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). In co-operation with the Faculty of Science, the Mathematics Faculty offers a four-year honours program in Bioinformatics leading either to the BCS or Bachelor of Science (BSc).

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 Transfer Students 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, resumes, and other biographical material before determining a candidate’s suitability for university studies. You 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 online courses in Algebra & Geometry and 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

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, and 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, and 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 honors 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.

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
List of Academic Programs/Plans

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

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/Business Option
- Computer Science/Digital Hardware Option

Computer Science also offers other plans. See below.

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

Statistics plans:
- 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/Financial Analysis and Risk Management - Professional Risk Management Specialization
Plans administered by the Dean's Office:

- **Computational Mathematics**
- **Mathematics/Teaching (co-op only)**
- **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/Digital Hardware Option**
- **Computer Science/Software Engineering Option**

**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 Bachelor of Science (BSc) Academic Plans**
The Faculty of Science and the David R. Cheriton School of Computer Science offer the following honours plans leading to a BSc degree:

- **Bioinformatics**
- **Biology and Bioinformatics**

**Honours Computer Science and Financial Management**
The BCFM Steering Committee administers this program which leads to the Bachelor of Computer Science 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
- Bioinformatics
- Biology and Bioinformatics
• 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
   - Financial Analysis and Risk Management
   - Health Informatics Option
   - Information Technology Management
   - Mathematics/Business Administration
   - Mathematics/Chartered Professional Accountancy
   - 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

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, MTHEL 131 is an admission requirement for the following plans:
   - Honours Actuarial Science
   - Honours Actuarial Science/Finance Option
   - Joint Actuarial Science
   - Actuarial Science Minor

**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
3. Non-Math Joint Honours plans
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.

Every BCS or BMath student’s plans must include:
- 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.

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.

Restrictions on Multiple-Plan Combinations

1. A stand-alone BMath plan cannot be combined with any BCS plan.
2. Combining Computational Mathematics and Computer Science has additional restrictions, and any such combination must be approved by advisors of both plans.
3. 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)
   - All plans offered by **Computational Mathematics**
   - All plans offered by **Computer Science**
   - All plans offered by **Pure Mathematics**
   - All plans offered by **Statistics**
   - All Math/Business plans other than Mathematical Economics

Specific Invalid Multiple-Plan Combinations
# Academic Plans and Requirements

## Degree Requirements for all Math students

### Table I – Degree Requirements

#### Legend
- * The minimum co-op work term course units for the Chartered Accountancy and Teaching plans are 2.0.
- ** 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>Co-op</th>
<th>Regular</th>
<th>Co-op</th>
<th>Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum course units (excluding courses with the subject COOP, PD, and WKRPT)</td>
<td>20.0</td>
<td>20.0</td>
<td>26.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Minimum COOP course units</td>
<td>2.5*</td>
<td>0</td>
<td>2.0</td>
<td>0</td>
</tr>
<tr>
<td>Minimum PD course units</td>
<td>2.5</td>
<td>0</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Minimum WKRPT course units</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Minimum non-math units</td>
<td>5.0</td>
<td>5.0</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Minimum Cumulative Average (<strong>CAV</strong>)</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Minimum Major Average (<strong>MAV</strong>)</td>
<td>65%</td>
<td>70%</td>
<td>65%</td>
<td>60%</td>
</tr>
<tr>
<td>- All AMATH (including Mathematical Physics), PMATH, and STAT plans</td>
<td>60%</td>
<td>70%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>- Mathematical Finance</td>
<td>60%</td>
<td>70%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>- All other plans</td>
<td>60%</td>
<td>70%</td>
<td>60%</td>
<td>60%</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>
<td>2.0**</td>
<td>2.0**</td>
</tr>
<tr>
<td>Maximum unusable course attempts</td>
<td>5.0</td>
<td>5.0</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>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Minimum number of full-time terms</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>English Writing Skills</td>
<td>Any plan offered by Computer Science or by Computational Mathematics</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

- All degree candidates must satisfy an English Writing Skills Requirement. See below.
First-Year English Writing Skills Requirement
All students in the Faculty of Mathematics must satisfy the following Writing Skills Requirement before enrolling in their 2A term:

- A grade of 60 or better on the Waterloo English Language Proficiency Exam (ELPE), or
- Successfully complete the study program offered by the University of Waterloo Writing Centre or
- Complete one of the following courses with a grade of at least 60%:

  ENGL 109 Introduction to Academic Writing
  ENGL/ESL 129R Written Academic English
  ENGL 140R The Use of English 1
  ESL 101R Oral Communications for Academic Purposes
  ESL 102R Error Correction in Academic Writing
  SPCOM 100 Interpersonal Communication
  SPCOM 111 Leadership, Communication, and Collaboration
  SPCOM 223 Public Speaking

Notes

1. Transfer credit for any of the above courses does not satisfy this requirement; the courses must be taken at the University of Waterloo.
2. Students will not be permitted to enrol in their 2A term until they have completed the Writing Skills Requirement. They will only be allowed to proceed after successful completion of the requirement.
3. A completed English Proficiency milestone on a student's academic record will indicate successful completion of this requirement.
4. Students in the Software Engineering program must satisfy this requirement as set down by the Faculty of Engineering.
5. Students in the Computing and Financial Management program must satisfy this requirement as set down by the Faculty of Arts.
6. Students who have written and failed ELPE should enrol in the Writing Centre or enrol in one of the above courses rather than attempt ELPE again.
No-Credit/Overlap Courses
Before enrolling in a course, students should check the Faculty of Mathematics No-Credit List and Course Overlap List, to determine whether or not the course will count towards their degree. See 'Other Course Rules' in Faculty Policies for further details.

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 2 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

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 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 satisfy 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 25.0 units of course attempts
4. Maximum of 4.0 units failed or excluded
5. 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)

Note
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 only be considered after an absence from the Faculty of several terms.

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 special major average (SMAV) 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

ACTSC 231 Mathematics of Finance
ACTSC 232 Introduction to Actuarial Mathematics
ACTSC 331 Life Contingencies 1
ACTSC 371 Introduction to Investments
ACTSC 431 Loss Models 1
ACTSC 432 Loss Models 2
ACTSC 446 Mathematical Models in Finance
ECON 101 Introduction to Microeconomics
ECON 102 Introduction to Macroeconomics
STAT 330 Mathematical Statistics
STAT 331 Applied Linear Models
STAT 333 Applied Probability
STAT 340 Computer Simulation of Complex System
AFM 101 Introduction to Financial Accounting
MTHEL 131 Introduction to Actuarial Practice

Four additional courses chosen from

Any 300- or 400-level ACTSC course
AFM 424/472 Equity Investments
STAT 431 Generalized Linear Models and their Applications or STAT 433 Stochastic Processes
STAT 443 Forecasting

One of

MATH 239 Introduction to Combinatorics
MATH 249 Introduction to Combinatorics (Advanced Level)
AMATH 231 Calculus 4
AMATH 250 Introduction to Differential Equations

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

One of

ENGL 119 Communications in Mathematics & Computer Science
HIST/MEDVL 115 Crusading in the Middle Ages
HIST 253 Canadian History: The Colonial Period
HIST 254 Canadian History: The National Period
HIST/MEDVL 260 Europe, 410 – 1303
HIST/MEDVL 304/RS 342 Heresy and Religious Crises in Late Medieval Europe
PSCI 101 Introduction to Political Ideas
PSCI 231 Government and Business
PSCI 260 Canadian Government & Politics
PSCI 283 International Political Economy
SPCOM 100 Interpersonal Communication
SPCOM 223 Public Speaking

Note:

1. Business Administration and Mathematics Double Degree students may substitute:
   - ECON 120W and 140W for ECON 101 and 102.
   - BUS 383W and 393W for ACTSC 371 and 372.
   - Completion of the Double Degree program for ENGL 119.
   - BUS 473W for one of the 'Four of' list of ACTSC courses and alternatives.

