Mathematics and Statistics

This section presents the requirements for programs in:

- **Mathematics B. Math. Honours**
- **Mathematics with Concentration in Stochastics B. Math. Honours**
- **Computational and Applied Mathematics and Statistics with Concentration B.Math. Honours**
- **Concentration in Applied Analysis**
- **Concentration in Applied Statistics and Probability**
- **Concentration in Discrete Mathematics**
- **Statistics B. Math. Honours**
- **Statistics with Concentration in Actuarial Science B. Math. Honours**
- **Mathematics B. Math. General**
- **Computer Mathematics B. Math. General**
- **Statistics B. Math. General**
- **Computer Science and Mathematics: Concentration in Computing Theory and Numerical Methods B. Math. Combined Honours**
- **Computer Science and Mathematics: Concentration in Statistics and Computing B. Math. Combined Honours**
- **Mathematics and Physics B.Sc. Double Honours**
- **Economics and Mathematics B.Math. Combined Honours**
- **Economics and Statistics B.Math. Combined Honours**
- **Mathematics (Combined B.Math./M.Sc.) B.Math.**
- **Statistics (Combined B.Math./M.Sc.) B.Math.**
- **Minor in Mathematics**
- **Minor in Statistics**

Program Requirements

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 2007or 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 the following subject codes:

BIOC, BIOL, CHEM, ENSC, ERTH, 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 4002 [0.5]	Advanced Accounting Problems
Economics	
ECON 4005 [0.5]	Operations Research II
Geography	
GEOG 3102 [0.5]	Geomorphology
GEOG 3103 [0.5]	Watershed Hydrology
GEOG 3105 [0.5]	Climate and Atmospheric Change
GEOG 3108 [0.5]	Soil Properties
GEOG 4000/ ENST 4400 [0.5]	Field Studies
GEOG 4005/ ENST 4005 [0.5]	Directed Studies in Geography
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
Geomatics	
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
Psychology	
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

1. MATH 1805/COMP 1805 can be counted only as a half-credit free elective in Mathematics and Statistics programs.
2. 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, COMS 3001, CRCJ 3001,ECON 1401, ECON 1402, ECON 2201 (no longer offered), ECON 2202 (no longer offered),ECON 2210, ECON 2220, ECON 2400 (no longer offered), ECON 3001, ECON 4001, ECON 4002, ECON 4004, ECON 4025, ECON 4706, ECON 4707, ECON 4713, ECOR 2606, GEOG 2006, GEOG 3003, NEUR 2001, NEUR 2002, NEUR 3001, NEUR 3002, PSCI 2702, PSYC 2001, PSYC 2002, PSYC 3000 [1.0], SOCI 3000, SOCI 3002, SOCI 4009, SOWK 3001, SYSC 2510.
   Students who have completed ECON 2201 (no longer offered) and ECON 2202 (no longer offered) 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 (no longer offered) and ECON 2202 (no longer offered) is B- or higher in each.
3. BUSI 1402, BUSI 2402 and COMP 1001 may not count for credit in the Computer Mathematics Honours or General program, even as free electives.
4. 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)		
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. 3.5 credits in:		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)	
3. 2.0 credits in:		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)	
4. 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)	
5. 1.0 credit from 3000-level Honours Sequence		1.0
6. 1.5 credits in MATH or STAT at the 4000-level or higher		1.5
7. 0.5 credit in:		0.5

MATH 4905 [0.5]	Honours Project (Honours)	
B. Credits Not Included in the Major CGPA (8.5 credits)		
8. 4.0 credits not in MATH, STAT or COMP, consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
9. 4.5 credits in free electives		4.5
Total Credits		20.0

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

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

3. 3.0 credits in:		3.0
MATH 3001 [0.5]	Real Analysis 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)	
4. 0.5 credit from:		0.5
STAT 3553 [0.5]	Regression Modeling (Honours)	
MATH 3801 [0.5]	Linear Programming	
5. 0.5 credit in STAT at the 4000-level		0.5
6. 1.0 credit in MATH or STAT at the 4000-level or higher		1.0
Total Credits		5.0

Computational and Applied Mathematics and Statistics 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. 6.5 credits in one of the concentrations described below, also included in the Major CGPA:		6.5
3. 0.5 credit in:		0.5
MATH 4905 [0.5]	Honours Project (Honours)	
B. Credits Not Included in the Major CGPA (6.0 credits)		
4. 1.0 credit in Natural Science electives at the 1000 level or above		1.0
5. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		3.0
6. 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 Statistics (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	
3. 6.0 credits in:		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)	
4. 1.0 credit from:		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		
5. 0.5 credit from the 3000-level Honours Sequence or MATH or STAT at the 4000-level or higher		0.5
6. 1.5 credits in STAT at the 4000-level		1.5
B. Credits Not Included in the Major CGPA (7.5 credits)		
7. 4.0 credits not in MATH, STAT or COMP, consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
8. 3.5 credits in free electives		3.5
Total Credits		20.0

Statistics with Concentration in Actuarial Science
B. Math. Honours (20.0 credits)

A. Credits Included in the Major CGPA (13.0 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	
3. 6.5 credits in:		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)	
4. 1.0 credit from:		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		
5. 0.5 credit from the 3000-level Honours Sequence or MATH or STAT at the 4000-level or higher		0.5
6. 1.5 credits in:		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. Credits Not Included in the Major CGPA (7.0 credits):		
7. 3.0 credits in:		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	
8. 2.5 credits in:		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	
9. 1.0 credit in Natural Science electives		1.0
10. 0.5 credit in free electives		0.5
Total Credits		20.0

Mathematics
B. Math. General (15.0 credits)

