

# Mathematics and Statistics

A Co-operative Education Option is available for Honours programs in the B.Math. degree. Consult the Co-operative Education (<http://www.carleton.ca/calendars/2012-13/undergrad/regulations/co-operativeeducation>) section of this Calendar.

## Graduation Requirements

In addition to the program and academic performance evaluation requirements listed below, students must satisfy the University regulations common to all undergraduate students (see the Academic Regulations (<http://www.carleton.ca/calendars/2012-13/undergrad/regulations>) section of this Calendar).

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

## Course Prerequisites

The following courses central to B.Math. programs have grade requirements in their prerequisites:

- MATH 2000 requires C+ in MATH 1002, or B+ in (MATH 2007 or MATH 1005), and C+ in MATH 1102, or B+ in (MATH 1107 or MATH 1104).
- MATH 2100 requires C+ in MATH 1102, or B+ in MATH 2107.
- MATH 2454 requires C+ in (MATH 1002 or MATH 2007), and C+ in (MATH 1102 or MATH 2107).
- STAT 2655 requires C+ in (MATH 1002 or MATH 2007 or MATH 1005), and C+ in (MATH 1102 or MATH 1107 or MATH 1104).
- MATH 2007 requires MATH 1004 or C- in (MATH 1007 or MATH 1009).
- MATH 2107 requires MATH 1104 or C- in MATH 1107

## Course Categories for B.Math. Programs

The following categories of courses are used in the specification of the programs.

### 2000-level Honours Sequence

The following courses constitute the 2000-level Honours Sequence:

MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)
MATH 2100 [1.0]	Algebra II (Honours)
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
MATH 2907 [0.5]	Directed Studies (Honours)

### 3000-level Honours Sequence

The following courses constitute the 3000-level Honours Sequence:

MATH 3001 [0.5]	Real Analysis (Honours)
MATH 3002 [0.5]	Calculus of Differential Equations and Geometry (Honours)
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)
MATH 3106 [0.5]	Introduction to Group Theory (Honours)
MATH 3158 [0.5]	Rings and Fields (Honours)
MATH 3306 [0.5]	Elements of Set Theory (Honours)
MATH 3355 [0.5]	Number Theory and Applications (Honours)
MATH 3806 [0.5]	Numerical Analysis (Honours)
MATH 3807 [0.5]	Mathematical Software (Honours)
MATH 3855 [0.5]	Discrete Structures and Applications (Honours)
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)
STAT 3553 [0.5]	Regression Modeling (Honours)
STAT 3558 [0.5]	Elements of Probability Theory (Honours)
STAT 3559 [0.5]	Mathematical Statistics (Honours)

### Natural Science Electives

All courses with subject codes:

BIOC, BIOL, CHEM, ENSC, EARTH, ISCI, NSCI, PHYS

### Approved Arts or Social Sciences Electives

All courses offered by the Faculty of Arts and Social Sciences and the Faculty of Public Affairs are acceptable as Arts or Social Sciences Electives except for the following courses, which are only accepted for credit as free electives in any program of the School. See item 3 under Prohibited and Restricted Courses below concerning Computer Mathematics programs.

### Business

BUSI 1001 [0.5]	Principles of Financial Accounting
BUSI 1002 [0.5]	Management Accounting
BUSI 1004 [0.5]	Financial Accounting for Business Students
BUSI 1005 [0.5]	Managerial Accounting for Business Students
BUSI 1402 [0.5]	Introduction to Business Information and Communication Technologies
BUSI 2001 [0.5]	Intermediate Accounting I
BUSI 2002 [0.5]	Intermediate Accounting II
BUSI 2402 [0.5]	Business Applications Development
BUSI 3001 [0.5]	Accounting for Business Combinations
BUSI 3008 [0.5]	Intermediate Management Accounting and Control

BUSI 4000 [0.5]	Accounting Theory
BUSI 4002 [0.5]	Advanced Accounting Problems

### Economics

ECON 4005 [0.5]	Operations Research II
ECON 4706 [0.5]	Econometrics I
ECON 4707 [0.5]	Econometrics II

### Geography

GEOG 3102 [0.5]	Geomorphology
GEOG 3103 [0.5]	Watershed Hydrology
GEOG 3105 [0.5]	Climate and Atmospheric Change
GEOG 3108 [0.5]	Soil Properties
GEOG 4000/ENST 4400 [0.5]	Field Studies

GEOG 4005/ENST 4005 [0.5]	Directed Studies in Geography
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GEOG 4101 [0.5]	Quaternary Geography
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GEOG 4103/ENVE 3003 [0.5]	Water Resources Engineering
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GEOG 4104 [0.5]	Microclimatology
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GEOG 4108 [0.5]	Permafrost
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### Geomatics

GEOM 2007 [0.5]	Geographic Information Systems
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GEOM 3002 [0.5]	Air Photo Interpretation and Remote Sensing
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GEOM 3005 [0.5]	Geospatial Analysis
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GEOM 3007 [0.5]	Cartographic Theory and Design
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GEOM 4003 [0.5]	Remote Sensing of the Environment
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GEOM 4008 [0.5]	Advanced Topics in Geographic Information Systems
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GEOM 4009 [0.5]	Applications in Geographic Information Systems
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### Psychology

PSYC 2200 [0.5]	Biological Foundations of Behaviour
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PSYC 2700 [0.5]	Introduction to Cognitive Psychology
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PSYC 3207 [0.5]	Human Neuropsychology
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PSYC 3506 [0.5]	Cognitive Development
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PSYC 3700 [1.0]	Cognition (Honours Seminar)
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PSYC 3702 [0.5]	Perception
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PSYC 4001 [0.5]	Special Topics in Psychology
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### Prohibited and Restricted Courses

- MATH 1805/COMP 1805 can be counted only as a half-credit free elective in Mathematics and Statistics programs.
- The following courses may not be counted for academic credit (even as free electives) in any program offered by the School of Mathematics and Statistics: ECON 2201, ECON 2202, ECON 2400, ECON 4004 Operations Research I, GEOG 2006, GEOG 3003, PSYC 2001, PSYC 2002, PSYC 3000 [1.0], SOWK 3502, SOCI 4003. Students who have completed ECON 2201 and ECON 2202 and who wish to enter a B.Math. General program may be exempted from taking STAT 2507

and STAT 2509 only with permission of the School of Mathematics and Statistics, and provided the grade in ECON 2201 and ECON 2202 is B- or higher in each.

- BUSI 1402, BUSI 2402 and COMP 1001 may not count for credit in the Computer Mathematics Honours or General program, even as free electives.
- Only one of MATH 3806, COMP 3806, CMPS 3800 or MATH 3800 may count for credit in a B.Math. program.

### Program Requirements

In B.Math. programs the following selections for first year courses are permitted substitutions:

MATH 1002 [1.0]	Calculus and Introductory Analysis I (may be replaced with both of the following)
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MATH 1007 [0.5]	Elementary Calculus I or MATH 1004 [0.5] Calculus for Engineering or Physics
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MATH 2007 [0.5]	Elementary Calculus II or MATH 1005 [0.5] Differential Equations and Infinite Series for Engineering or Physics
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MATH 1102 [1.0]	Algebra I (may be replaced with both of the following)
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MATH 1107 [0.5]	Linear Algebra I or MATH 1104 [0.5] Linear Algebra for Engineering or Science
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MATH 2107 [0.5]	Linear Algebra II
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A higher standard must be achieved in the following courses if these are used to fulfill the requirements of the program. See *Academic Performance Evaluation*, Item 2.

MATH 1004 [0.5]	Calculus for Engineering or Physics
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MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics
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MATH 1007 [0.5]	Elementary Calculus I
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MATH 1104 [0.5]	Linear Algebra for Engineering or Science
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MATH 1107 [0.5]	Linear Algebra I
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MATH 2007 [0.5]	Elementary Calculus II
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MATH 2107 [0.5]	Linear Algebra II
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### Mathematics

#### B.Math. Honours (20.0 credits)

UBMT

#### A. Credits Included in the Major CGPA (11.0 credits)

**1. 2.0 credits in:** 2.0

MATH 1002 [1.0]	Calculus and Introductory Analysis I
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MATH 1102 [1.0]	Algebra I
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**2. 3.5 credits in:** 3.5

MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)
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MATH 2100 [1.0]	Algebra II (Honours)
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MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
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STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)
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STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
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**3. 2.0 credits in:** 2.0

MATH 3001 [0.5]	Real Analysis (Honours)	
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)	
MATH 3106 [0.5]	Introduction to Group Theory (Honours)	
MATH 3158 [0.5]	Rings and Fields (Honours)	
4. .05 credit from:		0.5
MATH 3002 [0.5]	Calculus of Differential Equations three hours a week and one hour tutorial. Forms and Geometry (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
5. 1.0 credit from	3000-level Honours Sequence	1.0
6. 1.5 credits in	MATH or STAT at the 4000-level or higher	1.5
7. 0.5 credit in:		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
<b>B. Credits Not Included in the Major CGPA (9.0 credits)</b>		
8. 4.0 credits not in	MATH, STAT or COMP, consisting of:	4.0
a.	1.0 credit in Natural Science Electives	
b.	2.0 credits in Approved Arts or Social Sciences	
c.	1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences	
9. 5.0 credits in	free electives	5.0
Total Credits		20.0

### Mathematics with Specialization in Stochastics B.Math. Honours (20.0 credits)

5B

Items 3, 4, 5 and 6 in the Mathematics degree requirements are replaced by:

3. 3.0 credits in:		3.0
MATH 3001 [0.5]	Real Analysis (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
STAT 4501 [0.5]	Probability Theory (Honours)	
4. 0.5 credit from:		0.5
STAT 3553 [0.5]	Regression Modeling (Honours)	
MATH 3801 [0.5]	Linear Programming	
5. 0.5 credit in	STAT at the 4000-level	0.5
6. 1.0 credit in	MATH or STAT at the 4000-level or higher	1.0
Total Credits		5.0