STAT 334 is not an acceptable substitute for STAT 330 or 333.

Actuarial Science/Finance Option
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)
AMATH 231 Calculus 4
AMATH 250 Introduction to Differential Equations

All of
ACTSC 231 Mathematics of Finance
ACTSC 232 Introduction to Actuarial Mathematics
ACTSC 331 Life Contingencies 1
ACTSC 371 Introduction to Investments
ACTSC 372 Corporate Finance
ACTSC 431 Loss Models 1
ACTSC 445 Quantitative Risk Management
ACTSC 446 Mathematical Models in Finance
AFM 101 Introduction to Financial Accounting
AFM 102 Introduction to Managerial Accounting
ECON 101 Introduction to Microeconomics
ECON 102 Introduction to Macroeconomics
MTHEL 131 Introduction to Actuarial Practice
STAT 330 Mathematical Statistics
STAT 331 Applied Linear Models
STAT 333 Applied Probability
STAT 340 Computer Simulation of Complex Systems

Four additional courses chosen from

Any 300- or 400-level ACTSC course
AFM 424/472 Equity Investments
STAT 431 Generalized Linear Models or STAT 433 Stochastic Processes
STAT 443 Forecasting

One of

ENGL 119 Communications in Mathematics & Computer Science
HIST/MEDVL 115 Crusading in the Middle Ages
HIST 253 Canadian History: The Colonial Period
HIST 254 Canadian History: The National Period
HIST/MEDVL 260 Europe, 410 – 1303
HIST/MEDVL 304/RS 342 Heresy and Religious Crises in Late Medieval Europe
PSCI 101 Introduction to Political Ideas
PSCI 231 Government and Business
PSCI 260 Canadian Government & Politics
PSCI 283 International Political Economy
SPCOM 100 Interpersonal Communication
SPCOM 223 Public Speaking

**Joint Actuarial Science**

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. Note that at least 26 math courses are required.

One of

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

All of

ACTSC 231 Mathematics of Finance
ACTSC 232 Introduction to Actuarial Mathematics
ACTSC 331 Life Contingencies 1
ACTSC 431 Loss Models 1
ACTSC 432 Loss Models 2
STAT 330 Mathematical Statistics
STAT 333 Applied Probability
AFM 101 Introduction to Financial Accounting
MTHEL 131 Introduction to Actuarial Practice
Three additional courses chosen from

Any 300- or 400-level ACTSC course
AFM 424/472 Equity Investments
STAT 331 Applied Linear Models
STAT 340 Computer Simulation of Complex Systems
STAT 431 Generalized Linear Models and their Applications
STAT 443 Forecasting

**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:

**Legend**
* MATH 237 requires permission of department.
** AMATH 350 is an antirequisite of AMATH 351 and 353, and choosing this course limits selection in the "One of" lists below.

One of

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

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 Introduction to Business Organization (see Laurier calendar)
ACTSC 231 Mathematics of Finance
ACTSC 371 Introduction to Investments
ACTSC 372 Corporate Finance
ACTSC 445 Quantitative Risk Management
ACTSC 446 Mathematical Models in Finance
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 1 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

Note
MATH 147 and 148 provide highly desirable background for students in the Mathematical Finance plan.

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)
ACTSC 231 Mathematics of Finance
ACTSC 232 Introduction to Actuarial Mathematics
ACTSC 331 Life Contingencies 1
ACTSC 431 Loss Models 1
STAT 330 Mathematical Statistics
STAT 333 Applied Probability
AFM 101 Introduction to Financial Accounting
MTHEL 131 Introduction to Actuarial Practice

One additional 300- or 400-level ACTSC course.

Applied Mathematics

Applied Mathematics Overview
Applied Mathematics is motivated mathematics, or mathematics to a purpose. It reflects the belief that there exists a basic order and harmony in the universe which may be described by the logical structures of mathematics. Thus, it is no coincidence that some of the greatest mathematicians of the past were also interested in engineering and physics.

This rich, classical tradition of Applied Mathematics is typified by the ongoing work in Theoretical and Fluid Mechanics, General Relativity, and Quantum Theory, at the interface among Mathematics, Theoretical Physics, and Engineering, and covering such diverse areas as the study of supersonic flow, the behaviour of ocean waves, the structure of space-time and cosmology, and the fundamental symmetry properties of the world of atoms and molecules. In addition, newer areas, such as Control Theory and Signal/Image Processing, analyze processes ranging from optimal control of a space vehicle to the coding, compression and transmission of signals and images. As scientists find out more and more about the mechanisms that make the world "tick," we also find that more, often new, mathematics is necessary to systematize, digest, and take advantage of this wealth of knowledge in all scientific areas. This need is often reflected in a keen interest among applied mathematicians in ordinary and partial differential equations and their discretizations.

In their first two years, all Applied Mathematics students take the same core courses as are taken by other Mathematics students, in order to acquire a sound mathematical background. At the same time, since the application of analytical reasoning to a wide variety of problems is the essence of Applied Mathematics, there is room for courses in scientific disciplines which are heavy users of mathematics, such as Physics or Engineering. In the upper years, the focus is on courses more specifically related to their chosen area of specialization. It is our experience that Applied Mathematics graduates find their career opportunities to be excellent and varied.

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/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.

Two additional 300- or 400-level AMATH courses.

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.).

Recommended course

AMATH/PMATH 331 Applied Real Analysis

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/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/PMATH 331 Applied Real Analysis

Applied Mathematics/Biology Option
This plan has the same course requirements as Honours Applied Mathematics, with the following additional requirements:

All of

AMATH/BIOL 382 Computational Modeling of Cellular Systems

All of
BIOL 130 Introductory Cell Biology
BIOL 239 Genetics

An additional 2.5 units of BIOL courses at least 1.5 units of which are at the 300- or 400-level.

Recommended course

BIOL 364 Mathematical Modeling in Biology

**Applied Mathematics/Earth Science Option**
This plan has the same course requirements as [Honours Applied Mathematics](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) with the following additional requirements:

All of

- AMATH/EARTH 310 Environmental Informatics
- AMATH 361 Continuum Mechanics
- AMATH 463 Fluid Mechanics

All of

- EARTH 121 Introductory Earth Sciences
- EARTH 122 Introductory Environmental Sciences
- PHYS 122 Waves, Electricity and Magnetism

An additional 2.5 units of EARTH courses at least 1.5 units of which are at the 300- or 400-level.

**Applied Mathematics/Economics Option**
This plan has the same course requirements as [Honours Applied Mathematics](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) with the following additional requirements:

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 1
- ECON 202 Macroeconomic Theory 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](http://ugradcalendar.uwaterloo.ca/printing/?groupID=117) with the following additional requirements:

All of

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

An additional 1.5 units of PHYS courses at least 1.0 units of which are at the 300- or 400-level or 1.5 units from the following list:

- 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

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 additional requirements:

**Fluids and Heat**
All of

- PHYS 122 Waves, Electricity and Magnetism
- AMATH 271 Introduction to Theoretical Mechanics
- AMATH 342 Computational Methods for Differential Equations
- AMATH 361 Continuum Mechanics
- AMATH 463 Fluid Mechanics

One of

- CO 250 Introduction to Optimization
- CO 255 Introduction to Optimization (Advanced Level)
- CO 367 Nonlinear Optimization
- STAT 331 Applied Linear Models
- STAT 340 Computer Simulation of Complex Systems

All of

- GENE 123 Electrical Engineering
- 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

**Communication and Control**
All of

- PHYS 122 Waves, Electricity and Magnetism
- AMATH 342 Computational Methods for Differential Equations
- AMATH 455 Control Theory

One of

- CO 250 Introduction to Optimization
- CO 255 Introduction to Optimization (Advanced Level)
- CO 367 Nonlinear Optimization
- CS 475 Computational Linear Algebra
- STAT 331 Applied Linear Models
- STAT 340 Computer Simulation of Complex Systems

All of

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

Two of

ECE 411 Digital Communications
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

**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/PMATH 331 Applied Real Analysis
AMATH/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
ECE 403/PHYS 358 Thermal Physics
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 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/PMATH 331 Applied Real Analysis
AMATH/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 444 Applications of Computational 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 441 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 450-471.)