A. Credits Included in the Major CGPA (7.5 credits)		
1. 0.5 credit in:		0.5
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
2. 1.0 credit in:		1.0
MATH 1007 [0.5]	Elementary Calculus I	
or MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 2007 [0.5]	Elementary Calculus II	
or MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
Note: MATH 1002 may replace MATH 1007 and MATH 2007.		
3. 1.0 credit in:		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	
Note: MATH 1102 may replace MATH 1107 and MATH 2107.		
4. 2.0 credits in:		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	
5. 3.0 credits from:		3.0
STAT 2509 [0.5]	Introduction to Statistical Modeling II	
MATH or STAT at the 3000-level or higher		
Excluding:		
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)		
6. 4.0 credits not in MATH, STAT or COMP, consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
7. 3.5 credits in free electives.		3.5
Total Credits		15.0

Computer Mathematics
B. Math. General (15.0 credits)

A. Credits Included in the Major CGPA (10.5 credits)		
1. 0.5 credit in:		1.5
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
2. 1.0 credit in:		
MATH 1007 [0.5]	Elementary Calculus I	
or MATH 1004 [0.5]	Calculus for Engineering or Physics	
and		
MATH 2007 [0.5]	Elementary Calculus II	
or MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
Note: MATH 1002 may replace MATH 1007 and MATH 2007.		
3. 1.0 credit in:		1.0
MATH 1107 [0.5]	Linear Algebra I	
or MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
and		
MATH 2107 [0.5]	Linear Algebra II	
Note: MATH 1102 may replace MATH 1107 and MATH 2107.		
4. 2.5 credits in:		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	
5. 2.5 credits in:		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	
6. 0.5 credit from:		0.5
MATH 2108 [0.5]	Abstract Algebra I	
MATH 3101 [0.5]	Algebraic Structures with Computer Applications	
7. 1.0 credit from:		1.0
MATH 3801 [0.5]	Linear Programming	
MATH 3802 [0.5]	Combinatorial Optimization	
MATH 3800 [0.5]	Mathematical Modeling and Computational Methods	
MATH 3807 [0.5]	Mathematical Software (Honours)	
MATH 3809 [0.5]	Introduction to Number Theory and Cryptography	
8. 1.0 credit in MATH or STAT at the 3000 level		1.0
9. 0.5 credit in MATH or STAT at the 2000 level or higher		0.5
B. Credits Not Included in the Major CGPA (4.5 credits)		
10. 4.0 credits not in MATH, STAT or COMP, consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
11. 0.5 credit in free electives.		0.5
Total Credits		15.0

Statistics
B. Math. General (15.0 credits)

A. Credits Included in the Major CGPA (7.5 credits)		
1. 0.5 credit in:		0.5
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
2. 1.0 credit in:		1.0
MATH 1007 [0.5]	Elementary Calculus I	
or MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 2007 [0.5]	Elementary Calculus II	
or MATH 1005 [0	Differential Equations and Infinite Series for Engineering or Physics	
Note: MATH 1002 may replace MATH 1007 and MATH 2007.		
3. 1.0 credit in:		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	
Note: MATH 1102 may replace MATH 1107 and MATH 2107.		
4. 4.0 credits in:		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	
5. 0.5 credit from:		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	
6. 0.5 credit in MATH or STAT at the 2000 level		0.5
B. Credits Not Included in the Major CGPA (7.5 credits)		
7. 4.0 credits not in MATH, STAT or COMP, consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
8. 3.5 credits in free electives.		3.5
Total Credits		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)		
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 in Computing Theory and Numerical Methods		
4. 3.0 credits from:		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	
5. 0.5 credit from:		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)	
6. 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 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)	
7. 0.5 credit in COMP at the 3000 level or above.		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. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
Total Credits		20.0

Note:

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

Business	
BUSI 2400 [0.5]	Foundations of Information Systems
BUSI 4400 [0.5]	IS Strategy, Management and Acquisition
BUSI 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. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives	
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] & PHYS 1002 [0.5]	Foundations of Physics I Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I 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	
6. 3.0 credits in:		3.0
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	
7. 1.0 credit in PHYS at the 4000-level		1.0
8. 1.0 credit from:		1.0
a. MATH 4905 or PHYS 4907 or PHYS 4908 plus 0.5 credit 4000-level MATH or PHYS		
b. PHYS 4909 [1.0]		
B. Credits Not Included in the Major CGPA (4.5 credits)		
9. 1.0 credit from:		1.0
BIOL 1103 [0.5] & BIOL 1104 [0.5]	Foundations of Biology I Foundations of Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I Elementary Chemistry II	
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth The Earth System Through Time	
10. 0.5 credit in:		0.5
COMP 1005 [0.5]	Introduction to Computer Science I	
11. 0.5 credit from:		0.5
NSCI 1000 [0.5]	Seminar in Science	
Approved courses outside the faculties of Science and Engineering and Design		
12. 1.5 credits in approved courses outside the faculties of Science and Engineering and Design		1.5
13. 1.0 credit in free electives		1.0
Total Credits		21.5

Economics and Mathematics
B.Math. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (15.5 credits)		
1. 7.5 credits in:		7.5
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
MATH 1102 [1.0]	Algebra I	
MATH 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)	
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 in:**		0.5
	MATH 4905 [0.5]	Honours Project (Honours)	
4.	**1.0 credit in** MATH or STAT at the 4000-level		1.0
5.	**4.0 credits in:**		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	
6.	**2.0 credits in** ECON at the 4000-level		2.0
B. Credits Not Included in the Major CGPA (4.5 credits)			
8.	**1.0 credit in:**		1.0
	COMP 1005 [0.5]	Introduction to Computer Science I	
	COMP 1006 [0.5]	Introduction to Computer Science II	
9.	**1.0 credit in** Natural Science Electives		1.0
10.	**2.5 credits in** free electives		2.5
Total Credits			20.0

Notes:

1. An Honours Essay (ECON 4908 [1.0]) may be written by students with Overall and Major CGPAS of 9.50 or higher. In cases where a grade of B- or higher is earned on this essay, it may count for 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 Undergraduate Supervisor.
2. The following courses do not count for credit in this program: ECON 1401, ECON 1402, ECON 2201 (no longer offered), ECON 2202 (no longer offered), ECON 2210, ECON 2220, ECON 2400 (no longer offered), ECON 3001, ECON 4001, ECON 4002, ECON 4004, ECON 4025, ECON 4706, ECON 4707, and ECON 4713.

