ugmath@mathstat.yorku.ca

2014 – 2015

Undergraduate Supplemental Calendar

Department of Mathematics & Statistics

• Applied Mathematics • Computational Mathematics • Mathematics for Commerce • Mathematics for Education • Pure Mathematics • Statistics • International Dual Degree Mathematics and Statistics •

Undergraduate Program Offices

N502 / N503 Ross

416-736-5902 www.math.yorku.ca

ugmath@mathstat.yorku.ca

Monday – Friday

9:00a.m. – 12:00p.m. and 1:00p.m. to 3:00p.m.

Administrative Offices: N520 Ross

416-736-5250 (main office) – 416-736-5757 (fax)

mathstat@yorku.ca (general enquiries)

Office Hours: Monday – Friday

8:30a.m. – 4:30p.m.

(Closed at 3:30p.m. on Friday's only

from June until Labour Day)

science | YORK UNIVERSITÉ UNIVERSITY

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The calendar maintained by the Registrar's Office contains a complete listing of courses, not all of which are offered every year. Moreover, some older prerequisites will be found there for the benefit of students who are returning to their studies after taking some time off. Since this supplementary calendar provides a more streamlined listing of courses and prerequisites that are relevant to a particular academic year, students are encouraged to consult it first when selecting their courses.

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Guide for Returning Students

The Department has new requirements for all of its programs. However, if you began your studies at York in Summer 2012, or earlier, you may complete your program under the old requirements which were in effect at the time you began your studies at York.

In the degree checklists at the back of this booklet, the old program requirements (pp. 34–47) are listed before the new ones (pp. 48–55). If you began your academic program prior to FW2008/09, please see an Undergraduate Supplemental Calendar such as 2011–2012. If a degree program requirement is not being currently offered, you must see the Undergraduate Program Director in N505 Ross to discuss a degree requirement equivalent to replace it. Feel free to bring your questions to the Undergraduate Office.

Guide for New Students

The Department has new requirements for all of its programs. Since you are beginning your studies at York in September 2014, you must meet these new requirements. In particular, you do not have the option of completing your program by meeting the old requirements.

The first three terms of study of all our honours programs is the Mathematics/Statistics Core. In the first year, it consists of two semesters of calculus (MATH 1300 and 1310), statistics (MATH 1131) and an introduction to mathematical thinking (MATH 1200). In the second year, it consists of multivariable calculus (MATH 2310) and probability (MATH 2030) in the Fall term and two semesters of linear algebra (MATH 1021 and 2022). In addition, the appropriate computing course(s) should be taken in your first year: CSE 1020/1030 for the Computational Math program and CSE 1560 for all other math and statistics programs.

In your second year you will begin taking specialized courses in the area of your selected program. At that point, you will have a familiarity with various types of mathematics and statistics so that you can make an educated choice of a specific program. Note that it is an easy procedure to change from one specific program to another.

In the degree checklists at the back of this booklet, the new program requirements (pp. 48–55) are listed after the old ones (pp. 36–48). Feel free to bring your questions to the Undergraduate Office.

Guide for New Transfer Students

The Department has new requirements for all of its programs. Since you are beginning your studies at York in September 2014, you must see the Undergraduate Program Director in N505 Ross to discuss and clarify your situation.

Guide for MATH 2031 1.00 Probability Explorations

This course will not be offered in FW 2014 and students taking MATH 2030 3.00 in FWS 2014/2015 are exempted from the requirement of taking it.

The description given below is tentative, pending curricular review:

Proposed calendar copy: Exploration of probability theory using mathematical calculation, experiment, and computer simulation. Prior experience communicating mathematics (e.g., as in SC/MATH 1200 3.00) is an asset, but is not required.
Prerequisite or corequisite: SC/MATH 2030 3.00.

Message from the Departmental Chair

Welcome to the Department of Mathematics and Statistics. Whether you are majoring in one of our programs, taking a course required by another program, or taking a course for general interest, we want to help you to learn and enjoy mathematics and/or statistics. The faculty members in this Department value both the beauty and the utility of their discipline. They are dedicated to exploring and developing new ideas in mathematics and statistics, and to helping you to explore, understand, appreciate and make use of those ideas. Ideas are much more than facts. They are harder to acquire, but infinitely more valuable.

This supplemental calendar is intended to help you choose the programs and courses best suited to your needs and interests. Much effort has gone into making it accurate, and it contains much information not available elsewhere. The program checklists towards the back of this publication lay out our Department's program requirements, perhaps more clearly than any other York document. Please also consult the "official, legally binding" regulations in the York Undergraduate Programs Calendar, at www.yorku.ca.

Programs

The Department is especially happy to welcome students choosing to major in one of our many excellent programs, through the Faculty of Science. I urge you to stay in touch with your professors and to ask about, as well as get involved, in student clubs. We offer a diverse set of degree programs, designed to respond to the many differing interests and career aspirations of our students. The current programs are outlined throughout this supplemental calendar. We would like to hear from you if you are unsure as to which program best suits you, if you are contemplating a change, or simply if you feel some advice would be helpful.

Where to go for help

The Department's faculty and staff members are pleased to offer you their assistance. Questions concerning your program, or enrolment in courses, are best handled by the Undergraduate Program Offices (**ugmath@mathstat.yorku.ca**). Students may contact Madeline Salzarulo, Undergraduate Program Secretary, in N502 Ross (**416-736-5902**), Monday–Friday, 9:00a.m.–noon and 1:00p.m.–3:00p.m. Should you need further information on academic matters, please make an appointment with one of the Undergraduate Program Directors: P. Gibson (Pure Mathematics); E. Furman (Mathematics for Commerce); M. Haslam (Applied Mathematics and Computational Mathematics); S. Wang (Statistics); and W. Whiteley (Mathematics for Education). Some introductory courses will have quite large enrolments, and we urge you to take advantage of the Math/Stat Lab (S525 Ross) and your tutorials, if available, as these will provide some of the individual attention you may require. Other courses may provide help through the Bethune College PASS peer assistance program and students are encouraged to take advantage of this as well. You will find that your teaching assistants, instructors, and course coordinators are eager to help if you encounter difficulties in a course. Don't wait until the end of a course to deal with a problem; contact your instructor for help or advice sooner, not later. Faculty members' office hours can be found through the Department's Main Office in N520 Ross (416-736-5250). Appointments to see the Chair can be made with Susan Rainey, Secretary to the Chair, in N522 Ross (ext. 22555). Most Department members are quite happy to correspond with you by e-mail. The Department also has general Undergraduate and Graduate information available on-line at www.math.yorku.ca. In addition, the course descriptions in this supplemental calendar will be available on the web.

Our goals

You may find that a variety of teaching methods are used in your mathematics and statistics courses. But whatever methods may be used, faculty members have certain goals in common. They want to help you to learn the basic material of the course, to understand how and why this material was developed, and to know how to apply it. Through problem-solving, you will acquire skills in critical thinking and logical analysis that will serve you well in many careers, particularly those that demand a sound understanding of mathematics or statistics. It is important to develop the ability and desire to pursue knowledge independently, to understand the power and elegance of abstract reasoning, and to appreciate the role of mathematics in human culture and the sciences.

Prizes and awards

Each year the Department offers several prizes and awards for outstanding achievements in mathematics and statistics courses. Department members have contributed substantially to some of these. Students receiving any of these will be honoured at the annual Department Awards Ceremony, and their names will be displayed in the halls of the Department and on the Departmental web page. Other prizes (e.g. the **Allen S. Berg Award** in Applied Mathematics) are awarded at the Faculty level.

Students are listed on the **Chair's Honour Roll** for having achieved a high grade point average over all Departmental courses (at least two full course equivalents without second digit 5). An outstanding student in each of the year-levels 2, 3, and 4 in a Departmental program is chosen for the **Irvine R. Pounder Award**. Professor Pounder was one of the two founding members of the Department, and the award was established by the Department in 1990–91 on the occasion of the hundredth anniversary of

his birth. The other founder of the Department is commemorated in the **Alice Turner Awards**, which are awarded to outstanding MATH Majors in a Departmental degree program, one to a three-year and one to a four-year degree graduate. The **Moshe Shimrat Prize Fund** rewards York students (or secondary school students) selected by the department for their interest and demonstrated ability in mathematical problem-solving. The **George R. and Mary L. Wallace Award** was established by the family and friends of G.R. Wallace, the late Senior Vice-President and Chief Actuary of the Zurich Life Insurance Company. It is awarded annually to outstanding Department Honours students in Applied Mathematics, and in the Actuarial and Operations Research streams of the Mathematics for Commerce program. The **George & Frances Denzel Award** is awarded for excellence in Statistics. The **Linda Herskowitz Award** is awarded to a (preferably female) department major who, through her achievements, best honours the memory of this long-time former staff member. The **Abe Karrass/Donald Solitar Bursary** honours the memory of Professor Abe Karrass, and is awarded to an outstanding student in a Department Honours program with an interest in Mathematics Education. The **Ray and Joe Abramson Award in Mathematics and Statistics** is given to an academically strong student who demonstrates involvement in a math-related club or extracurricular activity. In addition, some awards are partially based on demonstrated financial need. Students should also inquire in January with their Math/Stat instructors about the possibility of summer employment through the NSERC Undergraduate Summer Research Program.

For all awards except the Linda Herskowitz Award, recipients are chosen by the Department on the basis of student records. No applications are needed or accepted for these awards.

Applications for the Linda Herskowitz Award may be submitted to the Chair by September 15. To be eligible for this bursary, the student must be a Canadian citizen or permanent resident. Applications must include a Bursary Application form (available from N520 Ross) as well as a statement from the student, with supporting material as appropriate, explaining how the student meets the criteria of the award (e.g. involvement in departmental or university activities outside the classroom, or community service outside the university).

Mathematics contests

There are two international mathematics contests open to undergraduate students. One, **The William Lowell Putnam Mathematical Competition**, has students working on a number of challenging mathematics problems during an all-day examination late in the fall term (see page 7 of this supplemental calendar). The other, **The Mathematical Contest in Modelling**, involves one or more teams of students who are given a weekend to develop a mathematical model for a challenging applied problem (see page 7). In both cases, practice sessions will be held under the guidance of a member of the faculty. Announcements about these contests will be made in classes and posted in the Math/Stat Student Common Room (N537 Ross) at the appropriate times. We invite you to test your skills.

We wish you success in your studies.

J. Steprāns, Department Chair

Problems?

Where to go for help

Information

See the next section of this supplemental calendar for sources of information, and elsewhere in the supplemental calendar as well. The *main York Undergraduate Programs Calendar* will answer many questions that are not addressed here. Please remember in particular that the main Calendar contains the "official, legally binding" statements of all university and faculty regulations. (York's website, www.yorku.ca, has the Calendar on-line, as well as a wealth of other information about the university.)

Course-related Problems?

The first person to speak with is **your instructor.** Do not wait until the end of a course to try to resolve problems; deal with them as soon as you see them coming. If for any reason your instructor's answers do not satisfy you, and the course is a multi-section one, seek out the **"Coordinator"** (the professor responsible for all sections of the course). It is part of his/her job to try to resolve problems with a course. If your problem remains unresolved or you feel uncomfortable regarding some issue, visit the **Undergraduate Director**, Professor P. Gibson (416-736-5250).

If you feel you need personal attention outside class time, one resource is **your instructor**. Faculty members have regular office hours when they are available to their students for contact outside class. Another source of academic help is **the tutorial session (if there is one) in your course**, which must be announced in class by your instructor within the first week or two of classes.

The Math Lab and Stats Lab

This year, these labs, collectively called the Maths/Stats Lab, housed in S525 Ross (fifth floor of the south wing of the Ross Building), provide tutorial help for the following first and second year courses: MATH 1013/1014, 1025, 1131, 1190, 1200, 1300/1310, 1505, 1510, 1513, 1520, 1530/1540, 1532, 1550, 1021/2022, 2030, 2560/2570, 2565.

Note: MATH 1019/1090 have their own tutorial sessions.

See also "Where to go for help" on page 3.

General Information

Choice of Courses

Students should take care to enrol in the mathematics courses most appropriate to their interests, needs and background. In many cases, courses with similar titles may be intended for very different audiences. Students should be guided by the information given in this publication and should consult an advisor in case of doubt.

When selecting courses, please note the following:

1. A student choosing university-level mathematics courses for the first time should consider speaking to a staff member in the appropriate Undergraduate Office (see "Where to go for help", page 3 of this supplemental calendar).

2. With the exception of courses which are core requirements for degrees in the Department, students should not necessarily expect courses (especially some upper-level courses) offered in a given calendar year to be offered also the following year. This applies to both Fall/Winter and Summer courses. The Department tries to offer some courses in alternate years, partly to allow variety in choice of topic. In some cases, information about the year a course is expected to be offered next can be found in the **Course Offerings** section later in this supplemental calendar.

3. In Summer 2014, this department is planning to offer the following courses:

   MATH 1013, 1014, 1019, 1021, 1025, 1090, 1131, 1190, 1300, 1310, 1505, 1510, 1520, 1581, 2022, 2030, 2131, 2320, 2560, 3170, and 3330.

4. Note that instructors for some courses may change after publication of this supplemental calendar.

5. MATH 1510 6.00 is intended for students who have a weak mathematical background, even those who may have one or more 12Us in mathematics or OACs or equivalents. It can serve as preparation for MATH 1520 3.00, which provides an entrance to further calculus courses.

6. Calculus options for first-year students:

   (a) Science students (particularly those majoring in Biology, Geography, Kinesiology and Health Science, or Psychology) who do not require other specific calculus courses to satisfy degree requirements, or as prerequisites for higher-level courses, may take MATH 1505 6.00 to satisfy the Faculty of Science 1000-level mathematics requirement. Other students should be guided by paragraphs (b) and (c) below.

   (b) A student with at least one 12U or OAC in mathematics or equivalent, but without previous calculus, must begin the study of calculus with MATH 1510 6.00 and/or MATH 1520 3.00; a student with 12U Advanced Functions can begin without MATH 1510 6.00.

   (c) A student with 12U Calculus and Vectors or equivalent can begin with MATH 1013 3.00 or MATH 1300 3.00, and then take MATH 1014 3.00 or MATH 1310 3.00.

Linear Algebra requirements

1. Most students doing a BA or BA (Hons) or a BSc or BSc (Hons), except for the Bachelor Math for Commerce program, should take the sequence MATH 1021/2022 instead of MATH 2221/2222. Consult the checklists at the back of this supplemental calendar for the detailed requirements of each program.

2. For students whose program requires only a single semester of linear algebra, it is preferable to take MATH 1025 rather than MATH 1021 or MATH 2221.

Course Credit Exclusions

Specific regulations concerning "course credit exclusions" appear in the main York calendar. These were formally called degree credit exclusions. An exclusion occurs when two courses have overlapping material. As a general rule, you may not take both for degree credit. The concept of "equivalent" course or "course substitution" is different; see the main York calendar for explanations of both these concepts.

Student Ombuds Service

The Student Ombuds Service (SOS) is a peer-advising service designed to help York students, especially those in Bethune College and the Faculty of Science, find information they need. The SOS office is staffed with knowledgeable upper-year students and serves as a referral network and a resource centre. SOS members try to answer any questions about York University policies and procedures, and give general academic help and advice about University life. SOS resources include departmental supplemental calendars, graduate and professional school information, a tutor registry, and a study-group registry. We encourage you to drop by the SOS office at 208 Bethune College between 10 a.m. and 4 p.m. Monday through Friday. No appointment is necessary. You can also find information on the web at www.yorku.ca/sos, or e-mail them at sos@yorku.ca. The SOS is here for you, so don't hesitate to contact it if you need help.

Study Groups

We encourage students, especially those in 1000- and 2000-level courses, to form study groups early in the term, and to use them as a help in learning their course material. Your study group can help you, as a participant, in all sorts of ways (and you will help the group as well). Many people benefit from working together to solve problems, or just by having people around to help them get motivated to study.

Club Infinity

Club Infinity is York University's Mathematics Club. It is a small and informal group of students who have some interest in math. They meet on an irregular basis to work on club events or just party. There is no membership fee.

Each year they organize a number of events of interest to students involved in math, including: talks of a mathematical nature, given by professors, or graduate or undergraduate students, annual Pi Day celebrations, held on March 14, and their Semi-Annual Past Math Exam Sales, where copies of old math exams are sold.

