

# Mathematics and Statistics

A Co-operative Education Option is available for Honours programs in the B.Math. degree. Consult the Co-operative Education 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 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 or MATH 1005), 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

### 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. Courses in the 3000-level Honours Sequence have grade levels in their prerequisites

MATH 3001 [0.5]	Real Analysis I (Honours)
MATH 3002 [0.5]	Real Analysis II (Honours)
MATH 3003 [0.5]	Advanced Differential Calculus (Honours)

MATH 3057 [0.5]	Functions of a Complex Variable (Honours)
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)
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
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### 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
GEOG 4101 [0.5]	Two Million Years of Environmental Change
GEOG 4103/ ENVE 3003 [0.5]	Water Resources Engineering
GEOG 4104 [0.5]	Microclimatology
GEOG 4108 [0.5]	Permafrost
<b>Geomatics</b>	
GEOM 2007 [0.5]	Geographic Information Systems
GEOM 3002 [0.5]	Air Photo Interpretation and Remote Sensing
GEOM 3005 [0.5]	Geospatial Analysis
GEOM 3007 [0.5]	Cartographic Theory and Design
GEOM 4003 [0.5]	Remote Sensing of the Environment
GEOM 4008 [0.5]	Advanced Topics in Geographic Information Systems
GEOM 4009 [0.5]	Applications in Geographic Information Systems
<b>Psychology</b>	
PSYC 2700 [0.5]	Introduction to Cognitive Psychology
PSYC 3506 [0.5]	Cognitive Development
PSYC 3700 [1.0]	Cognition (Honours Seminar)
PSYC 3702 [0.5]	Perception
PSYC 4001 [0.5]	Special Topics in Psychology

### 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: BIOL 3604, COMM 3001, CRCJ 3001, ECON 1401, ECON 1402, ECON 2201, ECON 2202, ECON 2400, ECON 4001, ECON 4002, ECON 4004, ECON 4025, ECON 4706, ECON 4707, ECON 4713, ECOR 2606, GEOG 2006, GEOG 3003, NEUR 2002, PSCI 2702, PSYC 2001, PSYC 2002, PSYC 3000 [1.0], SOCI 2002, SOCI 3003, SOCI 4009, SOWK 2502  
Students who have completed ECON 2201 and ECON 2202 and 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.

### Mathematics

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

##### A. Credits Included in the Major CGPA (11.5 credits)

<b>1. 2.5 credits in:</b>		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
<b>2. 3.5 credits in:</b>		3.5
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>3. 2.0 credits in:</b>		2.0
MATH 3001 [0.5]	Real Analysis I (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>4. 0.5 credit from:</b>		0.5
MATH 3002 [0.5]	Real Analysis II (Honours)	
MATH 3003 [0.5]	Advanced Differential Calculus (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
<b>5. 1.0 credit from 3000-level Honours Sequence</b>		1.0
<b>6. 1.5 credits in MATH or STAT at the 4000-level or higher</b>		1.5
<b>7. 0.5 credit in:</b>		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
<b>B. Credits Not Included in the Major CGPA (8.5 credits)</b>		
<b>8. 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>9. 4.5 credits in free electives</b>		4.5
Total Credits		20.0

### Mathematics with Specialization in Stochastics

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

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

<b>3. 3.0 credits in:</b>		3.0
MATH 3001 [0.5]	Real Analysis I (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)	
<b>4. 0.5 credit from:</b>		0.5

STAT 3553 [0.5]	Regression Modeling (Honours)	
MATH 3801 [0.5]	Linear Programming	
<b>5. 0.5 credit in STAT</b>	at the 4000-level	0.5
<b>6. 1.0 credit in MATH or STAT</b>	at the 4000-level or higher	1.0
<b>Total Credits</b>		<b>5.0</b>

## Computational and Applied Mathematics and Statistics

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

#### A. Credits included in the Major CGPA (14.0 credits)

##### 1. 8.0 credits in: 8.0

MATH 1002 [1.0]	Calculus and Introductory Analysis I
MATH 1102 [1.0]	Algebra I
MATH 1800 [0.5]	Introduction to Mathematical Reasoning
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)
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##### 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 4708 [0.5]	Asymptotic Methods of Applied Mathematics (Honours)	
MATH 4801 [0.5]	Topics in Combinatorics (Honours)	
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)	
MATH 4803 [0.5]	Computable Functions (Honours)	
MATH 4805 [0.5]	Theory of Automata (Honours)	
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)	
MATH 4807 [0.5]	Game Theory (Honours)	
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)	
MATH 4809 [0.5]	Mathematical Cryptography (Honours)	
MATH 4811 [0.5]	Combinatorial Design Theory (Honours)	
MATH 4816 [0.5]	Numerical Analysis for Differential Equations (Honours)	
MATH 4821 [0.5]	Quantum Computing (Honours)	
MATH 4822 [0.5]	Wavelets and Digital Signal Processing (Honours)	
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</b>	at the 3000-level or above	1.0
<b>B. Credits Not Included in the Major CGPA (6.0 credits)</b>		
<b>8. 1.0 credit in Natural Sciences</b>	(1000-level or above)	1.0
<b>9. 2.0 credits in Approved Arts or Social Science Electives</b>		2.0
<b>10. 1.0 credit at the 2000-level or above in Natural Sciences or Approved Arts or Social Sciences</b>		1.0
<b>11. 2.0 credits in free electives</b>		2.0
<b>Total Credits</b>		<b>20.0</b>

## Computational and Applied Mathematics and Statistics with Concentration

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

#### A. Credits included in the Major CGPA (14.0 credits)

##### 1. 7.0 credits in: 7.0

MATH 1002 [1.0]	Calculus and Introductory Analysis I
MATH 1102 [1.0]	Algebra I
MATH 1800 [0.5]	Introduction to Mathematical Reasoning
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)	
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	
2. One of the concentrations described below, also included in the Major CGPA:		6.5
<b>3. 0.5 credit in:</b>		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
<b>B. Credits Not Included in the Major CGPA (6.0 credits)</b>		
4. 1.0 credit in Natural Science electives at the 1000 level or above		1.0
5. 2.0 credits in Approved Arts or Social Sciences electives		2.0
6. 1.0 credit at the 2000 level or above in Natural Science or Approved Arts or Social Sciences		1.0
7. 2.0 credits in free electives		2.0
Total Credits		20.0

### Concentration in Applied Analysis (6.5 credits)

#### Requirements:

2a. 3.0 credits in:		3.0
MATH 2100 [1.0]	Algebra II (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
MATH 3855 [0.5]	Discrete Structures and Applications (Honours)	
2b. 1.0 credit from:		1.0
MATH 4700 [0.5]	Partial Differential Equations (Honours)	
MATH 4701 [0.5]	Topics in Differential Equations (Honours)	
MATH 4703 [0.5]	Dynamical Systems (Honours)	
MATH 4708 [0.5]	Asymptotic Methods of Applied Mathematics (Honours)	
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)	
MATH 4816 [0.5]	Numerical Analysis for Differential Equations (Honours)	
2c. 0.5 credit in MATH at the 4000 level		0.5
2d. 2.0 credits in MATH or STAT at the 3000 level or above		2.0
Total Credits		6.5