### Computational and Applied Mathematics and Statistics

#### B.Math. Honours (20.0 credits)

9N

##### A. Credits included in the Major CGPA (13.5 credits)

1. 7.5 credits in:		7.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	

MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0]	Algebra II (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
2. 1.5 credits in:		1.5
MATH 3804 [0.5]	Design and Analysis of Algorithms I	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
3. 0.5 credits from:		0.5
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	
4. 1.0 credit from:		1.0
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
& MATH 3855 [0.5]	and Discrete Structures and Applications (Honours)	
or		
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
and one of		
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	
5. 0.5 credit in:		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
6. 1.5 credits from:		1.5
MATH 4109 [0.5]	Fields and Coding Theory (Honours)	
MATH 4700 [0.5]	Partial Differential Equations (Honours)	
MATH 4703 [0.5]	Dynamical Systems (Honours)	
MATH 4801 [0.5]	Topics in Combinatorics (Honours)	
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)	
MATH 4803 [0.5]	Computable Functions (Honours)	
MATH 4805 [0.5]	Theory of Automata (Honours)	
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)	
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)	
MATH 4809 [0.5]	Mathematical Cryptography (Honours)	
MATH 4811 [0.5]	Combinatorial Design Theory (Honours)	
STAT 4500 [0.5]	Parametric Estimation (Honours)	
STAT 4501 [0.5]	Probability Theory (Honours)	
STAT 4502 [0.5]	Survey Sampling (Honours)	

STAT 4503 [0.5]	Applied Multivariate Analysis (Honours)	
STAT 4504 [0.5]	Statistical Design and Analysis of Experiments (Honours)	
STAT 4507 [0.5]	Statistical Inference (Honours)	
STAT 4508 [0.5]	Stochastic Models (Honours)	
STAT 4509 [0.5]	Advanced Mathematical Modeling (Honours)	
STAT 4555 [0.5]	Monte Carlo Simulation (Honours)	
STAT 4601 [0.5]	Data Mining I (Honours)	
STAT 4603 [0.5]	Time Series and Forecasting (Honours)	
STAT 4604 [0.5]	Statistical Computing (Honours)	
<b>7. 1.0 credit in MATH or STAT at the 3000-level or above</b>		<b>1.0</b>
<b>B. Credits Not Included in the Major CGPA (6.5 credits)</b>		
<b>8. 1.0 credit in Natural Sciences (1000-level or above)</b>		<b>1.0</b>
<b>9. 2.0 credits in Approved Arts or Social Science Electives</b>		<b>2.0</b>
<b>10. 1.0 credit at the 2000-level or above in Natural Sciences or Approved Arts or Social Sciences</b>		<b>1.0</b>
<b>11. 2.5 credits in free electives</b>		<b>2.5</b>
<b>Total Credits</b>		<b>20.0</b>

## Statistics

### B.Math. Honours (20.0 credits)

90

#### A. Credits Included in the Major CGPA (12.0 credits)

<b>1. 2.0 credits in:</b>		<b>2.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
<b>2. 1.0 credit in:</b>		<b>1.0</b>
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	
<b>3. 6.0 credits in:</b>		<b>6.0</b>
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
STAT 4500 [0.5]	Parametric Estimation (Honours)	
MATH 4905 [0.5]	Honours Project (Honours)	
<b>4. 1.0 credit from:</b>		<b>1.0</b>
MATH 2100 [1.0]	Algebra II (Honours)	
or		
MATH 3107 [0.5]	Linear Algebra III	
and 0.5 credit from:		
3000-level Honours Sequence:		
MATH 3705 [0.5]	Mathematical Methods I	

MATH 3801 [0.5]	Linear Programming	
MATH 3807 [0.5]	Mathematical Software (Honours)	
MATH 3809 [0.5]	Introduction to Number Theory and Cryptography	
Mathematics or Statistics at the 4000-level or higher		
<b>5. 0.5 credit from the 3000-level Honours Sequence or MATH or STAT at the 4000-level or higher</b>		<b>0.5</b>
<b>6. 1.5 credits in STAT at the 4000-level</b>		<b>1.5</b>
<b>B. Credits Not Included in the Major CGPA (8.0 credits)</b>		
<b>7. 4.0 credits not in MATH, STAT or COMP, consisting of:</b>		<b>4.0</b>
a. 1.0 credit in Natural Science Electives		
b. 2.0 credits in Approved Arts or Social Sciences		
c. 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences		
<b>8. 4.0 credits in free electives</b>		<b>4.0</b>
<b>Total Credits</b>		<b>20.0</b>

## Mathematics

### B.Math. General (15.0 credits)

UBMT

#### A. Credits Included in the Major CGPA (7.0 credits)

<b>1. 2.0 credits in:</b>		<b>2.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
<b>2. 2.0 credits in:</b>		<b>2.0</b>
MATH 2008 [0.5]	Intermediate Calculus	
MATH 2108 [0.5]	Abstract Algebra I	
MATH 2404 [0.5]	Ordinary Differential Equations I	
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
<b>3. 3.0 credits from:</b>		<b>3.0</b>
STAT 2509 [0.5]	Introduction to Statistical Modeling II	
MATH or STAT at the 3000-level or higher		
<b>Excluding:</b>		
MATH 3101 [0.5]	Algebraic Structures with Computer Applications	
STAT 3502 [0.5]	Probability and Statistics	
<b>B. Credits Not Included in the Major CGPA (8.0 credits)</b>		
<b>4. 4.0 credits not in MATH, STAT or COMP, consisting of:</b>		<b>4.0</b>
a. 1.0 credit in Natural Science Electives		
b. 2.0 credits in Approved Arts or Social Sciences		
c. 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences		
<b>5. 4.0 credits in free electives</b>		<b>4.0</b>
<b>Total Credits</b>		<b>15.0</b>

## Computer Mathematics

### B.Math. General (15.0 credits)

91

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

<b>1. 2.0 credits in:</b>		<b>2.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
<b>2. 2.5 credits in:</b>		<b>2.5</b>
COMP 1005 [0.5]	Introduction to Computer Science I	



COMP 1006 [0.5]	Introduction to Computer Science II	
COMP 2001 [0.5]	Introduction to Systems Programming	
COMP 2002 [0.5]	Abstract Data Types and Algorithms	
COMP 2004 [0.5]	Introduction to Software Engineering	
<b>3. 2.5 credits in:</b>		<b>2.5</b>
MATH 2008 [0.5]	Intermediate Calculus	
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
STAT 2605 [0.5]	Probability Models	
MATH 3804 [0.5]	Design and Analysis of Algorithms I	
MATH 3825 [0.5]	Discrete Structures and Applications	
<b>4. 0.5 credit from:</b>		<b>0.5</b>
MATH 2108 [0.5]	Abstract Algebra I	
MATH 3101 [0.5]	Algebraic Structures with Computer Applications	
<b>5. 1.0 credit from:</b>		<b>1.0</b>
MATH 3801 [0.5]	Linear Programming	
MATH 3802 [0.5]	Combinatorial Optimization	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
MATH 3807 [0.5]	Mathematical Software (Honours)	
MATH 3809 [0.5]	Introduction to Number Theory and Cryptography	
<b>6. 1.0 credit in MATH or STAT at the 3000-level excluding</b>		<b>1.0</b>
STAT 3502 [0.5]	Probability and Statistics	
<b>7. 0.5 credit in MATH or STAT at the 2000-level or higher</b>		<b>0.5</b>
<b>B. Credits Not Included in the Major CGPA (5.0 credits)</b>		
<b>8. 4.0 credits not in MATH, STAT or COMP, consisting of:</b>		<b>4.0</b>
a. 1.0 credit in Natural Science Electives		
b. 2.0 credits in Approved Arts or Social Sciences		
c. 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences		
<b>9. 1.0 credit in free electives</b>		<b>1.0</b>
<b>Total Credits</b>		<b>15.0</b>

## Statistics

### B.Math. General (15.0 credits)

90

#### A. Credits Included in the Major CGPA (7.0 credits)

<b>1. 2.0 credits in:</b>		<b>2.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
<b>2. 4.0 credits in:</b>		<b>4.0</b>
MATH 2008 [0.5]	Intermediate Calculus	
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
STAT 2509 [0.5]	Introduction to Statistical Modeling II	
STAT 3503 [0.5]	Regression Analysis	
STAT 3504 [0.5]	Analysis of Variance and Experimental Design	
STAT 3507 [0.5]	Sampling Methodology	
STAT 3508 [0.5]	Elements of Probability Theory	
STAT 3509 [0.5]	Mathematical Statistics	
<b>3. 0.5 credit from:</b>		<b>0.5</b>

COMP 1005 [0.5]	Introduction to Computer Science I	
BUSI 1402 [0.5]	Introduction to Business Information and Communication Technologies	
ECOR 1606 [0.5]	Problem Solving and Computers	
<b>4. 0.5 credit in 2000-level MATH or STAT</b>		<b>0.5</b>
<b>B. Credits Not Included in the Major CGPA (8.0 credits)</b>		
<b>5. 4.0 credits not in MATH, STAT or COMP, consisting of:</b>		<b>4.0</b>
a. 1.0 credit in Natural Science Electives		
b. 2.0 credits in Approved Arts or Social Sciences		
c. 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences		
<b>6. 4.0 credits in free electives</b>		<b>4.0</b>
<b>Total Credits</b>		<b>15.0</b>

## Computer Science and Mathematics

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

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

#### A. Credits Included in the Major CGPA (15.0 credits)

<b>1. 4.0 credits in:</b>		<b>4.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0]	Algebra II (Honours)	
<b>2. 5.5 credits in:</b>		<b>5.5</b>
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
COMP 3805 [0.5]	Discrete Structures and Applications (Honours)	
<b>3. 0.5 credit from:</b>		<b>0.5</b>
MATH 4905 [0.5]	Honours Project (Honours)	
COMP 4905 [0.5]	Honours Project	
<b>and for the concentration in Computing Theory and Numerical Methods</b>		
<b>4. 2.5 credits in:</b>		<b>2.5</b>
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
MATH 3801 [0.5]	Linear Programming	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
COMP 4804 [0.5]	Design and Analysis of Algorithms II	

<b>5. 0.5 credit from:</b>	0.5
MATH 3001 [0.5]	Real Analysis (Honours)
MATH 3002 [0.5]	Calculus of Differential Flectures three hours a week and one hour tutorial.orns and Geometry (Honours)
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)