The club operates out of N537 Ross, the Math/Stat Student Common Room. This is a place where students can go to eat, work on assignments, play cards, discuss math problems, or just socialize. You don't have to be a member of the club; the room is open to all. The room is generally open on weekdays. Visit the website: www.math.yorku.ca/infinity.

ASAYU: Actuarial Students' Association

The ASAYU, Actuarial Students' Association at York University is designed to help students who are interested in actuarial science matters on multiple levels. Those levels consist of study groups, peer advising, exam preparation, and most importantly, the Actuarial Convention held in early January. The convention is created in partnership with the Actuarial Students' National Association and its other member universities. The convention is a three day event consisting of a career fair for students, followed by workshops, seminars, and networking opportunities with other future actuaries.

The Association will focus on growing the network of both alumni and current students. Also, with a new year brings new opportunities for students to get involved in the actuarial community. The ASAYU has a constant outreach for new members, ideas, and fresh faces to join! If you are interested in joining the club or have any questions on anything, simply e-mail the club at Asayu@yorku.ca.

To get more information, visit and bookmark the website, http://www.math.yorku.ca/asayu

Guidelines for Ethical Research Involving Humans

All students who conduct research that involves interviews have a duty to comply with the Senate policies on ethical conduct for research involving humans. This means, for example, that those conducting interviews normally have a duty to inform the persons being interviewed about the nature and purpose of the research, and about whether the results of the interview will remain confidential. Student research procedures involving human participants must be approved by the student's course director. See yorku.ca/secretariat/policies. The responsibilities of students, instructors, departments and the university with regard to ethical conduct of research involving humans are too complex to summarize here.

Information for Majors

The Department of Mathematics and Statistics offers degree programs in six major subjects:

Applied Mathematics (BA or BSc)
Computational Mathematics (BSc)
Mathematics (BA or BSc)
Mathematics for Commerce (BA)
Statistics (BA or BSc)
Mathematics for Education (BA or BSc)

These three-year programs and their four-year versions (BA (Hons), BSc (Hons)) are described in the next section. Detailed lists of course requirements for each program appear on pages towards the back of this publication. A student should choose one of these majors based on interest and employment goals; one can change their major later, if the requirements of the new major can be met.

Course Numbering

MATH courses with second digit 5 cannot be used to satisfy major or minor degree requirements in this Department, except in the Bachelor Mathematics for Commerce programs and in other programs in a few cases as specifically noted in program descriptions. With the exception of MATH 1530, MATH courses with third digit **3** involve probability and statistics.

"In-department" Credits, "In-Faculty" Credits

These topics are rather technical; if you are in any doubt about them in particular cases, consult an advisor.

Upper-level courses

In choosing courses, students should bear in mind the prerequisites for courses which they may wish to take in later years. Also, students are cautioned that some courses may be given only in alternate years. The "Special Topics" and "Topics in" courses (MATH 4100 3.00, MATH 4130 3.00, MATH 4930 3.00) may be offered in both terms and may be repeated with different topics. The prerequisites for each course are usually certain 3000-level courses in the appropriate subject area. When registering for these courses, note any letter immediately following the four-digit course number. It indicates the version of the course being given; the same version may not be taken again later for credit.

Putnam Competition

Over 500 institutions and over 4000 contestants across North America took part in the 74th William Lowell Putnam Mathematical Competition, held in December 2013. These York students took valuable time from their studies at exam time, to compete in the venerable Putnam:

Mihai Alboiu, John Campbell, Samuel Dupuis, Justin Kim, Xin Man, Pavel Shuldiner, Alireza Taghavi, Emanoil Theodorescu.

Coach: Professor Youness Lamzouri

Modelling Competition

The Mathematical Contest in Modelling allows teams from around the world to compete against each other by spending a weekend intensively analyzing a realistic problem in Applied Mathematics. In January/ February 2014, one team competed from York:

Alex Ashbourne, Christopher Dobronyi and Angie Raad.

Coach: Professor Michael Chen

Programs

Computational Mathematics

The Specialized Honours BSc in Computational Mathematics is designed to introduce students to the full process of the application of mathematics, with emphasis on core mathematical subjects, mathematical modelling, and diverse computational methodologies for analyzing these models. Some examples of applications include controlling heat flow in manufacturing processes, pricing a stock option, and assessing risks associated with insurance policies.

In addition to taking core courses in mathematics, statistics, and computer science, each student chooses one of the following two areas of specialization: Applied and Industrial Mathematics (with an emphasis in numerical analysis and differential equations) or Financial Mathematics (applications to business and the financial industry, with additional courses in operations research and economics).

Applied Mathematics

The Applied Mathematics Program aims to give students a solid base of knowledge of mathematics which has important applications in computer science, psychology, economics, business, and other fields. Our graduates have pursued a variety of careers including business, industry and government as well as teaching. Many have found jobs in various fields related to computing. Some of our students have continued on to graduate studies in mathematics and other areas. Students can obtain qualifications in operations research or the actuarial profession (see the section below entitled Career Information). There are potential jobs for our students wherever mathematics is employed.

Students in Applied Mathematics in the Faculty of Science may pursue a course of study leading to either a BSc (usually three years) or a BSc (Hons) (usually four years). Students may combine the study of Applied Mathematics with that of another subject such as Physics, Earth and Space Science and Engineering, Biology, or Computer Science and thereby graduate with a BSc (Hons) Double Major or, in some cases, a BSc (Hons) Major/Minor in two subjects. Applied Mathematics students interested in Economics, Psychology, or another subject may pursue a combined Program by selecting a BA (Hons) Double Major or Major/Minor Program. For example, an Economics-Applied Mathematics Major/Minor BA (Hons) would be a natural combination. Our students are given the opportunity to take electives in other areas of interest, such as business administration.

All students take a common core of courses in Calculus, Differential Equations, Linear Algebra, Symbolic Computing (MAPLE), and Numerical Analysis. The core of required courses is larger for Honours students. There is a wide choice of elective courses in Applied Mathematics, including Mathematical Modelling, Graph Theory, Operations Research, Partial Differential Equations, Advanced Numerical Analysis, and Complex Variables. In addition, students can select a number of optional courses from outside the Program. Courses in the Program stress applications of mathematics and computing to the solution of problems arising in many facets of science, engineering and commerce.

Some possible areas of concentration and corresponding recommended courses are:

Numerical Analysis: MATH 3242, MATH 4141, MATH 4143

Discrete Applied Math/Operations Research: MATH 3090, MATH 3170, MATH 3260, MATH 4090, MATH 4141, MATH 4160, MATH 4161, MATH 4170, MATH 4430, MATH 4431

Applied Math in Physical Sciences/Differential Equations: MATH 3090, MATH 3271, MATH 3410, MATH 4090, MATH 4141, MATH 4830, EATS 2470

Statistical Applied Math: MATH 3131, MATH 3132, MATH 3034, MATH 3330, MATH 3430, MATH 4230, MATH 4430, MATH 4431, MATH 4630, MATH 4730, MATH 4830, MATH 4930

(In all cases, you should make sure that you satisfy all your degree requirements, given in the checklists towards the back of this supplemental calendar.)

All students entering Applied Mathematics are carefully advised concerning their course of study by a member of the Program. The instructors in Applied Mathematics courses are available

throughout the year for additional advice and help with specific course-related problems.

If you would like further information, please contact the Program Director, Professor Michael Haslam.

Mathematics

The Honours Programs in Mathematics (BA and BSc) are suitable for students who enjoy the intellectual challenge of pure mathematics. These Programs provide an excellent background for many occupations demanding skills in mathematical reasoning and techniques. They are ideal for students who intend to pursue graduate study in mathematics. An Honours Program in mathematics emphasizes the understanding of concepts, abstraction and reasoning; these then become the tools for problem-solving, as well as the language and environment in which problems are solved (for many problems the solutions are called "proofs"). Many students who creditably complete a York Honours degree in mathematics are routinely accepted (with financial support included!) into graduate schools across North America. Taking mathematics in combination with Computer Science, Statistics, or Economics makes for a very impressive curriculum vitae for a graduate seeking a career in Industry, Government, or Business.

Mathematics is one of the oldest academic disciplines. A mathematician is known as one who has exceptional reasoning, critical thinking, and problem-solving skills. While the public knows of the *utility* of mathematics, less well known is the fact that most mathematicians do math *because they love it*. The Honours Programs are designed to help you cultivate this same passion. You will meet like-minded classmates and you will find that your studies are a rewarding and exciting adventure bringing you to the frontier of scientific discovery.

The Bachelor Program (BA and BSc) provides a three-year degree in mathematics that is less demanding than the Honours Program and is very flexible. It allows the student to select courses in a wide variety of pure and applied mathematical areas. Students can also choose a liberal arts education with a moderate emphasis on mathematics, for example, with Mathematics as a Minor in an Honours Major/ Minor degree.

Statistics

Statistics is an interdisciplinary field providing the foundations and techniques required to collect, analyse and present information in an effective and efficient manner. Through its applications in almost every branch of modern professional life and research, statistics is a fast-growing discipline which provides a statistician with a variety of career opportunities. A Program in statistics is an exploration of the nature of measurement, relationships amongst measured variables, chance variation, probability, uncertainty, inductive logic and inference. The Honours and Bachelor BA and BSc Programs in Statistics provide both the mathematical foundations and the methods needed in applications. They also provide exposure to a variety of computing environments, an essential asset for nearly all careers today. Statistics combines naturally with studies in the health sciences, life, physical and social sciences, economics, administrative studies and environmental studies. The Honours Programs also provide excellent preparation for subsequent graduate studies in statistics.

Beginning in 2008–2009, students in first year who wish to pursue an Honours program with a major in Statistics must plan to complete the Mathematics/Statistics Core (see page 2) and MATH 2131 3.00 prior to entering their third year of study.

Mathematics for Commerce

Mathematics for Commerce is an excellent environment for students who wish to obtain a background in the type of mathematics that can be applied in a business-oriented career. Courses such as Introduction to Computer Use, Mathematics of Investment and Actuarial Science, Mathematics with Management Applications, Operations Research, Regression Analysis, and Sample Survey Design provide students with the necessary mathematical and statistical skills, techniques and confidence to succeed in a very demanding business world.

Graduates of this Program go on to various careers in business, industry, government, schools, colleges and universities. They become actuaries, investment managers, consultants, analysts, or statisticians. Examples of activities in which they may be involved are: solving optimization problems, project management, inventory control, forecasting, analysing data, investigating patterns and trends, creating mathematical models, evaluating pension funds, and determining premiums for life insurance policies. Of course, many of the Program's students also pursue graduate degrees in areas such as Business Administration, Education, Environmental Studies, and Law.

Mathematics for Commerce offers a Bachelor BA Program, a Specialized Honours BA Program, an Honours Major BA Program, and an Honours Minor BA Program. The Honours Major may not be combined with any other Honours Major or Minor. The Honours Minor *must* be combined with some other Honours Major.

The *Bachelor degree* is usually completed in three years and requires a total of 90 credits.

The *Honours Minor Program* is combined with an Honours Major from another department, as part of a Program totaling 120 credits.

The *Honours Major degree* is usually completed in four years and requires a total of 120 credits.

The Honours Major degree is offered in two streams:

- *The Actuarial Stream*
  An actuary is a professional concerned with the design and administration of insurance policies, pension plans, government welfare plans, and similar programs. The main responsibility of actuaries is to ensure that these programs operate on a sound financial basis. To do this, they use many areas of mathematics and statistics, as well as general principles of economics and finance. In North America, the standard way to become an actuary is to pass the examinations set and administered by either the Society of Actuaries or the Casualty Actuarial Society. No university courses can be accepted in place of these examinations, but university courses can do a great deal to prepare students for them. Additional information can be found at both www.math.yorku.ca/Careers/actuary.html and www.soa.org, and can also be obtained from Professor E. Furman at 416-736-5250.

- *The Operations Research Stream*
  Operations Research is the scientific study of any problem relating to optimal management of a system.

The Programs of study at York can provide the student with the diverse background needed to prepare for work in operations research. The Canadian Operational Research Society (CORS) offers a diploma to students who complete a prescribed array of courses. At York it is possible to earn a CORS diploma and an Honours degree simultaneously. For additional information, please see page 10.

The *Specialized Honours* degree is usually completed in four years and requires a total of 120 credits. It has only an Actuarial Stream.

Mathematics for Education

Mathematics teaching, at all levels, is a rewarding career, and there is a continuing need for qualified teachers of mathematics in Ontario. In addition, Mathematics Education is a rapidly growing, interdisciplinary area of study and research at the graduate level.

This honours degree program is aimed at students considering a career in teaching mathematics or research in mathematics education. Students may already be enrolled in Concurrent Education, or may intend to apply to Concurrent Education or to take a one year Consecutive Education program. This program ensures a broad background in mathematics and encourages students to develop a wider perspective on mathematics and on the teaching and learning of mathematics. The program also provides a solid background in core mathematics, as well as a range of upper level mathematics, similar to that provided in many liberal arts colleges. As such, it will leave a number of options open at all stages during the program or on graduation, in addition to the BEd pathway.

The program (even the minor) includes all the key courses needed to have Mathematics as a first teachable subject in a B.Ed. program. Any students planning to teach at the Intermediate/Senior level will need to select general education, elective and other courses to develop a second teachable subject, and room has been left for that. For clarity, we emphasize that this program does not replace the BEd program required for certification as a teacher in Ontario. Courses in pedagogy, including the pedagogy of mathematics, will be provided in degree programs in a Faculty of Education.

The program also provides a solid common core with mathematics programs in Applied Mathematics, Pure Mathematics, Statistics, and Mathematics for Commerce. With an appropriate choice in their fourth semester, students will be able to transfer to, or form a double major with, each of these other Mathematics programs. Conversely, students from all these Mathematics programs will be able to transfer into Mathematics for Education, or form a double major, with at most 3.00 additional credits, after second year. Contact Walter Whiteley (whiteley@mathstat.yorku.ca) for further information. See also the Section on Mathematics teaching in the Careers section (page 9).

International Dual Degree Program in Mathematics and Statistics

In cooperation with the University of L'Aquila (Italy) an intensive and rigorous Bachelor of Science program in Mathematics and Statistics has been established. The program provides York students with the opportunity to gain international experience and earn, in addition to their Honours BSc degree at York, the Italian *Laurea di primo livello* at the University of L'Aquila within the normal four-year time frame. The program enables students to acquire the necessary background in Mathematics and Statistics, suitable especially for those who wish to pursue a career in international business or academia. Because of its large body of mandatory courses in Mathematics and Statistics the program is particularly demanding and will be of interest to students with academic performance of B average and higher. After two years of study at York, but before the completion of the York degree program requirements, students will be eligible to study as York international exchange students for up to one year at the University of L'Aquila, earn York credits for specified courses taken at L'Aquila towards their York degree program, and at the same time fulfill the degree program requirements for the *Laurea di primo livello* at L'Aquila, the Italian equivalent of a 90-credit BSc. All exchanges under this program are administered by York International in collaboration with the *Ufficio Internazionale* at the University of L'Aquila. The Program Coordinator at York is Professor Walter Tholen (416-736-2100, ext. 33918).

Glendon College Mathematics Courses

The following is a selection of courses offered in 2014-2015 by the Department of Mathematics at Glendon College, that are equivalent to courses offered at "Mathstat" (Mathematics and Statistics, Keele Campus). "Equivalent courses" are acceptable for degree program credit both at the Glendon campus and at the Keele campus. For further information, contact the Glendon Mathematics Department, 329 York Hall, Glendon College, at 416-487-6731.

Courses are listed with the following information: Mathstat course equivalent: Glendon course identifiers.

- MATH 1300: GL/MATH 1930 3.00, Calculus I
- MATH 1310: GL/MATH 1940 3.00, Calculus II
- MATH 2221: GL/MATH 2650 3.00, Linear Algebra I
- MATH 2222: GL/MATH 2660 3.00, Linear Algebra II.
- MATH 2560: GL/MATH 1610 3.00, Introductory Statistics I
- MATH 2570: GL/MATH 1620 3.00, Introductory Statistics II
- MATH 2580: GL/MATH 2680 6.00, Mathematics of Investment and Actuarial Science
- MATH 3210: GL/MATH 3320 3.00, Principles of Mathematical Analysis

Career Information

There is available, in both N537 Ross and S525 Ross, a massive ring binder of information on careers that use mathematics, and another, on how to apply for postgraduate studies. Some of this information is already on the Web, linked to the Department's home page; additional pages are under construction. We mention some of the career categories below.