### Concentration in Applied Statistics and Probability (6.5 credits)

#### Requirements:

2a. 2.5 credits in:		2.5
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)	
2b. 1.5 credits from:		1.5
STAT 4500 [0.5]	Parametric Estimation (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 4506 [0.5]	Nonparametric Methods (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)	
2c. 2.5 credits in MATH or STAT at the 3000 level or above		2.5
Total Credits		6.5

### Concentration in Discrete Mathematics (6.5 credits)

#### Requirements:

2a. 3.0 credits in:		3.0
MATH 2100 [1.0]	Algebra II (Honours)	
MATH 3801 [0.5]	Linear Programming	
MATH 3802 [0.5]	Combinatorial Optimization	
MATH 3806 [0.5]	Numerical Analysis (Honours)	
MATH 3855 [0.5]	Discrete Structures and Applications (Honours)	
2b. 1.0 credit from:		1.0
MATH 4109 [0.5]	Fields and Coding Theory (Honours)	
MATH 4801 [0.5]	Topics in Combinatorics (Honours)	
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)	
MATH 4803 [0.5]	Computable Functions (Honours)	
MATH 4805 [0.5]	Theory of Automata (Honours)	
MATH 4807 [0.5]	Game Theory (Honours)	
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)	
MATH 4811 [0.5]	Combinatorial Design Theory (Honours)	
2c. 0.5 credit in MATH at the 4000 level		0.5
2d. 2.0 credits in MATH or STAT at the 3000 level or above		2.0
Total Credits		6.5

### Statistics

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

##### A. Credits Included in the Major CGPA (12.5 credits)

1. 2.5 credits in:		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
2. 1.0 credit in:		1.0

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>		6.0
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>		1.0
MATH 2100 [1.0]	Algebra II (Honours)	
or		
MATH 3107 [0.5]	Linear Algebra III	
and 0.5 credit from:		
3000-level Honours Sequence, or:		
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	
or 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>		0.5
<b>6. 1.5 credits in STAT at the 4000-level</b>		1.5
<b>B. Credits Not Included in the Major CGPA (7.5 credits)</b>		
<b>7. 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>8. 3.5 credits in free electives</b>		3.5
<b>Total Credits</b>		<b>20.0</b>
<b>Statistics with Concentration in Actuarial Science</b>		
<b>B. Math. Honours (20.0 credits)</b>		
<b>A. Credits Included in the Major CGPA (13.0 credits)</b>		
<b>1. 2.5 credits in:</b>		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
<b>2. 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>3. 6.5 credits in:</b>		6.5
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 2660 [0.5]	Mathematics for Finance (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>		1.0
MATH 2100 [1.0]	Algebra II (Honours)	
or		
MATH 3107 [0.5]	Linear Algebra III	
and 0.5 credit from:		
3000-level Honours Sequence, or:		
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	
or 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>		0.5
<b>6. 1.5 credits in:</b>		1.5
STAT 4508 [0.5]	Stochastic Models (Honours)	
STAT 4603 [0.5]	Time Series and Forecasting (Honours)	
and		
STAT 4555 [0.5]	Monte Carlo Simulation (Honours)	
or STAT at the 4000-level		
<b>B. Credits Not Included in the Major CGPA (7.0 credits):</b>		
<b>7. 3.0 credits in:</b>		3.0
BUSI 1001 [0.5]	Principles of Financial Accounting	
BUSI 1002 [0.5]	Management Accounting	
ECON 1000 [1.0]	Introduction to Economics	
ECON 2020 [0.5]	Intermediate Microeconomics I: Producers and Market Structure	
ECON 2102 [0.5]	Intermediate Macroeconomics I	
<b>8. 2.5 credits in:</b>		2.5
BUSI 2504 [0.5]	Business Finance I	
BUSI 2505 [0.5]	Business Finance II	
BUSI 3500 [0.5]	Applied Corporate Finance	
BUSI 3502 [0.5]	Investments	
BUSI 3512 [0.5]	Derivatives	
or		
ECON 2030 [0.5]	Intermediate Microeconomics II: Consumers and General Equilibrium	
ECON 3050 [0.5]	Introduction to Financial Economics	

ECON 4051 [0.5]	Financial Asset Pricing	
ECON 4052 [0.5]	Corporate Financial Economics	
and one of:		
ECON 2103 [0.5]	Intermediate Macroeconomics II	
ECON 3607 [0.5]	Monetary and Financial Institutions	
ECON 4053 [0.5]	Financial Market Modeling	
<b>9. 1.0 credit in</b>	Natural Science electives	1.0
<b>10. 0.5 credit in</b>	free electives	0.5
<b>Total Credits</b>		<b>20.0</b>

## Mathematics

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

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

<b>1. 2.5 credits in:</b>		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
<b>2. 2.0 credits in:</b>		2.0
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>		3.0
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. Credits Not Included in the Major CGPA (7.5 credits)

<b>4. 4.0 credits not in</b>	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	
<b>5. 3.5 credits in</b>	free electives	3.5
<b>Total Credits</b>		<b>15.0</b>

## Computer Mathematics

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

#### A. Credits Included in the Major CGPA (10.5 credits)

<b>1. 2.5 credits in:</b>		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
<b>2. 2.5 credits in:</b>		2.5
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	

COMP 2404 [0.5]	Introduction to Software Engineering	
<b>3. 2.5 credits in:</b>		2.5
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>		0.5
MATH 2108 [0.5]	Abstract Algebra I	
MATH 3101 [0.5]	Algebraic Structures with Computer Applications	
<b>5. 1.0 credit from:</b>		1.0
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</b>	MATH or STAT at the 3000-level	1.0
<b>excluding</b>		
STAT 3502 [0.5]	Probability and Statistics	
<b>7. 0.5 credit in</b>	MATH or STAT at the 2000-level or higher	0.5
<b>B. Credits Not Included in the Major CGPA (4.5 credits)</b>		
<b>8. 4.0 credits not in</b>	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	
<b>9. 0.5 credit in</b>	free electives	0.5
<b>Total Credits</b>		<b>15.0</b>

## Statistics

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

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

<b>1. 2.5 credits in:</b>		2.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
<b>2. 4.0 credits in:</b>		4.0
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>		0.5
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</b>	2000-level MATH or STAT	0.5
<b>B. Credits Not Included in the Major CGPA (7.5 credits)</b>		
<b>5. 4.0 credits not in</b>	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	
<b>6. 3.5 credits in</b>	free electives	3.5
<b>Total Credits</b>		15.0