Economics and Statistics
B.Math. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (15.5 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 2454 [0.5]	Ordinary Differential Equations (Honours)	
	STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	
	STAT 2559 [0.5]	Basics of Statistical Modeling (Honours)	
	MATH 3107 [0.5]	Linear Algebra III	
	STAT 3506 [0.5]	Stochastic Processes and Applications (Honours)	
	STAT 3553 [0.5]	Regression Modeling (Honours)	
	STAT 3558 [0.5]	Elements of Probability Theory (Honours)	
	STAT 3559 [0.5]	Mathematical Statistics (Honours)	
	STAT 4502 [0.5]	Survey Sampling (Honours)	
	STAT 4503 [0.5]	Applied Multivariate Analysis (Honours)	
2.	**0.5 credit in:**		0.5
	MATH 4905 [0.5]	Honours Project (Honours)	
3.	**0.5 credit in** STAT at the 4000-level		0.5
4.	**4.0 credits in:**		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	
5.	**2.0 credits in** ECON at the 4000-level		2.0
B. Credits Not Included in the Major CGPA (4.5 credits)			
6.	**1.0 credit in:**		1.0
	COMP 1005 [0.5]	Introduction to Computer Science I	
	COMP 1006 [0.5]	Introduction to Computer Science II	
7.	**1.0 credit in** Natural Science Electives		1.0
8.	**2.5 credits in** free electives		2.5
Total Credits			20.0

Notes:

1. An Honours Essay (ECON 4908 [1.0] may be written by students with Overall and Major CGPAs of 9.50 or higher. In cases where a grade of B- or higher is earned on this essay, it may count for 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 Undergraduate Supervisor.
2. MATH 2100 [1.0] may replace MATH 3107 and 0.5 credit in free electives in this program.
3. The following courses do not count for credit in this program: ECON 1401, ECON 1402, ECON 2201 (no longer offered), ECON 2202 (no longer offered), ECON 2210, ECON 2220, ECON 2400 (no longer offered), ECON 3001, ECON 4001, ECON 4002,

ECON 4004, ECON 4025, ECON 4706, ECON 4707, and ECON 4713.

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. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
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)	
2. 1.5 credits in MATH or STAT at the 4000 level or above		1.5
B. Credits Not Included in the Major CGPA (5.0 credits)		
3. 4.0 credits not in MATH, STAT, or COMP consisting of:		4.0
a. 1.0 credit in Natural Science Electives		
b. 3.0 credits from Natural Science, or Approved Arts and Social Sciences electives		
4. 1.0 credit 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.

5. 1.5 credits at the 5000-level or higher in MATH or STAT	1.5
6. 1.0 credit at the 5000-level or higher in mathematics or statistics or from another department or school	1.0
7. Either:	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

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

1. 1.0 credit from:		1.0
MATH 1007 [0.5] & MATH 2007 [0.5]	Elementary Calculus I Elementary Calculus II	
or		
MATH 1004 [0.5] & MATH 1005 [0.5]	Calculus for Engineering or Physics Differential Equations and Infinite Series for Engineering or Physics	
or		
MATH 1002 [1.0]	Calculus and Introductory Analysis I	
2. 1.0 credit from:		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	
or		
MATH 1102 [1.0]	Algebra I	
3. 0.5 credit from:		1.0
MATH 1800 [0.5]	Introduction to Mathematical Reasoning	
or		
0.5 credit in MATH at 2000-level		
4. 1.0 credit in MATH at the 2000-level or higher		1.0
5. 0.5 credit in MATH at the 3000-level or higher		
6. The remaining requirements of the major discipline(s) and degree must be satisfied.		
Total Credits		4.0

Note: As a prerequisite, MATH 1800 opens more options at the 2000-level and above. It is recommended that students taking MATH 1800 do so as early as possible.

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:

1. 0.5 credit from:		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	
2. 0.5 credit from:		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	
3. 1.0 credit from:		1.0
STAT 2507 [0.5] & STAT 2509 [0.5]	Introduction to Statistical Modeling I Introduction to Statistical Modeling II	
or		
STAT 3502 [0.5] & STAT 2509 [0.5]	Probability and Statistics Introduction to Statistical Modeling II	
or		
STAT 2606 [0.5] & STAT 2607 [0.5]	Business Statistics I Business Statistics II	
or		
ECON 2210 [0.5] & ECON 2220 [0.5]	Introductory Statistics for Economics Introductory Econometrics	
4. 1.5 credits in:		1.5
STAT 3503 [0.5]	Regression Analysis	
STAT 3504 [0.5]	Analysis of Variance and Experimental Design	
STAT 3507 [0.5]	Sampling Methodology	
5. 0.5 credit from:		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:

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

Regulations

In addition to the program requirements described here 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.

Academic Performance Evaluation

Bachelor of Mathematics

The standard procedures for Academic Performance Evaluation are followed with the following additions:

Good Standing at any Academic Performance Evaluation requires that the CGPA over the following courses be at least 7.00 for Honours programs and at least 5.00 for General programs:

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

B.Sc. Regulations

The regulations presented in this section apply to all Bachelor of Science programs. In addition to the requirements presented here, students must satisfy the University regulations common to all undergraduate students including the process of Academic Performance Evaluation (see the *Academic Regulations of the University* section of this Calendar).

Breadth Requirement for the B.Sc.

Students in Bachelor of Science Honours, Major, or General programs must present the following credits at graduation:

1. 2.0 credits in Science Continuation courses not in the major discipline; **students completing a double major are considered to have completed this requirement providing they have 2.0 credits in science continuation courses in each of the two majors**
2. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000)

In most cases, the requirements for individual B.Sc. programs, as stated in this Calendar, contain these requirements, explicitly or implicitly.