Mathematics Teaching and Co-registration in Education

There is a continuing need for qualified mathematics teachers in Ontario, and a shortage of qualified mathematics teachers in other parts of North America. The Department places great importance on encouraging and helping students interested in Mathematics Education, in both its undergraduate and its graduate programs. Students may pursue a BEd degree **concurrently** with their BA or BSc degree, or **consecutively**, following graduation.

To be admitted to a faculty of education, you will need to have documentation showing volunteer or paid experience with tutoring, working in a school, etc. as well as a background of appropriate mathematics courses. A number of school boards offer paid positions as "tutors in the classroom" in mathematics and science, and there are also volunteer opportunities in Ontario.

Students seeking a **Concurrent BEd** degree normally apply to the Faculty of Education for admission in their first or second year. For further information, contact the Faculty of Education in Winters College (416-736-5002). Students seeking a **Consecutive BEd** degree are advised that intermediate/senior certification requires two teaching subjects — four full courses or equivalent are recommended in the second subject. There are Consecutive Education programs at a number of Ontario universities, including several programs at York University. Not all programs have the same admission criteria, so students should get a range of advice when preparing their applications. For further information on the York Programs, contact the Faculty of Education.

The Mathematics for Education BSc Program is designed to include all of the recommendations below, as well as provide easy transfer with other mathematics programs, after three or four semesters at York. If you are interested in this option, check with the advisors in the department, or the contacts below, in late summer or the fall.

Courses for mathematics as teachable subject should be chosen in consultation with a mathematics education adviser. The following range of courses must be included for a first or second teachable in Mathematics as a concurrent education student, and is recommended for students applying to consecutive education:

1. 6 credits in calculus
2. 6 credits in linear algebra
3. 6 credits in probability and statistics
4. 6 credits in proof-based mathematics

These courses cover the basic requirement for a second teachable (24 credits). For a first teachable in mathematics (36 credits), and for additional breadth in a second teachable, students are encouraged to include a wider range of mathematics, and should consider courses such as History of Mathematics MATH 4400, Computational Mathematics MATH 3090, Operations Research MATH 3170, and Geometry MATH 3050. When offered, Topics in Mathematics Education MATH 4100 3.00 is strongly recommended.

Students working towards an honours specialist in Mathematics (54 credits plus additional Ministry of Education requirements), may major not only in the Mathematics for Education program but in any of the other programs within Mathematics and Statistics, i.e., Mathematics, Applied Mathematics, Statistics, Mathematics for Commerce, and Computational Mathematics. With appropriate course selection, each of these programs offers good opportunities for preparation in mathematics.

Students considering mathematics as a teaching subject, who need advice on their mathematics programs, should contact Professor Walter Whiteley (whiteley@yorku.ca).

Graduate Studies

York offers several graduate Programs in mathematics and statistics- www.yorku.ca/gradmath; for details enquire at the Graduate Program Office in N519 Ross (416-736-2100 ext. 33974, or, to leave a message, 416-736-5250). Students who may wish to pursue graduate work at York or elsewhere should choose upper-level undergraduate courses with care. Advice on this can be sought from faculty members. A ring binder of information on applying to graduate schools is available in N537 and S525 Ross.

Actuarial Mathematics

Students who are interested in the actuarial profession can pick up a copy of a pamphlet available in the Undergraduate Office, N502 Ross. This pamphlet provides information about the courses at York which prepare students for the examinations of the Society of Actuaries, or the Casualty Actuarial Society. In particular, in order to become an actuary, a student needs to fulfil VEE (Validation of Education Experience) requirements. To do this, a student will have to take certain courses in Economics, Corporate Finance, and Applied Statistics at an accredited university. York is such an accredited university and offers all courses to meet this new VEE requirement. Details may be found at the website http://actsci.math.yorku.ca/degprog.html. In addition, students can contact Professor E. Furman (efurman@mathstat.yorku.ca).

Science and Technology Studies

Science and Technology Studies (STS) is an interdisciplinary program that offers courses of study leading to either a BA or BSc degree. Its purpose is to expand our understanding of science and technology by exploring their social, cultural, philosophical and material dimensions. To achieve that purpose, the program draws upon the disciplines of both the humanities and social sciences to offer courses treating specific scientific ideas, as well as courses addressing broader topics such as science and gender, science and religion, and technology and cultural values. Students are encouraged to draw connections across traditional boundaries as they seek an intellectual appreciation for the sciences and technology as powerful means for understanding, embodying and shaping the world and ourselves. You will learn to analyse complex ideas about science and technology, and to discover how to trace the origins and implications of events and patterns of thought in the past and present. For more information, please consult the Science and Technology Studies supplemental calender available at 218 Bethune College.

CORS Diploma in Operational Research

Operations Research or Operational Research (OR) deals with making the "best" decision when confronted with many choices plus a variety of constraints in a large-scale problem. Examples of typical problems are: minimizing operating costs in a large hospital while maintaining quality service to patients, finding the shortest route for a delivery truck which must make many stops, and scheduling jobs on a large construction project to finish in the shortest possible time. The problems are represented by mathematical models and various algorithms are used to find the optimal solution. Because of the magnitude of these problems, computers are usually needed to execute the algorithms.

Employment opportunities in OR usually occur with large organizations with complex operations such as transportation, manufacturing, utilities or government agencies (including the military). Other employers include management consulting firms which offer OR expertise to other companies. Some current areas in which OR practitioners are employed are: organizational design, industrial engineering, supply chain

management, decision technology, enterprise resource planning and expert systems. To encourage students to study OR and seek employment in this field, the Canadian Operational Research Society (CORS) offers a Diploma in Operational Research to students who complete a prescribed set of courses.

In the Department of Mathematics and Statistics one can satisfy the requirements for the CORS Diploma while completing an Honours degree. This is simplest in Applied Mathematics and in Mathematics for Commerce (Operations Research Stream) since many of the courses required for the Diploma are part of the degree requirements. In other programs, careful planning in choosing courses may be required. The courses required for the Diploma are listed below. Students are also encouraged to become student members of CORS and participate in its meetings. This is a very good way in which to meet practitioners in the field of OR and find out more about potential job opportunities. A membership in CORS listed on your resume will indicate to future employers your seriousness about a career in this field. You can find out more about CORS from its web page (www.cors.ca).

The Faculty Liaison for the CORS Diploma is Professor M. Chen, chensy@mathstat.yorku.ca, N628 Ross 416-736-2100, ext. 22591.

Course Requirements for the CORS Diploma

Changes to the course requirements below are presently under consideration.

To obtain the CORS Diploma, a student must have graduated from an Honours program, must be a member of CORS, and must have completed the following courses with at least a B average.

1. MATH 3171, MATH 3172 and MATH 4170—OR courses
2. MATH 2131 and MATH 3330—statistics courses
3. CSE/1020/1030 or CSE/1520/1530 or CSE/1540 or CSE/1560—computer languages
4. one of OMIS/MGTS 4000, OMIS/MGTS 4550, OMIS/MGTS 4560. These courses are offered by the Schulich School of Business. All these courses have MATH 2131 and MATH 3170 or 3171/3172 as pre-requisites.

Students are strongly encouraged to select additional courses from the following list in preparation for a career in OR:

- MATH 3260—graph theory
- MATH 4130B, MATH 4280, MATH 4430, MATH 4830, MATH 4930A—additional statistics courses
- MATH 3280—actuarial science
- ECON 3580, ECON 3590—accounting
- OMIS/MGTS 4670, OMIS/MGTS 4710, OMIS/MGTS 4720—information systems
- additional OMIS/MGTS course from item 4 in the list of required courses above.
- CSE 2031—Software Tools
- OMIS/MGTS 3670—Spreadsheet-Based Decision Support
- OMIS/MGTS 3730—Database Management with Microsoft Access

Note that these courses may have additional prerequisites.

COURSE OFFERINGS

Note that instructors for some courses may change after publication of this supplemental calendar.

1000-level Courses

MATH 1013 3.00 FW
Applied Calculus I

Calendar copy: Introduction to the theory and applications of both differential and integral calculus. Limits. Derivatives of algebraic and trigonometric functions. Riemann sums, definite integrals and the Fundamental Theorem of Calculus. Logarithms and exponentials, Extreme value problems, Related rates, Areas and Volumes. Prerequisite: SC/MATH 1515 3.00 or SC/MATH 1520 3.00, or a high school calculus course. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1300 3.00, SC/MATH 1505 6.00, SC/MATH 1513 6.00, SC/MATH 1530 3.00, SC/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, AP/ECON 1530 3.00.

Three lecture hours. Tutorials may be offered, and "MathLab" help will be available. The text will be J. Stewart, *Calculus, Early Transcendentals*, 7th ed. The bookstore will have a package including various supplementary items. All students are expected to have a copy of the text.

BIOLOGY AND KINESIOLOGY STUDENTS ARE ADVISED TO CONSIDER CAREFULLY WHETHER THEY SHOULD BE TAKING MATH 1013/1014 OR MATH 1505. SEEK ADVICE BEFORE ENROLLING IF YOU ARE UNCERTAIN.

Anyone majoring in a Mathematics and Statistics program should take MATH 1300 3.00 instead of MATH 1013 3.00.

Coordinators: **Fall: J. Heffernan** (jmheffer@yorku.ca)
Winter: M.W. Wong (mwwong@mathstat.yorku.ca)

MATH 1014 3.00 FW
Applied Calculus II

Calendar copy: Calculus in Polar Coordinates. Techniques of Integration. Indeterminate Forms. Improper Integrals. Sequences, infinite series and power series. Approximations. Introduction to ordinary differential equations. Prerequisite(s): One of SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1300 3.00, or SC/MATH 1513 6.00; for non-science students only, six credits from SC/MATH 1530 3.00 and SC/MATH 1540 3.00, SC/MATH1550 6.00, AP/ECON 1530 3.00 and AP/ECON 1540 3.00. Course credit exclusions: SC/MATH 1010 3.00, SC/MATH 1310 3.00, SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00.

Applications and Techniques of Integration. Indeterminate Forms. Improper Integrals. Introduction to ordinary differential equations with applications. Calculus in Polar Coordinates. Sequences, infinite series and power series.

This course is a sequel to MATH 1013, and will use the same textbook.

Coordinators: **Fall: M.W. Wong** (mwwong@mathstat.yorku.ca)
Winter: J. Heffernan (jmheffer@mathstat.yorku.ca)

CSE/MATH 1019 3.00 FW
Discrete Mathematics for Computer Science

Calendar copy: Introduction to abstraction. Use and development of precise formulations of mathematical ideas. Informal introduction to logic; introduction to naïve set theory; induction; relations and functions; big O-notation; recursive definitions, recurrence relations and their solutions; graphs and trees. Three lecture hours per week. Plus drop-in optional problem sessions as well as instructor office hours, as these are announced in each term. Prerequisites: SC/MATH 1190 3.00, or two 4U Math courses, including MHF4U (Advanced Function). Course credit exclusion: SC/MATH 2320 3.00, SC/CSE/MATH 1028 3.00.

The curriculum is an introduction to basic ideas and methods in Discrete Mathematics. There will be a short review of concepts from formal logic and the idea of a mathematical proof (including mathematical induction). Sets and functions will be covered, including the growth of functions and Big-Oh notation. The second half of the course will be devoted to recursion and introductory methods in counting, including the pigeonhole principle, and the solution of linear recurrences.

Coordinator: **B. van Rensburg** (rensburg@yorku.ca)

MATH 1021 3.00 FW
Linear Algebra I

Calendar copy: Linear equations, matrices, Gaussian elimination, determinants and vector spaces. This course covers material similar to that in SC/MATH 2221 3.00 but at a more advanced level. Required in Specialized Honours statistics and in all applied mathematics, mathematics and mathematics for commerce programs except the BA Program in Mathematics for Commerce. Prerequisite: One 12U or OAC mathematics course or equivalent. Course credit exclusions: SC/MATH 1025 3.00, SC/MATH 2021 3.00, SC/MATH 2221 3.00, GL/MATH/MODR 2650 3.00.

Note: MATH 1540 3.00 may not be taken for credit by anyone taking, or anyone who has passed, MATH 1021.

After the concepts in logic and set theory, the most fundamental idea in all of mathematics is that of a FUNCTION. The simplest type of function is a LINEAR function, and linear functions (also called linear transformations) are what linear algebra is about. Thus, linear algebra is mathematically more basic than, for instance, differential calculus, where more complicated functions are approximated locally by linear ones. Apart from underpinning much of mathematics, linear algebra has a vast range of applications — from quantum mechanics (where it is crucial) to computer graphics to business and industry (via statistics and linear programming).

Additional topics: Euclidean *n*-space, lines and planes, linear transformations from $\mathbb{R}^n$ to $\mathbb{R}^m$, abstract vector spaces, basis and dimension, rank and nullity of a matrix.

The text will be K. Kuttler, *A First Course in Linear Algebra* (available as a free download).

Coordinators: **Fall: A. Weiss** (weiss@mathstat.yorku.ca)
Winter: TBA

MATH 1025 3.00 FW
Applied Linear Algebra

Calendar copy: *Topics include spherical and cylindrical coordinates in Euclidean 3-space, general matrix algebra, determinants, vector space concepts for Euclidean n-space (e.g. linear dependence and independence, basis, dimension, linear transformations etc.), an introduction to eigenvalues and eigenvectors. Prerequisites: One 12U or OAC mathematics course or equivalent. Course credit exclusions: SC/MATH 1021 3.00, SC/MATH 2021 3.00, SC/MATH 2221 3.00, GL/MATH/MODR 2650 3.00.*

Note: MATH 1540 3.00 may not be taken for credit by anyone taking, or anyone who has passed, MATH 1025.

MATH 1025 3.00 gives a one-term intensive introduction to linear algebra, with emphasis on its applications. This course is particularly appropriate for students taking Science or Engineering programs which require one term's worth of linear algebra.

The text has not been chosen yet.

Coordinators: Fall: H. Joshi (hjoshi@mathstat.yorku.ca)
Winter: A. Chan (ssachan@yorku.ca)

MATH 1028 3.00 W
Discrete Math for Engineering

Calendar Copy: Introduction to discrete mathematics for engineering disciplines, including an introduction to propositional logic and application to switching circuits; sets, relations and functions; predicate logic and proof techniques; induction with applications to program correctness; basic counting techniques with applications; graphs and trees with applications in circuit analysis, information storage and retrieval, Huffman coding; automata and applications in software engineering. Three lecture hours and two hours of mandatory tutorials per week. Prerequisites: MHF4U and MCV4U. Course Credit Exclusions: LE/SC/CSE 1019 3.0, SC/MATH 1019 3.00, SC/MATH 2320 3.00.

Coordinator: TBA (Computer Science)

MATH 1090 3.00 FW
Introduction to Logic for Computer Science

Calendar copy: The syntax and semantics of propositional and predicate logic. Applications to program specification and verification. Optional topics include set theory and induction using the formal logical language of the first part of the course. Prerequisite: SC/MATH 1190 3.00 or SC/MATH 1019 3.00. Note: This course may not be taken for degree credit by any student who has passed SC/MATH 4290 3.00.

By taking this course, students will be able to master the syntax and proof techniques of propositional and predicate logic, as well as their informal semantics. The proper understanding of propositional logic is fundamental to all levels of computer programming, even the most basic, while the ability to correctly use variables, scope and quantifiers is crucial in the use of loops, subroutines, and modules, and in software design. Logic is used in many areas of computer science, including digital design, program verification, databases, artificial intelligence, computability and complexity, algorithm analysis, and software specification. Every program implicitly asserts a theorem to the effect that the program will do what its documentation says it will. Proving that theorem is not merely a matter of luck or patient debugging. Making a correct program can be greatly aided by a logical analysis of what it is supposed to do, and, for small pieces of code, a proof that the code works can be produced hand-in-hand with the construction of the code itself.