<b>6. 1.0 credit from:</b>	1.0
MATH 4801 [0.5]	Topics in Combinatorics (Honours)
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)
MATH 4803 [0.5]	Computable Functions (Honours)
MATH 4805 [0.5]	Theory of Automata (Honours)
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)

**7. 1.0 credit in Computer Science at the 3000-level or higher** 1.0

**and for the concentration in Statistics and Computing**

**4. 2.5 credits in:**

MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
STAT 3558 [0.5]	Elements of Probability Theory (Honours)
STAT 3559 [0.5]	Mathematical Statistics (Honours)

**5. 0.5 credit from:**

STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)
STAT 3553 [0.5]	Regression Modeling (Honours)

**6. 1.0 credit in STAT at the 4000-level**

**7. 1.0 credit in COMP at the 4000-level**

**B. Credits Not Included in the Major CGPA (5.0 credits)**

**8. 4.0 credits not in MATH, STAT or COMP, consisting of:** 4.0

- 1.0 credit in Natural Science Electives
- 2.0 credits in Approved Arts or Social Sciences or Business
- 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences

**9. 1.0 credit in free electives** 1.0

Total Credits 20.0

**Note:**

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

**Business**

BUSI 2400 [0.5]	Foundations of Information Systems
BUSI 4400 [0.5]	IS Strategy, Management and Acquisition
BUSI 4402 [0.5]	Information Systems Practicum

BUSI 4406 [0.5]	Decision Making and Support Systems
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**Engineering**

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

**Mathematics and Physics**

**B.Sc. Double Honours (21.5 credits)**

67

Note that the following courses have minimum grade requirements in their prerequisites. Refer to the section Course Prerequisites in the Mathematics and Statistics programs section of the calendar.

MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)
MATH 2100 [1.0]	Algebra II (Honours)
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)

**Requirements:**

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

**1. 7.0 credits in:** 7.0

MATH 1002 [1.0]	Calculus and Introductory Analysis I
MATH 1102 [1.0]	Algebra I
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)
MATH 2100 [1.0]	Algebra II (Honours)
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
MATH 3705 [0.5]	Mathematical Methods I
MATH 3001 [0.5]	Real Analysis (Honours)
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)
MATH 3106 [0.5]	Introduction to Group Theory (Honours)

**2. 0.5 credit from:** 0.5

MATH 3002 [0.5]	Calculus of Differential Flectures three hours a week and one hour tutorial.orns and Geometry (Honours)
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)

**3. 1.0 credit in Mathematics (MATH, STAT) at the 4000-level or higher** 1.0

**4. 1.0 credit from:** 1.0

PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion

PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher over PHYS 1007 & PHYS 1008)	
<b>5. 1.5 credits in:</b>		1.5
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2604 [0.5]	Modern Physics I	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
<b>6. 3.5 credits in:</b>		3.5
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	
PHYS 4708 [0.5]	Introduction to Quantum Mechanics II	
<b>7. 1.0 credit in PHYS at the 4000-level or higher</b>		1.0
<b>8. 1.0 credit from:</b>		1.0
MATH 4905 [0.5]	Honours Project (Honours)	
PHYS 4907 [0.5]	Fourth-Year Project	
PHYS 4908 [0.5]	Fourth-Year Project	
	and 0.5 credit in math or physics at the 4000- level	
<b>or</b>		
PHYS 4909 [1.0]	Fourth-Year Project	
<b>B. Credits Not Included in the Major CGPA (5.0 credits)</b>		
<b>9. 1.0 credit from:</b>		1.0
BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II	
ERTH 1006 [0.5] & EARTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time	
<b>10. 0.5 credit in:</b>		0.5
COMP 1005 [0.5]	Introduction to Computer Science I	
<b>11. 0.5 credit in COMP</b>		0.5
<b>12. 0.5 credit in:</b>		0.5
NSCI 1000 [0.5]	Seminar in Science (or Approved Arts or Social Sciences)	
<b>13. 1.5 credits in Approved Arts or Social Sciences Electives</b>		1.5
<b>14. 1.0 credit in free electives</b>		1.0
<b>Total Credits</b>		<b>21.5</b>

**Note:** In Item 2 above, MATH 4003 is highly recommended.

## Biostatistics

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

9M

#### A. Credits Included in the Major CGPA (13.5)

<b>1. 3.5 credits in:</b>		3.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 2008 [0.5]	Intermediate Calculus	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
MATH 4905 [0.5]	Honours Project (Honours)	
<b>2. 0.5 credit from:</b>		0.5
MATH 3815 [0.5]	Mathematics for Molecular Biology	
MATH 3816 [0.5]	Mathematics for Evolutionary Biology	
<b>3. 4.5 credits in:</b>		4.5
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
STAT 3503 [0.5]	Regression Analysis	
STAT 3504 [0.5]	Analysis of Variance and Experimental Design	
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3508 [0.5]	Elements of Probability Theory	
STAT 3509 [0.5]	Mathematical Statistics	
STAT 4605 [0.5]	Statistical Methods in Biostatistics (Honours)	
STAT 4606 [0.5]	Practices in Biostatistics (Honours)	
<b>4. 4.0 credits in:</b>		4.0
BIOL 1103 [0.5]	Foundations of Biology I	
BIOL 1104 [0.5]	Foundations of Biology II	
BIOL 2104 [0.5]	Introductory Genetics	
BIOL 2200 [0.5]	Cellular Biochemistry	
BIOL 2600 [0.5]	Introduction to Ecology	
BIOL 3104 [0.5]	Molecular Genetics	
BIOL 3609 [0.5]	Evolutionary Concepts	
BIOL 4103 [0.5]	Population Genetics	
<b>5. 0.5 credit from:</b>		0.5
BIOC 3008 [0.5]	Bioinformatics	
BIOC 4008 [0.5]	Computational Systems Biology	
<b>6. 0.5 credit in STAT at the 4000-level</b>		0.5
<b>B. Credits Not Included in the Major CGPA (6.5 credits)</b>		
<b>7. 1.0 credit in:</b>		1.0
BIOC 3101 [0.5]	General Biochemistry I	
BIOC 3102 [0.5]	General Biochemistry II	
<b>8. 2.0 credits in:</b>		2.0
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
CHEM 2203 [0.5]	Organic Chemistry I	
CHEM 2204 [0.5]	Organic Chemistry II	
<b>9. 1.0 credit from:</b>		1.0
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	

PHYS 1007 [0.5]	Elementary University Physics I	
& PHYS 1008 [0.5]	and Elementary University Physics II	
<b>10. 1.0 credit in:</b>		1.0
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	
<b>11. 1.0 credit in</b>	Approved Arts or Social Sciences Electives	1.0
<b>12. 0.5 credit in</b>	free elective	0.5
<b>Total Credits</b>		20.0

## Economics and Mathematics

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

9B

#### A. Credits Included in the Major CGPA (15.0 credits)

<b>1. 7.0 credits in:</b>		7.0
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0]	Algebra II (Honours)	
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
MATH 3001 [0.5]	Real Analysis (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
<b>2. 0.5 credit from:</b>		0.5
MATH 3002 [0.5]	Calculus of Differential Equations three hours a week and one hour tutorial forms and Geometry (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
<b>3. 0.5 credit in:</b>		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
<b>4. 1.0 credit in</b>	MATH or STAT at the 4000-level	1.0
<b>5. 4.0 credits in:</b>		4.0
ECON 1000 [1.0]	Introduction to Economics	
ECON 2020 [0.5]	Intermediate Microeconomics I: Producers and Market Structure	
ECON 2030 [0.5]	Intermediate Microeconomics II: Consumers and General Equilibrium	
ECON 2102 [0.5]	Intermediate Macroeconomics I	
ECON 2103 [0.5]	Intermediate Macroeconomics II	
ECON 4020 [0.5]	Advanced Microeconomic Theory	
ECON 4021 [0.5]	Advanced Macroeconomic Theory	
<b>6. 2.0 credits in</b>	ECON at the 4000-level	2.0

#### B. Credits Not Included in the Major CGPA (5.0 credits)

<b>8. 1.0 credit in:</b>		1.0
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	

<b>9. 1.0 credit in</b>	Natural Science Electives	1.0
<b>10. 3.0 credits in</b>	free electives	3.0
<b>Total Credits</b>		20.0

#### Notes:

1. An Honours Essay (ECON 4908 [1.0]) with a grade of B- or higher may be written by students with Overall and Major CGPAs of 7.50 or higher to earn 1.0 credit in ECON at the 4000-level. Qualified students who choose to pursue the Honours Essay option must first complete an Honours essay prospectus to the satisfaction of both their adviser and the Department of Economics B.A. program supervisor.
2. ECON 2400 does not count for credit in this program.
3. Only one of STAT 4603 and ECON 4713 can count for credit in this program.

## Economics and Statistics

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

9C

#### A. Credits Included in the Major CGPA (15.0 credits)

<b>1. 8.0 credits in:</b>		8.0
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
MATH 3107 [0.5]	Linear Algebra III	
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
STAT 4502 [0.5]	Survey Sampling (Honours)	
STAT 4503 [0.5]	Applied Multivariate Analysis (Honours)	

#### 2. 0.5 credit in:

MATH 4905 [0.5]	Honours Project (Honours)	0.5
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#### 3. 0.5 credit in STAT at the 4000-level

#### 4. 4.0 credits in:

ECON 1000 [1.0]	Introduction to Economics	
ECON 2020 [0.5]	Intermediate Microeconomics I: Producers and Market Structure	
ECON 2030 [0.5]	Intermediate Microeconomics II: Consumers and General Equilibrium	
ECON 2102 [0.5]	Intermediate Macroeconomics I	
ECON 2103 [0.5]	Intermediate Macroeconomics II	
ECON 4020 [0.5]	Advanced Microeconomic Theory	
ECON 4021 [0.5]	Advanced Macroeconomic Theory	

#### 5. 2.0 credits in ECON at the 4000-level

#### B. Credits Not Included in the Major CGPA (5.0 credits)



<b>6. 1.0 credit in:</b>	1.0
COMP 1005 [0.5] Introduction to Computer Science I	
COMP 1006 [0.5] Introduction to Computer Science II	
<b>7. 1.0 credit in Natural Science Electives</b>	1.0
<b>8. 3.0 credits in free electives</b>	3.0
<b>Total Credits</b>	<b>20.0</b>

**Notes:**

1. An Honours Essay (ECON 4908 [1.0] with a grade of B- or higher may be written by students with Overall and Major CGPAs of 7.50 or higher to earn 1.0 credit in ECON at the 4000-level. Qualified students who choose to pursue the Honours Essay option must first complete an Honours essay prospectus to the satisfaction of both their adviser and the Department of Economics B.A. program supervisor.
2. MATH 2100 [1.0] may replace MATH 3107 and 0.5 credit in free electives in this program.
3. ECON 2400 does not count for credit in this program.
4. Only one of STAT 4603 and ECON 4713 can count for credit in this program.