**Computer Science and Mathematics:  
Concentration in Computing Theory and  
Numerical Methods**

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

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

<b>1. 4.5 credits in:</b>		4.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	
MATH 2100 [1.0]	Algebra II (Honours)	
<b>2. 6.0 credits in:</b>		6.0
COMP 1405 [0.5]	Introduction to Computer Science I	
COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
COMP 3805 [0.5]	Discrete Structures and Applications (Honours)	
<b>3. 0.5 credit from:</b>		0.5
COMP 4905 [0.5]	Honours Project	
MATH 4905 [0.5]	Honours Project (Honours)	
Concentration in Computing Theory and Numerical Methods		
<b>4. 3.0 credits from:</b>		3.0
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	
STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
MATH 3801 [0.5]	Linear Programming	
MATH 3806 [0.5]	Numerical Analysis (Honours)	

COMP 4804 [0.5]	Design and Analysis of Algorithms II	
<b>5. 0.5 credit from:</b>		0.5
MATH 3001 [0.5]	Real Analysis I (Honours)	
MATH 3002 [0.5]	Real Analysis II (Honours)	
MATH 3003 [0.5]	Advanced Differential Calculus (Honours)	
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)	
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)	
<b>6. 1.0 credit from:</b>		1.0
MATH 4109 [0.5]	Fields and Coding Theory (Honours)	
MATH 4801 [0.5]	Topics in Combinatorics (Honours)	
MATH 4802 [0.5]	Introduction to Mathematical Logic (Honours)	
MATH 4803 [0.5]	Computable Functions (Honours)	
MATH 4805 [0.5]	Theory of Automata (Honours)	
MATH 4806 [0.5]	Numerical Linear Algebra (Honours)	
MATH 4807 [0.5]	Game Theory (Honours)	
MATH 4808 [0.5]	Graph Theory and Algorithms (Honours)	
MATH 4811 [0.5]	Combinatorial Design Theory (Honours)	
MATH 4816 [0.5]	Numerical Analysis for Differential Equations (Honours)	
MATH 4821 [0.5]	Quantum Computing (Honours)	
MATH 4822 [0.5]	Wavelets and Digital Signal Processing (Honours)	
<b>7. 0.5 credit in</b>	COMP at the 3000-level or above.	0.5
<b>B. Credits Not Included in the Major CGPA (4.0 credits)</b>		
<b>8. 4.0 credits not in</b>	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 or Business	
c.	1.0 credit at the 2000-level or higher in Natural Science electives or in Approved Arts and Social Sciences	
<b>Total Credits</b>		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]	Business Analytics

**Engineering**

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

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

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

**1. 4.5 credits in:** 4.5

MATH 1002 [1.0] Calculus and Introductory Analysis I

MATH 1102 [1.0] Algebra I

MATH 1800 [0.5] Introduction to Mathematical Reasoning

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

MATH 2100 [1.0] Algebra II (Honours)

**2. 6.0 credits in:** 6.0

COMP 1405 [0.5] Introduction to Computer Science I

COMP 1406 [0.5] Introduction to Computer Science II

COMP 2401 [0.5] Introduction to Systems Programming

COMP 2402 [0.5] Abstract Data Types and Algorithms

COMP 2404 [0.5] Introduction to Software Engineering

COMP 2406 [0.5] Fundamentals of Web Applications

COMP 2804 [0.5] Discrete Structures II

COMP 3000 [0.5] Operating Systems

COMP 3004 [0.5] Object-Oriented Software Engineering

COMP 3005 [0.5] Database Management Systems

COMP 3804 [0.5] Design and Analysis of Algorithms I

COMP 3805 [0.5] Discrete Structures and Applications (Honours)

**3. 0.5 credit from:** 0.5

COMP 4905 [0.5] Honours Project

MATH 4905 [0.5] Honours Project (Honours)

Concentration:

**4. 3.0 credits in:** 3.0

MATH 2454 [0.5] Ordinary Differential Equations (Honours)

MATH 3806 [0.5] Numerical Analysis (Honours)

STAT 2559 [0.5] Basics of Statistical Modeling (Honours)

STAT 2655 [0.5] Introduction to Probability with Applications (Honours)

STAT 3558 [0.5] Elements of Probability Theory (Honours)

STAT 3559 [0.5] Mathematical Statistics (Honours)

**5. 0.5 credit from:** 0.5

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

STAT 3553 [0.5] Regression Modeling (Honours)

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

**7. 0.5 credit in COMP at the 4000-level.** 0.5

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

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

a. 1.0 credit in Natural Science electives

b. 2.0 credits in Approved Arts or Social Sciences or Business

c. 1.0 credit at the 2000-level or higher in Natural Science electives or in Approved Arts and Social Sciences

Total Credits

20.0

**Mathematics and Physics**

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

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

**A. Credits Included in the Major CGPA (17.0 credits)**

**1. 7.5 credits in:** 7.5

MATH 1002 [1.0] Calculus and Introductory Analysis I

MATH 1102 [1.0] Algebra I

MATH 1800 [0.5] Introduction to Mathematical Reasoning

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 I (Honours)

MATH 3008 [0.5] Ordinary Differential Equations (Honours)

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

**2. 0.5 credit from:** 0.5

MATH 3002 [0.5] Real Analysis II (Honours)

MATH 3003 [0.5] Advanced Differential Calculus (Honours)

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

PHYS 3007 [0.5] Third Year Physics Laboratory: Selected Experiments and Seminars

PHYS 3606 [0.5] Modern Physics II

**3. 1.0 credit in 4000-level or higher MATH, STAT** 1.0

**4. 1.0 credit from:** 1.0

PHYS 1001 [0.5] Foundations of Physics I & PHYS 1002 [0.5] and Foundations of Physics II (recommended)

PHYS 1003 [0.5] Introductory Mechanics and & PHYS 1004 [0.5] Thermodynamics and Introductory Electromagnetism and Wave Motion

PHYS 1007 [0.5] Elementary University Physics I & PHYS 1008 [0.5] and Elementary University Physics II (with an average grade of B- or higher)

