically excluded course,
• is eligible for credit towards the student’s degree (e.g., ECON 211 would not be included in the CAV because all Math students are barred from taking it) and towards their particular plan (e.g., CS 330 would not be included in a computer science major’s average because it is only for non-majors).

Term Average (TAV): The TAV is just like the CAV except that the courses included are limited to those taken in a specific term. A TAV is computed for each term in which a student is enrolled in the Faculty of Mathematics.

Major Average (MAV): Courses included in the MAV and average requirements are contained in the table below.

Special Major Average (SMAV): Some plans have a special major average, or SMAV. A SMAV is a kind of MAV. The specific courses in a SMAV are defined in the next section.

Notes

1. Courses taken in fall 2013 or later cannot be excluded.
2. Failing grades less than 32 and grades of DNW (did not write exam), FTC (failure to complete), NMR (no mark reported), and WF (withdraw/failure) are counted as 32 for average-calculation purposes.

Major Averages for Math Students
<table>
<thead>
<tr>
<th>Major/Plan</th>
<th>Average(s)</th>
<th>Relevant Courses</th>
<th>Minimum required average</th>
<th>Minimum courses for MAV or SMAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuarial Science</td>
<td>SMAV</td>
<td>ACTSC 231, 232, STAT 230/240, 231/241, and all 300/400-level math courses</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>Applied Mathematics, Combinatorics and Optimization, Mathematical Optimization, Mathematical Physics, Pure Mathematics, Statistics</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>65%</td>
<td>3</td>
</tr>
<tr>
<td>Computing and Financial Management</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All courses from the Faculty of Arts</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>Computer Science</td>
<td>MAV</td>
<td>CS 136, 138, 146, all subsequent CS major courses, as well as CS courses numbered 600 and higher, CO 487, ECE 222,429, SE 212, 240, 382, 463, 464, 465, and STAT 440</td>
<td>60%</td>
<td>2</td>
</tr>
<tr>
<td>Information Technology Management</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All BUS, COMM, MSCI, and STV courses</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics/Business Administration</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All AFM, BUS, COMM, ECON, HRM, MSCI, and MTHEL courses</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics/Chartered Professional Accountancy</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All AFM, COMM, ECON, and MSCI courses (this special major average is calculated after the 1B term and includes courses cross-listed with these labels)</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematical Economics</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All ECON courses</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematical Finance</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics/Financial Analysis and Risk Management</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All ACTSC, AFM, BUS, COMM, ECON, and MATBUS courses (including courses cross-listed with these labels)</td>
<td>70%</td>
<td>3</td>
</tr>
<tr>
<td>All plans not listed above</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>3</td>
</tr>
</tbody>
</table>

**Co-op Regulations**

**General Regulations**

- Co-operative mathematics students are expected to follow the normal academic/work-term sequence appropriate to their plan from admission through to graduation.
- Students admitted at the 1A level, with the exception of those in the Mathematics/Chartered Professional Accountancy and Bachelor of Business Administration (BBA)/Bachelor of Mathematics (BMath) Double Degree plans, will normally have eight academic terms and six work terms.
- Students may not end their sequence with a work term.
- Students’ requests to re-arrange their sequence will normally be approved if all the criteria listed on the [Academic/Work Term Sequence Change form](#) are met. Students who alter their sequence without obtaining prior approval may be required to withdraw from the co-op system. It is the student’s responsibility to deal with any timetabling difficulties that may arise and to select courses for subsequent terms.

**Professional Development (PD) courses**

- As specified in [Table 1](#), co-op students are required to complete a minimum of five different [Professional Development (PD) courses](#).
- PD 1 is required in the academic term prior to the first work term and PD 11 is required during the first work term.
- Students in the Bachelor of Mathematics in Computer Science and Bachelor of Computer Science plans must include PD 10, Professional Responsibility in Computing, as one of their PD courses.
- With the exception of PD 1, PD courses are normally taken during co-op work terms.
- Students are required to take a PD course each work term until the requirement is completed.

**Work Reports**
- Co-op students must submit a work report following every work term until they have completed four acceptable work reports. Successful completion of PD 11 meets the requirement for a first work report.

**Co-op Standing Rules**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Co-op Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any of the following:</td>
<td>Withdraw from co-op</td>
</tr>
<tr>
<td>- The student is required to withdraw from the Faculty</td>
<td></td>
</tr>
<tr>
<td>- The student is on academic probation after a full-time academic term for the second time</td>
<td></td>
</tr>
<tr>
<td>- Two unemployed or failed work-term opportunities</td>
<td></td>
</tr>
<tr>
<td>- Three missing or failed PD courses</td>
<td></td>
</tr>
<tr>
<td>- Two missing or failed work reports</td>
<td></td>
</tr>
<tr>
<td>- The S&amp;P Committee deems that the student is unlikely to profit from further participation in co-op or is not making satisfactory progress toward fulfilling co-op degree requirements. Presentation of such requests to S&amp;P result in a notification to the student and an opportunity to reply prior to S&amp;P’s decision.</td>
<td>Withdraw from co-op</td>
</tr>
</tbody>
</table>

No standing above applies, and any of the following:
- The student is on academic probation after a full-time term for the first time
- Two missing or failed PD courses and one missing or failed work report.