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 430-487, 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/PMATH 331 Applied Real Analysis
- AMATH/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

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
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 430-487, 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/PMATH 331 Applied Real Analysis
AMATH/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 430-487, 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 450-471)

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 Stochastic Processes  
STAT 435 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 Introduction to Business Organization (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 1 (see Laurier calendar)  
CS 338 Computer Applications in Business: Databases  
ECON 102 Introduction to Macroeconomics  
MSCI 432 Production and Service Operations Management  
STAT 371 Statistics for Business 1  
STAT 372 Statistics for Business 2

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 Land 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.

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
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/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 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 246 as prerequisites, CS 241 requires CS 246 as a prerequisite.
- CS 240 and 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
- 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 246 require CS 136 as a prerequisite.

Four additional courses

- AMATH/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 473 Medical Image Processing
- CS 476 Numerical Computation for Financial Modeling
- CS 482 Computational Techniques in Biological Sequence Analysis
- CS 483 Computational Techniques in Structural Bioinformatics
- 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

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

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
AMATH/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 473 Medical Image Processing
CS 476 Numerical Computation for Financial Modeling
CS 482 Computational Techniques in Biological Sequence Analysis
CS 483 Computational Techniques in Structural Bioinformatics
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 course having) a CS label.

**Computer Science**

**Computer Science Overview**

Computer Science is centred around the study of information. It is concerned with 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. It is also concerned with the physical machines that perform these operations, with the elemental units of which these machines are composed, with the organization of these units into efficient information processing systems, and with the exploration of the limits of the abilities of these machines.

Computer Science is recognized as an independent discipline with an inherently mathematical nature. Its activity ranges from theoretical areas such as the theory of automata, system organization and logic design, formal languages and computability theory to applied areas such as scientific computing, programming languages, bioinformatics, software management, and computer systems.

The advent of the computer has facilitated a systems approach to solving many problems in science, business, and industry. There is currently a great demand for information analysts to define how systems will perform these functions and for programmers to implement production systems on computers.

The following regular and co-operative plans are accredited by the Computer Science Accreditation Council, which is sponsored by the [Canadian Information Processing Society](http://www.cips-cics.ca). 

- 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 Bioinformatics and plans involving Joint Honours Computer Science has not been sought.

**Computer Science Major Plans**

CS major plans are listed in Admission to Specific Honours Academic Plans.

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 134, 136, or 146
- have a Cumulative Mathematics Average of at least 65% (calculated over all math and computer science courses) and a CS major average of at least 70%

Advanced standing students from within the Faculty satisfying these conditions are normally admitted; applicants without some of these conditions will be considered on an individual basis. Students are normally not considered for admission beyond the 2B level.

**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

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

One additional course chosen from

CO 487 Applied Cryptography
CS 440-498
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 selection of upper-year CS courses must include at least one course from each of at least two of the following area groups:

Systems and SE: CS 343, 349, 442, 444, 445, 446, 447, 450, 452, 454, 456, 457, 458
Applications: CS 348, 448, 449, 473, 476, 482, 483, 484, 485, 486, 488
Mathematical Foundations of CS: CS 360, 365, 370, 371, 462, 466, 467, 475, 487

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

1.0 units from the humanities (subjects from ARTS, CHINA, CLAS, CMW, CROAT, DAC, DRAMA, DUTCH, EASIA, ENGL, FINE, FR, GER, GRI, HIST, HUMSC, ITAL, ITALST, JAPAN, JS, KOREA, LAT, MUSIC, PHIL, POLISH, PORT, REES, RS, RUSS, SI, SPAN, SPCOM)
1.0 units from the social sciences (subjects from AFM, ANTH, APPLS, BUS, ECON, GEOG, HRM, INTST, INTTS, ISS, LS, MSCI, NATST, PACS, PSCI, PSYCH, REC, SMF, SOC, SOCWK, SPD, 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, ENVS, ERS, GERON, HLTH, KIN, PLAN)

Note: No course can be used to satisfy more than one of the above requirements.

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

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
  \[ \text{MATH 237 Calculus 3 for Honours Mathematics} \]
  \[ \text{MATH 247 Calculus 3 (Advanced Level)} \]

One of
  \[ \text{MATH 239 Introduction to Combinatorics} \]
  \[ \text{MATH 249 Introduction to Combinatorics (Advanced Level)} \]

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

One of
  \[ \text{AMATH 242/CS 371 Introduction to Computational Mathematics} \]
  \[ \text{CS 370 Numerical Computation} \]

One of
  \[ \text{CS 360 Introduction to the Theory of Computing} \]
  \[ \text{CS 365 Models of Computation} \]

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

Three additional courses labelled ACTSC, AMATH, CO, PMATH, STAT, excluding the following:
  \[ \text{Courses with requisites normally excluding Honours CS students} \]
  \[ \text{Courses cross-listed with a CS course} \]
  \[ \text{Courses explicitly listed in CS major plans as alternatives to CS courses} \]
  \[ \text{Readings and Topics courses} \]
  \[ \text{ACTSC 221, CO 353, 380, 480} \]

The 5.0 non-math units must satisfy the same restrictions as specified for the Bachelor of Computer Science.

**Business Administration and Computer Science 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 a fall (September-to-December) term.
Students who successfully complete this plan will be eligible to attend both universities' convocation ceremonies and be awarded a Waterloo Honours Bachelor of Computer Science (BCS) degree and a Laurier Honours Bachelor of Business Administration (BBA) degree from Wilfrid Laurier University 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 ten 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 specified courses (12 units) taken at Waterloo and 24 specified courses (12 units) at Laurier. The remaining four elective courses (two units) 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 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 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 BCS or Bachelor of Mathematics (BMath) plan respectively, depending upon their individual circumstances.

**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
ENGL 210F Genres of Business Communication

Four additional CS courses chosen from CS 340-398, 440-489, with at least two chosen from CS 440-489. The selection of upper-year CS courses must include at least one course from each of at least two of the following area groups:

- Systems and SE: CS 343, 349, 442, 444, 445, 446, 447, 450, 452, 454, 456, 457, 458
- Applications: CS 348, 448, 449, 473, 476, 482, 483, 484, 485, 486, 488
- Mathematical Foundations of CS: CS 360, 365, 370, 371, 462, 466, 467, 475, 487
From Wilfrid Laurier University (Laurier)
All of

BUS 111W Introduction to Business Organization
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 1
BUS 288W Organizational Behaviour 1
BUS 352W Introduction to Marketing Management
BUS 354W Human Resources Management
BUS 362W Building and Managing Products, Services and Brands
BUS 385W Operations Management 1
BUS 393W Financial Management 2
BUS 395W Operations Management 2
BUS 398W Organizational Behaviour 2
BUS 481W Business Policy 1
BUS 491W Business Policy 2
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.