**5. 2.0 credits in:** 2.0

PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2401 [0.5]	Thermal Physics	
PHYS 2604 [0.5]	Modern Physics I	
<b>6. 3.0 credits in:</b>		<b>3.0</b>
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
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</b>		<b>1.0</b>
<b>8. 1.0 credit from:</b>		<b>1.0</b>
a. MATH 4905 or PHYS 4907 or PHYS 4908 plus 0.5 credit 4000-level MATH or PHYS		
b. PHYS 4909 [1.0]		
<b>B. Credits Not Included in the Major CGPA (4.5 credits)</b>		
<b>9. 1.0 credit from:</b>		<b>1.0</b>
BIOL 1003 [0.5]	Introductory Biology I	
& BIOL 1004 [0.5]	and Introductory Biology II	
BIOL 1103 [0.5]	Foundations of Biology I	
& BIOL 1104 [0.5]	and Foundations of Biology II	
CHEM 1001 [0.5]	General Chemistry I	
& CHEM 1002 [0.5]	and General Chemistry II	
CHEM 1005 [0.5]	Elementary Chemistry I	
& CHEM 1006 [0.5]	and Elementary Chemistry II	
ERTH 1006 [0.5]	Exploring Planet Earth	
& EARTH 1009 [0.5]	and The Earth System Through Time	
<b>10. 0.5 credit in:</b>		<b>0.5</b>
COMP 1005 [0.5]	Introduction to Computer Science I	
<b>11. 0.5 credit from:</b>		<b>0.5</b>
NSCI 1000 [0.5]	Seminar in Science	
Approved Arts or Social Sciences		
<b>12. 1.5 credits in Approved Arts or Social Sciences Electives</b>		<b>1.5</b>
<b>13. 1.0 credit in free electives</b>		<b>1.0</b>
<b>Total Credits</b>		<b>21.5</b>

## Biostatistics

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

#### A. Credits Included in the Major CGPA (14.0)

<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 1800 [0.5]	Introduction to Mathematical Reasoning	
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 MATH 3815, MATH 3816</b>		<b>0.5</b>
<b>3. 4.5 credits in STAT 2665, STAT 2559, STAT 3503, STAT 3504, STAT 3506, STAT 3508, STAT 3509, STAT 4605, STAT 4606</b>		<b>4.5</b>
<b>4. 4.0 credits in:</b>		<b>4.0</b>

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>		<b>0.5</b>
BIOC 3008 [0.5]	Bioinformatics	
BIOC 4008 [0.5]	Computational Systems Biology	
<b>6. 0.5 credit in STAT at the 4000-level</b>		<b>0.5</b>
<b>B. Credits Not Included in the Major CGPA (6.0 credits)</b>		
<b>7. 1.0 credit in:</b>		<b>1.0</b>
BIOC 3101 [0.5]	General Biochemistry I	
BIOC 3102 [0.5]	General Biochemistry II	
<b>8. 2.0 credits in:</b>		<b>2.0</b>
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>		<b>1.0</b>
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics	
& PHYS 1004 [0.5]	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>		<b>1.0</b>
COMP 1005 [0.5]	Introduction to Computer Science I	
COMP 1006 [0.5]	Introduction to Computer Science II	
<b>11. 1.0 credit in Approved Arts or Social Sciences Electives</b>		<b>1.0</b>
<b>Total Credits</b>		<b>20.0</b>

## Economics and Mathematics

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

#### A. Credits Included in the Major CGPA (15.5 credits)

<b>1. 7.5 credits in:</b>		<b>7.5</b>
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
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 I (Honours)	
STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
STAT 3559 [0.5]	Mathematical Statistics (Honours)	
<b>2. 0.5 credit from:</b>		<b>0.5</b>

MATH 3002 [0.5]	Real Analysis II (Honours)	
MATH 3003 [0.5]	Advanced Differential Calculus (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 MATH or STAT at the 4000-level</b>		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 ECON at the 4000-level</b>		2.0
<b>B. Credits Not Included in the Major CGPA (4.5 credits)</b>		
<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 Natural Science Electives</b>		1.0
<b>10. 2.5 credits in free electives</b>		2.5
Total Credits		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)

##### A. Credits Included in the Major CGPA (15.5 credits)

<b>1. 8.5 credits in:</b>		8.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
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)	
<b>2. 0.5 credit in:</b>		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
<b>3. 0.5 credit in STAT at the 4000-level</b>		0.5
<b>4. 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>5. 2.0 credits in ECON at the 4000-level</b>		2.0
<b>B. Credits Not Included in the Major CGPA (4.5 credits)</b>		
<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. 2.5 credits in free electives</b>		2.5
Total Credits		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. 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)

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

##### 1. 7.5 credits in: 7.5

MATH 1002 [1.0] Calculus and Introductory Analysis I

MATH 1102 [1.0] Algebra I

MATH 1800 [0.5] Introduction to Mathematical Reasoning

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 I (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)

##### 2. 0.5 credit from: 0.5

MATH 3002 [0.5] Real Analysis II (Honours)

MATH 3003 [0.5] Advanced Differential Calculus (Honours)

MATH 3008 [0.5] Ordinary Differential Equations (Honours)

##### 3. 0.5 credit from 3000-level Honours Sequence or MATH or STAT at the 4000-level or higher 0.5

##### 4. 1.5 credits at the 4000-level or higher in MATH or STAT 1.5

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

##### 5. 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

##### 6. 1.0 credit in free electives 1.0

Total Credits 15.0

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

##### 1. 6.0 credits in: 6.0

MATH 1002 [1.0] Calculus and Introductory Analysis I

MATH 1102 [1.0] Algebra I

MATH 1800 [0.5] Introduction to Mathematical Reasoning

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)

##### 2. 2.0 credits in: 2.0

MATH 3001 [0.5] Real Analysis I (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)

##### 3. 0.5 credit from: 0.5

MATH 3002 [0.5] Real Analysis II (Honours)

MATH 3003 [0.5] Advanced Differential Calculus (Honours)

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

MATH 3008 [0.5] Ordinary Differential Equations (Honours)

##### 4. 1.5 credits at the 4000-level or higher in MATH or STAT 1.5

Total Credits 10.0

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

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

##### 1. 8.5 credits in: 8.5

MATH 1002 [1.0] Calculus and Introductory Analysis I

MATH 1102 [1.0] Algebra I

MATH 1800 [0.5] Introduction to Mathematical Reasoning

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 I (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</b>	at the 4000-level or higher in Mathematics or Statistics	1.5
<b>B. Credits Not Included in the Major CGPA (5.0 credits)</b>		
<b>3. 4.0 credits</b>	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	
<b>4. 1.0 credit</b>	in free electives	1.0
Total Credits		15.0

### 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</b>	at the 5000-level or higher in MATH or STAT	1.5
<b>6. 1.0 credit</b>	at the 5000-level or higher in mathematics or statistics or from another department or school	1.0
<b>7. Either:</b>		2.0
	MATH 4905 and 1.5 credits in MATH or STAT at the 5000-level or higher	
	or	
	an M.Sc. thesis in Mathematics	
Total Credits		4.5

### Minors

#### Minor in Mathematics (4.0 credits)

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>		1.0
MATH 1007 [0.5]	Elementary Calculus I	
& MATH 2007 [0.5]	and Elementary Calculus II	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
& MATH 1005 [0.5]	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>		1.0
MATH 1107 [0.5]	Linear Algebra I	
or MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2107 [0.5]	Linear Algebra II	
<b>or</b>		
MATH 1102 [1.0]	Algebra I	
<b>3. 1.0 credit</b>	in MATH at the 2000-level or higher	1.0
<b>4. 1.0 credit</b>	in MATH at the 3000-level or higher	1.0