No standing above applies, and in the most recent work term, the Employer Evaluation was Excellent or Outstanding.

No standing above applies.

The following table describes the implications of the standings listed above.

<table>
<thead>
<tr>
<th>Co-op Standing</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdraw from co-op</td>
<td>The student must withdraw from co-op, and will be transferred to the most closely matching regular plan for which the student is admissible, if one exists.</td>
</tr>
<tr>
<td>Co-op probation</td>
<td>The student must meet with a co-op advisor to determine conditions necessary to remediate their co-op standing. A student who is on probation in co-op solely because of their academic standing will be placed in Good co-op standing if they return to Good or Excellent academic standing after one full-time academic term without missing or failing any PD courses or work reports. The student’s access to the co-op employment process will be blocked pending completion of remedial requirements.</td>
</tr>
<tr>
<td>Good co-op standing</td>
<td>Eligible to continue in co-op.</td>
</tr>
<tr>
<td>Excellent co-op standing</td>
<td>Eligible to continue in co-op.</td>
</tr>
</tbody>
</table>

**Courses on a Work Term**
- Co-op students on a work term are limited to one course (0.5 units), unless they have written support from their employer to take two courses (1.0 units). COOP, PD, and WKRPT courses are not included in these limits.

**Transferring into Co-op**
• Late transfers to the co-op system are considered once per term. Admission is very competitive and is a function of availability and demonstrated academic performance at the university level.
• Regular students in the Faculty of Mathematics may apply to transfer to the co-op system of study in their 1B term. To be eligible, at the time of admission to co-op, such students must have successfully completed between 4.0 and 6.0 units, including transfer credits.
• Non-co-op students from other faculties at the University of Waterloo may apply to transfer to the co-op system in the Faculty of Mathematics at the end of their 1B term, as part of the internal transfer process.
• Non-co-op students external to the University of Waterloo are eligible to apply for co-op in the Faculty of Mathematics only if, at the time of admission, they have successfully completed no more than 3.0 units of math transfer credits and between 4.0 and 6.0 transfer credits overall.
• Applications to transfer to co-op from co-op students external to the University of Waterloo will be considered on a case-by-case basis.

Course Load
• The standard course load is five courses per term (2.5 units). A student may take up to 2.75 units without special permission.
• Students who have a cumulative average of 80% or more and are in Excellent standing have a maximum course load of 3.25 units. Honours co-op students should not enrol in six courses with a view to graduating in fewer than eight terms, because co-op students must complete at least eight full-time terms to graduate with the co-op designation.
• If a student has courses with INC (incomplete course work) grades on their record, the total unit weight of those courses and the courses enrolled for the current term may not normally exceed 3.25 units. A student may obtain permission from an academic advisor to exceed this limit if an INC will not be completed in the current term because the course is not offered.
• If, during a student's first 1A term in the Faculty of Mathematics, a student fails one or more courses and has a CAV of less than 65%, then the student’s course load for the following term will be reduced to 2.0 units. Students who will likely be required to withdraw and are also enrolled in the subsequent term may continue in a non-degree term enrolled in a maximum of 2.5 units. Exceptions may be brought to the Associate Dean by plan/program advisors, and will be dealt with on a case-by-case basis.

Discretion in the Application of Policies
The Faculty may, in extenuating circumstances, make exceptions to its policies. For example, students who experience difficulties beyond their control, such as serious illness, may be allowed to continue in a plan when a strict interpretation of policy would force them out.

Students should consult their academic advisor to determine whether their circumstances are appropriate to warrant asking for an exception.

Normally, the S&P Committee considers petitions for exceptions to Faculty or University policies and regulations. Students wishing to petition S&P should consult their academic advisor.

Exceptions
For students near graduation, any student who has:

1. exceeded the limit for failed or excluded units in Table I, or
2. accumulated more than 5.0 units of unusable course attempts, and
3. has no more than 0.5 units remaining to satisfy degree requirements, may enrol in one additional term. The student will still qualify for an Honours degree if, at the end of that term, they:
   • satisfied all degree requirements other than the failure or attempt limit,
   • have credit for at least 1.5 units in the additional term, and
   • have no failed or excluded courses, WDs (withdrawn, no credit granted), or CLC's (no credit granted, in average) in that term.

No student may take advantage of this provision more than once.