Five additional 300- or 400-level BUS elective courses (2.5 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 Undergraduate Calendar and/or one of the plan's academic advisors at Laurier.

2. Students may, in certain circumstances, be permitted to have one minor or option designation on their Waterloo Bachelor of Computer Science (BCS) diploma and transcript. Such a designation must be either
   - the Software Engineering Option to the BCS degree, or
   - in a Waterloo discipline outside the areas of study offered by Waterloo's Faculty of Mathematics and outside those 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 Undergraduate 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 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.

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. the 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

Two of (communications courses)

- CS 492 The Social Implications of Computing
- ENGL 109 Introduction to Academic Writing
- ENGL 119 Communications in Mathematics & Computer Science
- ENGL 210* (various Writing courses)
- SPCOM 100 Interpersonal Communication or SPCOM 223 Public Speaking or SPCOM 225 Interviewing or SPCOM 324 Small Group Communication or SPCOM 325 Organizational Communication

Six of (business courses)

- ACTSC 231 Mathematics of Finance
- 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 Introduction to Business Organization (see Laurier calendar)
- ARBUS 200 The Principles of Entrepreneurship
- ARBUS 302/ECON 344 Marketing: 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 1 (see Laurier calendar)
- BUS 491W Business Policy 2 (see Laurier calendar)
- COMM 400 Entrepreneurship, Technology and the Emerging Information Economy
- ECON 101 Introduction to Microeconomics
- ECON 102 Introduction to Macroeconomics
- HRM 200 Basic Human Resources Management
- MSCI 211 Organizational Behaviour or PSYCH 338 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 designated as BU in the Laurier calendar. Non-math courses may have enrolment limits or may not easily fit schedules.

**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
Embedded Microprocessor Systems

Microprocessor Systems and Interfacing for Mechatronics Engineering

One of

ECE 224 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 Engineering
MTE 120 Circuits

All of

ECE 124 Digital Circuits and Systems
ECE 327 Digital Hardware Systems
ECE 423 Embedded Computer Systems (first offered in 2014)

Recommended courses

ECE 455 Embedded Software

Software Engineering Option

The Software Engineering Option is available only for the Bachelor of Computer Science plan. 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 Faculty Options, Engineering section. Given that the option involves two faculties, it has slightly different realizations in those faculties. Students who complete this option within the Faculty of Mathematics do not qualify for the professional engineering designation. The course requirements are the same as for the Bachelor of Computer Science with the following constraints on upper-year CS courses:

All of

CS 348 Introduction to Database Management

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

Applications

Two of

CS 343 Concurrent and Parallel Programming
CS 349 User Interfaces
CS 442 Principles of Programming Languages
CS 444 Compiler Construction
CS 448 Database Systems Implementation
CS 449 Human-Computer Interaction
CS 450 Computer Architecture or ECE 429 Computer Architecture
CS 452 Real-time Programming
CS 454 Distributed Systems or ECE 454 Distributed Computing
CS 456 Computer Networks or ECE 428 Computer Networks and Security
CS 457 System Performance Evaluation
CS 458 Computer Security and Privacy
CS 473 Medical Image Processing
CS 484 Computational Vision
CS 485 Machine Learning: Statistical and Computational Foundations
CS 486 Introduction to Artificial Intelligence or ECE 457A Cooperative and Adaptive Algorithms
or ECE 457B Fundamentals of Computational Intelligence
CS 488 Introduction to Computer Graphics

The following constraints apply to the non-math and free-choice courses:

**Societal Issues**
One of

ARBUS 202/PHIL 215 Professional and Business Ethics
CS 492 The Social Implications of Computing
GENE 411 Engineering Law and Ethics
GENE 412/PHIL 315 Ethics and The Engineering Profession
ME 401 Law for the Professional Engineer
STV 100 Society, Technology and Values: Introduction
STV 202 Design and Society
STV 302 Information Technology and Society

*Note: Choosing CS 492 (a math course) from this list does not reduce the overall requirement to take 5.0 non-math units.*

**Business Issues**
One of

BUS 111W Introduction to Business Organization (see Laurier calendar)
BUS 121W Functional Areas of the Organization (see Laurier calendar)
COMM 400 Entrepreneurship, Technology and the Emerging Information Economy
HRM 200 Basic Human Resources Management
MSCI 211 Organizational Behaviour
MSCI 311 Organizational Design and Technology
MSCI 454 Technical Entrepreneurship

*Note: Courses labelled BUS are offered by the School of Business and Economics at Wilfrid Laurier University.*

**Communication**
May be replaced with an additional course from the societal or business lists.
One of

ENGL 109 Introduction to Academic Writing
ENGL 119 Communications in Mathematics & Computer Science
ENGL 140R The Use of English 1
ENGL 210E Genres of Technical Communication
ENGL 210F Genres of Business Communication
ENGL 309E/SPCOM 323 Speech Writing
ENGL 376R Applied English Grammar 1
ENGL 392A Information Design
ENGL 392B Visual Rhetoric
SPCOM 100 Interpersonal Communication
SPCOM 223 Public Speaking
SPCOM 225 Interviewing
SPCOM 324 Small Group Communication

*Note: Non-math courses may have enrolment limits or may not easily fit schedules.*

**Joint Computer Science (Bachelor of Mathematics)**
See [Bachelor of Computer Science and Bachelor of Mathematics Academic Plan Combinations](http://ugradcalendar.uwaterloo.ca/) 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. 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/).

**Joint Bachelor of Computer Science**
Students in this plan must satisfy all the requirements of [Table 1](http://ugradcalendar.uwaterloo.ca/), 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 340-398, 440-489.
Two additional courses chosen from CS 440-489, 499T.
Ten non-math courses satisfying the same restrictions as specified for the Bachelor of Computer Science.

Bioinformatics
This decade has seen an exponential growth in the amount of genetic sequence and protein structure data available to biologists. These data have catalyzed a revolution in how biological and medical science is conducted in both academia and industry. However, due to the sheer volume and complexity of the data,
modern computational techniques are required to store, manipulate, visualize, and explore it. Bioinformatics is the interdisciplinary area that applies the latest ideas of computer science to this wealth of new data to solve important biological problems, study the interactions of small molecules with biological receptors, and search for novel therapies for disease. It requires a sophisticated understanding of both the problem domain in biology and the appropriate analytical skills in computer science.

Although Bioinformatics is offered in both co-op and regular, it is intended primarily for co-op students. Regular students will not be able to follow a "traditional" term sequence and will definitely need to study in some spring terms.

Three Bioinformatics degrees are available. All Bioinformatics students are required to fulfill the requirements in Table 1, the following core requirements, plus the additional requirements specific to one of the Bioinformatics degrees.

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** 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)

One of

- **BIOL 150** Organismal and Evolutionary Ecology
- **BIOL 165** Diversity of Life
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 308 Principles of Molecular Biology
BIOL 309 Analytical Methods in Molecular Biology
BIOL 365 Resources in Bioinformatics
BIOL 465 Current Topics in 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
CHEM 237 Introductory Biochemistry
CHEM 266 Basic Organic Chemistry 1
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 482 Computational Techniques in Biological Sequence Analysis
CS 483 Computational Techniques in Structural Bioinformatics

Recommended courses

BIOL 331 Advanced Cell Biology
BIOL 342 Molecular Biotechnology 1
BIOL 359 Evolution
CHEM 333 Metabolism 1 (for students interested in Biochemistry)
STAT 333 Applied Probability

Notes

1. Students in Bioinformatics may not claim a Biology minor with a BCS degree.
2. Students in Bioinformatics may not claim a Computer Science minor with a Bachelor of Science degree.
3. A student can qualify for at most one of the following three degrees, regardless of which courses are taken.