5. The remaining requirements of the major discipline(s) and degree must be satisfied.	
Total Credits	4.0

#### Minor in Statistics (4.0 credits)

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>		0.5
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>		0.5
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>		1.0
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
& STAT 2509 [0.5]	and Introduction to Statistical Modeling II	
STAT 3502 [0.5]	Probability and Statistics	
& STAT 2509 [0.5]	and Introduction to Statistical Modeling II	
STAT 2606 [0.5]	Business Statistics I	
& STAT 2607 [0.5]	and Business Statistics II	
<b>or</b>		
ECON 2201 [0.5]	Statistical Methods in Economics	
& ECON 2202 [0.5]	and Business I and Statistical Methods in Economics and Business II	
<b>4. 1.5 credits in:</b>		1.5
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>		0.5
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		4.0

##### 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**  
**School of Mathematics and Statistics**  
**Faculty of Science**

**Note:**

• See also the course listings under Statistics (STAT) in this Calendar.

**Prerequisites for First-year Mathematics Courses in B.Math. Programs**

Students who do not have the required Ontario Grade 12 Mathematics courses or equivalents may take MATH 0005 Precalculus: Functions and Graphs and MATH 0006 Precalculus: Trigonometric Functions and Complex Numbers in lieu of Advanced Functions, MATH 0107 Algebra and Geometry in lieu of the algebra component of Calculus and Vectors. These 0000-level mathematics courses serve as alternate prerequisites for MATH 1002 [1.0] Calculus and Introductory Analysis I and MATH 1102 [1.0] Algebra I. These courses would be in addition to the minimum 15.0 credits required in General programs, or 20.0 credits required in Honours programs.

**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. Strongly recommended for students intending to specialize in mathematics, statistics, physics, or related areas.  
Precludes additional credit for BIT 1000, BIT 1100, BIT 1200, BIT 2004, 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 and one half hours 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 to areas and volumes.  
Precludes additional credit for BIT 1000, BIT 1100, BIT 1200, MATH 1002, MATH 1007, MATH 1009.  
Prerequisite(s): Ontario Grade 12 Mathematics: Advanced Functions, or MATH 0005 and MATH 0006, or equivalent. Restricted to students in the Faculty of Engineering, or in certain B.Sc. and B.A.S. programs where specified.  
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. Sequences and series, convergence tests, estimation of sums. Power series, Taylor series, remainders. Fourier series. Precludes additional credit for BIT 2004, 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. Restricted to students in the Faculty of Engineering, or in certain B.Sc. programs where specified. 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, BIT 1200, MATH 1002, MATH 1004, MATH 1009, MATH 1401/ECON 1401, MATH 1402/ECON 1402. 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. Precludes additional credit for BIT 1000, BIT 1100, BIT 1200, BUSI 1705 (no longer offered), MATH 1002, MATH 1004, MATH 1007, MATH 1401/ECON 1401, MATH 1402/ECON 1402. 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. 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; emphasis on proofs and theory. Precludes additional credit for BIT 1001, BIT 1101, BIT 1201, 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 and a half hours a week.

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

Systems of linear equations. Matrix algebra. Determinants. Invertible matrix theorem. Cramer's rule. Vector space  $\mathbb{R}^n$ ; subspaces, bases. Eigenvalues, diagonalization. Linear transformations, kernel, range. Complex numbers (including De Moivre's theorem). Inner product spaces and orthogonality. Applications. Precludes additional credit for BIT 1001, BIT 1101, BIT 1201, MATH 1102, MATH 1107, MATH 1119, MATH 1401/ECON 1401, MATH 1402/ECON 1402. Note: MATH 1119 is not an acceptable substitute for MATH 1104. 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, the School of Computer Science, or in certain B.Sc. and B.A.S. programs where specified. 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, BIT 1201, MATH 1102, MATH 1104, MATH 1119, MATH 1401/ECON 1401, MATH 1402/ECON 1402. 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 for, but is not an acceptable substitute for: BIT 1001, BIT 1101, BIT 1201, MATH 1102, MATH 1104, MATH 1107. BUSI 1704 (no longer offered), MATH 1109 (no longer offered), MATH 1401/ECON 1401, MATH 1402/ECON 1402.

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

Also listed as ECON 1401.

Precludes additional credit for BIT 1000, BIT 1001, BIT 1100, BIT 1101, BIT 1201; MATH 1007, MATH 1009, MATH 1104, MATH 1107, 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 BIT 1000, BIT 1001, BIT 1100, BIT 1101, BIT 1201; MATH 1007, MATH 1009, MATH 1104, MATH 1107, 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 1800 [0.5 credit]****Introduction to Mathematical Reasoning**

Elementary logic, propositional and predicate calculus, quantifiers, sets and functions, bijections and elementary counting, the concept of infinity, relations, well ordering and induction. The practice of mathematical proof in elementary number theory and combinatorics.

Precludes additional credit for MATH 1805/COMP 1805.

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

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

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

Introduction to discrete mathematics and discrete structures. Topics include: propositional logic, predicate calculus, set theory, complexity of algorithms, mathematical reasoning and proof techniques, recurrences, induction, finite automata and graph theory. Material is illustrated through examples from computing. Also listed as COMP 1805.

Precludes additional credit for MATH 1800.

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

Lectures three hours a week, tutorial one hour 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 BIT 2005, MATH 2004, MATH 2008, and MATH 3009.

Prerequisite(s): i) MATH 1002 with a grade of C+ or higher, or (MATH 2007 or MATH 1005 with a grade of B+ or higher and permission of the School); and ii) MATH 1102 with a grade of C+ or higher, or MATH 1107 or MATH 1104 with a grade of B+ or higher; and iii) MATH 1800 (MATH 1800 may be taken concurrently, with permission of the School); 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**

Curves and surfaces. Polar, cylindrical and spherical coordinates. Partial derivatives, gradients, extrema and Lagrange multipliers. Exact differentials. Multiple integrals over rectangular and general regions. Integrals over surfaces. Line integrals. Vector differential operators. Green's Theorem, Stokes' theorem, Divergence Theorem. Applications.

Precludes additional credit for BIT 2005, MATH 2000, and MATH 2008.

Prerequisite(s): i) MATH 1005 or MATH 2007; and ii) MATH 1104 or MATH 1107; or permission of the School.

Restricted to students in the Faculty of Engineering, or in certain B.Sc. programs where specified.

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 BIT 2004, MATH 1002, 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 BIT 2005, MATH 2000, and MATH 2004.