The main objective of the course is to enable the student to write and annotate correct formal proofs of "theorems", especially in predicate logic. A big secondary goal is to help the student to tell the difference between a theorem and a nontheorem, and to "DISprove" nontheorems. The student will be immersed in proof methodologies of propositional, and, much more extensively, of predicate, logic, via well-annotated and well-structured proofs in both the "equational" and the "Hilbert" style of structuring proofs. Semantics will be introduced (informally, in the predicate case), partly to breathe "meaning" into the formal syntax of logic, and partly as an indispensable tool for producing the "disproofs" mentioned above.

The text will be G. Tourlakis, *Mathematical Logic* (Wiley, 2008).

Coordinators: Fall: P. Szeptycki (szeptyck@yorku.ca)
Winter: TBA

MATH 1131 3.00 FW
Introduction to Statistics I

Calendar copy: Displaying and describing distributions; relations in categorical data; Simpson's paradox and the need for design; experimental design and sampling design; randomization; probability laws and models; central limit theorem; statistical inference including confidence intervals and tests of significance; matched pairs; simulation. Prerequisite: At least one 12U mathematics course or OAC in mathematics is recommended. Course credit exclusion: SC/MATH 2560 3.00, GL/MATH/MODR 1610 3.00, SC/BIOL 2060 3.00.

Testing a new drug, pricing a derivative asset, evaluating the effects of free trade, making sound investment decisions, and predicting who will win the World Series are all activities that have in common the need to make sense out of ambiguous data. The modern discipline of statistics serves as a guide to scientists, policy makers and business managers who must draw inferences or make decisions on the basis of uncertain information.

Topics include collection and analysis of data, graphical methods to represent data, numerical methods for describing univariate data both for samples and population, summarizing bivariate data, random variables and probability distributions, sampling variability and sampling distributions, estimation and testing using a single sample, comparison of two populations.

It is recommended that students have at least one OAC in mathematics or a 12U mathematics course, but the mathematical level of the course will be quite elementary. Although students might be making use of the computer to calculate statistics, to create statistical plots, and to obtain a better appreciation of statistical concepts, no previous experience in computing is required. Students will receive all the necessary instruction about how to use the statistical computer package chosen by the instructor.

Although this course is recommended for students who wish to major in statistics, the concepts are broadly applicable and it should be interesting to students who do not plan to specialize in statistics.

Coordinators: Fall: Y. Fu (yuejiao@mathstat.yorku.ca)
Winter: X. Gao (xingao@mathstat.yorku.ca)

MATH 1190 3.00 FW
Introduction to Sets and Logic
(formerly: MATH 1120 3.00, MATH 1090 3.00)

Calendar copy: Topics include logic, sets, functions, relations, modular arithmetic and applications of elementary number theory, proof techniques, induction. Prerequisite: One 12U or OAC mathematics course or equivalent, or SC/MATH 1710 6.00. NCR Note: This course may not be taken for degree credit by any student who has passed any 3000- or higher-level mathematics course. Course credit exclusion: GL/CSLA/MATH/MODR 1650 3.00.

It is also intended for math majors and other students wanting an introduction to discrete mathematics. The topics covered are widely used throughout mathematics; many will crop up again in other mathematics courses. The purpose of this course is to give these topics a thorough treatment early in a student's mathematical studies, with the intention of enhancing his or her understanding of future courses, irrespective of whether those courses have MATH 1190 as a prerequisite. The emphasis will be on understanding the basic ideas, and developing an appreciation for mathematical reasoning, proofs and problem solving.

There is considerable overlap between the topics of MATH 1190 and those of the course MATH 1019 (see the MATH 1019 entry earlier in this supplemental calendar). Math majors can choose to take either of these two courses (see the Mathematics BA, BSc checklists at the back of this supplemental calendar), but, before choosing, they should note that:

The coverage of topics in MATH 1019 should be at a higher "level" and perhaps at a faster pace than in MATH 1190. Moreover, MATH 1190 cannot be taken for degree credit by any student who has already passed MATH 1019. Note also that MATH 1019 is a program requirement in Computer Science.

The text will be K.H. Rosen, *Discrete Mathematics and its Applications*, 7th ed. (McGraw-Hill).

Coordinators: **Fall: TBA**
Winter: Y. Lamzouri (lamzouri@mathstat.yorku.ca)

MATH 1200 3.00 Y
Problems, Conjectures and Proofs

Calendar copy: Extended exploration of elementary problems leading to conjectures, partial solutions, revisions, and convincing reasoning, and hence to proofs. Emphasis on problem solving, reasoning, and proving. Regular participation is required. Prerequisite: 12U Advanced Functions (MHF4U) or Advanced Functions and Introductory Calculus (MCB4U).
NCR note: Not open to any student who is taking or has passed a MATH course at the 3000 level or higher.

Most High School mathematics problems are solved using algorithmic methods or via reference to model solutions. One purpose of this course is to enable students to develop the confidence and ability to attack richer and more demanding problems. The attempt to check work and to explain one's discoveries to others leads naturally to the need for explanation. Learning how to present convincing reasoning — or proof — is one of the course outcomes.

With an emphasis on communication/convincing argument, there is a critical contribution to be made by: group work, reading a proposed 'proof' including other student's work, presenting and discussing as a whole class. There is also value in working through several different approaches to solve a problem, and taking the time to understand an alternative approach offered by a peer in the class. Doing mathematics well includes talking and listening to mathematics and there will be assignments that require collaborative work with another student in the class, as well as support for forming study groups.

The main goal of this course is to develop skills that lead to understanding and communicating a convincing argument. Support will be given for proof presentation, especially for the kinds of proofs that students are expected to produce in their second year and higher level courses. This includes inductions, and arguments with counting and with inequalities. Formal proof writing exercises will be introduced in the second half of the course, once problem solving and informal justification skills reach an acceptable level.

Class and tutorial attendance is mandatory and active participation is expected of all students.

The text will be M. Liebeck, *A Concise Introduction to Pure Mathematics*.

Coordinator: **J. Steprāns** (steprans@yorku.ca)

MATH 1300 3.00 FW
Differential Calculus with Applications

Calendar copy: Limits, derivatives with applications, antiderivatives, fundamental theorem of calculus, beginnings of integral calculus. Prerequisite: SC/MATH 1515 3.00 or SC/MATH 1520 3.00 or SC/MATH 1710 6.00 or a high school calculus course. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1505 6.00, SC/MATH 1513 6.00, SC/MATH 1530 3.00, SC/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, AP/ECON 1530 3.00.

Differential calculus is the study of how quantities change. Although the concepts are introduced to study the geometry of curves, applications can be made to the sciences, engineering and economics. After a brief review of functions and trigonometry, limits are defined and computed. Continuous functions are defined, and the Intermediate Value and Maximum Value Theorems are stated. The derivative is defined as a limit and is used to study tangent lines to curves as well as motion along a straight line. The Mean Value Theorem and L'Hopital's Rule are studied. Applications are made to curve sketching, related rates problems and maxima-minima.

The definite integral is defined to compute area, and its properties are determined. The Fundamental Theorems of Calculus are proved and applied to evaluate definite integrals.

Grades: The final grade will be determined by a combination of assignments, quizzes, tests and a common final exam.

Text: S. O. Kochman, *Single Variable Calculus, Concepts, Applications, Theory*, 4th ed. (Pearson Custom Publishing, 2011, and the *Student Manual*).

Coordinators: **Fall: K. Bugajska** (bugajska@yorku.ca)
Winter: S.O. Kochman (kochman@yorku.ca)

MATH 1310 3.00 FW
Integral Calculus with Applications

Calendar copy: Transcendental functions, differential equations, techniques of integration, improper integrals, infinite series. Prerequisite(s): One of SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1300 3.00, or SC/MATH 1513 6.00; or, for non-science students only, six credits from SC/MATH 1530 3.00 and SC/MATH 1540 3.00, SC/MATH 1550 6.00, AP/ECON 1530 3.00 and AP/ECON 1540 3.00. Course credit exclusions: SC/MATH 1010 3.00, SC/MATH 1014 3.00, SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00.

This is the second in a series of introductory calculus courses. It is designed to follow MATH 1300 3.00. We continue

the study of integral calculus. The first half of the course emphasizes methods of integration. Exponential and logarithm functions are introduced. Improper integrals are used to study unbounded areas. Applications are made to compute volumes, approximate areas and compute distance traveled. Simple differential equations are solved with applications to exponential growth and mixing problems.

Infinite sequences and series are studied. Functions are represented by Taylor series and power series are used to compute limits and approximate integrals.

Grades: The final grade will be based on a combination of assignments, quizzes, in-class tests and a common final exam.

Text: S.O. Kochman, *Single Variable Calculus, Concepts, Applications, Theory*, 4th ed. (Pearson Custom Publishing, 2011 and the *Student Manual*).

Coordinators: **Fall**: **S. Moghadas** (moghadas@mathstat.yorku.ca)
Winter: TBA

MATH 1505 6.00 Y
Mathematics for the Life and Social Sciences

Calendar copy: A presentation of the elements of single-variable differential and integral calculus, elementary linear algebra and introductory probability and statistics. This course is designed to provide a comprehensive mathematical background for students of the biological and social sciences. Emphasis is placed on basic mathematical skills and their applications. Prerequisite: At least one 12U or OAC mathematics course or SC/MATH 1510 6.00. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1010 3.00, SC/MATH 1013 3.00, SC/MATH 1014 3.00, SC/MATH 1300 3.00, SC/MATH 1310 3.00, SC/MATH 1513 6.00, SC/MATH 1530 3.00, SC/MATH 1540 3.00, SC/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, GL/MATH/MODR 1940 3.00, AP/ECON 1530 3.00, AP/ECON 1540 3.00.

The course is designed for students in programs that only require 6 credits of mathematics. It combines selected material from other courses in calculus, linear algebra and statistics, with applications given to the life sciences.

Topics include derivatives of algebraic and transcendental functions with applications to maxima and minima and rates of growth, techniques of integration, applications of the integral, systems of linear equations, sample spaces, discrete and continuous probability distributions.

The text and grading scheme have not been determined yet.

Coordinator: N. Purzitsky (purzit@mathstat.yorku.ca)

MATH 1510 6.00 Y
Fundamentals of Mathematics

Calendar copy: Designed for the student whose mathematical background is weak and who wishes to take further courses in mathematics. Topics include algebraic equations and inequalities; simple sequences and series; analytic geometry; trigonometry; functions, including algebraic, exponential, logarithmic and trigonometric functions. Prerequisites: Ontario Grade 11 Functions or Functions & Relations (new curriculum) or Grade 12 Advanced Mathematics (old curriculum). NCR Note: May not be taken by any student who has taken or is currently taking another university course in mathematics or statistics except for SC/MATH 1500 3.00 or SC/MATH 1515 3.00 or SC/MATH 1520 3.00. Course credit exclusions: SC/MATH 1710 6.00, GL/ITEC/MATH/MODR 1670 6.00.

The course is a survey of topics that would normally be taken in secondary school, prior to the final year. It is intended for students whose mathematics background is weak, because of an interruption in their education.

Coordinator: J. Chawla (chawla@yorku.ca)

MATH 1520 3.00 FW
Introduction to Calculus, with Vectors

Calendar Copy: Elements of vectors in 2- and 3-space including dot products, cross products, lines, and planes; elements of differential calculus including limits and derivatives. Designed for student who have not taken (or who have performed inadequately in) Ontario high school calculus. Prerequisite: One of: MATH 1510 6.00, an OAC mathematics course, 12U Advanced Functions (MHF4U), or equivalent; or permission of the department. This course may be taken at the same time as the second half of MATH 1510 6.00. Course credit exclusions: SC/MATH 1513 6.00, SC/MATH 1515 3.00. NCR Note: May not be taken by any student who has passed or is currently taking another university course in calculus, with the exception of students taking SC/MATH 1550 6.00 concurrently.

This course covers the elements of differential calculus including limits, rates of changes, derivatives, methods of differentiation, applications of derivatives, related rates, extreme values, maximum and minimum problems and curve sketching. The course also covers elements of vectors in 2- and 3-space including dot products, cross products, lines, and planes.

Supplemental material for vectors will be announced.

Coordinators: Fall: H. Joshi (hjoshi@mathstat.yorku.ca)
Winter: P. Szeptycki (szeptyck@yorku.ca)

MATH 1530 3.00 FW
Introductory Mathematics for Economists I

Calendar Copy: Introduces and develops topics in differential calculus and integral calculus with applications to marginal analysis and profit maximization. Prerequisite: Grade 12U Advanced Functions or equivalent. Prerequisites/Co-requisites: AP/ECON 1000 3.00 or AP/ECON 1010 3.00, or equivalent. Recommended completion: high-school calculus or equivalent. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1300 3.00, SC/MATH 1505 6.00, SC/MATH 1513 6.00, SC/MATH 1550 6.00, GL/MATH/MODR 1930 3.00. Note: Acceptable course substitutes are available in the Calendar.

Note: This course is not currently offered by the Mathematics and Statistics Department. The Department of Economics is now responsible for all sections.

The pair MATH 1530 3.00 and MATH 1540 3.00 is designed to give the student an introduction to mathematics sufficient for a thorough understanding of modern textbooks in economic theory. The emphasis is on the acquisition of tools for later use and on an understanding of both concepts and techniques for applications, rather than on theoretical proofs or a rigorous development of the mathematics involved. The pair is similar to MATH 1550 6.00.

Topics will include single-variable differentiation, limits, continuity, series, exponential and logarithmic functions, single-variable optimization, and integration. Applications to problems in economics involving supply and demand functions, maximization of profits, elasticity of demand and consumers' surplus will be considered.

Course material will be announced in class.

The final grade may be based on term tests and/or assignments and a final examination. Instructors will announce details in class.

MATH 1532 3.00 FW
Statistics for Business and Society

Calendar Copy: An introduction to statistics with an emphasis on concepts and applications relevant in the Business and Society program. Students learn basic and practical statistical techniques to explore and analyze data. Emphasis is placed on statistical reasoning and the critical interpretation of statistical information such as that seen in the media and journals. NCR note: SC/MATH 1532 3.00 may not be taken for credit by any student who has successfully completed or is concurrently enrolled in SC/MATH 1131 3.00, SC/MATH 2560 3.00, SC/MATH 2570 3.00, SC/BIOL 2060 3.00 or equivalents. Course credit exclusions: AK/MATH 1720 3.00; SC/NATS 15003.00.

This course is an introduction to statistics specifically designed for students in the Business and Society program in the Division of Social Science. Students learn basic and practical statistical techniques to explore and analyze data. Emphasis is placed on statistical reasoning and the critical interpretation of statistical information such as that seen in the media and in journals.

There is also a strong emphasis on acquiring practical skills in data exploration with spreadsheet software such as Excel or Calc. The course includes weekly tutorials in a computer lab.

Grading is based on

1. Assignments including lab exercises: 30%
2. Structured project based on the analysis of real data: 25%
3. Mid-term test: 20%
4. Final exam: 25%

The text is to be announced.

Coordinators: Fall: Y. Wu (wuyh@mathstat.yorku.ca)
Winter: S. Wang (stevenw@mathstat.yorku.ca)

MATH 1540 3.00 FW
Introductory Mathematics for Economists II

Calendar Copy: Introduces and develops topics in comparative statics of general function models and matrix algebra with applications to input-output models, unconstrained and constrained optimization with applications to microeconomic and macroeconomic models, and elements of linear programming with applications to decision-making in economics. Prerequisite: AP/ECON 1530 3.00 or equivalent. Prerequisites/Co-requisites: AP/ECON 1000 3.00 or AP/ECON 1010 3.00, or equivalent. Note: No credit will be retained for this course for students who have successfully completed or who are currently enrolled in SC/MATH 1021 3.00, SC/MATH 1025 3.00, or SC/MATH 2221 3.00. Course credit exclusions: SC/MATH 1505 6.00, SC/MATH 1550 6.00, GL/MATH/MODR 2650 3.00. Note: Acceptable course substitutes are available in the Calendar.

Note: This course is not currently offered by the Mathematics and Statistics Department. The Department of Economics is now responsible for all sections.

This course is normally taken by students who have completed MATH 1530 3.00 and are in the Bachelor Mathematics for Commerce Program.

The material that is covered in the course is mainly matrix algebra and functions of many variables. The material will be covered in a way that will be of interest to students in economics and business. The emphasis will be on the acquisition and use of tools rather than on a rigorous development of the tools. Applications will include the solution of linear equations, and maxima and minima of functions of several variables, with and without constraints.

The text and grading scheme are anticipated to be the same as those for MATH 1530 3.00.