Bachelor of Science (Honours Bioinformatics)
This plan requires the following additional courses:

All of

BIOL 331 Advanced Cell Biology
BIOL 342 Molecular Biotechnology 1
CS 350 Operating Systems

One of

BIOL 434 Human Molecular Genetics
Any fourth-year Biochemistry course

Bachelor of Science (Honours Biology and Bioinformatics)
This plan requires the following additional courses:

All of

BIOL 331 Advanced Cell Biology
BIOL 342 Molecular Biotechnology 1
BIOL 434 Human Molecular Genetics
Two additional third- or fourth-year Biology or Biochemistry courses.

**Bachelor of Computer Science (Honours Bioinformatics Option)**
This plan requires the following additional courses:

All of

- CS 350 Operating Systems

Two additional courses from CS 340-398, 440-489, 498.

One additional course from CS 440-498.

**Note:**
At least one of these three courses must be from either the Systems and SE list or the Mathematical Foundations list for the Bachelor of Computer Science.

Recommended courses

- CS 348 Introduction to Database Management
- CS 486 Introduction to Artificial Intelligence

**Computer Science Minor**
A "Computer Science Minor" is available to all Honours and four-year General students except in combination with plans that are offered by the School of Computer Science (including shared plans such as Software Engineering, Computing and Financial Management, and any joint plans involving Computer Science).

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 Engineers
- MATH 136 Linear Algebra 1 for Honours Mathematics
- MATH 146 Linear Algebra 1 (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 (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 116 Introduction to Computer Science 2
- CS 136 Elementary Algorithm Design and Data Abstraction
- CS 146 Elementary Algorithm Design and Data Abstraction (Advanced Level)

Two of

- CS 230 Introduction to Computers and Computer Systems
- CS 234 Data Types and Structures
- CS 246 Object-Oriented Software Development
Four additional CS courses numbered 200 or higher. The average of all passed CS courses on the student’s record (including repeated courses) must be at least 60% and at most two CS courses may have failing grades.

Notes

1. Some CS courses are not available to students pursuing a CS minor. Consult individual course requisites for details.
2. CS 241 may be substituted for CS 230, and CS 240 may be substituted for CS 234. CS 240 and CS 241 are ordinarily only available to CS majors.

Accelerated Master's Academic Plans in Computer Science

This plan is intended to shorten the usual time required to obtain a Master of Mathematics (MMath). The accelerated plan streamlines the process by allowing a student to complete two graduate courses during their 4A/4B terms that will count towards a MMath degree. This plan will appeal to both Bachelor of Computer Science (BCS) and Bachelor of Mathematics (BMath) students who already have a good idea of a research project for a master’s degree. The graduate courses they take towards an MMath should be chosen in discussion with their academic advisor and the graduate officer and must be declared extra to their undergraduate degree.

In order to be eligible for this plan an overall average of at least 80% is required. Students are encouraged to apply during their 3B academic term. Applications will also be considered during the 3A term or, in exceptional circumstances, at the start of the 4A term. Application forms are available from the administrative assistant for graduate studies. In addition to submitting a graduate application form and three letters of reference, students will need to submit a plan for their studies. This plan will include 1) a preferred supervisor, 2) the two graduate courses to be taken in 4A/4B, 3) an outline of proposed research.

Students in this plan will receive financial support of $1,000 per term during their fourth year and will also be guaranteed financial support during their graduate studies should they maintain the required average in the plan. Students are encouraged to apply for scholarships during September of their 4A term. These include both Natural Sciences and Engineering Research Council of Canada (NSERC) and the Ontario Graduate Scholarship Program (OGS).

Computing and Financial Management

Computing and Financial Management Overview and Degree Requirements

The objective of the Computing and Financial Management 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 Computing and Financial Management program is offered jointly by the David R. Cheriton School of Computer Science and the School of Accounting and Finance. Students will be considered to 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 the Computing and Financial Management program 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 this program must fulfill all the requirements of Table I except that the Writing Skills Requirement is 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 424/472 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
http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
AFM 291 Intermediate Financial Accounting 1
Any AFM course at the 300- or 400-level not listed above.
ECON 201 Microeconomic Theory 1
ECON 202 Macroeconomic Theory 1
ECON 231 Introduction to International Economics
ECON 332 International Finance
ECON 344 Marketing: 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, 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 requirements are those of the Faculty of Arts. Students will be required to have a minimum of 75% in Ontario Academic Credit (OAC) 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 his or her 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 330 Health Informatics

**One of**

- HLTH 333 Experimental Methods and Observational Methods in Epidemiology
- HLTH 344 Evaluation, Qualitative, and Survey Methods

**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 a fall (September to December) 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 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 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**

- 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)

**All of**

- ACTSC 231 Mathematics of Finance
- CO 370 Deterministic OR Models
- CS 330 Management Information Systems
- STAT 371 Statistics for Business 1
- STAT 372 Statistics for Business 2
Seven additional 200- or 300- or 400-level math courses.

From Wilfrid Laurier University (Laurier)
All of

BUS 111W Introduction to Business Organization
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 1
BUS 288W Organizational Behaviour 1
BUS 352W Introduction to Marketing Management
BUS 354W Human Resources Management
BUS 362W Building and Managing Products, Services and Brands
BUS 385W Operations Management 1
BUS 393W Financial Management 2
BUS 395W Operations Management 2
BUS 398W Organizational Behaviour 2
BUS 481W Business Policy 1
BUS 491W Business Policy 2
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.

Five additional 300- or 400- level BUS elective courses (2.5 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 Undergraduate 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 Undergraduate 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

http://ugradcalendar.uwaterloo.ca/printing/?groupID=117
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 Statistics for Business 1
- STAT 372 Statistics for Business 2

All of

- AFM 101 Introduction to Financial Accounting
- AFM 102 Introduction to Managerial Accounting
- BUS 111W Introduction to Business Organization (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 1 (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

One ENGL or SPCOM course (0.5 units).
Four additional courses (2.0 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 a 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 as one of their seven math electives or as one of their four ECON electives.*

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 201 Microeconomic Theory 1
- ECON 202 Macroeconomic Theory 1
- ECON 301 Microeconomic Theory 2
- ECON 302 Macroeconomic Theory 2
- ECON 401 Microeconomic Theory 3
- ECON 402 Macroeconomic Theory 3
- ECON 421 Econometrics
- ECON 472 Senior Honours Essay

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/PMATH 331 Applied Real Analysis
- AMATH 350 Differential Equations for Business and Economics
- STAT 331 Applied Linear Models
- STAT 443 Forecasting
Seven additional math courses*.
Four additional courses (2.0 units).

Notes

1. To remain eligible to continue in this plan, students must have a special major average (SMAV) of at least 75%. This criterion will apply once a student has completed at least three courses towards the average.
2. 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 Statistics for Business 1
STAT 372 Statistics for Business 2
Two additional math courses.

All of

AFM 102 Introduction to Managerial Accounting
BUS 111W Introduction to Business Organization (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 1 (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 338 Organizational Psychology

One of

ENGL 109 Introduction to Academic Writing
ENGL 119 Communications in Mathematics & Computer Science
ENGL 210* (various writing courses)
Any SPCOM course

Two additional 300- or 400- level BUS courses.