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 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): i) MATH 1102 with a grade of C+ or higher, or (MATH 2107 with a grade of B+ or higher and permission of the School); and ii) MATH 1800 (MATH 1800 may be taken concurrently, with permission of the School); 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): i) MATH 1102 or MATH 2107; and ii) MATH 1800 (MATH 1800 may be taken concurrently, with permission of the School); or COMP 1805 or MATH 1805; or permission of the School.

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 BIT 2004, MATH 1005, 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 I (Honours)**

Metric spaces and their topologies, continuous maps, completeness, compactness, connectedness, introduction to Banach spaces.

Prerequisite(s): MATH 2000 with a grade of C- or higher; or (MATH 3009 and MATH 1800) each with a grade of B or higher, and permission of the instructor; or permission of the School.

Lectures three hours a week and one hour tutorial.

**MATH 3002 [0.5 credit]****Real Analysis II (Honours)**

Function spaces, pointwise and uniform convergence, Weierstrass approximation theorem, Lebesgue measure and Lebesgue integral on the real line, Hilbert space, Fourier series.

Prerequisite(s): MATH 3001 with a grade of C- or higher, or permission of the School.

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

**MATH 3003 [0.5 credit]****Advanced Differential Calculus (Honours)**

Review of multivariable differentiation and integration. Vector fields, differential forms and exterior algebra. Introduction to manifolds and tangent bundles. Stokes' Theorem. Applications such as differential equations and the calculus of variations.

Prerequisite(s): MATH 3001 with a grade of C- or higher, or permission of the School.

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

**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): i) MATH 2000 with a grade of C- or higher, or (MATH 3009 with a grade of B or higher, and permission of the instructor); and ii) MATH 2454 with a grade of C- or higher, or (MATH 2404 with a grade of B or higher, and permission of the instructor).

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 mappings.

Precludes additional credit for MATH 3007 and PHYS 3807.

Prerequisite(s): MATH 2000 with a grade of C- or higher; or (MATH 2008 or MATH 2004 with a grade of B or higher, and permission of the instructor); 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): i) MATH 2107 or MATH 1102; and ii) either COMP 1805/MATH 1805 or MATH 1800 (MATH 1800 may be taken concurrently, with permission of the School); 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 with a grade of C- or higher; or (MATH 2108 or MATH 3101 with a grade of B or higher; and MATH 1800 with a grade of B or higher; and permission of the instructor); 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, fields, polynomial rings over a field, algebraic extensions of fields, the fundamental theorem of Galois theory, finite fields, applications.

Precludes additional credit for MATH 3108.

Prerequisite(s): MATH 2100 with a grade of C- or higher, or (MATH 2108 or MATH 3101 with a grade of B or higher and MATH 1800 with a grade of B or higher and permission of the instructor), 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 with a grade of C- or higher; or (MATH 2108 or MATH 3101 with a grade of B or higher; and MATH 1800 with a grade of B or higher; and permission of the instructor); 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 with a grade of C- or higher; or (MATH 2108 or MATH 3101 with a grade of B- or higher; and permission of the instructor); 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): i) one of COMP 2402 or SYSC 2100; and ii) one of COMP 2804 or MATH 3855 or MATH 3825 or COMP 3805.

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 with a grade of C- or higher; or (MATH 1005 or MATH 2007 with a grade of C+ or higher); and ii) MATH 1102 with a grade of C- or higher; or (MATH 1107 or MATH 1104 with a grade of C- or higher; and permission of the instructor); 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 with a grade of C- or higher.

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 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 (no longer offered), and MATH 3855 and COMP 3805.

Prerequisite(s): 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 (no longer offered) and MATH 3825.

Prerequisite(s): MATH 2100 with a grade of C- or higher; or (MATH 2108 or MATH 3101) with a grade of B or higher.

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.

**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 Differential Equations (Honours)**

Topics in the theory and application of differential equations; for example, hyperbolic systems, fluid dynamics, nonlinear wave equations, optimal mass transport, control theory, calculus of variations.

Prerequisite(s): i) MATH 3008; and ii) one of MATH 3001 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 4708 [0.5 credit]****Asymptotic Methods of Applied Mathematics (Honours)**

Asymptotic series: properties, matching, application to differential equations. Asymptotic expansion of integrals: elementary methods, methods of Laplace, stationary phase and steepest descent, Watson's lemma, Riemann-Lebesgue lemma. Perturbation methods: regular and singular perturbation for differential equations, multiple scale analysis, boundary layer theory, WKB theory.

Prerequisite(s): MATH 3057 and at least one of MATH 3008 or MATH 3705, or permission of the School. Also offered at the graduate level, with different requirements, as MATH 5408, for which additional credit is precluded.

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 3855 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 3855 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 3106 or MATH 3158 or MATH 3855 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 3106 or MATH 3158 or MATH 3855 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 3855, 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.

Lectures three hours a week.

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

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

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

## Statistics (STAT) Courses

### School of Mathematics and Statistics

#### Faculty of Science

#### **STAT 2507 [0.5 credit]**

##### **Introduction to Statistical Modeling I**

A data-driven introduction to statistics. Basic descriptive statistics, introduction to probability theory, random variables, discrete and continuous distributions, contingency tables, sampling distributions, distribution of sample mean, Central Limit Theorem, interval estimation and hypothesis testing. A statistical software package will be used.

Precludes additional credit for BIT 2000, BIT 2100 (no longer offered), BIT 2300 (no longer offered), ECON 2201, ENST 2006, GEOG 2006, GEOG 3003, STAT 2606, and STAT 3502. May not be counted for credit in any program if taken after successful completion of STAT 2559.

Prerequisite(s): an Ontario Grade 12 university-preparation Mathematics or equivalent, or permission of the School of Mathematics and Statistics.

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

#### **STAT 2509 [0.5 credit]**

##### **Introduction to Statistical Modeling II**

A data-driven approach to statistical modeling. Basics of experimental design, analysis of variance, simple linear regression and correlation, nonparametric procedures. A statistical software package will be used.

Precludes additional credit for STAT 2607, ECON 2202.

Prerequisite(s): STAT 2507 or STAT 2606 or STAT 3502; or permission of the School.

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

#### **STAT 2559 [0.5 credit]**

##### **Basics of Statistical Modeling (Honours)**

Estimation and hypothesis testing for one and two samples, analysis of categorical data, basics of experimental design, analysis of variance, simple linear regression and correlation. Nonparametric procedures. A statistical software package will be used.

Prerequisite(s): STAT 2655 or permission of the School.

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

#### **STAT 2605 [0.5 credit]**

##### **Probability Models**

Basic probability; discrete random variables with focus on binomial and Poisson random variables; continuous random variables, transformation theorem, simulating continuous random variables; exponential random variable, normal random variable, sums of random variables, central limit theorem. Elements of Markov chains, and introduction to Poisson processes. Restricted to students in Bachelor of Computer Science, Bachelor of Mathematics in Computer Mathematics, and Bachelor of Engineering in Communications Engineering.