Extended Absences and Withdrawals

First-year Withdrawal
A first-year student who has never previously been registered at a degree-granting post-secondary institution will normally be permitted to withdraw from all of their courses without academic penalty until the last official day of lectures for their first term. These courses will continue to appear on the student’s academic record with a grade of WD. Even though a WD appears, these attempts will not impact a
student's academic progress. Such students may resume their studies after an absence of two terms (eight months). Students wishing to pursue this option should contact the Registrar's Office.

**Readmission**
A student who has completed at least one term of study and who has been inactive (i.e., not registered as a candidate for a Faculty of Mathematics degree or on an approved Letter of Permission) for at least five consecutive academic terms must apply for readmission.

For example, a student whose last term of enrolment was spring 2016 would not need to apply for readmission if they returned to study in winter 2018 or earlier. However, if this student remained inactive until spring 2018 or later, then they would need to apply for readmission.

Application for readmission must include a résumé covering the inactive period, and must include transcripts from any post-secondary institutions attended in the interim. If the student is readmitted, Faculty policies in effect at the time of readmission will apply unless otherwise stated by the Faculty.

**Grades**
- The University's [grading system](#) describes the grading practice at Waterloo and lists the letter conversion scale for courses taken prior to fall 2001 and Wilfrid Laurier University (Laurier) courses with a letter grade, non-numeric grades, and unit weights.
- CS 499T is the only course in the Faculty of Mathematics for which numerical grades are not assigned.
- Students in the Faculty of Mathematics may not register for official Audit (AUD) status in a course. This policy applies to all undergraduate students in Mathematics, including non-degree students and students on exchange from other universities, but does not apply to post-degree students.

**Other Course Rules**

**Courses on Letter of Permission**
Students in Good or Excellent standing are normally permitted to take non-math courses at other universities on a part-time basis during terms off campus, provided that the courses are not explicitly required for their particular plan. A Letter of Permission may not be used for any Faculty of Mathematics course. Students wishing to take courses at other universities must submit a completed Letter of Permission Form to the Registrar's Office before taking each course. The S&P Committee will not approve courses taken elsewhere for degree credit after the fact.

Courses taken on a Letter of Permission will be recorded on a student's academic record as transfer credits (CR - credit granted) or transfer failures (TF - transfer failure) as appropriate. A grade of 60 or higher will be recorded as a credit and a grade of less than 50 will be recorded as a failure. Grades of 50-59 will result in the course not being recorded on a student’s record.

It will be the student's responsibility to ensure that an official transcript from the host institution is sent to the University of Waterloo Registrar's Office within two months of the completion of the course. Otherwise, a transfer failure will be automatically recorded. Any changes a student wishes to make to an authorized Letter of Permission must be approved in advance by the S&P Committee.

**Course Prerequisites**
At any time prior to the completion of lectures, if the Faculty discovers that a student has enrolled in a course offered by the Faculty without the appropriate prerequisites and without being granted an override of those prerequisites, the Faculty may purge the student's registration in the course. Such purging may be done at the request of the instructor, the department offering the course, or the Faculty, but not without the consent of the instructor.

**Double Counting of Courses**
With the exception of specially approved double-degree plans (e.g., BBA/BMath Double Degree plan with Wilfrid Laurier University), the Faculty of Mathematics does not allow students to have more than 50% of the course units that they are counting for Mathematics Faculty degree credit be ones that have previously been used, or that are being used simultaneously, to obtain a second degree from another University of Waterloo faculty or from another university.

**Policy for Late Switches from Advanced MATH Courses to the Regular Equivalents**
At any time before the end of the "Drop, Penalty 1" period, students may switch from an advanced section MATH or STAT course to the equivalent course at the regular honours level:
Students making this kind of switch will normally only be graded based on course elements from the regular section course. Any marks from the advanced section course will be disregarded. Students are responsible for making up any material in the regular section course that they may have missed, and are required to discuss their situation with the regular section instructor as soon as possible after making the switch.

Students in MATH 147 who have transfer credit for MATH 137 may elect instead to drop the class, retroactive to the first day of lectures. If such a student chooses to switch to MATH 137 instead, then they will forfeit any transfer credit for MATH 137.

Students in MATH 247 who have already gained credit for MATH 237 may elect instead to drop the class, retroactive to the first day of lectures.

The School of Computer Science has a special rule for any first-year student who has never been previously registered for full-time study at a degree-granting post-secondary institution (e.g. a university or college) and wishes to transfer from CS 135 to CS 115 (fall and winter terms) or from CS 145 to CS 135 (fall term).

**Residency Requirement**
Students must normally complete at least 50% of the minimum number of math courses and at least 50% of the total number of units required for a Faculty of Mathematics degree while registered at the University of Waterloo. Students transferring into a co-op system of study must complete at least five work terms, unless otherwise specified by plan requirements.