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
PACS 202 Conflict Resolution
PACS 323 Negotiation: Theories and Strategies
PSYCH 339 Personnel Psychology
Any AFM, BUS (see Laurier calendar), COMM, ECON, HRM, MSCI, PSCI, or STV course

Four additional courses (2.0 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 post-graduate 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, 102, 131; MATH 135/145, MATH 137/147; one of CS 115, 135, 145; one of MATH 136/146, 138/148; and one of ECON 101, 102. 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 and 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 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

- 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
CS 330 Management Information Systems
STAT 373 Regression and Forecasting Models in Finance

One of

AFM 231 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 331/433 Business Strategy
AFM 351/451 Audit Strategy
AFM 362 Taxation 1 for Accountants
AFM 363 Taxation 2 for Accountants
AFM 391 Intermediate Financial Accounting 2
AFM 401 Accounting Theory
AFM 411 Connections Across Competencies for Accounting Professionals
AFM 462 Taxation 3 for Public Accountants
AFM 481 Cost Management Systems
AFM 482 Performance Measurement and Organization Control
AFM 491 Advanced Financial Accounting
COMM 103 Mathematical Introduction to Economics or (ECON 101 Introduction to Microeconomics and ECON 102 Introduction to Macroeconomics)
SPCOM 111 Leadership Communication, and Collaboration

Five additional math courses (2.5 units).

Two additional AFM, COMM, ECON, MSCI, or math courses (1.0 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.

**Tuition**
This is a cost-recovery plan as defined by the Ministry of Education and Training. 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 designsations.

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:

One of

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

All of

- ACTSC 231 Mathematics of Finance
- 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 Statistics for Business 1
- STAT 372 Statistics for Business 2

One of

- ACTSC 446 Mathematical Models in Finance
- 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 Introduction to Business Organization (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)
BUS 481W Business Policy 1 (see Laurier calendar)
COMM 321 Intermediate Accounting for Finance
COMM 421 Financial Statement Analysis
ECON 202 Macroeconomic Theory 1

One of

HRM 200 Basic Human Resources Management
MSCI 211 Organizational Behaviour
PSYCH 338 Organizational Psychology

**Professional Risk Management Specialization**

All of

AMATH/PMATH 331 Applied Real Analysis
CS 338 Computer Applications in Business: Databases
MATBUS 472 Risk Management

One of

ACTSC 445 Quantitative Risk Management
MATBUS 471 Fixed Income Securities

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.

Plans for Students outside the Mathematics Faculty

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)
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.

**Combinatorics and Optimization Minor**
Combinatorics and Optimization minor requirements

**Computer Science Minor**
Computer Science minor requirements

**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
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. The MATH courses listed above may be replaced by more advanced courses for honours mathematics students. For example, instead of MATH 116 or 117 or 127, a student may take MATH 137 or 147.

Pure Mathematics Minor

Pure Mathematics minor requirements

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 2 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.

Notes

1. Students in Mathematical Studies may not pursue a joint or double honours plan from within the Faculty of Mathematics.
2. 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 Introduction to Business Organization (see Laurier calendar)

One of

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

Three additional courses chosen from

PACS 202 Conflict Resolution
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/ACTSC 291 Corporate Finance 1
- ACTSC 221 Mathematics of Investment
- ACTSC 231 Mathematics of Finance
- 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.

**Note**

1. Students in Mathematical Studies may not pursue a joint or double honours plan from within the Faculty of Mathematics.

**Mathematics/Teaching**

**Mathematics/Teaching Overview**
The co-operative Mathematics Teaching plan is an integrated one that is offered jointly by the Faculty of Mathematics at the University of Waterloo and the Faculty of Education at Queen's University. This plan combines academic studies in mathematics, teaching experience in secondary schools, and professional training, with the graduate fully qualified as a secondary school mathematics teacher in Ontario.

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. (Consult the **Study/Work Sequence** section.) Details concerning this and the Faculty of Education component are available from the academic advisors or the co-ordinator for this option.

**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 Mathematics of Investment  
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/PMATH 331 Applied Real Analysis  
AMATH/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 101/101R Introductory Psychology

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

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

Recommended non-math courses include

PHYL 311 Philosophy of Education
SOC 207 Sociology of Education

Notes

1. Successful completion of the academic requirements for any of the departmental honours plans "X" in the Faculty of Mathematics, whether leading to a Bachelor of Computer Science (BCS) or 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" (Since 3B and 4B courses are not normally offered in the spring term, it will be difficult to satisfy this alternative.)

2. The Bachelor of Education requirements are completed during an eight-month education study unit in the Faculty of Education at Queen's University in Kingston. This unit occurs in the fall and winter terms following completion of 3B.

3. The selection of courses required for the BMath Teaching must include a second teaching subject in one of the following disciplines: biology, chemistry, computer science, or physics. Eight courses (four units) are required to qualify for a second teaching subject.

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

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
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 Elementary 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 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/PMATH 331 Applied Real Analysis
PMATH 351 Real Analysis

One of

AMATH/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 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

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

One of

AMATH/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/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 101/101R Introductory Psychology

One of

PSYCH 211 Developmental Psychology
PSYCH 212/212R Educational Psychology

Notes

1. The Bachelor of Education requirements are completed during an eight-month education study unit in the Faculty of Education at Queen's University in Kingston. This unit occurs in the fall and winter terms following completion of 3B.
2. The selection of courses required for the Bachelor of Mathematics (BMath) Teaching must include a second teaching subject in one of the following disciplines: biology, chemistry, computer science, or physics. Four units are required to qualify for a second teaching subject.
3. Candidates are required to have a half-year university course in Developmental Psychology (or equivalent), or a full-year university course in Introductory Psychology before receiving the Bachelor of Education.
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:

Legend
* MATH 237 requires permission of department.
** AMATH 350 is an antirequisite of AMATH 351 and 353, and choosing this course limits selection in the last "One of" lists below.

One of

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

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 Introduction to Financial Accounting (see Laurier calendar)
AFM 131/ARBUS 101 Introduction to Business in North America or BUS 111W Introduction to Business Organization (see Laurier calendar)
ACTSC 231 Mathematics of Finance
ACTSC 371 Introduction to Investments
ACTSC 372 Corporate Finance
ACTSC 445 Quantitative Risk Management
ACTSC 446 Mathematical Models in Finance
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 1 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

Note
MATH 147 and 148 provide highly desirable background for students in the Mathematical
Finance plan.

**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 six faculty members (three from Computer Science and three from Electrical and Computer Engineering, including the appropriate Electrical and Computer Engineering Theme Area Chair 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. The Software Engineering Curriculum Committee reports to the Software Engineering Program Board and consults with both the Computer Science Curriculum 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.

**English Language Proficiency Requirement**

Students in the Software Engineering program must satisfy this requirement as set down by the Faculty of Engineering (see Engineering's English Language Proficiency Requirement).

**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. BSE students have three additional plans directly supported by their program:

- **Option in Management Sciences** (from Engineering)
- **Business Option** (from Computer Science), and
- **Cognitive Science Minor** (a university-wide minor)

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 his or her term average minus his or her 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 his or her 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.