Precludes additional credit for STAT 2655 and STAT 3502. Prerequisite(s): MATH 1007 or MATH 1004 or MATH 1002, and MATH 1104 or MATH 1107 (or MATH 1102).

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

#### **STAT 2606 [0.5 credit]**

##### **Business Statistics I**

Introduction to statistical computing; probability concepts; descriptive statistics; estimation and testing of hypotheses. Emphasis on the development of an ability to interpret results of statistical analyses with applications from business. Restricted to students in the School of Business. Precludes additional credit for BIT 2000, BIT 2100 (no longer offered), BIT 2300 (no longer offered), ECON 2201, ENST 2006, GEOG 2006, STAT 2507, and STAT 3502.

Prerequisite(s): MATH 1009 with a grade of C- or better, or permission of the School.

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

#### **STAT 2607 [0.5 credit]**

##### **Business Statistics II**

Topics include: experimental design, multiple regression and correlation analysis, covariance analysis, and introductory time series. Use of computer packages.

Restricted to students in the School of Business.

Precludes additional credit for STAT 2509, ECON 2202.

Prerequisite(s): STAT 2606.

Lectures three hours a week and one hour laboratory.

#### **STAT 2655 [0.5 credit]**

##### **Introduction to Probability with Applications (Honours)**

Axioms of probability, basic combinatorial analysis, conditional probability and independence, discrete and continuous random variables, joint and conditional distributions, expectation, central limit theorem, sampling distributions, simulation and applications to descriptive statistics. A statistical software package will be used.

Precludes additional credit for STAT 2605.

Prerequisite(s): one of MATH 1002 or MATH 2007 or MATH 1005 with a grade of C+ or better; and one of MATH 1102 or MATH 1107 or MATH 1104 with a grade of C+ or better.

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

**STAT 2660 [0.5 credit]****Mathematics for Finance (Honours)**

Interest rates, growth of money, discount functions, yield rates, time value of money, annuities, cash flows and portfolios, loans, mortgages, bonds, immunization, swaps, hedging and investment strategies, stocks and financial markets, arbitrage.

Prerequisite(s): i) one of MATH 1002 or MATH 2007 or MATH 1005, grade of C+ or higher; and ii) one of MATH 1102 or MATH 1107 or MATH 1104, grade of C+ or higher; or permission of the School.

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

**STAT 3502 [0.5 credit]****Probability and Statistics**

Axioms of probability; conditional probability and independence; random variables; distributions: binomial, Poisson, hypergeometric, normal, gamma; central limit theorem; sampling distributions; point estimation: maximum likelihood, method of moments; confidence intervals; testing of hypotheses: one and two populations; engineering applications: acceptance sampling, control charts, reliability.

Precludes additional credit for BIT 2000, BIT 2100 (no longer offered), BIT 2300 (no longer offered), ECON 2201, STAT 2507, STAT 2605, and STAT 2606.

Prerequisite(s): MATH 2004 and enrolment in the Faculty of Engineering or B.Sc. programs of the Department of Physics [except Double Honours Mathematics and Physics].

Lectures three hours a week and one hour laboratory.

**STAT 3503 [0.5 credit]****Regression Analysis**

Review of simple and multiple regression with matrices, Gauss-Markov theorem, polynomial regression, indicator variables, residual analysis, weighted least squares, variable selection techniques, nonlinear regression, correlation analysis and autocorrelation. Computer packages are used for statistical analyses.

Precludes additional credit for STAT 3553.

Prerequisite(s): i) STAT 2509 or STAT 2607, or ECON 2200, or ECON 2202, or equivalent; and ii) MATH 1102 or MATH 1107 or MATH 1109 or equivalent; or permission of the School.

Lectures three hours a week and one hour laboratory.

**STAT 3504 [0.5 credit]****Analysis of Variance and Experimental Design**

Single and multifactor analysis of variance, orthogonal contrasts and multiple comparisons, analysis of covariance; nested, crossed and repeated measures designs; completely randomized, randomized block, Latin squares, factorial experiments, related topics. Computer packages are used for statistical analyses.

Precludes additional credit for STAT 4504.

Prerequisite(s): STAT 3503 or permission of the School.

Lectures three hours a week and one hour laboratory.

**STAT 3506 [0.5 credit]****Stochastic Processes and Applications (Honours)**

Conditional probability and conditional expectation; Stochastic modeling; discrete time Markov chains including classification of states, stationary and limiting distributions; exponential distribution and the Poisson processes; queueing models; applications to computer systems, operations research and social sciences.

Prerequisite(s): STAT 2655 with a grade of C- or higher; or permission of the School.

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

**STAT 3507 [0.5 credit]****Sampling Methodology**

The sample survey as a vehicle for information collection in government, business, scientific and social agencies. Topics include: planning a survey, questionnaire design, simple random, stratified, systematic and cluster sampling designs, estimation methods, problem of non-response, related topics.

Prerequisite(s): one of STAT 2507, or STAT 2509, STAT 2606, STAT 2607, ECON 2200, ECON 2201 or ECON 2202 or equivalent; or permission of the School.

Lectures three hours a week and one hour laboratory.

**STAT 3508 [0.5 credit]****Elements of Probability Theory**

Discrete and continuous distributions, moment-generating functions, marginal and conditional distributions, transformation theory, limiting distributions.

Precludes additional credit for STAT 3558 and STAT 3608.

Prerequisite(s): i) MATH 2008 (or MATH 2004 or MATH 2009); and ii) one of STAT 2507, STAT 2606, ECON 2200, or ECON 2201 or permission of the School.

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

**STAT 3509 [0.5 credit]****Mathematical Statistics**

Point and interval estimation, sufficient statistics, hypothesis testing, chi-square tests with enumeration data. Precludes additional credit for STAT 3559.

Prerequisite(s): STAT 3508 or permission of the School.

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

**STAT 3553 [0.5 credit]****Regression Modeling (Honours)**

Linear regression - theory, methods and application(s). Normal distribution theory. Hypothesis tests and confidence intervals. Model selection. Model diagnostics. Introduction to weighted least squares and generalized linear models.

Precludes additional credit for STAT 3503.

Prerequisite(s): i) STAT 2559 with a grade of C- or higher, or STAT 2509 with a grade of B or higher; and ii) a grade of C- or higher in MATH 1102 or MATH 1107 or MATH 1104; or permission of the School.

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

**STAT 3558 [0.5 credit]****Elements of Probability Theory (Honours)**

Random variables and moment-generating functions, concepts of conditioning and correlation; laws of large numbers, central limit theorem; multivariate normal distribution; distributions of functions of random variables, sampling distributions, order statistics.