MATH 1550 6.00 Y
Mathematics with Management Applications

Calendar copy: This course is designed to provide a mathematical background for students in the BBA Honours program. It is also suitable for the bachelor program in mathematics for commerce, but should not be taken by those who intend to major in any other program in mathematics or statistics or in computer science. It includes calculus, matrix algebra and elements of optimization with applications to management. Prerequisite: SC/MATH 1515 3.00 or SC/MATH 1520 3.00 (may also be taken as a first-term corequisite), or a high school calculus course. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1300 3.00, SC/MATH 1505 6.00, SC/MATH 1513 6.00, SC/MATH 1530 3.00, SC/MATH 1540 3.00, GL/MATH/MODR 1930 3.00, AP/ECON 1530 3.00, AP/ECON 1540 3.00. NCR Note: This course may not be taken by any student who has passed or is taking SC/MATH 1021 3.00, SC/MATH 1025 3.00, SC/MATH 2021 3.00, SC/MATH 2221 3.00, GL/MATH/MODR 2650 3.00 or equivalent.

This course is designed primarily for students interested in business programs. It satisfies a requirement for entry to the delayed entry BBA (Hons) Programs in the Schulich School of Business.

One theme of the course is optimization — how to maximize or minimize a function subject to certain constraints. Most of the course is a discussion of calculus and its applications; matrix theory and its applications are also discussed. The emphasis will be on techniques and on applications to business and management problems. The content of this course is very similar to that of the two courses MATH 1530 3.00 and MATH 1540 3.00. These courses will satisfy the requirements for the programs mentioned above, and they are suitable for those who plan to major in economics.

Those who wish a stronger foundation in calculus, or who wish to major in any Mathematics program other than those mentioned above, should avoid calculus courses with second digit 5.

The text and grading scheme have not been determined as this supplemental calendar goes to press.

Coordinator: TBA

MATH 1581 3.00 FW
Business Mathematics I

Calendar copy: This course is an introduction to interest rates (simple, compound), annuities (ordinary, due, deferred), amortization (mortgages, other debts), sinking funds, bonds (face value, bond rate, price, yield rate) and depreciation (straight line, constant percentage). Prerequisite: Ontario Grade 11 mathematics or equivalent. Course credit exclusion: SC/MATH 2580 6.00, GL/MATH 2680 6.00.

A different title for this course might be “The Mathematics of Money”. As money moves through time, the force of interest must be taken into account. Doing so requires mathematical calculations, and this course introduces some of those

calculations. While the background required is only (the equivalent of) Ontario Grade 11 mathematics, the course will be a university-level mathematics course that requires problem-solving skills. This course will be offered in both Fall term and Winter term. It should be particularly attractive to students in the Business and Society Program, and also to students in economics and business-related areas. The course emphasizes problem-solving rather than theory. Computers (spreadsheets) will not be used; student will need a hand-held calculator which can at least calculate exponents and logarithms.

Tentatively, the text will be R.L. Brown, S. Kopp and P. Zima, , *Mathematics of Finance*, latest edition (McGraw-Hill Ryerson Limited), but only about half the text (and not exactly the first half) will be covered.

The grading scheme for the course has not been determined, but it will likely involve one or two tests and a final examination.

Coordinators: Fall: D. Tanny (tanny@mathstat.yorku.ca)
Winter: TBA

2000-level Courses

MATH 2001 3.00 F
Real Analysis I

Calendar copy: Axioms for, and properties of, the real numbers; sequences; functions of a real variable, continuity, and differentiation. Rigorous definitions of convergence and limit underpin a proof-based treatment of the subject material. Intended for Honours students in Mathematics. Prerequisites: SC/MATH 1200 3.00, SC/MATH 1300 3.00. Course credit exclusion: SC/MATH 3110 3.00. NCR note: MATH 2001 3.00 is not open to any student who has passed MATH 1010 3.00

This is the first in a three course sequence in Analysis (to be followed by MATH 3001 and MATH 4010) for honours stream Mathematics majors. The course develops the theory of real numbers and, in part, functions of a real variable with full mathematical rigour. Beginning with an axiomatic study of the real numbers as an ordered field, the fundamental properties of the reals are then derived from these axioms. In particular, the greatest lower bound property, Archimedean property and Bolzano-Weierstrass theorem are proved. Then sequences and series are studied, along with the notions of open and closed intervals. Building on the basic theory of the reals, functions on the line are introduced and the underpinnings of calculus are developed in full rigour. Here, the familiar topics of continuity, differentiation, and Riemann integration are developed from a more advanced perspective.

The text has not yet been chosen.

Coordinator: P. Szeptycki (szeptyck@yorku.ca)

MATH 2015 3.00 FW
Applied Multivariate and Vector Calculus

Calendar copy: Topics covered include partial derivatives; grad, div, curl and Laplacian operators; line and surface integrals; theorems of Gauss and Stokes; double and triple integrals in various coordinate systems; extrema and Taylor series for multivariate functions. Prerequisite: One of SC/MATH 1010 3.00, SC/MATH 1014 3.00, SC/MATH 1310 3.00; or SC/MATH 1505 6.00 plus permission of the course coordinator. Course credit exclusions: SC/MATH 2010 3.00, SC/MATH 2310 3.00, GL/MATH/MODR 2670 3.00, GL/MATH 3200 3.00.

Topics covered include partial derivatives; grad, div, curl and Laplacian operators; extrema and Taylor series for multivariate functions; double and triple integrals in various coordinate systems; line and surface integrals; theorems of Green, Gauss and Stokes.

The textbook is J. Stewart, *Calculus: Early Trans-cendentals, Ed. 7E (*Chapters 12–16), 2012.

Coordinator: Hm. Zhu (hmzhu@mathstat.yorku.ca)

MATH 2022 3.00 W
Linear Algebra II

Calendar copy: Inner product spaces, linear transformations, eigenvalues, diagonalization, least squares, quadratic forms and Markov chains. Similar to MATH 2222 3.00 but at a more advanced level. Required in Specialized Honours applied mathematics, Specialized Honours statistics and in all mathematics and mathematics for commerce programs except the BA program in mathematics for commerce. Prerequisite: one of SC/MATH 1021 3.00, SC/MATH 2021 3.00, GL/MATH/MODR 2650 3.00 or permission of the course coordinator. Course credit exclusions: SC/MATH 2222 3.00, GL/MATH/MODR 2660 3.00.

For a general description of the subject "linear algebra", see the supplemental calendar entry for MATH 1021 3.00.

Additional topics: General linear transformations, matrix of a linear transformation from *V* to *W* relative to bases for V and W, effect of a change of bases.

The text will be K. Kuttler, *A First Course in Linear Algebra* (available as a free download).

Coordinator: A. Weiss (weiss@mathstat.yorku.ca)

MATH 2030 3.00 FW
Elementary Probability

Calendar copy: Introduction to the theory of probability as preparation for further study in either mathematical or applied probability and statistics. Topics include probability spaces, conditional probability, independence, random variables, distribution functions, expectation, Chebyshev's inequality, common distributions, moment-generating functions and limit theorems. Prerequisite: One of SC/MATH 1010 3.00, SC/MATH 1014 3.00, SC/MATH 1310 3.00.

This course provides an introduction to the theory of probability. It covers the mathematics used to calculate probabilities and expectations, and discusses how random variables can be used to pose and answer interesting problems arising in nature. It is required for most programs in Mathematics and Statistics, or in Computer Science. Subsequent courses that use the material covered include mathematical statistics, operations research, mathematical finance, stochastic processes, as well as more advanced courses in probability.

Coordinators: Fall: D. Tanny (tanny@mathstat.yorku.ca)
Winter: S. Chamberlin (chamber@mathstat.yorku.ca)

MATH 2031 1.00
Probability Explorations

Proposed calendar copy: Exploration of probability theory using mathematical calculation, experiment, and computer simulation. Prior experience communicating mathematics (e.g., as in SC/MATH 1200 3.00) is an asset, but is not required. Prerequisite or corequisite: SC/MATH 2030 3.00.

Note: This course will not be offered in FW 2014.

The description given above is tentative, pending curricular review.

MATH 2041 3.00 F
Symbolic Computation Laboratory I

Calendar copy: An introduction to symbolic computing in the Maple environment. Topics from single-variable differential and integral calculus, including simple ordinary differential equations, are covered. Both mathematical understanding and applications are emphasized. Three lecture hours, open laboratory hours. One term. Three credits. Prerequisites: SC/CSE 1540 3.00 (formerly COSC) or equivalent computing experience; SC/MATH 1010 3.00 or SC/MATH 1014 3.00 or SC/MATH 1310 3.00.

Many of the technological advances that come from scientific innovation depend on efficient means of computation and analysis of large amounts of data. Before digital computers became widely available, these sorts of computations were largely done by hand or with the aid of mechanical calculation tools or tables. However, for every computation tool that we have available, there are always mathematical problems that are beyond the limits of our computational power. For example, the ability to factor an 800 digit integer which is the product of two primes or find the determinant of a large matrix is out of the reach of our current computational tools.

This course will use the program Maple to answer numerical and discrete computation questions which would otherwise be too difficult to do by hand or the use of a simple calculator. Maple is an example of a Computer Algebra System (CAS) but other examples such as sage, Mathematica and Matlab are similarly capable of doing a wide range of computations and other many specialized programs (such as R, GAP and Macaulay) are particularly efficient at certain types of computations.

Your assignments will be to complete worksheets and computation tasks and the grade for the class will also include the results of in class tests and quizzes.

Coordinator: Q. Wang

MATH 2131 3.00 W
Introduction to Statistics II

Calendar copy: This course is a continuation of MATH 2030 3.00. It provides students with an introduction to statistical methods with an emphasis on applications using continuous probability models. Prerequisites: SC/MATH 1131 3.00; SC/MATH 2030 3.00; SC/MATH 2015 3.00 or SC/MATH 2310 3.00.

This course serves as an introduction to mathematical statistics, and is devoted to the study of the basic probability tools needed in the theory of statistical inference. Topics include joint distributions, multivariate change of variables formula, conditional and marginal distributions, conditional expectation, covariance and correlation, and moment generating functions. Distributional results including those associated with normally distributed observations are examined. The course ends with a look at some statistical applications such as ANOVA or linear regression (time permitting).

The topics considered in this course require a solid knowledge of univariate and multivariate calculus.

Coordinator: S. Chamberlin (chamber@mathstat.yorku.ca)

MATH 2200 3.00 Y
Extended Problems Conjectures and Proofs

Calendar Copy: Extended exploration of problems leading to conjectures, partial solutions, and proofs. Problems build on reasoning which may be applied to fields such as analysis, algebra or number theory. Regular participation is required. Prerequisites: SC/MATH 1300 3.00, SC/MATH 1310 3.00, SC/MATH 1021 3.00 or equivalents; taking or has taken a math course at the 3000 level or higher. Course credit exclusion: SC/MATH 1200 3.00.

This class will be offered for students did not take Math 1200 in their first two years of study. The main purpose of the course is to develop communication and analytic skills that will allow students to attack problems where there is no obvious method of solution. To present a convincing argument in mathematics, we try to use clearly defined language, logic, and symbolic manipulation in a way that conveys to the reader that a mathematical statement is true. Students who take this course will develop the skills necessary to present a convincing argument by engaging challenging problems and reasoning. Topics may include definitions, theorems and examples from subjects such as algebra, analysis or number theory.

Coordinator: S. Moghadas (moghadas@yorku.ca)

MATH 2221 3.00
Linear Algebra with Applications I

Calendar copy: Systems of linear equations, linear and affine subspaces of Euclidean n-space, the Gauss-Jordan algorithm, matrices and matrix algebra, determinants, vector space concepts for Euclidean n-space (linear dependence and independence, basis, dimension etc.), various applications. Prerequisite: A 12U mathematics course or OAC algebra or any university mathematics course. Course credit exclusions: SC/MATH 1021 3.00, SC/MATH 1025 3.00, SC/MATH 2021 3.00, GL/MATH/MODR 2650 3.00.

Note: This course will not be offered in FW 2014.

MATH 2222 3.00
Linear Algebra with Applications II

Calendar copy: Linear transformations and their representation by matrices, change of basis and similarity, eigenvalues and eigenvectors, diagonalization, inner product spaces, orthogonality, the Gram-Schmidt algorithm, least squares approximations, abstract vector spaces, various applications. Prerequisite: One of SC/MATH 1021 3.00, SC/MATH 1025 3.00, SC/MATH 2221 3.00 or GL/MATH/MODR 2650 3.00. Course credit exclusions: SC/MATH 2022 3.00, GL/MATH/MODR 2660 3.00.

Note: This course will not be offered in FW 2014.

MATH 2270 3.00 W
Differential Equations

Calendar copy: Introduction to differential equations, including a discussion of the formation of mathematical models for real phenomena; solution by special techniques; applications; linear equations; solutions in series; other topics if time permits. Prerequisites: One of SC/MATH 2010 3.00, SC/MATH 2015 3.00 or SC/MATH 2310 3.00; one of SC/MATH 1021 3.00, SC/MATH 1025 3.00, or SC/MATH 2221 3.00. Course credit exclusion: SC/MATH 2271 3.00, GL/MATH 3400 3.00

Differential equations have played a central role in mathematics and its applications for the past three hundred years. Their importance in applications stems from the interpretation of the derivative as a rate of change, a familiar example being velocity. Many of the fundamental laws of physical science are best formulated as differential equations. In other areas, too, such as biology and economics, which involve the study of growth and change, such equations are of fundamental importance.

In this course we will study some important types of linear differential equations and their solutions. Topics will include first-order (differential) equations; homogeneous second and higher order equations with constant coefficients; the particular solution of inhomogeneous second-order equations; first-order linear systems, solutions and phase plane; series-form solutions of equations with variable coefficients; solutions by use of Laplace transforms. Some nonlinear systems will be explored using linearization and phase portrait analysis.

Students will use the symbolic computational computer language MAPLE to study the behaviour of differential equations. No prior experience with this language is necessary.

Coordinator: Hp. Zhu
(huaiping@mathstat.yorku.ca)

MATH 2271 3.00 W
Differential Equations for Scientists and Engineers

Calendar Copy: Introduction to ordinary and partial differential equations, including their classification, boundary conditions, and methods of solution. Equations, methods, and solutions relevant to science and engineering are emphasized, and exploration is encouraged with the aid of software. Three lecture hours per week. One term. Three credits. Prerequisites: One of SC/MATH 2010 3.00, SC/MATH 2015 3.00, SC/MATH 2310 3.00 or equivalent; one of SC/MATH 1025 3.00, SC/MATH 2022 3.00, SC/MATH 2222 3.00 or equivalent. Course Credit Exclusions: SC/MATH 2270 3.00, GL/MATH 3400 3.00

This course gives an overview of differential equations for students in science and engineering. The emphasis is on ordinary differential equations, and the classical methods of solutions for a variety of types of equations are covered. General first order equations, as well as linear second order equations, are discussed, both in terms of general theory and particular solution techniques. Series solutions for second order equations are presented. Methods of solution for second order linear equations are extended to higher order equations. Boundary value problems for partial differential equations are presented, with the main solution technique being separation of variables and Fourier series.

The text is D.G. Zill and M.R. Cullen, *Differential Equations with Boundary-Value Problems* (York University Custom Edition, 2012).

Coordinator: M. Haslam (mchaslam@mathstat.yorku.ca)

MATH 2280 3.00 F
The Mathematical Theory of Interest

Calendar copy: Topics include measurement of interest, annuities, amortization of loans, bonds, sinking funds and depreciation. The course is at a level which will prepare students for the interest theory portion of the Society of Actuaries examinations. Prerequisite: SC/MATH 1010 3.00 or SC/MATH 1014 3.00 or SC/MATH 1310 3.00. Course credit exclusions: SC/MATH 2580 6.00, SC/MATH 2581 3.00, GL/MATH 2680 6.00.

Actuarial science is the branch of mathematics dealing with insurance and financial risk. This course focuses on interest-only financial calculations (e.g. bonds, loans, mortgages). Topics include: measurement of interest, annuities, amortization of loans, bonds, sinking funds and depreciation. The course is designed to prepare students for the interest theory portion of the FM actuarial exam. This course is at a level aimed at students in the Actuarial Stream, Mathematics for Commerce Honours Program, and requires knowledge of calculus.