**Academic Curriculum**

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

**The term by term academic component of the program for students entering Fall 2011 and later is as follows:**
<table>
<thead>
<tr>
<th>Term</th>
<th>Course and Title</th>
<th>Cls</th>
<th>Tut</th>
<th>Lab</th>
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<tr>
<td>1A Fall</td>
<td>CS 137 Programming Principles</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ECE 105 Physics of Electrical Engineering 1</td>
<td>3</td>
<td>1</td>
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<tr>
<td></td>
<td>ECE 140 Linear Circuits</td>
<td>3</td>
<td>2</td>
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<tr>
<td></td>
<td>MATH 115 Linear Algebra for Engineering</td>
<td>3</td>
<td>2</td>
<td>0</td>
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<tr>
<td></td>
<td>MATH 117 Calculus 1 for Engineering</td>
<td>3</td>
<td>2</td>
<td>0</td>
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<tr>
<td></td>
<td>SE 101 Introduction to Methods of Software Engineering**</td>
<td>1</td>
<td>0</td>
<td>2</td>
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<tr>
<td>1B Winter</td>
<td>SE 102 Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>CS 138 Introduction to Data Abstraction and Implementation</td>
<td>3</td>
<td>1</td>
<td>2</td>
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<tr>
<td></td>
<td>ECE 106 Physics of Electrical Engineering 2</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
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<td>ECE 124 Digital Circuits and Systems</td>
<td>3</td>
<td>1</td>
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<td></td>
<td>MATH 119 Calculus 2 for Engineering</td>
<td>3</td>
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<tr>
<td></td>
<td>MATH 135 Algebra for Honours Mathematics</td>
<td>3</td>
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<tr>
<td>2A Fall</td>
<td>SE 201 Seminar</td>
<td>1</td>
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<td>CHE 102 Chemistry for Engineers</td>
<td>3</td>
<td>2</td>
<td>0</td>
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<td></td>
<td>CS 241 Foundations of Sequential Programs</td>
<td>3</td>
<td>1</td>
<td>2</td>
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<td></td>
<td>ECE 222 Digital Computers</td>
<td>3</td>
<td>1</td>
<td>3*</td>
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<td>SE 212 Logic and Computation</td>
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<td></td>
<td>STAT 206 Statistics for Software Engineering</td>
<td>3</td>
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<tr>
<td></td>
<td>Elective (see note 1)</td>
<td>3</td>
<td>+</td>
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<tr>
<td></td>
<td>WKRPT 200 Work-term Report</td>
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<tr>
<td></td>
<td>TPM 000 CR/NCR</td>
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<tr>
<td>3A Winter</td>
<td>SE 301 Seminar</td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td>CS 341 Algorithms</td>
<td>3</td>
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<tr>
<td></td>
<td>CS 349 User Interfaces ***</td>
<td>3</td>
<td>0</td>
<td>1</td>
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<tr>
<td></td>
<td>SE 350 Operating Systems</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>SE 465 Software Testing and Quality Assurance ***</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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<tr>
<td>3B Fall</td>
<td>SE 302 Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CS 343 Concurrent and Parallel Programming</td>
<td>3</td>
<td>0</td>
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<td></td>
<td>CS 348 Introduction to Database Management</td>
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<td></td>
<td>SE 380 Introduction to Feedback Control</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>SE 390 Design Project Planning ***</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SE 464 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>
<td>+</td>
</tr>
<tr>
<td></td>
<td>WKRPT 300 Work-term Report</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4A Spring</td>
<td>SE 401 Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>ECE 358 Computer Networks</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>SE 463 Software Requirements Specification and Analysis ***</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SE 490 Design Project 1 ***</td>
<td>2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Two Electives (see note 1)</td>
<td>3</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>WKRPT 400 Work-term Report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4B Winter</td>
<td>SE 402 Seminar</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SE 491 Design Project 2 ***</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Five Electives (see note 1)</td>
<td>3</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Four Advanced Technical Electives (ATE):
The advanced technical electives comprise primarily 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 pre-requisites. Other courses may be approved by the Program Director. Courses offered by the Department of Systems Design Engineering require instructor consent.

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 473 Medical Image Processing
CS 484 Computational Vision
CS 485 Machine Learning: Statistical and Computational Foundations
CS 486 Introduction to Artificial Intelligence
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 417 Image Processing
ECE 418 Communications Networks
ECE 419 Communication System Security
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 of

An additional course from the CS and ECE lists above

CO 487 Applied Cryptography
CS 462 Formal Languages and Parsing
CS 466 Algorithm Design and Analysis
CS 467 Introduction to Quantum Information Processing
CS 475 Computational Linear Algebra
CS 487 Introduction to Symbolic Computation
CS 489 Advanced Topics in Computer Science
CS 490 Information Systems Management
ECE 406 Algorithm Design and Analysis
SE 498 Advanced Topics in Software Engineering
SE 499 Project
SYDE 533 Conflict Resolution
SYDE 575 Image Processing

One of

An additional course from the ATE lists above

CS 360 Introduction to the Theory of Computing
CS 365 Models of Computation
CS 370 Numerical Computation
CS 371 Introduction to Computational Mathematics
ECE 207 Signals and Systems
ECE 224 Embedded Microprocessor Systems
ECE 327 Digital Hardware Systems
SYDE 348 User Centred Design Methods

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:
BIOL 130 (including 130L), 239, 240, 273, CHE 161, CHEM 262 (including 262L), EARTH 121 (including 121L), ECE 209, PHYS 234, 246, 275, 334, 375

Four 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, 119, 140R, 210F, SPCOM 100, 223, 324, 432

Two additional courses on Humanities and Social Sciences:
Complementary Studies Elective List C

Notes

1. There are eleven electives. As detailed above, these electives must include four advanced technical electives, two science electives, and four linkage electives. For their remaining elective, students may choose to take any of an additional advanced technical elective, an additional science elective, any course from the complementary studies electives lists, a foreign-language linguistics or grammar course, BUS 111W, BUS 121W (see Wilfrid Laurier University calendar), COMM 400, or any other course approved by the SE Program Advisor. Advanced Technical Electives may not be taken before the 3A term; 400-level Advanced Technical Electives may not be taken before the 3B term.
2. 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.
3. Foreign-language courses must be approved by the SE advisor.
4. With the permission of the Program Advisor, ECE 358 may be swapped with a 3A or 3B technical elective if required as a prerequisite for an ATE.

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 for 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 his or her 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 SPCM 223.

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

- 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 483 Computational Techniques in Structural Bioinformatics
- CS 485 Machine Learning: Statistical and Computational Foundations
- CS 486 Introduction to Artificial Intelligence

Note: CS 457, 485, and 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.

Note:
1. Business Administration and Mathematics Double Degree students may substitute:
   - AMATH 350 for AMATH 250.

   STAT 334 is not an acceptable course for the STAT major plan.

**Joint Statistics**
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

- 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.

**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 or 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 336 Computer Applications to Business: Databases
- CS 432 Business Systems Analysis
- ENGL 119 Communications in Mathematics & Computer Science
- GERON/HLTH 245 The Canadian Health Care System
- HTH 101 Introduction to Health 1

Two of
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.

Note
Business Administration and Mathematics Double Degree students may substitute:

- STAT 371 and STAT 372 for STAT 331 and STAT 332.
- STAT 334 for one of STAT 330 or STAT 333.

Faculty Policies

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
- 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

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Academic Enrolment Blocks
In some instances a student will be blocked from enrolling in classes. Any student with an enrolment block 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 reaches 4.0, 4.5, or 5.0 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.