**Program Requirements for Combined B.Math./M.Sc.**

This "fast-track" program combines the requirements for Bachelor of Mathematics in Mathematics or Statistics, and Master of Science in Mathematics, into a sequence that will enable exceptional students to complete in four years of study.

Entry to this program directly from an Ontario High School requires both of the following:

1. an average of 90 per cent or better on Grade 12 Mathematics: Advanced Functions and Grade 12 Mathematics: Calculus and Vectors;
2. an average of 85 per cent or better over six credits in Grade 12 courses of University or University/College type.

Admission, continuation and graduation from the undergraduate portion of the program requires a Major CGPA of 11.0 or better and Overall CGPA of 10.00 or better.

Before entry into the fourth year of this program, students must: obtain a recommendation from the School of Mathematics and Statistics to continue, apply to graduate with a B.Math. General degree, by the end of January of their third year, and submit an application for graduate studies to the School by mid-February.

**Undergraduate Portion**

Students may apply for admission to either the Mathematics or the Statistics versions of the program.

**Mathematics (Combined B.Math./M.Sc.) B.Math. (15.0 credits)**

9F

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

<b>1. 7.0 credits in:</b>	7.0
MATH 1002 [1.0] Calculus and Introductory Analysis I	
MATH 1102 [1.0] Algebra I	
MATH 2000 [1.0] Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0] Algebra II (Honours)	
MATH 2454 [0.5] Ordinary Differential Equations (Honours)	
STAT 2655 [0.5] Introduction to Probability with Applications (Honours)	
MATH 3001 [0.5] Real Analysis (Honours)	
MATH 3057 [0.5] Functions of a Complex Variable (Honours)	
MATH 3106 [0.5] Introduction to Group Theory (Honours)	
MATH 3158 [0.5] Rings and Fields (Honours)	
<b>2. 0.5 credit from:</b>	0.5
MATH 3002 [0.5] Calculus of Differential Flectures three hours a week and one hour tutorial.orns and Geometry (Honours)	
MATH 3008 [0.5] Ordinary Differential Equations (Honours)	
<b>3. 0.5 credit from 3000-level Honours Sequence or MATH or STAT at the 4000-level or higher</b>	0.5
<b>4. 1.5 credits at the 4000-level or higher in MATH or STAT</b>	1.5
<b>B. Credits Not Included in the Major CGPA (5.5 credits)</b>	
<b>5. 4.0 credits not in MATH, STAT or COMP, consisting of:</b>	4.0
a. 1.0 credit in Natural Science Electives	
b. 2.0 credits in Approved Arts or Social Sciences	
c. 1.0 credit at the 2000-level or higher, in Natural Science Electives or in Approved Arts and Social Sciences	
<b>6. 1.5 credits in free electives</b>	1.5
<b>Total Credits</b>	<b>15.0</b>

Students wishing to specialize in Stochastics may, with the permission of the School, replace **Credits Included in the Major CGPA** of the Mathematics version by:

<b>1. 5.5 credits in:</b>	5.5
MATH 1002 [1.0] Calculus and Introductory Analysis I	
MATH 1102 [1.0] Algebra I	
MATH 2000 [1.0] Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0] Algebra II (Honours)	
MATH 2454 [0.5] Ordinary Differential Equations (Honours)	
STAT 2559 [0.5] Basics of Statistical Modeling (Honours)	
STAT 2655 [0.5] Introduction to Probability with Applications (Honours)	
<b>2. 2.0 credits in:</b>	2.0
MATH 3001 [0.5] Real Analysis (Honours)	

STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
<b>3. 0.5 credit from:</b>		<b>0.5</b>
MATH 3002 [0.5]	Calculus of Differential Equations three hours a week and one hour tutorial forms and Geometry (Honours)	
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
<b>4. 1.5 credits at the 4000-level or higher in MATH or STAT</b>		<b>1.5</b>
<b>Total Credits</b>		<b>9.5</b>

### Statistics (Combined B.Math./M.Sc.) B.Math. (15.0 credits)

9G

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

<b>1. 8.0 credits in:</b>		<b>8.0</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0]	Algebra II (Honours)	
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
MATH 3001 [0.5]	Real Analysis (Honours)	
STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
STAT 3553 [0.5]	Regression Modeling (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
<b>2. 1.5 credits at the 4000-level or higher in Mathematics or Statistics</b>		<b>1.5</b>

#### B. Credits Not Included in the Major CGPA (5.5 credits)

<b>3. 4.0 credits not in MATH, STAT, or COMP consisting of:</b>		<b>4.0</b>
a. 1.0 credit in Natural Science Electives		
b. 2.0 credits in Approved Arts or Social Sciences		
c. 1.0 credit at the 2000-level or higher in Natural Science Electives or in Approved Arts and Social Sciences		
<b>4. 1.5 credits in free electives</b>		<b>1.5</b>
<b>Total Credits</b>		<b>15.0</b>

### Graduate Portion - M.Sc.

During the graduate portion of the "fast-track" program, the student is registered as a graduate student and is covered by the regulations of the Faculty of Graduate Studies.

<b>5. 1.5 credits at the 5000-level or higher in MATH or STAT</b>	<b>1.5</b>
<b>6. 1.0 credit at the 5000-level or higher in mathematics or statistics or from another department or school</b>	<b>1.0</b>

7. Either:	2.0
MATH 4905 and 1.5 credits in MATH or STAT at the 5000-level or higher	
1.5 credits in MATH or STAT at the 5000-level or higher	
or	
an M.Sc. thesis in Mathematics	

<b>Total Credits</b>	<b>4.5</b>
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### Minors

#### Minor in Mathematics (4.0 credits)

MD

This minor is open to students in all undergraduate programs except programs of the School of Mathematics and Statistics.

#### Requirements

<b>1. 1.0 credit from:</b>		<b>1.0</b>
MATH 1007 [0.5] & MATH 2007 [0.5]	Elementary Calculus I and Elementary Calculus II	
MATH 1004 [0.5] & MATH 1005 [0.5]	Calculus for Engineering or Physics and Differential Equations and Infinite Series for Engineering or Physics	
<b>or</b>		
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
<b>2. 1.0 credit from:</b>		<b>1.0</b>
MATH 1107 [0.5] or MATH 1107 [0.5]	Linear Algebra I	
MATH 2107 [0.5]	Linear Algebra II	
<b>or</b>		
MATH 1102 [1.0]	Algebra I	
<b>3. 1.0 credit in MATH at the 2000-level or higher</b>		<b>1.0</b>
<b>4. 1.0 credit in MATH at the 3000-level or higher</b>		<b>1.0</b>
<b>5. The remaining requirements of the major discipline(s) and degree must be satisfied.</b>		
<b>Total Credits</b>		<b>4.0</b>

#### Minor in Statistics (4.0 credits)

ME

This minor is open to students in all undergraduate programs except programs of the School of Mathematics and Statistics.

#### Requirements

<b>1. 0.5 credit from:</b>		<b>0.5</b>
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1007 [0.5]	Elementary Calculus I	
MATH 1009 [0.5]	Calculus: with Applications to Business	
<b>2. 0.5 credit from:</b>		<b>0.5</b>
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 1107 [0.5]	Linear Algebra I	
MATH 1119 [0.5]	Linear Algebra: with Applications to Business	
<b>3. 1.0 credit from:</b>		<b>1.0</b>
STAT 2507 [0.5] & STAT 2509 [0.5]	Introduction to Statistical Modeling I and Introduction to Statistical Modeling II	

STAT 3502 [0.5] & STAT 2509 [0.5]	Probability and Statistics and Introduction to Statistical Modeling II	
STAT 2606 [0.5] & STAT 2607 [0.5]	Business Statistics I and Business Statistics II	
<b>or</b>		
ECON 2201 [0.5] & ECON 2202 [0.5]	Statistical Methods in Economics and Business I and Statistical Methods in Economics and Business II	
<b>4. 1.5 credits in:</b>		<b>1.5</b>
STAT 3503 [0.5]	Regression Analysis	
STAT 3504 [0.5]	Analysis of Variance and Experimental Design	
STAT 3507 [0.5]	Sampling Methodology	
<b>5. 0.5 credit from:</b>		<b>0.5</b>
COMP 1005 [0.5]	Introduction to Computer Science I	
BUSI 1402 [0.5]	Introduction to Business Information and Communication Technologies (Business students only)	
ECOR 1606 [0.5]	Problem Solving and Computers (Engineering students only)	
6. The remaining requirements of the major discipline(s) and degree must be satisfied.		
Total Credits		<b>4.0</b>

**Notes:**

- Item 1 above may be satisfied by credit in MATH 1002. Item 2 may be satisfied by credit in MATH 1102.
- With approval an alternate introductory statistics course may be used to satisfy Item 3 above.

**Mathematics (MATH) Courses**

**Mathematics & Statistics**

**Faculty of Science**

**MATH 0005 [0.5 credit]**

**Precalculus: Functions and Graphs**

Review of algebraic manipulations. Polynomials: the remainder theorem, and the factor theorem; graphing. Real and Complex roots. Absolute values. Inequalities. Functions, including composition of functions, and Inverse functions. Logarithmic and exponential functions. Not available for degree credit for students who have successfully completed: Grade 12 Mathematics - Advanced Functions, or an equivalent High School functions course.

Prerequisite(s): Grade 11 Functions (University/College Preparation), or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 0006 [0.5 credit]**

**Precalculus: Trigonometric Functions and Complex Numbers**

Angles and the unit circle, radian measure. Definitions of trigonometric functions. Fundamental relations, Law of Sines and Cosines. Analytic trigonometry, graphs, inverse functions.