Precludes additional credit for STAT 3508 and STAT 3608.

Prerequisite(s): i) STAT 2655 with a grade of C- or higher; and ii) MATH 2000 with a grade of C- or higher, or (a grade of C+ or higher in MATH 2008 or MATH 2004, and permission of the instructor); or permission of the School. Lectures three hours a week, tutorial one hour a week.

**STAT 3559 [0.5 credit]****Mathematical Statistics (Honours)**

Empirical distribution functions, Monte Carlo methods, elements of decision theory, point estimation, interval estimation, tests of hypotheses, robustness, nonparametric methods.

Precludes additional credit for STAT 3509.

Prerequisite(s): STAT 3558 with a grade of C- or higher; or (STAT 3508 with a grade of B or higher, and permission of the instructor); or permission of the School.

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

**STAT 4500 [0.5 credit]****Parametric Estimation (Honours)**

Preliminaries on probability theory; exact and asymptotic sampling distributions; unbiasedness, consistency, efficiency, sufficiency and completeness; properties of maximum likelihood estimators; least squares estimation of location and scale parameters based on order statistics and sample quantiles; Best Asymptotically Normal (BAN) estimators.

Prerequisite(s): STAT 3559 or permission of the School.

Also offered at the graduate level, with different requirements, as STAT 5600, for which additional credit is precluded.

Lectures three hours a week.

**STAT 4501 [0.5 credit]****Probability Theory (Honours)**

Introduction to probability, characteristic functions, probability distributions, limit theorems.

Prerequisite(s): STAT 3506 and STAT 3558 or permission of the School.

Lectures three hours a week.

**STAT 4502 [0.5 credit]****Survey Sampling (Honours)**

Basic concepts in sampling from finite populations; simple random sampling; stratified sampling; choice of sampling unit; cluster and systematic sampling; introduction to multistage sampling; ratio estimation; sampling with unequal probabilities and with replacement; replicated sampling; related topics.

Prerequisite(s): i) STAT 2559 or STAT 2509; and ii) either STAT 3559, or a grade of C + or better in STAT 3509; or permission of the School.

Lectures three hours a week.

**STAT 4503 [0.5 credit]****Applied Multivariate Analysis (Honours)**

Selected topics in regression and correlation non-linear models. Multivariate statistical methods, principal components, factor analysis, multivariate analysis of variance, discriminant analysis, canonical correlation, analysis of categorical data.

Prerequisite(s): STAT 3553 or (STAT 3509 and STAT 3503) or permission of the School.

Also offered at the graduate level, with different requirements, as STAT 5509, for which additional credit is precluded.

Lectures three hours a week.

**STAT 4504 [0.5 credit]****Statistical Design and Analysis of Experiments (Honours)**

An extension of the designs discussed in STAT 2559 to include analysis of the completely randomized design, designs with more than one blocking variable, incomplete block designs, fractional factorial designs, multiple comparisons; and response surface methods.

Precludes additional credit for STAT 3504 and ECON 4706. PSYC 3000 is precluded for additional credit for students registered in a Mathematics program.

Prerequisite(s): STAT 3553 or STAT 3503; or permission of the School of Mathematics and Statistics.

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

**STAT 4506 [0.5 credit]****Nonparametric Methods (Honours)**

Order statistics; projections; U-statistics; L-estimators; rank, sign, and permutation test statistics; relative efficiency of tests; nonparametric tests of goodness-of-fit, homogeneity, symmetry, and independence and their efficiency; nonparametric density estimation, elements of nonparametric regression analysis.

Prerequisite(s): STAT 3559 or permission of the School.

Lectures three hours a week.

**STAT 4507 [0.5 credit]****Statistical Inference (Honours)**

Sufficient statistics, simple and composite hypotheses, most powerful and similar region tests, distribution-free tests, confidence intervals, goodness-of-fit and likelihood ratio tests, large sample theory, Bayesian and likelihood methods, sequential tests.

Prerequisite(s): STAT 4500 or permission of the School.

Also offered at the graduate level, with different requirements, as STAT 5501, for which additional credit is precluded.

Lectures three hours a week.

**STAT 4508 [0.5 credit]****Stochastic Models (Honours)**

Review of discrete Markov chains and Poisson processes; continuous time Markov chains; pure jump Markov processes, and birth and death processes including the Q-matrix approach; the Kolmogorov equations; renewal theory; introduction to Brownian motion; queueing theory. Prerequisite(s): STAT 3506 or permission of the School.

Also offered at the graduate level, with different requirements, as STAT 5701, for which additional credit is precluded.

Lectures three hours a week.

**STAT 4509 [0.5 credit]****Advanced Mathematical Modeling (Honours)**

Real-life situations in the physical, social, and life sciences are often modeled using mathematical tools. This course will examine various models and techniques used in their analysis, e.g., matrix procedures in connection with population models. Students will use a computer package to obtain numerical results.

Prerequisite(s): i) MATH 2454 and STAT 2655 (or MATH 2404 and STAT 2605) and ii) STAT 3506; or permission of the School.

Also offered at the graduate level, with different requirements, as STAT 5601, for which additional credit is precluded.

Lectures three hours a week.

**STAT 4555 [0.5 credit]****Monte Carlo Simulation (Honours)**

Basic ideas and algorithms of Monte Carlo; simulation of basic stochastic processes. Brownian motion and the Poisson process, applications to financial modelling, queueing theory. Output analysis; variance reduction. Markov chain Monte Carlo methods; Gibbs sampling, simulated annealing and Metropolis-Hastings samplers with applications.

Precludes additional credit for STAT 3555 (no longer offered).

Prerequisite(s): STAT 3558, or a grade of B or higher in STAT 3508, or permission of the School.

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

**STAT 4601 [0.5 credit]****Data Mining I (Honours)**

Data visualization; knowledge discovery in datasets; unsupervised learning: clustering algorithms; dimension reduction; supervised learning: pattern recognition, smoothing techniques, classification. Computer software will be used.

Prerequisite(s): STAT 3553 or STAT 3503 or MATH 3806, or permission of the School.

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

**STAT 4603 [0.5 credit]****Time Series and Forecasting (Honours)**

Time series regression. Nonstationary and stationary time series models. Nonseasonal and seasonal time series models. ARIMA (Box-Jenkins) models. Smoothing methods. Parameter estimation, model identification, diagnostic checking. Forecasting techniques. A statistical software package will be used.

Prerequisite(s): STAT 3553 or STAT 3503, or permission of the School.

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

**STAT 4604 [0.5 credit]****Statistical Computing (Honours)**

Statistical computing techniques, pseudo-random number generation, tests for randomness, numerical algorithms in statistics; optimization techniques; environments for data analysis, efficient programming techniques; statistics with mainstream software.

Prerequisite(s): STAT 3553 or STAT 3503 or permission of the School.

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