Students admitted to B.Sc. programs by transfer from another institution must present at graduation (whether taken at Carleton or elsewhere):

1. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000) if, on transfer, the student received credit for fewer than 10.0 credits.
2. 1.0 credit in courses outside of the faculties of Science and Engineering and Design (but may include NSCI 1000) if, on transfer, the student received credit for 10.0 or more credits.

Declared and Undeclared Students

Students who are registered in a program within the degree are called Declared students. Most students designate a program of study when they first apply for admission and so begin their studies as Declared students. Students may also choose to begin their studies within the B.Sc. degree without being registered in a program. These students are referred to as Undeclared students. The recommended course pattern for Undeclared students is provided in the Undeclared entry of the Programs section of this Calendar. Undeclared students normally must apply to enter a program before beginning their second year of study. The Science Student Success Centre (SSSC) provides Undeclared students guidance to the appropriate support services in making this decision.

Change of Program within the B.Sc. Degree

Students may transfer to a program within the B.Sc. degree if upon entry to the new program they would be in good academic standing.

Other applications for change of program will be considered on their merits; students may be accepted in the new program in *Good Standing* or on *Academic Warning*.

Applications to declare or change their program within the B.Sc. Degree must be made online through Carleton Central by completing a Change of Program Elements (COPE) application form within the published deadlines. Acceptance into a program or into a program element or option is subject to any enrolment, and/or specific program, program element or option requirements as published in the relevant Calendar entry.

Minors, Concentrations and Specializations

Students may add a minor, concentration or specialization by completing a Change of Program Elements (COPE) application form online through Carleton Central. Acceptance into a minor, concentration or specialization requires that the student be in *Good Standing* and is subject to any specific requirements of the intended

Minor, Concentration or Specialization as published in the relevant Calendar entry.

Experimental Science Requirement

Students in B.Sc. Honours, Major, or General degree programs must present at graduation at least two full credits of experimental science chosen from two different departments or institutes from the list below:

Approved Experimental Science Courses

Biochemistry	
BIOC 2200 [0.5]	Cellular Biochemistry
BIOC 4001 [0.5]	Methods in Biochemistry
BIOC 4201 [0.5]	Advanced Cell Culture and Tissue Engineering
Biology	
BIOL 1103 [0.5]	Foundations of Biology I
BIOL 1104 [0.5]	Foundations of Biology II
BIOL 2001 [0.5]	Animals: Form and Function
BIOL 2002 [0.5]	Plants: Form and Function
BIOL 2104 [0.5]	Introductory Genetics
BIOL 2200 [0.5]	Cellular Biochemistry
BIOL 2600 [0.5]	Introduction to Ecology
Chemistry	
CHEM 1001 [0.5]	General Chemistry I
CHEM 1002 [0.5]	General Chemistry II
CHEM 1005 [0.5]	Elementary Chemistry I
CHEM 1006 [0.5]	Elementary Chemistry II
CHEM 2103 [0.5]	Physical Chemistry I
CHEM 2203 [0.5]	Organic Chemistry I
CHEM 2204 [0.5]	Organic Chemistry II
CHEM 2206 [0.5]	Organic Chemistry IV
CHEM 2302 [0.5]	Analytical Chemistry I
CHEM 2303 [0.5]	Analytical Chemistry II
CHEM 2800 [0.5]	Foundations for Environmental Chemistry
Earth Sciences	
ERTH 1006 [0.5]	Exploring Planet Earth
ERTH 1009 [0.5]	The Earth System Through Time
ERTH 2102 [0.5]	Mineralogy to Petrology
ERTH 2404 [0.5]	Engineering Geoscience
ERTH 2802 [0.5]	Field Geology I
ERTH 3111 [0.5]	Vertebrate Evolution II
ERTH 3112 [0.5]	Vertebrate Evolution I
ERTH 3204 [0.5]	Mineral Deposits
ERTH 3205 [0.5]	Physical Hydrogeology
ERTH 3806 [0.5]	Structural Geology
Food Sciences	
FOOD 3001 [0.5]	Food Chemistry
FOOD 3002 [0.5]	Food Analysis
FOOD 3005 [0.5]	Food Microbiology
Geography	
GEOG 1010 [0.5]	Global Environmental Systems
GEOG 3108 [0.5]	Soil Properties
Neuroscience	
NEUR 3206 [0.5]	Sensory and Motor Neuroscience
NEUR 3207 [0.5]	Integrative Neuroscience
NEUR 4600 [0.5]	Advanced Lab in Neuroanatomy
Physics	
PHYS 1001 [0.5]	Foundations of Physics I
PHYS 1002 [0.5]	Foundations of Physics II
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion
PHYS 1007 [0.5]	Elementary University Physics I
PHYS 1008 [0.5]	Elementary University Physics II
PHYS 2202 [0.5]	Wave Motion and Optics
PHYS 2604 [0.5]	Modern Physics I
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars
PHYS 3606 [0.5]	Modern Physics II
PHYS 3608 [0.5]	Modern Applied Physics

Course Categories for B.Sc. Programs

Science Geography Courses

GEOG 1010 [0.5]	Global Environmental Systems
GEOG 2006 [0.5]	Introduction to Quantitative Research
GEOG 2013 [0.5]	Weather and Water
GEOG 2014 [0.5]	The Earth's Surface
GEOG 3003 [0.5]	Quantitative Geography
GEOG 3010 [0.5]	Field Methods in Physical Geography
GEOG 3102 [0.5]	Geomorphology
GEOG 3103 [0.5]	Watershed Hydrology
GEOG 3104 [0.5]	Principles of Biogeography
GEOG 3105 [0.5]	Climate and Atmospheric Change
GEOG 3106 [0.5]	Aquatic Science and Management
GEOG 3108 [0.5]	Soil Properties
GEOG 4000 [0.5]	Field Studies
GEOG 4005 [0.5]	Directed Studies in Geography
GEOG 4013 [0.5]	Cold Region Hydrology
GEOG 4017 [0.5]	Global Biogeochemical Cycles
GEOG 4101 [0.5]	Two Million Years of Environmental Change
GEOG 4103 [0.5]	Water Resources Engineering
GEOG 4104 [0.5]	Microclimatology
GEOG 4108 [0.5]	Permafrost