Trigonometric identities and equations. Applications in science and engineering. Complex numbers in polar form, de Moivre's Theorem, n-th roots of complex numbers.

Prerequisite(s): Grade 11 Functions (University/College Preparation), or MATH 0005, or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 0107 [0.5 credit]**

**Algebra and Geometry**

Vectors in the plane and in 3-space. Linear combinations and linear independence. Equations of lines and planes in space. Solution of systems of linear equations. Proofs by induction. Binomial Theorem. Logic.

Prerequisite(s): Grade 11 Functions (University/College Preparation) or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 1002 [1.0 credit]**

**Calculus and Introductory Analysis I**

Elementary functions. Limits. Continuity. Differentiation.

L'Hôpital's rules. Indefinite and definite integrals. Improper integrals. Sequences and series, Taylor's formulae.

Introduction to differential equations. Proofs and theory will be emphasized in this course.

Strongly recommended for students intending to specialize in mathematics, statistics, physics, or related areas.

Precludes additional credit for MATH 1004, MATH 1005, MATH 1007, MATH 1009, and MATH 2007.

Prerequisite(s): Grade 12 Mathematics: Advanced Functions, and Grade 12 Mathematics: Calculus and Vectors, with grades of at least 75% in each; or MATH 0005 and MATH 0006 with grades of B/better in each; or equivalents; or permission of the School of Mathematics and Statistics.

Lectures three hours a week, tutorial one hour a week.

**MATH 1004 [0.5 credit]**

**Calculus for Engineering or Physics**

Limits. Differentiation of the elementary functions.

Rules of differentiation. Inverse trigonometric functions.

Applications of differentiation: max-min problems, curve sketching, approximations. Definite and indefinite integrals, techniques of integration. Applications: area, volume, centre of mass, moment of inertia.

Restricted to students in the Faculty of Engineering, or in B.Sc. programs of the Department of Physics (except Double Honours Mathematics and Physics).

Precludes additional credit for MATH 1002, MATH 1007, MATH 1009. BIT 1000, BIT 1100

Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005 and MATH 0006, or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 1005 [0.5 credit]****Differential Equations and Infinite Series for Engineering or Physics**

First-order differential equations. Second-order linear equations with constant coefficients, undetermined coefficients, variation of parameters. Systems of equations. Sequences and series, convergence tests, estimation of sums. Power series, Taylor series, remainders. Fourier series.

Restricted to students in the Faculty of Engineering, or in B.Sc. programs of the Department of Physics (except Double Honours Mathematics and Physics).

Precludes additional credit for MATH 1002, MATH 2007, and MATH 2404.

Prerequisite(s): i) MATH 1004; and ii) MATH 1104 (or MATH 1107), either previously or concurrently; or equivalents; or permission of the School. .

Lectures three hours a week, tutorial one hour a week.

**MATH 1007 [0.5 credit]****Elementary Calculus I**

Limits. Differentiation of the elementary functions, including trigonometric functions. Rules of differentiation. Applications of differentiation: max-min problems, curve sketching, approximations. Introduction to integration: definite and indefinite integrals, areas under curves, fundamental theorem of calculus.

Precludes additional credit for BIT 1000, BIT 1100, MATH 1002, MATH 1004, MATH 1009.

Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions; or MATH 0005 and MATH 0006; or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 1009 [0.5 credit]****Calculus: with Applications to Business**

Applications of mathematics to business. Limits. Differentiation of the elementary functions. Rules of differentiation. Max-min problems, curve sketching. Functions of several variables, partial differentiation, constrained max-min. Definite and indefinite integrals.

This course is not acceptable for (substitute) credit in any of the following degree programs: B.Math., and also B.Sc., B.C.S., B.Eng., B.I.D.

Precludes additional credit for MATH 1002, MATH 1004, MATH 1007, MATH 1401/ECON 1401, MATH 1402/ECON 1402, BIT 1000, BIT 1100.

Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005, or equivalent.

Lectures three hours a week, tutorial one hour a week.

**MATH 1102 [1.0 credit]****Algebra I**

Properties of numbers, modular arithmetic, mathematical induction, equivalence relations. Vector spaces, matrix algebra, linear dependence, bases, linear transformations, bilinear and quadratic forms, inner products, eigenvalues, diagonalization. Proofs and theory will be emphasized in this course.

Strongly recommended for students intending to specialize in mathematics, statistics, physics, or related areas. Note: MATH 1119 is not an acceptable substitute for half of MATH 1102.

Precludes additional credit for MATH 1104, MATH 1107, MATH 1119, MATH 2107.

Prerequisite(s): Grade 12 Mathematics: Advanced Functions, and Grade 12 Mathematics: Calculus and Vectors, with grades of at least 75% in each; or MATH 0005, MATH 0006, and MATH 0107 with grades of at least B in each; or equivalents; or permission of the School of Mathematics and Statistics.

Lectures three hours a week, tutorial one hour a week.

**MATH 1104 [0.5 credit]****Linear Algebra for Engineering or Science**

Systems of linear equations. Matrix algebra. Determinants. Complex numbers. Eigenvalues. Diagonalization and applications.

Note: MATH 1119 is not an acceptable substitute for MATH 1104.

Precludes additional credit for BIT 1001, BIT 1101, MATH 1102, MATH 1107, MATH 1119.

Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005, or equivalent, or permission of the School. Restricted to students in the Faculty of Engineering, in B.Sc. programs of the Department of Physics (except Double Honours Mathematics and Physics), or in the School of Computer Science. .

Lectures three hours a week and tutorial one hour a week.

**MATH 1107 [0.5 credit]****Linear Algebra I**

Systems of linear equations; vector space of n-tuples, subspaces and bases; matrix transformations, kernel, range; matrix algebra and determinants. Dot product. Complex numbers (including de Moivre's Theorem, and n-th roots). Eigenvalues, diagonalization and applications.

Note: MATH 1119 is not an acceptable substitute for MATH 1107.

Precludes additional credit for BIT 1001, BIT 1101, MATH 1102, MATH 1104 and MATH 1119.

Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005, or equivalent, or permission of the School.

Lectures three hours a week and tutorial one hour a week.

**MATH 1119 [0.5 credit]****Linear Algebra: with Applications to Business**

Introduction to systems of linear equations, geometric interpretation in two and three dimensions, introduction to matrices, vector addition and scalar multiplication, linear dependence, matrix operations, rank, inversion, invertible matrix theorem, determinants. Use of illustrative examples related to business.

This course is not acceptable for (substitute) credit in any of the following degree programs: B.Math., and also B.Sc., B.C.S., B.Eng., B.I.D.

Precludes additional credit for, but is not an acceptable substitute for: MATH 1102, MATH 1104, MATH 1107.

Precludes additional credit for MATH 1109, MATH 1401/ ECON 1401, MATH 1402/ECON 1402, BIT 1001, BIT 1101.

Prerequisite(s): Ontario Grade 12 Mathematics of Data Management; or Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005, or equivalent, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 1401 [0.5 credit]****Elementary Mathematics for Economics I**

Functional relations: including functional forms and error terms. Graphing economic magnitudes: scatter diagrams, time-series graphs, and functional relationships. Applied calculus: the mechanics of differentiation and integration, elasticity, and consumer/producer surplus. Applied algebra: solving systems of linear equations and Keynesian national-income analysis. Approaches to problem solving.

This course is not acceptable for (substitute) credit in any of the following degree programs: B.Math., and also B.Sc., B.C.S., B.Eng., B.I.D.

Also listed as ECON 1401.

Precludes additional credit for MATH 1009 and MATH 1119.

Prerequisite(s): Ontario Grade 12 U Advanced Functions, or MATH 0005, or equivalent; and ECON 1000 or FYSM 1003, which may be taken concurrently with MATH 1401/ ECON 1401.

Lectures three hours a week, tutorial one hour a week.

**MATH 1402 [0.5 credit]****Elementary Mathematics for Economics II**

Calculus: including partial differentiation, definite and indefinite integrals, techniques of integration, and unconstrained optimization. Vectors and matrices: scalar multiplication, inner product, linear dependence, matrix operations, rank, invertible matrix theorem, and determinants.

Economic applications such as profit maximization, comparative statics, and the Leontief input-output model.

This course is not acceptable for (substitute) credit in any of the following degree programs: B.Math., and also B.Sc., B.C.S., B.Eng., B.I.D.

Also listed as ECON 1402.

Precludes additional credit for MATH 1009 and MATH 1119.

Prerequisite(s): ECON 1000 or FYSM 1003 with a grade of C- or higher, and ECON 1401/MATH 1401 with a grade of C- or higher.

Lectures three hours a week, tutorial one hour a week.

**MATH 1805 [0.5 credit]****Discrete Structures I**

An introduction to discrete mathematics and discrete structures. Topics include: propositional and predicate calculus, Boolean algebra, introduction to complexity of algorithms, mathematical reasoning, counting, recurrences, relations, introduction to graphs.

Also listed as COMP 1805.

Prerequisite(s): two Grade 12 university-preparation Mathematics courses; and one of: COMP 1005 or COMP 1405 or SYSC 1100 (which may be taken concurrently).

Lectures three hours a week.

**MATH 2000 [1.0 credit]****Calculus and Introductory Analysis II (Honours)**

Higher dimensional calculus, chain rule, gradient, line and multiple integrals with applications. Use of implicit and inverse function theorems. Real number axioms, limits, continuous functions, differentiability, infinite series, uniform convergence, the Riemann integral.

Precludes additional credit for MATH 2004, MATH 2008, MATH 2009 and MATH 3009.

Prerequisite(s): i) MATH 1002 with a grade of C+ or higher, or MATH 2007 with a grade of B+ or higher; and ii) MATH 1102 with a grade of C+ or higher, or MATH 1107 with a grade of B+ or higher; or permission of the School.

Lectures three hours a week and one hour tutorial.



**MATH 2004 [0.5 credit]****Multivariable Calculus for Engineering or Physics**

Fourier series; expansions for even and odd functions; half-range expansions. Surfaces in  $R^3$ . Differential calculus of functions of several variables. Extrema and Lagrange multipliers. Exact differentials. Line integrals. Double integrals; polar coordinates; applications. Triple integrals; cylindrical and spherical coordinates; applications.