The text will be S. Broverman, *Mathematics of Investment and Credit* (latest edition). This course also requires that students have a BA II Plus calculator from Texas Instruments.

Coordinator: TBA

MATH 2281 3.00 W
Financial Economics

Calendar Copy: A quantitative introduction to financial economics. The topics include arbitrage pricing theory, forwards and futures, American and European options, interest rate derivatives, yield curves, arbitrage hedging and pricing, put-call parity, arbitrage bounds, binomial model, Black-Scholes formula, risk-neutral valuation, trinomial model. The course ensures an adequate preparation for exam MFE of the Society of Actuaries. Prerequisites: SC/MATH 2280 3.00; SC/MATH 2030 3.00.

This course is designed to follow MATH 2280, which treats the mathematics of cash flow and bonds. Building on that material, MATH 2281 goes on to consider other types of financial contracts. Its focus is the mathematical valuation of derivative securities, and a rigorous approach to arbitrage pricing theory in discrete time. It is a requirement for the actuarial stream of the specialized honours Math for Commerce program, and for the financial mathematics stream of the Computational Math program.

Coordinator: TBA

MATH 2310 3.00 F
Calculus of Several Variables with Applications

Calendar copy: Vector functions, partial derivatives, gradient, multiple integrals, line integrals, optimization, applications. Prerequisite: SC/MATH 1010 3.00 or SC/MATH1014 3.00 or SC/MATH 1310 3.00. Students should have a knowledge of vector algebra in two and three dimensions. Course credit exclusions: SC/MATH 2010 3.00, SC/MATH 2015 3.00, GL/MATH/MODR 2670 3.00, GL/MATH 3200 3.00.

This course is designed to follow MATH 1300/1310. It studies the calculus of functions in two and three dimensions, just as those earlier courses examined functions of one variable. In addition to the topics listed above, it covers lines, planes, curves, surfaces, polar coordinates, arc length, Lagrange multipliers, and change of coordinates in multiple

integrals. Students may opt to follow it with MATH 3010, which covers further topics in the calculus of vector functions.
Coordinator: TBA

MATH 2320 3.00 FW
Discrete Mathematical Structures

Calendar copy: Growth of functions (0, Omega, Theta notation), complexity of algorithms; recurrence relations, divide-and-conquer, generating functions; graph theory, Euler and Hamilton paths, Dijkstra's algorithm; trees, binary search, spanning trees, Prim and Kruskal algorithms. Required course in Information Technology. Prerequisite: SC/MATH 1190 3.00, or SC/MATH 1090 3.00, or any 2000-level MATH course without second digit 5. Students who have not taken SC/MATH 1190 3.00 or SC/MATH 2090 3.00 are advised to review set theory, functions, relations and induction proofs, before the course begins. Course credit exclusion: SC/CSE/MATH 1019 3.00, SC/CSE/MATH 1028 3.00.

Note: This course is a program requirement of ITEC, and is an elective in CSE.

Consultation with the Departments of Computer Science and of Mathematics, and with the ITEC Program, has led to the following list of topics for emphasis: "Big O" notation, complexity of formulae and algorithms, modular arithmetic, recursive definitions, general inductions, counting principles, recurrence relations and methods for solving them, trees and simple graph theory. The emphasis will include examples arising from algorithms and the ability to carry out analysis, problem solving, proofs and calculations which will be required in upper level courses.

The course does not require previous knowledge of computer science. A student of mathematics should enjoy this introduction to a variety of mathematical topics, many of which are not covered elsewhere. We will emphasize analysis, problem solving, and proofs.

The text will be K.H. Rosen, *Discrete Mathematics and its Applications* 7th ed. (McGraw-Hill).
Coordinators: Fall: TBA
Winter: Y. Lamzouri (lamzouri@mathstat.yorku.ca)

MATH 2560 3.00 F
Elementary Statistics I

Calendar copy: Displaying and describing distributions, normal distribution. Relationships between variables, regression and correlation. The need for design, experimental design and sampling design. Sampling distributions, bias, variability. Probability models, random variables, probability laws. Prerequisite: Ontario Grade 11 mathematics. Course credit exclusions: SC/MATH 1131 3.00, SC/BIOL 2060 3.00, AP/ECON 2500 3.00, AP/SC/GEOG 2420 3.00, HH/KINE 2050 3.00, GL/MATH/MODR 1610 3.00, SB/OMIS 1000 3.00, AS/POLS 3300 6.00, GL/POLS 2610 3.00, HH/PSYC 2020 6.00, HH/PSYC 2021 3.00, GL/SOCI 2610 3.00, SB/OMIS 1000 3.00.

Statistics is a collection of methods for observing and analyzing numerical data in order to make sensible decisions about them. In these courses the basic ideas of the analysis of data and of statistical inference will be introduced.

Little mathematical background is required; high school algebra is sufficient. Mathematical proofs will be minimal; reasoning and explanations will be based mostly on intuition, verbal arguments, figures, or numerical examples. Most of the examples will be taken from our daily life; many deal with the behavioural sciences, while others come from business, the life sciences, the physical sciences, and engineering.

Although students will be making some use of the computer to calculate statistics, to create statistical plots, and to obtain a better appreciation of statistical concepts, no previous experience in computing is required. Students will receive in class all the necessary instruction about how to use a statistical computer package.

Students who have taken MATH 2560 3.00 will normally take MATH 2570 3.00 in the second semester, where they will continue to investigate many basic statistical methods. Students who require only 3 credits of statistics may wish to consider one of MATH 1131 3.00, MATH 2565 3.00 or MATH 1532 3.00 instead.

The text will be D.S. Moore and G.P. McCabe, *Introduction to the Practice of Statistics*, 7th ed. (W.H. Freeman and Company). Normally, the first five chapters are covered in MATH 2560, and the remaining chapters are covered in MATH 2570.

The final grade may be based on assignments and quizzes, class tests, and a common final exam.
Coordinator: S. Wang (stevenw@mathstat.yorku.ca)

MATH 2565 3.00 FW
Introduction to Applied Statistics

Calendar copy: The aim of this course is to give students in various disciplines some fundamental tools in statistical inference. Through a mixture of theory given in lecture hours and practice acquired during lab time, the student will understand when and how to use statistical tools such as the z, t or chi-squared tests, regression analysis, analysis of variance and various other techniques. Prerequisites: High school MATH 11U or MATH 11U/C.
Course credit exclusions: SC/BIOL 2060 3.00, AP/ECON 2500 3.00, AP/SC/GEOG 2420 3.00, HH/KINE 2050 3.00, SC/MATH 2560 3.00, SC/MATH 2570 3.00, HH/PSYC 2020 6.00, SB/OMIS 1000 3.00.

Three lecture hours per week. Statistics plays a key role in almost all areas of human inquiry. Its importance has grown considerably with the availability of large amounts of data gathered electronically. This course presents an introduction to the concepts and methods of statistics including confidence intervals, tests of significance, regression, analysis of variance and other methods.
Coordinator: Y. Fu (yuejiao@mathstat.yorku.ca)

MATH 2570 3.00 W
Elementary Statistics II

Calendar copy: Binomial distribution, sampling distribution of sample proportions and means, central limit theorem. Confidence intervals, tests and decisions, abuse of tests. Inference for a single mean, comparing two means and for spread. Contingency tables. Simple regression and basic analysis of variance. Prerequisite: SC/MATH 2560 3.00 or SC/MATH 1131 3.00. Course credit exclusions: AP/SC/GEOG 2420 3.00, HH/KINE 3150 3.00, GL/MATH/MODR 1620 3.00, AS/POLS3300 6.00, GL/POLS 2620 3.00, HH/PSYC 2020 6.00, HH/PSYC 2022 3.00, GL/SOCI 2620 3.00.

See also the description for MATH 2560 3.00.

The text will be D.S. Moore and G.P. McCabe, *Introduction to the Practice of Statistics*, 7th ed. (W.H. Freeman and Company).
Coordinator: W. Liu (liuwei@mathstat.yorku.ca)

MATH 2580 6.00
Mathematics of Investment and Actuarial Science

Calendar copy: Theory of interest; annuities certain; amortization and sinking funds; evaluation of bonds and other investments; depreciation, depletion and capital cost; insurance, including mortality tables, principles of life annuities, premiums and reserves.

Note: This course has been retired and will not be offered again. Students whose program requires MATH 2580 6.00 should take both MATH 1581 3.00 and MATH 2581 3.00 in lieu of this course.

MATH 2581 3.00 W
Business Mathematics II

Calendar copy: Spreadsheets and their application to business mathematics; deepening of topics in Business Mathematics I, including continuous compound interest, perpetuities, annuities where payments vary, callable bonds, bond yield rate, capital budgeting; mortality tables, life annuities, life insurance. Prerequisites: SC/MATH 1581 3.00; SC/CSE 1520 3.00 or permission of the instructor. Course credit exclusions: SC/MATH 2280 3.00, SC/MATH 2580 6.00, GL/MATH 2680 6.00.

This course is the sequel to MATH 1581, which must be taken as a strict prerequisite. The text will be P. Zima, R.L. Brown and S. Kopp, *Mathematics of Finance*, 7th ed. (McGraw-Hill Ryerson Ltd.); we expect to cover in this course all the material from this text that is skipped in MATH 1581. A partial list of topics would include continuous compound interest, perpetuities, annuities where payments vary, callable bonds, bond yield rate, capital budgeting, mortality tables, life annuities, life insurance.

The course should be especially interesting to students of business and economics. Although the mathematical background required is minimal, it is preferred that students will have taken one other mathematics course at university before taking this one. Students who are contemplating a career in the actuarial profession, or wish a more advanced treatment of material should not take this course, but enrol in MATH 2280 3.00. Mathematics for Commerce students in the Actuarial Stream should enrol in MATH 2280 3.00.
Coordinator: Y. Molhylevskyy

MATH 2590 3.00 F
Thinking Mathematically I
(same as ED/MATH 2590 3.00)

Calendar copy: The main objectives of this course include providing opportunities for students to achieve success in thinking mathematically and to reflect on the learning and practice of mathematics. Intended primarily, but not exclusively, for Education students in the PJ and JI streams. Prerequisite: Successful completion of at least 24 credits or permission of the course director. Note: This course is not open to any student who has taken or is taking another university mathematics course unless permission of the course coordinator is obtained. NCR Note: This course may not be taken for credit by any student who has taken SC/MATH 1580 3.00.

The main objectives of this course include providing opportunities for students to achieve success in thinking mathematically and to reflect on the learning and practice of mathematics. Intended primarily, but not exclusively, for Education students in the PJ and JI streams, this course is designed to create a positive attitude towards mathematics through an examination of topics relevant to the study of mathematics at the elementary school level. All students who feel that their background in mathematics is incomplete, or whose past experiences have caused them to avoid mathematics, are particularly encouraged to take this course. In all work, an exploratory approach will be used, in which students will work individually and in small groups on selected problems and projects, using a mix of hands-on materials, appropriate technology, and pencil and paper. Throughout, the focus will be on developing students' communication skills in written, oral, visual and other forms within groups, with the larger class and the instructor.

The book J. Mason et al., *Thinking Mathematically*, is a basic resource. Material will also be drawn from other sources, including the internet. The final grade will be based on participation and a combination of assignments, projects and a journal.
Coordinator: TBA (Faculty of Education)

3000-level Courses

MATH 3001 3.00 W
Real Analysis II

Calendar Copy: *Numerical series, Riemann integration, Taylor polynomials, sequences and series of functions, uniform convergence, power series, introduction to metric spaces including compactness and completeness, Weierstrass Approximation Theorem. Continues MATH 2001. Proof-based, intended for Honours students in Mathematics. Prerequisites: SC/MATH 1010 3.00 or both SC/ MATH 2001 3.00 and SC/MATH 1310 3.00. Course credit exclusion: SC/MATH 3210 3.00*

This is the second in a three course sequence in Analysis (preceded by MATH 2001 and followed by MATH 4001) for honours stream mathematics majors. The course continues a rigorous exposition of analysis, begun in MATH 2001, with an emphasis on careful mathematical arguments, proofs and examples. The objectives of the course include understanding and writing mathematical arguments, as well as mastering course content. The course provides an essential theoretical background for a variety of higher level and graduate courses including those in analysis, probability, topology, mathematical statistics and numerical analysis.

Specific topics include Taylor polynomials, Taylor's Theorem with remainder, and some of the so called elementary functions. Riemann integration, infinite series, sequences and series of functions, power series, and an introduction to Fourier series will be presented in detail. Metric spaces will be introduced, and metric space topics include continuous functions in a more general setting, compactness, completeness, and some special metric spaces such as the continuous functions on the unit interval. Other topics include the Weierstrass Approximation Theorem and further topics in Fourier series (time permitting).
Coordinator: G. Monette (georges@yorku.ca)

MATH 3010 3.00 F
Vector Integral Calculus

Calendar copy: Integrability of continuous functions over suitable domains, iterated integrals and Fubini's theorem, counterexamples, change of variables, Jacobian determinants, polar and spherical coordinates, volumes, vector fields, divergence, curl, line and surface integrals, Green's and Stokes's theorems, differential forms, general Stokes's theorem. Prerequisite: SC/MATH 2010 3.00, or SC/MATH 2310 3.00; or SC/MATH 2015 3.00 and written permission of the mathematics undergraduate director (normally granted only to students proceeding in Honours programs in mathematics or in the Specialized Honours program in statistics). Prerequisite or corequisite: SC/MATH 2022 3.00 or SC/MATH 2222 3.00.

This course will be a rigorous study of the functions of several variables. The topics included are limits, continuity, differentiation, Implicit Function Theorem, Inverse Function Theorem, integration, line integrals, surface integrals, and elementary differential forms.
Coordinator: N. Purzitsky (purzit@mathstat.yorku.ca)

MATH 3020 6.00 Y
Algebra I

Calendar copy: Introduction to the basic concepts of abstract algebra, with applications: groups (cyclic, symmetric, Lagrange's theorem, quotients, homomorphism theorems); rings (congruences, quotients, polynomials, integral domains, PIDs and UFDs); fields (field extensions, constructions with ruler and compass, coding theory). Prerequisite: SC/MATH 2022 3.00 or SC/MATH 2222 3.00.

Note: This course has been retired and will not be offered again. It has been replaced with MATH 3021 3.00 and MATH 3022 3.00.

MATH 3021 3.00 F
Algebra I

Calendar copy: Introduction to the basic concepts of abstract algebra, with applications: groups (cyclic, symmetric, Lagrange's theorem, quotients, homomorphism theorems). Prerequisites: SC/MATH 1019 3.00 or SC/MATH 1190 3.00 or SC/MATH 1200 3.00; SC/MATH 2022 3.00 or SC/MATH 2222 3.00. Course credit exclusions: SC/MATH 3020 6.00, GL/MATH 3650 6.00 or GL/MODR 3650 6.00, GL/MATH 3510 3.0

Algebra I is a relatively simple but exciting subject which very often allows us to solve rather difficult problems in other disciplines of mathematics and of applied mathematics. In other words, it is very fruitful to express properties of other disciplines in terms of some algebraic structures. This gives not only a deeper understanding of a problem but often leads to its solution. This course is a first but necessary step in such direction. It introduces basic notions of the language of the Algebra.

The texbook will be J.A. Gallian, *Contemporary Abstract Algebra*, 8th ed.
Coordinator: Y. Gao (ygao@yorku.ca)

MATH 3022 3.00 W
Algebra II

Calendar copy: Continuation of Algebra I with the introduction of rings (congruences, quotients, polynomials, integral domains, PIDs and UFDs) and fields (field extensions, constructions with ruler and compass, coding theory). Prerequisites: SC/MATH 3021 3.00 or permission of the course coordinator. Course credit exclusions: SC/MATH 3020 6.00, GL/MATH 3650 6.00 or GL/MODR 3650 6.00, GL/MATH 3515 3.00.

This is a continuation of Math 3021. Algebra is one of the core parts of mathematics. It is concerned with properties of mathematical objects that can be expressed symbolically and it is used in almost every branch of mathematics. Algebraic methods provide not only solutions to problems in other areas of mathematics, but they also provide proofs that certain problems do not have solution. This is the case with some familiar problems such as trisection of an angle and solution of quintic equation in radicals. This course also supports students in learning how to write clear and concise proofs
and how to communicate mathematical ideas effectively.