Science Psychology Courses

PSYC 2001 [0.5]	Introduction to Research Methods in Psychology
PSYC 2002 [0.5]	Introduction to Statistics in Psychology
PSYC 2700 [0.5]	Introduction to Cognitive Psychology
PSYC 3000 [1.0]	Design and Analysis in Psychological Research
PSYC 3506 [0.5]	Cognitive Development
PSYC 3700 [1.0]	Cognition (Honours Seminar)
PSYC 3702 [0.5]	Perception
PSYC 2307 [0.5]	Human Neuropsychology I
PSYC 3307 [0.5]	Human Neuropsychology II

Science Continuation Courses

A course at the 2000 level or above may be used as a Science Continuation credit in a B.Sc. program if it is not in the student's major discipline, and is chosen from the following:

- BIOC (Biochemistry)
- BIOL (Biology)
- CHEM (Chemistry)
- COMP (Computer Science) A maximum of two half-credits at the 1000-level in COMP, excluding COMP 1001 may be used as Science Continuation credits.
- ERTH (Earth Sciences), except ERTH 2415 which may be used only as a free elective for any B.Sc. program. Students in Earth Sciences programs may use ERTH 2401, ERTH 2402, and ERTH 2403 only as free electives.
- Engineering. Students wishing to register in Engineering courses must obtain the permission of the Faculty of Engineering and Design.
- ENSC (Environmental Science)
- FOOD (Food Science and Nutrition)
- GEOM (Geomatics)
- HLTH (Health Sciences)
- MATH (Mathematics)
- NEUR (Neuroscience)
- PHYS (Physics), except PHYS 2903
- Science Geography Courses (see list above)
- Science Psychology Courses (see list above)
- STAT (Statistics)
- TSES (Technology, Society, Environment) except TSES 2305. Biology General, Major, and Honours students may use these courses only as free electives. Integrated Science and Environmental Science students may include these courses in their programs but may not count them as part of the Science Sequence.

Science Faculty Electives

Science Faculty Electives are courses at the 1000-4000 level chosen from:

- BIOC (Biochemistry)
- BIOL (Biology) Biology & Biochemistry students may use BIOL 1010 and BIOL 2005 only as free electives
- CHEM (Chemistry) except CHEM 1003, CHEM 1004 and CHEM 1007
- COMP (Computer Science) except COMP 1001
- ERTH (Earth Sciences) except ERTH 1010, ERTH 1011 and ERTH 2415. Earth Sciences students may use ERTH 2401, ERTH 2402, and ERTH 2403 only as free electives.
- Engineering
- ENSC 2001
- FOOD (Food Science and Nutrition)
- GEOM (Geomatics)
- HLTH (Health Science)
- MATH (Mathematics)
- NEUR (Neuroscience)
- PHYS (Physics) except PHYS 1901, PHYS 1902, PHYS 1905, PHYS 2903
- Science Geography (see list above)
- Science Psychology (see list above)
- STAT (Statistics)
- TSES (Technology, Society, Environment) Biology General, Major and Honours students may use these courses only as free electives.

Advanced Science Faculty Electives

Advanced Science Faculty Electives are courses at the 2000-4000 level chosen from the Science Faculty Electives list above.

Approved Courses Outside the Faculties of Science and Engineering and Design (may include NSCI 1000)

All courses offered by the Faculty of Arts and Social Sciences, the Faculty of Public Affairs, and the Sprott School of Business are approved as Arts or Social Sciences courses EXCEPT FOR: All Science Geography courses (see list above), all Geomatics (GEOM) courses, all Science Psychology courses (see list above). NSCI 1000 may be used as an Approved Course Outside the Faculties of Science and Engineering and Design.

Free Electives

Any course is allowable as a Free Elective providing it is not prohibited (see below). Students are expected to comply with prerequisite requirements and enrolment restrictions for all courses as published in this Calendar.

Courses Allowable Only as Free Electives in any B.Sc. Program

CHEM 1003 [0.5]	The Chemistry of Food, Health and Drugs
CHEM 1004 [0.5]	Drugs and the Human Body
CHEM 1007 [0.5]	Chemistry of Art and Artifacts
ERTH 1010 [0.5]	Our Dynamic Planet Earth
ERTH 1011 [0.5]	Evolution of the Earth
ERTH 2415 [0.5]	Natural Disasters
ISCI 1001 [0.5]	Introduction to the Environment
ISCI 2000 [0.5]	Natural Laws
ISCI 2002 [0.5]	Human Impacts on the Environment
MATH 0107 [0.5]	Algebra and Geometry
PHYS 1901 [0.5]	Planetary Astronomy
PHYS 1902 [0.5]	From our Star to the Cosmos
PHYS 1905 [0.5]	How Things Work: Physics in Everyday Life
PHYS 2903 [0.5]	Physics and the Imagination

Prohibited Courses

The following courses are not acceptable for credit in any B.Sc. program:

COMP 1001 [0.5]	Introduction to Computational Thinking for Arts and Social Science Students
MATH 0005 [0.5]	Precalculus: Functions and Graphs
MATH 0006 [0.5]	Precalculus: Trigonometric Functions and Complex Numbers
MATH 1009 [0.5]	Calculus: with Applications to Business
MATH 1119 [0.5]	Linear Algebra: with Applications to Business
MATH 1401 [0.5]	Elementary Mathematics for Economics I
MATH 1402 [0.5]	Elementary Mathematics for Economics II

Co-operative Education

For more information about how to apply for the Co-op program and how the Co-op program works please visit the Co-op website.

All students participating in the Co-op program are governed by the Undergraduate Co-operative Education Policy.

Undergraduate Co-operative Education Policy

Admission Requirements

Students can apply to co-op in one of two ways; directly from high school or after beginning a degree program at Carleton.