Precludes additional credit for: MATH 2008, MATH 2009 and MATH 2000.

Prerequisite(s): i) MATH 1005 or MATH 2007; and ii) MATH 1104 or MATH 1107; or permission of the School; enrolment in the Faculty of Engineering, or in B.Sc. programs of the Department of Physics (except Double Honours Mathematics and Physics).

Lectures three hours a week, tutorial one hour a week.

**MATH 2007 [0.5 credit]****Elementary Calculus II**

Techniques of integration, improper integrals. Polar coordinates, parametric equations. Indeterminate forms, sequences and series, Taylor's formula and series.

Precludes additional credit for MATH 1002 and MATH 1005.

Prerequisite(s): i) MATH 1004, or a grade of C- or higher in MATH 1007; or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 2008 [0.5 credit]****Intermediate Calculus**

Partial differentiation, chain rule, gradient, line and multiple integrals with applications, transformations of multiple integrals.

Precludes additional credit for: MATH 2004, MATH 2009, and MATH 2000.

Prerequisite(s): one of MATH 1002, MATH 1005 or MATH 2007, and one of MATH 1102, MATH 1104 or MATH 1107.

Lectures three hours a week and one hour tutorial.

**MATH 2009 [0.5 credit]****Intermediate Calculus for Science Students**

Differential equations; differential calculus of functions of several variables; multiple integration; introduction to Fourier series.

Precludes additional credit for: MATH 2004, MATH 2008, and MATH 2000.

Prerequisite(s): i) MATH 2007, or MATH 1002; and ii) MATH 1107 or MATH 1104 or MATH 1102; or their equivalents, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 2100 [1.0 credit]****Algebra II (Honours)**

Introduction to group theory: permutation groups, Lagrange's theorem, normal subgroups, homomorphism theorems. Introduction to ring theory: ring of polynomials, integral domains, ideals, homomorphism theorems. Hermitian form, spectral theorem for normal operators, classical groups.

Precludes additional credit for MATH 2108 and MATH 3101.

Prerequisite(s): MATH 1102 with a grade of C+ or higher, or MATH 2107 with a grade of B+ or higher, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 2107 [0.5 credit]****Linear Algebra II**

Finite-dimensional vector spaces (over  $R$  and  $C$ ), subspaces, linear independence and bases. Linear transformations and matrices. Inner product spaces (over  $R$  and  $C$ ); Orthonormal bases. Eigenvalues and diagonalization. Bilinear and quadratic forms; principal axis theorem.

Precludes additional credit for MATH 1102.

Prerequisite(s): i) MATH 1104, or a grade of C- or higher in MATH 1107 or MATH 1109; and ii) a grade of C- or higher in MATH 1007 or equivalent; or permission of the School. Note: in item i), MATH 1119 is NOT acceptable as a substitute for MATH 1109.

Lectures three hours a week and one hour tutorial.

**MATH 2108 [0.5 credit]****Abstract Algebra I**

Sets and relations, number theory, group theory, ring theory, cardinal numbers.

Precludes additional credit for MATH 3101 and MATH 2100.

Prerequisite(s): MATH 1102 or MATH 2107.

Lectures three hours a week and one hour tutorial.

**MATH 2210 [0.5 credit]****Introduction to Geometry**

An introduction to classical geometry; Euclidean plane geometry; plane tiling; polytopes in three and four dimensions; curved surfaces; Euler characteristic.

This course is intended for a general audience, and is available to B.Math. students for credit only as a free elective.

Prerequisite(s): Grade 12 Mathematics and second-year standing.

Lectures three hours a week, tutorial one hour a week.

**MATH 2404 [0.5 credit]****Ordinary Differential Equations I**

First-order equations, linear second- and higher-order equations, linear systems, stability of second-order systems.

Precludes additional credit for MATH 1005 and MATH 2454.

Prerequisite(s): MATH 1002 and MATH 1102 (or MATH 1107 and MATH 2007).

Lectures three hours a week and one hour tutorial.

**MATH 2454 [0.5 credit]****Ordinary Differential Equations (Honours)**

Existence and uniqueness theorems. First-order equations, linear second- and higher-order equations, linear systems, stability of second-order systems. Precludes additional credit for MATH 2404. Prerequisite(s): MATH 1002 or MATH 2007 or MATH 1005 with a grade of C+ or higher, and MATH 1102 or MATH 2107 with a grade of C+ or higher. Lectures three hours a week, tutorial one hour a week.

**MATH 2800 [0.5 credit]****Discrete Mathematics and Algorithms**

An introduction to discrete mathematics and algorithms in the context of the computational sciences. Basic number theory and counting methods, algorithms for strings, trees and sequences. Applications to DNA and protein sequencing problems. Analysis and complexity of algorithms. Only one of MATH 1805/COMP 1805 or MATH 2800/CMPS 2800 may count for credit in a B.Math. program. Also listed as CMPS 2800. Prerequisite(s): COMP 1006 and at least one of MATH 1007, MATH 1107, or STAT 2507. Lectures three hours a week.

**MATH 2907 [0.5 credit]****Directed Studies (Honours)**

Available only to Honours students whose program requires a 0.5 credit not offered by the School of Mathematics and Statistics.

**MATH 3001 [0.5 credit]****Real Analysis (Honours)**

Metric spaces and their topologies, continuous maps, completeness, compactness, connectedness, introduction to Banach spaces. Prerequisite(s): MATH 2000 or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3002 [0.5 credit]****Calculus of Differential Forms and Geometry (Honours)**

Differential forms and vector fields. Line and surface integrals. The divergence theorem and Stokes' theorem. Exterior algebra. Geometry of curves and surfaces. Mean and Gaussian curvatures. Gauss-Bonnet theorem. Prerequisite(s): MATH 2000 or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3007 [0.5 credit]****Functions of a Complex Variable**

Analytic functions, contour integration, residue calculus, conformal mapping. Intended for non-engineering students. Precludes additional credit for MATH 3057 and PHYS 3807. Prerequisite(s): one of MATH 2004, MATH 2008 or MATH 2009, or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3008 [0.5 credit]****Ordinary Differential Equations (Honours)**

Analytic ordinary differential equations: series solutions of ordinary differential equations about ordinary and regular singular points. Asymptotic solutions. Sturm-Liouville theory. Bessel and Legendre functions. Fourier series. Precludes additional credit for MATH 3404 and PHYS 3808. Prerequisite(s): MATH 2000; and MATH 2454. Lectures three hours a week and one hour tutorial.

**MATH 3009 [0.5 credit]****Introductory Analysis**

The real number system, sequences and series, functions of a single real variable, derivatives, the definite integral, uniform convergence. Precludes additional credit for MATH 2000. Prerequisite(s): one of MATH 2004, MATH 2008, MATH 2009, or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3057 [0.5 credit]****Functions of a Complex Variable (Honours)**

Analytic functions, contour integration, residue calculus, conformal mapping. Precludes additional credit for MATH 3007 and PHYS 3807. Prerequisite(s): MATH 2000 or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3101 [0.5 credit]****Algebraic Structures with Computer Applications**

Introduction to algebraic structures: groups, rings, fields, lattices, and Boolean algebras; with applications of interest to students in Computer Science. This course may not be used to meet the 3000-level course requirements in any General or Honours program in Mathematics and Statistics. Precludes additional credit for MATH 2108 and MATH 2100. Prerequisite(s): MATH 2107, or permission of the School. Lectures three hours a week and one hour tutorial.

**MATH 3106 [0.5 credit]****Introduction to Group Theory (Honours)**

Homomorphism theorems; groups acting on sets; permutation groups and groups of matrices; Sylow theory for finite groups; finitely generated abelian groups; generators and relations; applications. Precludes additional credit for MATH 3108. Prerequisite(s): MATH 2100, or permission of the School. Lectures three hours a week, tutorial one hour a week.

**MATH 3107 [0.5 credit]****Linear Algebra III**

Similarity and unitary triangularization of matrices. Direct methods of solving a system of linear equations. Iterative techniques. Bounds for eigenvalues. Power method and deflation techniques of approximation. Emphasis is primarily on computational aspects.

Prerequisite(s): i) a grade of C- or higher in MATH 1102 or MATH 2107; and ii) credit in MATH 1002 or MATH 2007; or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3108 [0.5 credit]****Abstract Algebra II**

Groups and rings. Permutations. Finite symmetry groups. Polynomials, unique factorization domains. Quotient rings, ideals. Field extensions, finite fields. Polynomial equations. Geometric constructions - three famous problems: duplication of the cube, trisection of an arbitrary angle, quadrature of the circle.

Precludes additional credit for MATH 3106 and MATH 3158.

Prerequisite(s): MATH 2108, or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3158 [0.5 credit]****Rings and Fields (Honours)**

Rings; integral domains; Euclidean and principal ideal domains; polynomial rings over a field; modules over principal ideal domains and applications; fields; algebraic extensions of fields; finite fields; applications.

Precludes additional credit for MATH 3108.

Prerequisite(s): MATH 2100, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 3206 [0.5 credit]****Plane Projective Geometry**

Axioms of Desarguesian geometry, principle of duality; projectivities, perspectivities, and the fundamental theorem; collineations (homologies and elations); correlations (polarities and conics); algebraic model; projective curves; introduction to finite projective planes.

Precludes additional credit for MATH 3256.

Prerequisite(s): MATH 2100 or MATH 2108 or MATH 3101.

Lectures three hours a week and one hour tutorial.

**MATH 3210 [0.5 credit]****Euclidean and Non-Euclidean Geometry**

Euclidean isometry and similarity groups; geometry of circles; inversion; hyperbolic geometry: Poincare disk model of the hyperbolic plane.

Precludes additional credit for MATH 3205.

Prerequisite(s): MATH 2100 or MATH 2108 or MATH 3101.

Lectures three hours a week, tutorial one hour a week.

**MATH 3306 [0.5 credit]****Elements of Set Theory (Honours)**

Axioms of set theory. Development of the systems of natural numbers and the real numbers. Axiom of choice, Zorn's lemma, well-ordering. The Schröder-Bernstein theorem, cardinal numbers, ordinal numbers, transfinite induction, cardinal and ordinal arithmetics.