The texbook will be J.A. Gallian, *Contemporary Abstract Algebra*, 8th ed.
Coordinator: Y. Gao (ygao@yorku.ca)

MATH 3034 3.00
Applied Categorical Data Analysis

Calendar copy: Regression using categorical explanatory variables, one-way and two-way analysis of variance. Categorical response data, two-way and three-way contingency tables, odds ratios, tests of independence, partial association. Generalized linear models. Logistic regression. Loglinear models for contingency tables. Prerequisite: SC/MATH 3033 3.00 or SC/MATH 3330 3.00.

Note: This course will not be offered in FW 2014.

MATH 3050 6.00
Introduction to Geometries

Calendar copy: Analytic geometry over a field with vector and barycentric coordinate methods, affine and projective transformations, inversive geometry, foundations of Euclidean and non-Euclidean geometry, applications throughout to Euclidean geometry. Prerequisite: SC/MATH 2022 3.00 or SC/MATH 2222 3.00 or permission of the course coordinator. Course credit exclusion: SC/MATH 3052 6.00.

Note: This course will not be offered in FW 2014.

MATH 3052 6.00 Y
Exploring Geometries

Calendar Copy: Exploration of various geometries, focusing on symmetry. Geometric reasoning and multiple representations. Learning with hands-on materials, dynamic software, group work, reflection, communication. Prerequisite: SC/MATH 2022 3.00 or 2222 3.00 or permission of the instructor. Course credit exclusion: SC/MATH 3050 6.00.

In this course, students explore several geometries (the Euclidean Plane, the Sphere, three-dimensional Euclidean

space) with a focus on symmetry. As part of learning the geometric material, there will be a focus on geometric reasoning, and on learning geometric concepts through multiple representations and multiple approaches to the mathematics. The course will explore central geometric questions through investigations, hands-on materials, dynamic geometry software (such as Geometer's Sketchpad and Spherical Easel), group work, individual reflections and communication with peers and the instructor in multiple forms. The course is designed to prepare the student for further studies in: (i) pure mathematics, (ii) applications of geometry (computer science, physics, biology, engineering), (iii) teaching geometry, and (iv) teaching mathematics with multiple representations. The formal prerequisites are minimal: familiarity with linear algebra and some mathematical maturity. Other background will developed as needed.

The text for the course is D. Henderson, *Experiencing Geometry on Plane and Sphere*, 3rd ed. (Prentice Hall).

Graded work will include regular assignments, including proofs, conjectures and open-ended explorations, oral presentations, written projects and possibly quizzes.

Coordinator: W. Whiteley (whiteley@mathstat.yorku.ca)

MATH 3090 3.00 F
Computational Mathematics

Calendar copy: Modelling (discrete and continuous, deterministic and stochastic) and practical solutions to general categories of applied problems. Case studies of solutions through modelling and representation of data. Implementation, numerical considerations, efficiency, and application of numerical algorithms. Three lecture hours per week. Prerequisites: SC/MATH 2022 3.00; SC/MATH 2030 3.00; SC/CSE 1560 3.00, or SC/CSE 2031 3.00 and SC/MATH 2041 3.00, or SC/CSE 1540 3.00 and SC/MATH 2041 3.00.

Modelling (discrete and continuous, deterministic and stochastic) and practical solutions to general categories of applied problems from the sciences and/or business applications. Case studies and simulations through modelling and representation of data. Implementation, effciency and application of numerical and stochastic algorithms.

Coordinator: H. Huang (hhuang@yorku.ca)

MATH 3131 3.00 F
Mathematical Statistics I

Calendar copy: Topics include common density functions, probability functions, principle of likelihood, the likelihood function, the method of maximum likelihood, likelihood regions, tests of hypotheses, likelihood ratio tests, goodness of fit tests, conditional tests and confidence sets with a view towards applications. Prerequisite: SC/MATH 2131 3.00 or permission of the course coordinator.

After a review of the basic concepts introduced in MATH 2131, we will cover the following topics: some standard multivariate distributions, some special distributions related to the normal distribution, convergence in probability and convergence in distribution, order statistics, maximum likelihood methods, sufficiency and the basis of hypothesis testing. If time permits, we will look at the distribution of special quadratic forms.

Coordinator: H. Massam (massam@mathstat.yorku.ca)

MATH 3132 3.00 W
Mathematical Statistics II

Calendar copy: Important examples and methods of statistical estimation and hypothesis testing are discussed in terms of their mathematical and statistical properties. Topics include sufficiency, Bayesian statistics, decision theory, most powerful tests, likelihood ratio tests. Prerequisite: SC/MATH 3131 3.00.

This course is a continuation of Math 3131 3.00. The basic nature of statistical inference will be studied. Topics include sufficiency, exponential family, decision theory, most powerful tests, likelihood ratio tests, Bayesian statistics, linear models, etc.

The final grade will be based on assignments, a presentation, a midterm exam, and a final exam.

Coordinator: Y. Wu (wuyh@mathstat.yorku.ca)

MATH 3170 6.00 Y
Operations Research I

Calendar copy: A study of linear programming; transportation problems, including network flows, assignment problems and critical path analysis; integer programming; dynamic programming and an introduction to stochastic models. Application to a set of problems representative of the field of operations research. Prerequisites: SC/MATH 1021 3.00 or SC/MATH 1025 3.00 or SC/MATH 2221 3.00; one of SC/CSE 1520 3.00, SC/CSE 1540 3.00 or SC/CSE 1020 3.00 or equivalent. Course credit exclusions: SC/MATH 2751 3.00, AP/ECON 3120 3.00, AP/ADMS 3331 3.00, AP/ADMS 3351 3.00, GL/MATH 3660 6.00.

Note: This course has been retired and will not be offered again. Students whose program requires MATH 3170 6.00 should take both MATH 3171 3.00 and MATH 3172 3.00 in lieu of this course.

MATH 3171 3.00 F
Linear Optimization

Calendar copy: This course introduces students to linear optimization (linear programming), including the problem formulation, simplex method, LP-duality theory, sensitivity analysis, and its business and industrial applications. Three lecture hours per week. Prerequisites: SC/MATH 1021 3.00 or SC/MATH 1025 3.00 or SC/MATH 2221 3.00. Course credit exclusions: SC/MATH 2751 3.00, AP/ECON 3120 3.00, AP/ADMS 3331 3.00, AP/ADMS 3351 3.00, GL/MATH 3660 6.00, SC/MATH 3170 6.00.

Coordinator: D. Tanny (tanny@mathstat.yorku.ca)

MATH 3172 3.0 W
Combinatorial Optimization

Calendar copy: This course introduces students to combinatorial optimization (integer programming), including problem formulation, branch-and-bound method, cutting-plane method, implicit enumeration, and its business and industrial applications, including transportation problem, network flow optimization etc. Three lecture hours per week. Prerequisites: SC/MATH 3171 3.00, SC/MATH 1021 3.00 or SC/MATH 1025 3.00 or SC/MATH 2221 3.00. Course credit exclusions: AP/ECON 3120 3.00, AP/ADMS 3331 3.00, AP/ADMS 3351 3.00, GL/MATH 3660 6.00, SC/MATH 3170 6.00.

Coordinator: D. Tanny (tanny@mathstat.yorku.ca)

MATH 3241 3.00 F
Numerical Methods I
(same as CSE 3121 3.00)

Calendar copy: An introductory course in computational linear algebra. Topics include simple error analysis, linear systems of equations, non-linear equations, linear least squares and interpolation. Prerequisites: One of SC/MATH 1010 3.00, SC/MATH 1014 3.00, SC/MATH 1310 3.00; one of SC/MATH 1021 3.00, SC/MATH 1025 3.00, SC/MATH 2221 3.00; one of SC/CSE 1540 3.00, SC/CSE 2031 3.00, or SC/CSE 2501 1.00. Course credit exclusion: SC/COSC 3121 3.00.

The course begins with a discussion of computer arithmetic and computational errors. Examples of ill-conditioned problems and unstable algorithms will be given. The first class of numerical methods introduced are those for nonlinear equations, i.e., the solution of a single equation in one variable. We then discuss the most basic problem of numerical linear algebra: the solution of a linear system of n equations in n unknowns. We discuss the Gauss algorithm and the concepts of error analysis, condition number and iterative refinement. We then use least squares to solve over determined systems of linear equations. The course emphasizes the development of numerical algorithms, the use of mathematical software, and interpretation of results obtained on some assigned problems.
Coordinator: D. Liang (dliang@mathstat.yorku.ca)

MATH 3242 3.00 W
Numerical Methods II
(same as CSE 3122 3.00)

Calendar copy: Algorithms and computer methods for solving problems of differentiation, integration, systems of non-linear equations and matrix eigenvalues. Prerequisite: SC/MATH 3241 3.00 or SC/CSE 3121 3.00. Course credit exclusion: SC/COSC 3122 3.00.

The course is a continuation of MATH 3241 3.00/ CSE 3121 3.00. The main topics include numerical differentiation, Richardson's extrapolation, elements of numerical integration, composite numerical integration, Romberg integration, adaptive quadrature methods, Gaussian quadrature, numerical improper integrals; fixed points for functions of several variables, Newton's method, quasi-Newton methods, steepest descent techniques, and homotopy methods; power method, Householder method and QR algorithms.

The final grade will be based on assignments, tests and a final examination.
Coordinator: D. Liang (dliang@mathstat.yorku.ca)

MATH 3243 1.00 FW
Communication in Applied Mathematics

Calendar copy: Effective communication is an important skill for applied mathematicians. This course facilitates the development of communication skills, as well as adaptive reasoning and the capacity to think logically about relationships among concepts using topics in numerical computations that are important in the area of applied mathematics. In this course students will learn to use different modes of communication: wiki, moodle, presentation, written reports, and group discussions. Opportunities are provided for students to read, interpret, reason, conjecture, discuss, write, and present topics in numerical computations such as error analysis, linear systems of equations, nonlinear equations, linear least squares and interpolation. Prerequisites: Mathematics and Statistics core and SC/MATH 3241 3.00.
Coordinator: J. Heffernan (jmheffer@yorku.ca)

MATH 3260 3.00 W
Introduction to Graph Theory

Calendar copy: Introductory graph theory with applications. Graphs, digraphs. Eulerian and Hamiltonian graphs. The travelling salesman. Path algorithms; connectivity; trees; planarity; colourings; scheduling; minimal cost networks. Tree searches and sortings, minimal connectors and applications from physical and biological sciences. Prerequisite: At least six credits from 2000-level mathematics courses without second digit 5.

Graph theory is a useful mathematical tool in many areas including chemistry, computer science, engineering and operations research.

This course serves as an introduction to graph theory. After covering the basic definitions and examples, we will study graph connectivity, planarity, graph colourings and matchings in bipartite graphs. If time permits, we will cover network flows.

The text has not been chosen yet.
Coordinator: I. Farah (ifarah@mathstat.yorku.ca)

MATH 3271 3.00 F
Partial Differential Equations

Calendar copy: Partial differential equations of mathematical physics and their solutions in various coordinates, separation of variables in Cartesian coordinates, application of boundary conditions; Fourier series and eigenfunction expansions; generalized curvilinear coordinates; separation of variables in spherical and polar coordinates. Prerequisites: SC/MATH 2270 3.00; SC/MATH 2010 3.00 or SC/MATH 2015 3.00 or SC/MATH 2310 3.00; SC/MATH 3010 3.00 is also desirable, though not essential, as prerequisite for students presenting SC/MATH 2010 3.00 or SC/MATH 2310 3.00.

This is a first course in partial differential equations. The aim is to use Fourier series, integral transforms and other analytic techniques to construct explicit formulas for the solutions of the standard partial differential equations arising in science and engineering. Among the most important equations to be studied are the heat equation, the Laplace equation and the wave equation.

The textbook is H.F. Weinberger, *A First Course in Partial Differential Equations with Complex Variables and Transform Methods*, (Dover, 1995).

The final grade is determined by assignments (20%), two mid-term tests (20% each) and a final exam (40%).
Coordinator: M.W. Wong (mwwong@mathstat.yorku.ca)

MATH 3280 6.00
Actuarial Mathematics

Calendar copy: Deterministic and stochastic models for contingent payments. Topics include survival distributions, life tables, premiums and reserves for life insurance and annuities, multiple life contracts, multiple decrement theory.

Note: This course has been retired and will not be offered again. Students whose program requires MATH 3280 6.00

should take both MATH 3280 3.00 and MATH 3281 3.00 in lieu of this course.

MATH 3280 3.00 F
Mathematics of Life Contingencies I

Calendar Copy: Probabilistic introduction to the mathematics of life contingencies. The course develops a theoretical basis for modeling the future lifetime of certain financial objects with an emphasis on insurance. Topics include international actuarial notation, life tables, life statuses, (multivariate) survival distributions, dependence, multiple decrement theory. The course ensures an adequate preparation for the MLC exam of the Society of Actuaries. Prerequisites : SC/ MATH 2131 3.00, SC/MATH 2280 3.00. Course credit exclusion SC/MATH 3280 6.00

Probabilistic introduction to the mathematics of life contingencies. The course develops a theoretical basis for modeling the future lifetime of certain financial objects with an emphasis on insurance. Topics include international actuarial notation, life tables, life statuses, (multivariate) survival distributions, dependence, multiple decrement theory. The course ensures an adequate preparation for the MLC exam of the Society of Actuaries. Three lecture hours per week plus one hour of faculty led tutorials per week.
Coordinator: E. Furman (efurman@mathstat.yorku.ca)

MATH 3281 3.00 W
Mathematics of Life Contingencies II

Calendar Copy: Intermediate level course on the mathematics of life contingencies. The course builds on SC/MATH 3280 3.00 and develops theoretical basis for pricing and supporting life-contingent products. Topics include economics of insurance, general insurances and annuities, (benefit) premiums and reserves, analysis of reserves, Hattendorf's theorem. The course ensures an adequate preparation for the MLC exam of the Society of Actuaries. Prerequisite: SC/MATH 3280 3.00. Course credit exclusion: SC/MATH 3280 6.00

Intermediate level course on the mathematics of life contingencies. The course builds on MATH 3280 3.00 and develops theoretical basis for pricing and supporting life-contingent products. Topics include economics of insurance, general insurances and annuities, (benefit) premiums and reserves, analysis of reserves, Hattendorf's theorem. The course ensures an adequate preparation for the MLC exam of the Society of Actuaries. Three lecture hours per week plus one hour of faculty led tutorials per week.
Coordinator: E. Furman (efurman@mathstat.yorku.ca)

MATH 3330 3.00 F
Regression Analysis

Calendar copy: Simple regression analysis, multiple regression analysis, matrix form of the multiple regression model, estimation, tests (t- and F-tests), multicollinearity and other problems encountered in regression, diagnostics, model building and variable selection, remedies for violations of regression assumptions. Prerequisites: One of SC/MATH 1131 3.00, SC/MATH 2570 3.00, HH/PSYC 2020 6.00, or equivalent; some acquaintance with matrix algebra (such as is provided in SC/MATH 1021 3.00, SC/MATH 1025 3.00, SC/MATH 1505 6.00, SC/MATH 1550 6.00, or SC/MATH 2221 3.00). Course credit exclusions: SC/MATH 3033 3.00, AP/ECON 4210 3.00, HH/PSYC 3030 6.00.

The course will focus on linear regression models for the analysis of data on several explanatory variables and a single response. The emphasis will be on understanding the different models and statistical concepts used for these models and on practical applications, rather than on the formal derivations of the models. The approach will require the use of matrix representations of the data, and the geometry of vector spaces, which will be reviewed in the course. Topics include simple linear regression, multiple linear regression, residual analysis and model selection.

Students will use the statistical software SAS for data analysis.

Details of the method of evaluating course performance will be distributed at the beginning of the course.
Coordinator: S. Chamberlin
(chamber@mathstat.yorku.ca)

MATH 3410 3.00 W
Complex Variables

Calendar copy: Analytic functions, the Cauchy-Riemann equations, complex integrals, the Cauchy integral theorem, maximum modulus theorem. Calculations of residues and applications to definite integrals, two-dimensional potential problems and conformal mappings. Prerequisite: SC/MATH 2010 3.00 or SC/MATH 2015 3.00 or SC/MATH 2310 3.00. (SC/MATH 3010 3.00 is also recommended as a prerequisite for students who have taken SC/MATH 2010 3.00.) Course credit exclusion: GL/MATH 4230 3.00.