If a student is admitted to co-op from high school, their grades will be reviewed two terms to one year prior to their first work term to ensure they continue to meet the academic requirements after their 1st or 2nd year of study. The time at which evaluation takes place depends on the program of study. Students will automatically be notified via their Carleton email account if they are permitted to continue.

Students not admitted to Carleton University with the co-op option on their degree can apply for admission via the co-operative education program website. To view application deadlines, visit carleton.ca/co-op.

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

English Language Proficiency

Students admitted to Carleton based on CAEL, IELTS or TOEFL assessments and who are required to take an ESL course must take and pass the Oral Proficiency in Communicative Settings (OPECS) Test. The test must be taken before being permitted to register in COOP 1000. Admission to the co-op program can be confirmed with a minimum score of 4+.

Participation Requirements

COOP 1000

Once a student has been given admission or continuation confirmation to the co-op option s/he must complete and pass COOP 1000 (a mandatory online 0.0 credit course). Students will have access to this course a minimum of two terms prior to their first work term and will be notified when to register.

Communication with the Co-op Office

Students must maintain contact with the co-op office during their job search and while on a work term. All email communication will be conducted via the students' Carleton email account.

Employment

Although every effort is made to ensure a sufficient number of job postings for all students enrolled in the co-op option of their degree program, no guarantee of employment can be made. Carleton's co-op program operates a competitive job search process and is dependent upon current market conditions. Academic performance, skills, motivation, maturity, attitude and potential will determine whether a student is offered a job. It is the student's responsibility to actively conduct a job search in addition to participation in the job search process operated by the co-op office. Once a student accepts a co-op job offer (verbally or written), his/her job search will end and access to co-op jobs will be removed for that term. Students that do not successfully obtain a co-op work term are expected to continue with their academic studies. The summer term is the exception to this rule. Students should also note that hiring priority is given to Canadian citizens for co-op positions in the Federal Government of Canada.

Registering in Co-op Courses

Students will be registered in a Co-op Work Term course while at work. The number of Co-op Work Term courses that a student is registered in is dependent upon the number of four-month work terms that a student accepts.

While on a co-op work term students may take a maximum of 0.5 credit throughout each four-month co-op work term. Courses must be scheduled outside of regular working hours.

Students must be registered as full-time before they begin their co-op job search (2.0 credits). All co-op work terms must be completed before the beginning of the final academic term. Students may not finish their degree on a co-op work term.

Work Term Assessment and Evaluation

To obtain a Satisfactory grade for the co-op work term students must have:

1. A satisfactory work term evaluation by the co-op employer;
2. A satisfactory grade on the work term report.

Students must submit a work term report at the completion of each four-month work term. Reports are due on the 16th of April, August, and December and students are notified of due dates through their Carleton email account.

Workplace performance will be assessed by the workplace supervisor. Should a student receive an unsatisfactory rating from their co-op employer, an investigation by the co-op program manager will be undertaken. An unsatisfactory employer evaluation does not preclude a student from achieving an overall satisfactory rating for the work term.

Graduation with the Co-op Designation

In order to graduate with the co-op designation, students must satisfy all requirements for their degree program in addition to the requirements according to each co-op program (i.e. successful completion of three or four work terms).

Note: Participation in the co-op option will add up to one additional year for a student to complete their degree program.

Voluntary Withdrawal from the Co-op Option

Students may withdraw from the co-op option of their degree program during a study term ONLY. Students at work may not withdraw from the work term or the co-op option until s/he has completed the requirements of the work term.

Students are eligible to continue in their regular academic program provided that they meet the academic standards required for continuation.

Involuntary or Required Withdrawal from the Co-op Option

Students may be required to withdraw from the co-op option of their degree program for one or any of the following reasons:

1. Failure to achieve a grade of SAT in COOP 1000
2. Failure to pay all co-op related fees
3. Failure to actively participate in the job search process
4. Failure to attend all interviews for positions to which the student has applied
5. Declining more than one job offer during the job search process
6. Continuing a job search after accepting a co-op position
7. Dismissal from a work term by the co-op employer
8. Leaving a work term without approval by the Co-op manager
9. Receipt of an unsatisfactory work term evaluation
10. Submission of an unsatisfactory work term report

Standing and Appeals

The Co-op and Career Services office administers the regulations and procedures that are applicable to all co-op program options. All instances of a student's failure during a work term or other issues directly related to their participation in the co-op option will be reported to the academic department.

Any decision made by the Co-op and Career Services office can be appealed via the normal appeal process within the University.

International Students

All International Students are required to possess a Co-op Work Permit issued by Citizenship and Immigration Canada before they can begin working. It is illegal to work in Canada without the proper authorization. Students will be provided with a letter of support to accompany their application. Students must submit their application for their permit before being permitted to view and apply for jobs on the Co-op Services database. Confirmation of a position will not be approved until a student can confirm they have received their permit. Students are advised to discuss the application process and requirements with the International Student Services Office.

Bachelor of Mathematics Honours, Combined B.Math./M.Sc.: Co-op Admission and Continuation Requirements

- Maintain full-time status in each study term (2.0 credits);
- Be eligible to work in Canada (for off-campus work)
- Have successfully completed COOP 1000 [0.0]

In addition to:

Students in any of these programs (excluding Biostatistics) must satisfy the following:

1. Completion of 5.0 or more credits (at least 2.0 in Mathematics/Statistics) at Carleton in any Honours program (excluding Biostatistics), or the Combined B.Math./M.Sc. ("Fast Track") programs, offered by the School of Mathematics and Statistics
2. A major CGPA of 8.00 or higher and an overall CGPA of 6.50 or higher

Students in the B.Math. (Combined Honours) Biostatistics program must satisfy the following:

1. Full-time student in the B.Math. Biostatistics program;
2. An overall CGPA of 8.00 or higher;
3. Successfully completed all required first year courses before beginning the first work term
4. Students must be eligible for third-year standing when they return for a study term after their first work term.