Prerequisite(s): MATH 2100 or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3355 [0.5 credit]****Number Theory and Applications (Honours)**

Congruences, distribution of primes, arithmetic functions, primitive roots, quadratic residues, quadratic reciprocity law, continued fractions, Diophantine equations, and applications: public key cryptography, primality testing and factoring in relation to cryptography.

Precludes additional credit for MATH 3809.

Prerequisite(s): MATH 2100, or a grade of B- or higher in MATH 2108 or MATH 3101, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 3404 [0.5 credit]****Ordinary Differential Equations II**

Series solutions of ordinary differential equations of second order about regular singular points; asymptotic solutions. Systems of ordinary differential equations of first order; matrix methods. Existence and uniqueness theorems. Nonlinear autonomous systems of order 2; qualitative theory. Numerical solutions of ordinary differential equations.

Precludes additional credit for MATH 3008.

Prerequisite(s): MATH 2404, MATH 2008; and MATH 1102 or MATH 2107.

Lectures three hours a week and one hour tutorial.

**MATH 3705 [0.5 credit]****Mathematical Methods I**

Laplace transforms, series solutions of ordinary differential equations, the Frobenius method. Fourier series and Fourier transforms, solutions of partial differential equations of mathematical physics, boundary value problems, applications.

This course may be taken for credit as a 3000-level Honours Mathematics course, by students in any Honours program in the School of Mathematics and Statistics.

Precludes additional credit for PHYS 3808.

Prerequisite(s): i) MATH 1005 or MATH 2404, and ii) MATH 2004 or MATH 2008 or MATH 2009; or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3800 [0.5 credit]****Modeling and Computational Methods for Experimental Science**

Mathematical modeling in the experimental sciences: design, analysis and pitfalls. Computational methods directly applicable to problems in science will be described, including: function evaluation, interpolation, solution of linear equations, root finding, integration, solution of differential equations, Fourier series and Monte Carlo methods.

Also listed as CMPS 3800.

Precludes additional credit for MATH 3806/COMP 3806.

Prerequisite(s): i) MATH 1107 or MATH 1104; ii) MATH 1005 or MATH 2007; and iii) knowledge of a computer language.

Lectures three hours a week.

**MATH 3801 [0.5 credit]****Linear Programming**

Formulation of linear programming problems, the simplex method, duality theory, implementations, extensions and applications. Network flow problems and the network simplex method.

Precludes additional credit for ECON 4004, SYSC 3200.

Prerequisite(s): MATH 1102 or MATH 2107, or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3802 [0.5 credit]****Combinatorial Optimization**

Dijkstra's algorithm and Bellman-Ford algorithm for the minimum weight dipath problem, the minimum weight spanning tree problem, augmenting path algorithm and preflow-push algorithm for the max-flow min-cut problem, connections to linear programming, matchings in bipartite graphs and the assignment problem, the transportation problem, and the general minimum-cost flow problem.

Prerequisite(s): MATH 3801, or permission of the School.

Lectures three hours a week, tutorial one hour a week.

**MATH 3804 [0.5 credit]****Design and Analysis of Algorithms I**

An introduction to the design and analysis of algorithms. Topics include: recurrence relations, sorting and searching, divide-and-conquer, dynamic programming, greedy algorithms, NP-completeness.

Also listed as COMP 3804.

Prerequisite(s): COMP 2002 or COMP 2402, and either COMP 1805 or both of MATH 2007 and MATH 2108 or equivalents.

Lectures three hours a week.

**MATH 3806 [0.5 credit]****Numerical Analysis (Honours)**

Elementary discussion of error, polynomial interpolation, quadrature, linear systems of equations and matrix inversion, non-linear equations, difference equations and ordinary differential equations.

Also listed as COMP 3806.

Precludes additional credit for MATH 3800.

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

Lectures three hours a week and one hour tutorial.

**MATH 3807 [0.5 credit]****Mathematical Software (Honours)**

Incorporation of basic numerical methods into efficient, reliable software. The course includes examination of existing software systems, e.g., linear systems, non-linear systems, optimization, or differential equations.

Also listed as COMP 3807.

Prerequisite(s): MATH 3806.

Lectures three hours a week and one hour tutorial.

**MATH 3808 [0.5 credit]****Mathematical Analyses of Games of Chance**

This course covers mathematics used in the modern casino gaming industry. The topics include probabilities, odds, house advantages, variance and risks, optimal strategies, random walks and gambler's ruin, and gaming revenue estimation. Examples are taken from various games such as Roulette, Blackjack, and Poker.

Prerequisite(s): one of STAT 2655, STAT 2605, STAT 2507, STAT 2606, STAT 3502, or MATH 3825 or MATH 3855.

Lectures three hours a week, tutorial one hour a week.

**MATH 3809 [0.5 credit]****Introduction to Number Theory and Cryptography**

Congruences, distribution of primes, general cryptographic systems, public key cryptographic systems and authentication using number theory, primality testing and factoring in relation to cryptography, continued fractions and Diophantine equations.

Prerequisite(s): MATH 2108 or MATH 3101 or MATH 2100; knowledge of a computer language.

Lectures three hours a week and one hour tutorial.

**MATH 3815 [0.5 credit]****Mathematics for Molecular Biology**

Linear recurrences; difference equations; graph theory and trees; heuristic and approximation algorithms; software tools; DNA sequencing methods; alignment; string similarity; genetic mapping.

Prerequisite(s): MATH 1102 (or MATH 1107); and MATH 1002 (or MATH 2007).

Lectures three hours a week.

**MATH 3816 [0.5 credit]****Mathematics for Evolutionary Biology**

Population dynamics; evolutionary trees; predator-prey models; game theory; evolutionary genetics; nonlinear dynamics and chaos; pattern formation.

Prerequisite(s): MATH 1002 (or MATH 2007); and MATH 1102 (or MATH 1107).

Lectures three hours a week.

**MATH 3819 [0.5 credit]****Modern Computer Algebra**

Algorithms for multiplication, division, greatest common divisors and factorization over the integers, finite fields and polynomial rings. Basic tools include modular arithmetic, discrete Fourier transform, Chinese remainder theorem, Newton iteration, and Hensel techniques. Some properties of finite fields and applications to cryptography.

Prerequisite(s): MATH 2108 or MATH 3101 or MATH 2100, or permission of the School.

Lectures three hours a week, tutorial/laboratory one hour a week.

**MATH 3825 [0.5 credit]****Discrete Structures and Applications**

Enumeration: elementary methods, inclusion and exclusion, recurrence relations, generating functions and applications. Graph theory and algorithms: connectivity, planarity, Hamilton paths and Euler trails. Error-correcting codes.

Precludes additional credit for MATH 3805 and MATH 3855.

Prerequisite(s): one of MATH 2108 or MATH 3101.

Lectures three hours a week, tutorial one hour a week.

**MATH 3855 [0.5 credit]****Discrete Structures and Applications (Honours)**

Enumeration: inclusion and exclusion, recurrence relations, generating functions and applications. Graph theory: connectivity, planarity, Hamilton paths and Euler trails. Error-correcting codes. Designs and finite geometries. Symmetry and counting.

Also listed as COMP 3805.

Precludes additional credit for MATH 3805 and MATH 3825.

Prerequisite(s): MATH 2100, or a grade of B or higher in MATH 2108 or MATH 3101.

Lectures three hours a week, tutorial one hour a week.

**MATH 3907 [0.5 credit]****Directed Studies**

Available only to students whose program requires a 0.5 credit not offered by the School of Mathematics and Statistics.

**MATH 3999 [0.0 credit]****Co-operative Work Term Report (Honours)**

On completion of each work term, the student must submit to the School of Mathematics and Statistics a written report on the work performed. Graded Sat or Uns.

Prerequisite(s): registration in the Co-operative Education Option of an Honours program offered by the School of Mathematics and Statistics, and permission of the School.

Four-month work term

**MATH 4002 [0.5 credit]****Fourier Analysis (Honours)**

Fourier series, Fourier integrals; introduction to harmonic analysis on locally compact abelian groups, Plancherel Theorem, Pontryagin duality; selected applications.

Prerequisite(s): MATH 3001 or permission of the School.

Lectures three hours a week.

**MATH 4003 [0.5 credit]****Functional Analysis (Honours)**

Banach spaces and bounded linear operators, Hahn-Banach extension and separation, dual spaces, bounded inverse theorems, uniform boundedness principle, applications. Compact operators.

Prerequisite(s): MATH 4007 or permission of the School.

Also offered at the graduate level, with different requirements, as MATH 5008, for which additional credit is precluded.

Lectures three hours a week.

**MATH 4007 [0.5 credit]****Measure and Integration Theory (Honours)**

Lebesgue measure and integration on the real line; sigma algebras and measures; integration theory;  $L_p$  spaces; Fubini's theorem; decomposition theorems and Radon-Nikodym derivatives.

Prerequisite(s): MATH 3001 or permission of the School.

Also offered at the graduate level, with different requirements, as MATH 5007, for which additional credit is precluded.

Lectures three hours a week.

**MATH 4102 [0.5 credit]****Group Representations and Applications (Honours)**

An introduction to the group representations and character theory, with selected applications.

Prerequisite(s): MATH 3106, or a grade of B or higher in MATH 3108.

Also offered at the graduate level, with different requirements, as MATH 5102, for which additional credit is precluded.

Lectures three hours a week.

**MATH 4105 [0.5 credit]****Rings and Modules (Honours)**

Fundamental concepts in rings and modules, structure theorems, applications.

Prerequisite(s): MATH 3158 or permission of the School.

Lectures three hours a week.



**MATH 4106 [0.5 credit]****Group Theory (Honours)**

Fundamental principles as applied to abelian, nilpotent, solvable, free and finite groups; representations.  
 Prerequisite(s): MATH 3106 or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5106, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4107 [0.5 credit]****Commutative Algebra (Honours)**

Fields, including algebraic and transcendental extensions, Galois theory, valuation theory; Noetherian commutative rings, including Noether decomposition theorem and localization.  
 Prerequisite(s): MATH 3158 or permission of the School.  
 Lectures three hours a week.