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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 his or her chosen plan, how many courses they are able to take in the next term, etc.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any of the following:</td>
<td></td>
</tr>
<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</td>
</tr>
<tr>
<td>- The student’s total unit value of unusable course attempts exceeds</td>
<td>Faculty</td>
</tr>
<tr>
<td>5.0 units, or</td>
<td></td>
</tr>
<tr>
<td>- The student did not pass at least two courses in his or her first</td>
<td></td>
</tr>
<tr>
<td>full-time 1A term, unless the one course passed is a math course with</td>
<td></td>
</tr>
<tr>
<td>a grade of at least 60% and the Standings and Promotions (S&amp;P)</td>
<td></td>
</tr>
<tr>
<td>Committee has approved the student to continue with his or her studies,</td>
<td></td>
</tr>
<tr>
<td>- The student cannot earn a degree within the permitted maximum number</td>
<td></td>
</tr>
<tr>
<td>of course attempts (this requirement may be waived at the discretion</td>
<td></td>
</tr>
<tr>
<td>of the student’s academic advisor) (see Table 1 in “Degree Requirements”),</td>
<td></td>
</tr>
<tr>
<td>- In the opinion of S&amp;P, the student is unlikely to profit from further</td>
<td></td>
</tr>
<tr>
<td>study in the Faculty or is not making satisfactory progress toward</td>
<td></td>
</tr>
<tr>
<td>fulfilling degree requirements</td>
<td></td>
</tr>
<tr>
<td>No standing above applies and any of the following:</td>
<td>Must change academic plan- plan average(s)</td>
</tr>
<tr>
<td>- Standing from the previous full-time term or equivalent is</td>
<td>too low</td>
</tr>
<tr>
<td>Conditional or Probation/Conditional and any major average (MAV) is</td>
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</tr>
<tr>
<td>below the required minimum, or</td>
<td></td>
</tr>
<tr>
<td>- Any MAV is below the required minimum and the plan’s administrators</td>
<td>Probability - Must raise overall program</td>
</tr>
<tr>
<td>do not give permission for the student to continue, or</td>
<td>average(s)</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 SMAV is below the</td>
<td></td>
</tr>
<tr>
<td>required minimum</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and all of the following:</td>
<td>Probability - Must raise plan average(s)</td>
</tr>
<tr>
<td>- The student’s cumulative average (CAV) is lower than 60%, and</td>
<td></td>
</tr>
<tr>
<td>- At least one major average (MAV) is between the required minimum and</td>
<td></td>
</tr>
<tr>
<td>5% lower than that, and</td>
<td></td>
</tr>
<tr>
<td>- The plan’s administrators have given permission for the student to</td>
<td></td>
</tr>
<tr>
<td>continue</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and the student’s CAV is lower than 60%</td>
<td>Probability - Must raise overall program</td>
</tr>
<tr>
<td>No standing above applies, at least one MAV is between the required</td>
<td>average(s)</td>
</tr>
<tr>
<td>minimum and 5% lower than that, and the plan’s administrators have</td>
<td></td>
</tr>
<tr>
<td>given permission for the student to continue</td>
<td></td>
</tr>
<tr>
<td>No standing above applies, and more than 1/3 of the passed and excluded</td>
<td>Marginal - Must improve</td>
</tr>
<tr>
<td>units taken while in the Faculty are excluded</td>
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</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>
<tr>
<td>The following table describes the implications of the standings listed</td>
<td></td>
</tr>
<tr>
<td>above.</td>
<td></td>
</tr>
</tbody>
</table>
Undergraduate Studies Calendar | University of Waterloo

Notes:

1. Courses taken in fall 2013 or later cannot be excluded.

http://ugradcalendar.uwaterloo.ca/printing/?groupId=117
2. A passed course may be repeated at most once unless an academic advisor has given prior approval. 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.

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### Major Averages for Math students

<table>
<thead>
<tr>
<th>Major/Plan</th>
<th>Averages</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>MAV</td>
<td>All math courses at any level</td>
<td>60%</td>
<td>2</td>
</tr>
<tr>
<td></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, Pure Mathematics, Mathematical Physics, Statistics</td>
<td>MAV</td>
<td>All math courses at any level</td>
<td>65%</td>
<td>3</td>
</tr>
<tr>
<td>Bioinformatics</td>
<td>MAV</td>
<td>Same as Computer Science plans (below)</td>
<td>60%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SMAV</td>
<td>All BIOL courses</td>
<td>60%</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, and CO 487, STAT 440, ECE 222 and 429, SE 212, 240, 382, 463, 464, and 465</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 or 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 300/400 level courses with subjects of AFM, BUS, COMM, ECON, HRM, MSCI, or MTHEL</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics/Chartered Professional Accountancy</td>
<td>SMAV</td>
<td>All AFM, COMM, ECON, or 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>75%</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 AFM, ACTSC, COMM, ECON, or 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>

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### 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](http://ugradcalendar.uwaterloo.ca/printing?groupID=117) 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 courses.
- PD1 and PD2 are required courses for co-op students in all Faculties except Engineering. PD1 is required in the academic term prior to the first work term and PD2 is required during the first work term.
- With the exception of PD 1, Professional Development 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 2 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 or marginal standing 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></td>
</tr>
</tbody>
</table>

| No standing above applies, and any of the following:                        | Co-op probation |
| - The student is on academic probation or marginal standing 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 | Excellent co-op standing |

| No standing above applies                                                   | Good co-op standing   |

The following table explains the consequences of the standings above:
**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.

**Co-op Standing**

<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 his/her academic standing will be placed in Good co-op standing if he/she returns 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>

**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 3.0 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 an honours degree.
- If a student has courses with INC (incomplete course work) grades on his/her 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.
- In the term after a student's first 1A term in the Faculty of Mathematics, the following rules apply:
  - Each failed course will reduce his/her course load by 0.5 units.
  - Each INC beyond the first will reduce the maximum course load by an additional 0.5 units.
  - No student’s maximum course load will be restricted in this way to less than 1.0 units. In that case, the student’s academic advisor may permit the student to enrol in 1.5 units.
  - Any student with a CAV less than 60% will have a maximum course load of 2.0 units.
  - If more than one of the preceding rules apply to a student, then the maximum course load is the minimum of those specified.
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, he/she:

   - satisfies all degree requirements other than the failure or attempt limit
   - has credit for at least 1.5 units in the additional term, and
   - has 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 his/her courses without academic penalty until the last official day of lectures for his/her first term. These courses will continue to appear on the student’s academic record with a grade of WD. 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 re-admission.

For example, a student whose last term of enrolment was spring 2010 would not need to apply for readmission if he or she returned to study in winter 2012 or earlier. However, if this student remained inactive until spring 2012 or later, then he or she would need to apply for readmission.

Application for readmission must include a resume covering the inactive period, including 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
- CS 499T is the only course in the Faculty of Mathematics for which numerical grades are not assigned.
- A grade of INC will automatically convert to an FTC after eight months, unless a later deadline is specified by the instructor.
- 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. 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.

**No-credit/Overlap courses:**
Some courses at the University may not be taken for credit towards a degree offered by the Faculty of Mathematics. These courses are identified on the [Course No-Credit List](#).

Other groups of courses cover similar material, and no more than one in any such group may count for credit towards a degree offered by the Faculty. These groups are listed on the [Course Overlap List](#).

It is the student’s responsibility to be aware of the contents of these lists.

**Policy for late switches from advanced section MATH courses to regular section equivalents:**
At any time before the end of the “Drop, Penalty 1” period, students may switch from an advanced section MATH course to the equivalent course at the regular honours level:

<table>
<thead>
<tr>
<th>Advanced Section</th>
<th>Regular Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 145</td>
<td>MATH 135</td>
</tr>
<tr>
<td>MATH 146</td>
<td>MATH 136</td>
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<tr>
<td>MATH 147</td>
<td>MATH 137</td>
</tr>
<tr>
<td>MATH 148</td>
<td>MATH 138</td>
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<tr>
<td>MATH 245</td>
<td>MATH 235</td>
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<tr>
<td>MATH 247</td>
<td>MATH 237</td>
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<tr>
<td>MATH 249</td>
<td>MATH 239</td>
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<tr>
<td>STAT 240</td>
<td>STAT 230</td>
</tr>
<tr>
<td>STAT 241</td>
<td>STAT 231</td>
</tr>
</tbody>
</table>

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 he/she 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.

**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.