Students in these programs must successfully complete four (4) work terms to obtain the co-op designation.

Co-op Work Term Course: MATH 3999

Work/Study Pattern:

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	**Pattern**	**Term**	**Pattern**	**Term**	**Pattern**	**Term**	**Pattern**	**Term**	**Pattern**
Fall	S	Fall	S	Fall	S	Fall	*W/S	Fall	S
Winter	S	Winter	S	Winter	S	Winter	*W/S	Winter	S
Summer	**O/W	Summer	*W	Summer	O/W	Summer	O/W		

Legend
S: Study
W: Work
O: Optional
***** indicates recommended work study pattern
****** student finds own employer for this work-term.

Admissions Information

Admission Requirements are for the 2018-2019 year only, and are based on the Ontario High School System. Holding the minimum admission requirements only establishes eligibility for consideration. The cut-off averages for admission may be considerably higher than the minimum. See also the **General Admission and Procedures** section of this Calendar. An overall average of at least 70% is normally required to be considered for admission. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. The overall average required

for admission is determined each year on a program by program basis. Consult admissions.carleton.ca for further details.

Note: Courses listed as *recommended* are not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Degree

- Bachelor of Mathematics (B. Math.) (Honours)
- Bachelor of Mathematics (B.Math.) (General)

Admission Requirements

Honours Program

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include two prerequisite courses (Advanced Functions and Calculus and Vectors).

The overall admission cut-off average and/or the prerequisite course average may be considerably higher than the stated minimum requirements for admission to the combined B.Math/M.Sc in Mathematics or Statistics.

Advanced Standing

Applications for admission beyond first year will be assessed on their individual merits. Applicants must normally be in Good Standing (see Undergraduate Calendar section 7.0 - Academic Regulations) for their year level. Advanced standing will be granted only for those subjects assessed as being appropriate for the program and the stream selected.

General Program

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include two prerequisite courses (Advanced Functions and Calculus and Vectors). Equivalent courses may be substituted between the old and new Ontario mathematics curriculum.

Advanced Standing

Applications for admission beyond first year will be assessed on their individual merits. Applicants must normally be in Good Standing (see Undergraduate Calendar section 7.0 - Academic Regulations) for their year level. Advanced standing will be granted only for those subjects assessed as being appropriate for the program and the stream selected.

Co-op Option

Direct Admission to the First Year of the Co-op Option

Applicants must:

1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Bachelor of Mathematics Honours program;
3. be eligible to work in Canada (for off-campus work placements).

Meeting the above requirements only establishes eligibility for admission to the program. The prevailing job market (and thus the availability of co-op placement) may limit enrolment in the co-op option.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.

Admissions Information

Admission Requirements are for the 2018-2019 year only, and are based on the Ontario High School System. Holding the minimum admission requirements only establishes eligibility for consideration. The cut-off averages for admission may be considerably higher than the minimum. See also the **General Admission and Procedures** section of this Calendar. An overall average of at least 70% is normally required to be considered for admission. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. The overall average required for admission is determined each year on a program by program basis. Consult admissions.carleton.ca for further details.

Note: Courses listed as *recommended* are not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Degrees

- B.Sc. (Honours)
- B.Sc. (General)
- B.Sc. (Major)

Admission Requirements

Honours Program

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. For most programs including Bioinformatics, Biology, Biochemistry, Biotechnology, Chemistry, combined Honours in Biology and Physics, Chemistry and Physics, Computational Biochemistry, Food Science and Nutrition, Neuroscience, Neuroscience and Mental Health, Nanoscience and Psychology, the six 4U or M courses must include Advanced Functions and two of Biology, Chemistry, Earth and Space Sciences or Physics. (Calculus and Vectors is strongly recommended).

Specific Honours Admission Requirements

For the Honours programs in Environmental Science, Geography, Geomatics and Earth Sciences, Calculus and Vectors may be substituted for Advanced Functions.

For the Honours programs in Physics and Applied Physics and for double Honours in Mathematics and Physics, Calculus and Vectors is required in addition to Advanced Functions and one of 4U Physics Chemistry, Biology, or Earth and Space Sciences. For all programs in Physics, 4U Physics is strongly recommended.

For the Combined Honours program in Chemistry and Computer Science, 4U Chemistry and Calculus and Vectors are strongly recommended.

For Honours in Psychology, a 4U course in English is recommended.

For Honours in Environmental Science, a 4U course in Biology and Chemistry is recommended.

Advanced Standing

For entry to an Honours program after the completion of 5.0 included credits, a student must have a major CGPA of 5.50 or higher, an overall CGPA of 4.50 or higher and the recommendation of the Honours department or committee. A student beginning the final 10.0 credits towards an Honours degree must present a major CGPA of 6.00 or higher, an overall CGPA of 5.00 or higher and the recommendation of the Honours department or committee. A student beginning the final 5.0 credits towards an Honours degree must present a major CGPA of 6.50 or higher and an overall CGPA of 5.00 or higher, as calculated for graduation. Advanced standing will be granted for studies undertaken elsewhere when these are recognized as the equivalent of subjects offered at Carleton University.

Major Program

General Program

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include Advanced Functions and two of Calculus and Vectors, Biology, Chemistry, Earth and Space Science or Physics (Calculus and Vectors is strongly recommended). For the B.Sc. Major in Physics. 4U Physics is strongly recommended. Equivalent courses may be substituted between the old and new Ontario mathematics curriculum.

Advanced Standing

For entry to a General or Major program after the completion of 5.0 included credits, a student must have a major and core CGPA of 3.50 or higher and an overall CGPA of 3.50 or higher. A student beginning the final 5.0 credits towards a General or Major degree must present a major and core CGPA of 4.00 or higher and an overall CGPA of 4.00 or higher, as calculated for graduation. Advanced standing will be granted for studies undertaken elsewhere when these are recognized as the equivalent of subjects offered at Carleton University.