**MATH 4108 [0.5 credit]****Homological Algebra and Category Theory (Honours)**

Axioms of set theory; categories, functors, natural transformations; free, projective, injective and flat modules; tensor products and homology functors, derived functors; dimension theory.  
 Prerequisite(s): MATH 3158 or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5108, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4109 [0.5 credit]****Fields and Coding Theory (Honours)**

Introduction to field theory, emphasizing the structure of finite fields, primitive elements and irreducible polynomials. The influence of computational problems will be considered. Theory and applications of error-correcting codes: algebraic codes, convolution codes, decoding algorithms, and analysis of code performance.  
 Prerequisite(s): MATH 2100, or MATH 3101 or MATH 2108 or equivalent; or permission of the School.  
 Lectures three hours a week.

**MATH 4205 [0.5 credit]****Introduction to General Topology (Honours)**

Topological spaces, maps, subspaces, product and identification topologies, separation axioms, compactness, connectedness.  
 Prerequisite(s): MATH 3001 or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5205, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4206 [0.5 credit]****Introduction to Algebraic Topology (Honours)**

An introduction to homotopy theory. Topics include the fundamental group, covering spaces and the classification of two-dimensional manifolds.  
 Prerequisite(s): MATH 3106 and MATH 4205; or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5206, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4207 [0.5 credit]****Foundations of Geometry (Honours)**

A study of at least one modern axiom system of Euclidean and non-Euclidean geometry, embedding of hyperbolic and Euclidean geometries in the projective plane, groups of motions, models of non-Euclidean geometry.  
 Prerequisite(s): MATH 3106 (may be taken concurrently) or permission of the School.  
 Lectures three hours a week.

**MATH 4208 [0.5 credit]****Introduction to Differentiable Manifolds (Honours)**

Introduction to differentiable manifolds; Riemannian manifolds; vector fields and parallel transport; geodesics; differential forms on a manifold; covariant derivative; Betti numbers.  
 Prerequisite(s): MATH 3002 or permission of the School.  
 Lectures three hours a week.

**MATH 4305 [0.5 credit]****Analytic Number Theory (Honours)**

Dirichlet series, characters, Zeta-functions, prime number theorem, Dirichlet's theorem on primes in arithmetic progressions, binary quadratic forms.  
 Prerequisite(s): MATH 3057 or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5305, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4306 [0.5 credit]****Algebraic Number Theory (Honours)**

Algebraic number fields, bases, algebraic integers, integral bases, arithmetic in algebraic number fields, ideal theory, class number.  
 Prerequisite(s): MATH 3158 (may be taken concurrently) or permission of the School.  
 Also offered at the graduate level, with different requirements, as MATH 5306, for which additional credit is precluded.  
 Lectures three hours a week.

**MATH 4600 [0.5 credit]****Case Studies in Operations Research (Honours)**

Applications of the principles of Operations Research to practical problems in business, management, and science. Students present at least one case and analyze cases in the published literature. Cases may also be presented by visiting practitioners.

Note: students in Honours Mathematics/Statistics programs may only take this course as a free option.  
Prerequisite(s): STAT 2509 (or STAT 2559) and MATH 3801; or permission of the School.  
Seminars three hours a week.

**MATH 4700 [0.5 credit]****Partial Differential Equations (Honours)**

First-order partial differential equations. Classification of second-order linear partial differential equations; the diffusion equation, wave equation and Laplace's equation; separation of variables; Fourier and Laplace transform methods for the solution of initial/boundary value problems; Green's functions.

Prerequisite(s): MATH 3057 and one of MATH 3008 or MATH 3705, or permission of the School.  
Lectures three hours a week.

**MATH 4701 [0.5 credit]****Topics in Partial Differential Equations (Honours)**

Theory of distributions, initial-value problems based on 2-dimensions wave equations, Laplace transform, Fourier integral transform, diffusion problems, Helmholtz equation with application to boundary and initial-value problems in cylindrical and spherical coordinates.

Prerequisite(s): MATH 3008 and one of MATH 3002 or MATH 3057 or permission of the School.  
Also offered at the graduate level, with different requirements, as MATH 5407, for which additional credit is precluded.  
Lectures three hours a week.

**MATH 4703 [0.5 credit]****Dynamical Systems (Honours)**

Basic concepts of dynamical systems. Vector formulation for systems. Theory of autonomous systems in one, two and higher dimensions. Limit sets, stability. Phase plane, qualitative interpretation, limit cycles and attractors. Parametric dependence, bifurcations and chaos. Applications.

Prerequisite(s): MATH 3001 and MATH 3008 or permission of the School.  
Lectures three hours a week.

**MATH 4801 [0.5 credit]****Topics in Combinatorics (Honours)**

An in-depth study of one or more topics from: generating functions, Polya's theory of counting, block designs, coding theory, partially ordered sets and Ramsey theory.

Prerequisite(s): MATH 2100 and MATH 3805 or permission of the School.  
Lectures three hours a week.

**MATH 4802 [0.5 credit]****Introduction to Mathematical Logic (Honours)**

Symbolic logic, propositional and predicate calculi, set theory and model theory, completeness.

Prerequisite(s): MATH 2100 or permission of the School.  
Lectures three hours a week.

**MATH 4803 [0.5 credit]****Computable Functions (Honours)**

Recursive functions and computability, algorithms, Church's thesis, Turing machines, computational logic, NP-completeness.

Also listed as COMP 4803.  
Prerequisite(s): MATH 2100 or MATH 3805 or permission of the School.  
Lectures three hours a week.

**MATH 4805 [0.5 credit]****Theory of Automata (Honours)**

Finite automata and regular expressions, properties of regular sets, context-free grammars, pushdown automata, deterministic context-free languages. Turing machines, the Chomsky hierarchy. Undecidability, intractable problems.

Also listed as COMP 4805.  
Prerequisite(s): MATH 3805 or MATH 3106 or MATH 3158 or permission of the School.  
Also offered at the graduate level, with different requirements, as MATH 5605, for which additional credit is precluded.  
Lectures three hours a week.

**MATH 4806 [0.5 credit]****Numerical Linear Algebra (Honours)**

Matrix computations, conditioning and stability, direct methods for linear systems, classical iterative methods: Jacobi, Gauss-Seidel; modern iterative methods, Arnoldi decomposition, GMRES and other Krylov subspace based methods for sparse and structured matrices; numerical solution of eigenvalue problems, implementation using suitable programming language, application to differential equations and optimization problems.

Also listed as COMP 4806.  
Prerequisite(s): MATH 1102 or MATH 2107; MATH 2000 and MATH 3806; or permission of the School.  
Lectures three hours a week.

**MATH 4807 [0.5 credit]****Game Theory (Honours)**

Two-person zero-sum games; infinite games; multistage games; differential games; utility theory; two-person general-sum games; bargaining problem; n-person games; games with a continuum of players.

Prerequisite(s): MATH 3801 or permission of the School.  
Also offered at the graduate level, with different requirements, as MATH 5607, for which additional credit is precluded.  
Lectures three hours a week.

**MATH 4808 [0.5 credit]****Graph Theory and Algorithms (Honours)**

Paths, circuits, Eulerian and Hamiltonian graphs, connectivity, colouring problems, matching, Ramsey theory, network flows.

Prerequisite(s): MATH 3805 or MATH 3106 or MATH 3158 or permission of the School.

Lectures three hours a week.

**MATH 4809 [0.5 credit]****Mathematical Cryptography (Honours)**

Topics covered include: a general survey of public key cryptography; classical applications of finite fields and number theory; relevant background in geometry and algebraic curves; computational issues concerning elliptic curves; elliptic curve cryptosystems; security issues.

Prerequisite(s): MATH 3158, or permission of the School.

Lectures three hours a week.

**MATH 4811 [0.5 credit]****Combinatorial Design Theory (Honours)**

Existence and construction of combinatorial designs: finite geometries, pairwise balanced designs, balanced incomplete block designs, Steiner triple systems, symmetric designs, PBD closure, latin squares, transversal designs, and applications to information theory.

Prerequisite(s): MATH 3805, or permission of the School.

Lectures three hours a week.

**MATH 4816 [0.5 credit]****Numerical Analysis for Differential Equations (Honours)**

Floating point arithmetic; numerical solution of ODEs; finite difference methods for PDEs; stability, accuracy and convergence: von Neumann analysis, CFL condition, Lax Theorem. Finite element methods: boundary value problems and elliptic PDEs. Spectral and pseudo-spectral methods.

Prerequisite(s): MATH 2454 and MATH 3806, or permission of the School.

Also offered at the graduate level, with different requirements, as MATH 5806, for which additional credit is precluded.

Lectures three hours a week.

**MATH 4821 [0.5 credit]****Quantum Computing (Honours)**

Space of quantum bits; entanglement. Observables in quantum mechanics. Density matrix and Schmidt decomposition. Quantum cryptography. Classical and quantum logic gates. Quantum Fourier transform. Shor's quantum algorithm for factorization of integers.

Prerequisite(s): MATH 1102 (or MATH 2107) with a grade of C+ or better, and permission of the School.

Also offered at the graduate level, with different requirements, as MATH 5821, for which additional credit is precluded.

Lectures three hours a week.

**MATH 4822 [0.5 credit]****Wavelets and Digital Signal Processing (Honours)**

Lossless compression methods. Discrete Fourier transform and Fourier-based compression methods. JPEG and MPEG. Wavelet analysis. Digital filters and discrete wavelet transform. Daubechies wavelets. Wavelet compression.

Prerequisite(s): MATH 1102 (or MATH 2107) with a grade of C+ or better, and permission of the School.

Also offered at the graduate level, with different requirements, as MATH 5822, for which additional credit is precluded.

**MATH 4905 [0.5 credit]****Honours Project (Honours)**

Consists of a written report on some approved topic or topics in the field of mathematics, together with a short lecture on the report.

Prerequisite(s): B.Math.(Honours) students only.

**MATH 4906 [0.5 credit]****Directed Studies (Honours)**

Prerequisite: B.Math.(Honours) students only.

**MATH 4907 [0.5 credit]****Directed Studies (Honours)**

Prerequisite: B.Math.(Honours) students only.

**Summer session:** some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at [central.carleton.ca](http://central.carleton.ca)

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at [central.carleton.ca](http://central.carleton.ca)