Co-op Option

Direct Admission to the First Year of the Co-op Option

Applicants must:

1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Bachelor of Science Honours program;
3. be eligible to work in Canada (for off-campus work placements).

Note that meeting the above requirements only establishes eligibility for admission to the program. The prevailing job market may limit enrolment in the co-op option.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.

Mathematics (MATH) Courses

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 2007, MATH 1004, MATH 1005, MATH 1007, MATH 1009, and MATH 2007.
Prerequisite(s): i) 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 at least B in each; or equivalents; and ii) MATH 1800 (may be taken concurrently); 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, BIT 2007, 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): i) 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; and ii) MATH 1800 (may be taken concurrently); 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 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 1200, 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.
Also listed as ECON 1402.
Precludes additional credit for BIT 1000, BIT 1001, BIT 1100, BIT 1101, BIT 1200, 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 with a grade of C+ or higher; or permission of the School.
Lectures three hours a week, tutorial one hour a week.

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 2007, 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 with a grade of C+ or higher; or permission of the School.
Lectures three hours a week, tutorial one hour a week.

MATH 2107 [0.5 credit]
Linear Algebra II
Finite-dimensional vector spaces (over R and C), subspaces, linear independence and bases. Linear transformations and matrices. Inner product spaces (over R and C); Orthonormal bases. Eigenvalues and diagonalization. Bilinear and quadratic forms; principal axis theorem.
Precludes additional credit for MATH 1102.
Prerequisite(s): i) MATH 1104, or a grade of C- or higher in MATH 1107 or MATH 1109; and ii) a grade of C- or higher in MATH 1007 or equivalent; or permission of the School. Note: in item i), MATH 1119 is NOT acceptable as a substitute for MATH 1109.
Lectures three hours a week and one hour tutorial.

MATH 2108 [0.5 credit]
Abstract Algebra I
Sets and relations, number theory, group theory, ring theory, cardinal numbers.
Precludes additional credit for MATH 3101 and MATH 2100.
Prerequisite(s): 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, BIT 2004.
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 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]
Mathematical Modeling and Computational Methods
Design and analysis of mathematical models for problems in science. Computational methods, 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, laboratory one hour a week.

MATH 3801 [0.5 credit]
Linear Programming
Systems of linear inequalities, formulation of linear programming problems, geometric method, the simplex method, duality theory, complementary slackness, sensitivity analysis, branch-and-bound method and cutting plane method for integer linear programming, applications and extensions.
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
Network flow problems, network simplex method, max-flow min-cut problem, integral polyhedra, minimum-weight spanning tree problem, maximum matching problem, maximum stable set problem, introduction to approximation algorithms.
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. Implementation of numerical methods using a computer language.
Precludes additional credit for MATH 3800.
Prerequisite(s): i) MATH 2000 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 B or higher and permission of the instructor).
Lectures three hours a week, laboratory one hour a week.

MATH 3807 [0.5 credit]
Mathematical Software (Honours)
Implementation of numerical methods using numerical software packages. Development of scientific and/or operations research applications using application programming interfaces of numerical or optimization libraries. Functional programming for data analysis and machine learning. Experience working with Python, C++, or Java is essential.
Also listed as COMP 3807.
Prerequisite(s): A grade of C- or higher in MATH 3806 or COMP 3806.
Lectures three hours a week, laboratory one hour a week.

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 authentification 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; Lp 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)
One-player games, two-player zero-sum games, multi-player games, games in normal form, games in extensive form, utility theory, Nash equilibrium and Nash arbitration scheme, games in characteristic function form, cooperative solutions, dominations, stable sets, core, Shapley value, applications of game theory.
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

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 (no longer offered), ECON 2210, 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, ECON 2220.
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 (no longer offered), ECON 2210, 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, ECON 2220.
Prerequisite(s): STAT 2606.
Lectures three hours a week and one hour laboratory.

STAT 2655 [0.5 credit]
Introduction to Probability with Applications (Honours)
Probability axioms, basic combinatorial analysis, conditional probability and independence, discrete and continuous random variables, joint and conditional distributions, expectation and moments, probability and moment generating functions, Chebyshev's inequality and weak law of large numbers, central limit theorem, sampling distributions, simulation and applications to descriptive statistics.
Precludes additional credit for STAT 2605.
Prerequisite(s): MATH 1002 with a grade of C+ or higher or MATH 2007 or MATH 1005 with a grade of B+ or higher; and MATH 1102 with a grade of C+ or higher or MATH 2107 with a grade of B+ or higher; or permission of the School.
Lectures three hours a week, tutorial one hour a week.

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 (no longer offered), ECON 2210, 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 2202 or ECON 2220 or equivalent; and ii) MATH 1102 or MATH 1107 or MATH 1119 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, STAT 2509, STAT 2606, STAT 2607, ECON 2201, ECON 2202, ECON 2210, ECON 2220, 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 Statistics (Honours)
Order statistics; projections; U-statistics; L-estimators; rank, sign, and permutation test statistics; nonparametric tests of goodness-of-fit, homogeneity, symmetry, and independence; nonparametric density estimation; nonparametric regression analysis: kernel estimators, orthogonal series estimators, smoothing splines; high-dimensional inference and false discovery.
Prerequisite(s): STAT 3559 or permission of the School.
Also offered at the graduate level, with different requirements, as STAT 5516, for which additional credit is precluded.
Lectures three hours a week.

STAT 4507 [0.5 credit]
Statistical Inference (Honours)
Sufficient statistics, simple and composite hypotheses, most powerful and similar region test, 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.

STAT 4607 [0.5 credit]
Bayesian Statistical Analysis (Honours)
Probability basics for Bayesian statistics. Bayesian inference for simple exponential families. Markov Chain Monte Carlo for posterior inference. Empirical Bayes. Hierarchical Bayes. Bayesian inference for the multivariate normal model. Bayesian linear regression. More advanced topics may be included. Computer software will be used.
Prerequisite(s): STAT 3553 or permission of the School.
Lectures three hours a week, laboratory one hour a week.

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

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