Some polynomials, such as $x^2+1= 0$, have no roots if we confine ourselves to the real number system, but do have roots if we extend the number system to complex numbers, which can be defined as the set of all numbers of the form $x+iy$,where x and y are real and $i^2=-1$, with basic arithmetic operations having the same structure as those of the real number system. The complex numbers defined so, include the reals (as a case y=0), and the extended system has the desirable property that not only $x^2+1=0$ but every polynomial equation has a root. In the system of complex numbers certain connections are seen between otherwise apparently unconnected real numbers. A striking example is one of the most beautiful identities in mathematics; namely Euler's formula $\exp(2\pi i)=1$ which is a simple consequence of the extension to complex variables of familiar exponential and trigonometric functions. The concepts and operations of calculus (differentiation, integration, power series, etc.) find their most natural setting in complex (rather than real) variables. The present course is intended to give the student a basic knowledge of complex numbers and functions and a basic facility in their use.
Coordinator: B. van Rensburg
(rensburg@yorku.ca)

MATH 3430 3.00 W
Sample Survey Design

Calendar copy: Principal steps in planning and conducting a sample survey. Sampling techniques including simple random sampling, stratified random sampling, cluster sampling and sampling with probabilities proportional to size. Estimation techniques including difference, ratio, and regression estimation. Prerequisite: SC/MATH 2131 3.00 or SC/MATH 3330 3.00.

This course deals with the peculiarities of sampling and inference commonly encountered in sample surveys in medicine, business, the social sciences, political science, natural resource management and market research. Attention will be focused on the economics of purchasing a specific quantity of information.

That is, methods for designing surveys that capitalize on characteristics of the population under study will be presented, along with associated estimators to reduce the cost of acquiring an estimate of specified accuracy. (The emphasis will be on the practical applications of theoretical results.)

The text will be R.L. Schaeffer, W. Mendenhall, L. Ott, and K.G. Gerow, *Elementary Survey Sampling*, 7th ed. (Brooks/Cole).

The final grade may be based on assignments (10%), class tests (30%) and a final examination (60%).

Coordinator: P. Peskun (peskun@mathstat.yorku.ca)

4000-level Courses

MATH 4000 3.00 FW and 6.00 Y
Individual Project

Calendar copy: A project of a pure or applied nature in mathematics or statistics under the supervision of a faculty member. The project allows the student to apply mathematical or statistical knowledge to problems of current interest. A report is required at the conclusion of the project. Prerequisites: Open to all students in Honours programs in the Department of Mathematics and Statistics. Permission of the program director is required. Applied mathematics students can enrol only after they have completed the core program in applied mathematics.

The student works under the supervision of a faculty member, who is selected by the course coordinator and the student. The project allows the student to apply mathematical or statistical knowledge to problems of current interest. A report is required at the conclusion of the project.

Students in the Applied Mathematics Honours Programs are particularly encouraged to take this course. The procedure is as follows: Each year, faculty members who are interested in supervising projects will submit project descriptions to the course coordinator for Applied Mathematics. Students will meet with the course coordinator for Applied Math, and they will jointly decide on a faculty member to supervise the project, taking into account the background and interests of students, as well as the availability and interests of faculty members.

The amount of work expected of the student is approximately ten hours per week, that is, the equivalent of a standard full-year (for 4000 6.00) or half-year (for 4000 3.00) course. The supervisor is expected to spend about one or two hours per week with the student averaged over the duration of the project. In addition to the final report, regular short written progress reports will be expected from the student at definite times during the course. The final grade will be based upon the final report as well as the interim progress reports.

- Applied Mathematics Coordinator: M. Haslam
- Mathematics for Education Coordinator: W. Whiteley
- Math for Commerce Coordinator: E. Furman
- Pure Mathematics Coordinator: P. Gibson
- Statistics Coordinator: S. Wang

MATH 4001 6.00 Y
Real Analysis III

Calendar Copy: Complex-valued functions of a real variable, topology of metric spaces, Stone's Theorem, Inverse and Implicit Function Theorems, Lebesgue measure on the real line, Lebesgue integration, introduction to Hilbert Space, Fourier series, Fourier transform. Intended for Honours Mathematics students. Prerequisites: SC/MATH 3210 3.00 or both SC/MATH 3001 3.00 and SC/MATH 2310 3.00. Course credit exclusion: SC/MATH 4010 6.00.

The text will be N.L. Carothers, *Real Analysis* (Cambridge University Press).

Coordinator: M. Walker (walker@yorku.ca)

MATH 4020 6.00
Algebra II

Calendar copy: Continuation of Algebra I, with applications: groups (finitely generated Abelian groups, solvable groups, simplicity of alternating groups, group actions, Sylow's theorems, generators and relations); fields (splitting fields, finite fields, Galois theory, solvability of equations); additional topics (lattices, Boolean algebras, modules). Prerequisite: SC/MATH 3020 6.00 or permission of the course coordinator. Course credit exclusion: SC/MATH 4241 3.00.

Note: This course has been retired and will not be offered again. Students whose program requires MATH 4020 6.00 should take both MATH 4021 3.00 and MATH 4022 3.00 in lieu of this course.

MATH 4021 3.00 W (Tele Course)
Algebra III

Calendar copy: Continuation of Algebra II, with applications: groups (finitely generated abelian groups, solvable groups, simplicity of alternating groups, generators and relations, group actions, Sylow's theorems); field extensions, splitting fields, finite fields. Prerequisite: SC/MATH 3020 6.00 or SC/MATH 3022 3.00 or permission of the course coordinator. Course credit exclusions: SC/MATH 4020 6.00, SC/MATH 4241 3.00.

The course will cover: groups, subgroups, cosets and direct products, homomorphisms and factor groups, permutations, the fundamental theorem of finitely generated abelian groups, Sylow theorems, and group representations.

This course will be streamed live from Western University.

Coordinator: Ajneet Dhillon

MATH 4022 3.00
Algebra IV

Calendar copy: Continuation of Algebra III, with applications: Galois theory, solvability of equations by radicals, additional

topics (cyclotomic extensions, lattices, Boolean algebras, module theory, category theory). Intended for Honours Mathematics students. Prerequisite: SC/MATH 4021 3.00 or permission of the course coordinator. Course credit exclusion: SC/MATH 4020 6.00.

Note: This course will not be offered in FW 2014.

MATH 4034 3.00
Data Mining

Calendar Copy: This course will review some of the principal methods used for data mining, with the goal of placing them in common perspective and providing a unifying overview. Prerequisites: SC/MATH 3034 3.00 and SC/MATH 3430 3.00 or permission of the course director. Corequisites: SC/MATH 4630 3.00 or SC/MATH 4730 3.00 or SC/MATH 4230 3.00.

Note: SAS and Splus computing environments will be used to facilitate course work.

Note: This course will not be offered in FW 2014.

MATH 4080 6.00
Topology

Calendar copy: Topological spaces, continuity, connectedness, compactness, nets, filters, metrization theorems, complete metric spaces, function spaces, fundamental group, covering spaces.

Note: This course will not be offered in FW 2014.

MATH 4081 3.00
Topology I

Calendar copy: An introduction to general topology: topological spaces, continuity, connectedness, compactness, topology of metric spaces, countability axioms, and separation axioms. Prerequisites: SC/MATH 3210 3.00 or SC/MATH 3001 3.00 or permission of the course coordinator. Course credit exclusion: SC/MATH 4080 6.00.

Note: This course will not be offered in FW 2014.

MATH 4090 3.00 W
Mathematical Modelling

Calendar copy: Discrete, continuous and probabilistic modelling of problems from industry, finance and the life and physical sciences. The ability to model complex problems is stressed. Three lecture hours. One term. Three credits. Note: Registration required in an Honours Program in Mathematics and Statistics, and the completion of all specified core courses in that program.

This course will introduce the student to traditional and newer methods of mathematical modelling. There will be an emphasis on problem solving skills. The topics include discrete (microscopic) and continuous (macroscopic) modelling, population dynamics, annuity and option pricing, and probabilistic modelling of behaviour. These subjects will be studied analytically and computationally.

The text is still to be determined.
Coordinator: J. Heffernan (jmheffer@yorku.ca)

MATH 4100A 3.00 W
Topics in Mathematical Education

Calendar copy: This course provides opportunities for students to examine topics in mathematics, and themes in mathematics education. The main focus will be on developing students' ability to unpack and communicate concepts in mathematics, and to think critically about what mathematicians do and what students do when they are learning mathematics. Prerequisites: A minimum of 21 credits in MATH courses without second digit "5"; permission of the course coordinator.

Note: Computer/Internet use is essential for course work.

This course provides opportunities for students to examine in-depth specific ideas in mathematics as well as themes and theories in mathematics education. The main focus will be on exploring different ways to unpack, repack and communicate concepts in mathematics, and to think critically and reflectively about how mathematics can be learnt, taught, and understood. Students will be encouraged to work with multiple representations and approaches and reflect on how peers also do the mathematics. We will look at sample concepts from a wide area of mathematics including both pure mathematics and applied mathematics, as well as concepts which are central to the Ontario curriculum. The course is designed as a 'capstone' course for students preparing to become teachers, but is relevant to anyone interested in reflecting on the learning of mathematics. We recommend you take the course in your final semester.
Coordinator: TBA

MATH 4130B 3.00 F
Topics in Probability and Statistics:
(same as GS/MATH 6633 3.00)
Introduction to the Theory and Methods of Time Series Analysis

Calendar copy: A systematic presentation of many statistical techniques for the analysis of time series data. The core topics include time dependence and randomness, trend, seasonality and error, stationary processes, ARMA and ARIMA processes, multivariate time series models and state-space models. Prerequisites: either SC/MATH 3033 3.00 or SC/MATH 3330 3.00; SC/MATH 3131 3.00; or permission of the course coordinator. Course credit exclusions: SC/CSE 3451 4.00, SC/EATS 4020 3.00, SC/MATH 4830 3.00, SC/MATH 4930C 3.00, SC/PHYS 4060 3.00, SC/PHYS 4250 3.00.

An additional topic is forecasting. The emphasis will be on the theory and methodology of the time-domain analysis based on ARIMA and state-space models.
Coordinator: A. Wong (august@yorku.ca)

MATH 4130K 3.00
Survival Analysis
(same as GS/MATH 6641 3.00)

Calendar copy: This course provides students with an introduction to the statistical methods for analyzing censored data which are common in medical research, industrial life-testing and related fields. Topics include accelerated life models, proportional hazards model, time dependent covariates.

Notes: This course will not be offered in FW 2014.

MATH 4141 3.00 F
Advanced Numerical Methods
(same as GS/MATH 6651 3.00, GS/PHYS 5070A 3.00)

Calendar copy: Numerical methods for solving ordinary differential equations; optimization problems: steepest descents, conjugate gradient methods; approximation theory: least squares, orthogonal polynomials, Chebyshev and Fourier approximation, Padé approximation. Prerequisite: SC/MATH 2270 3.00; SC/MATH 3242 3.00 or SC/CSE 3122 3.00.

The final grade will be based on assignments, tests and a final examination.
Coordinator: D. Liang (dliang@mathstat.yorku.ca)

MATH 4143 3.00 F
Scientific Computation for Financial Applications

Calendar copy: This course covers the basics numerical analysis/computational methods related to portfolio optimization, risk management and option pricing. It provides background material for computations in finance for two streams in the Computational Mathematics program and other interested students. Prerequisites: One of SC/MATH 2015 3.00 or SC/MATH 2310 3.00; SC/MATH 1131 3.00; SC/MATH 2030 3.00; One of SC/CSE 1530 3.00, SC/CSE 1540 3.00 or SC/MATH 2041 3.00.

This course introduces the basic concepts in mathematical finance. The topics include basic numerical methods; unconstrained and constrained optimization methods applied to portfolio selection; option pricing and risk management by MC simulation.

The text has not been chosen yet.
Coordinator: Hm. Zhu (hmzhu@mathstat.yorku.ca)

MATH 4160 3.00 F
Combinatorial Mathematics

Calendar copy: Topics from algebra of sets, permutations, combinations, occupancy problems, partitions of integers, generating functions, combinatorial identities, recurrence relations, inclusion-exclusion principle, Polya's theory of counting, permanents, systems of distinct representatives, Latin rectangles, block designs, finite projective planes, Steiner triple systems. Prerequisites: SC/MATH 2022 3.00 or SC/MATH 2222 3.00; six credits from 3000-level mathematics courses without second digit 5; or permission of the course coordinator.

We learn how to count in this course.

Methods used to enumerate finite sets include bijections, the principle of inclusion-exclusion, generating functions, recurrence relations and Polya's theory.

We will apply these methods to study the occupancy problem, derangements, partitions of integers, Catalan numbers, and simple graphs.
Coordinator: M. Zabrocki (zabrocki@mathstat.yorku.ca)

MATH 4161 3.00 W
Mathematics of Cryptography
(same as CSE/4161 3.00)

Calendar copy: Probability, information theory and number theory and applications to cryptography. Classical codes such as Caesar shift, Vigenere, ADFGVX, rectangular substitution, and others. Other topics: comma free codes, perfect secrecy, index of coincidence, public key systems, primality testing and factorization algorithms. Prerequisites: At least 12 credits from 2000-level (or higher) MATH courses (without second digit 5, or second digit 7); or SC/CSE 3101 3.00 or permission of the instructor.

In cryptography, our objective is to keep information secret from everyone except for those who are authorized to see it. We will start with classical codes such as Caesar shift and Vigenere. We will introduce symmetric key encryption and public key encryption, with examples like DES and RSA, respectively. We will learn the background in probability theory, information theory and number theory needed for the analysis of these cryptographic systems. Other topics include digital signature, message authentication and hash function.
Coordinator: A. Chan (ssachan@yorku.ca)

MATH 4170 6.00 Y
Operations Research II
(same as GS/MATH 6900 3.00 plus
GS/MATH 6901 3.00)

Calendar copy: Selected topics from game theory, decision theory, simulation, reliability theory, queuing theory, non-linear programming, classification, pattern-recognition and prediction. Each chapter contains an optimization problem and methods and algorithms for solving it. The course is rich in examples. Prerequisites: SC/MATH 2010 3.00 or SC/MATH 2015 3.00 or SC/MATH 2310 3.00; SC/MATH 2030 3.00; SC/MATH 3170 6.00; or permission of the course coordinator. Course credit exclusion: AS/MATH 4570 6.00.

This course deals with deterministic and probabilistic models based on optimization. The following topics will be discussed: 1) game theory (how to find the best strategies in a confrontation between two or more players with differing interests); 2) decision theory (how to act to minimize loss, subject to available data); 3) simulation (how to sample from a probability distribution and how to conduct statistical experiments by computer); 4) queueing theory (how to assess what may happen in a system where the customers arrive randomly, wait in line, and then get served); 5) nonlinear programming (how to optimize a nonlinear objective function subject to equality or inequality constraints). Time permitting, some additional topics (such as inventory theory or reliability) will also be discussed.

The text will be W.L. Winston, *Operations Research: Applications and Algorithms*, 4th ed.(Thompson- Brooks/Cole Publishing).

The final grade will be based on regular homework assignments, two midterm tests, and two exams (one in December and one in April).

The three prerequisites, in multivariable calculus, probability, and linear programming, are all important for this course.
Coordinator: TBA

MATH 4230 3.00
Nonparametric Methods in Statistics
(same as GS/MATH 6634 3.00)

Calendar copy: Order statistics; general rank statistics; one-sample, two-sample and k-sample problems; Kolmogorov-Smirnov statistics; tests of independence and relative efficiencies. Prerequisite: SC/MATH 3131 3.00; SC/MATH 3132 3.00 is recommended but not required.

Note: This course will not be offered in FW 2014.

MATH 4280 3.00 W
Risk Theory — Loss Models and Risk Measures

Calendar copy: A comprehensive introduction to the single-period mathematical risk theory. The course explores approaches to modeling and measuring (insurance) risks. Topics include (univariate) distribution theory: exponential dispersion models, elliptical distributions, (a,b,k,) class, heavy-tailness; risk measurement: Value-at-Risk, Expected Shortfall, coherency; policy modifications: deductibles, (co)insurance, limits. The course ensures an adequate preparation for the C exam of the Society of Actuaries. Three lecture hours per week plus one hour of faculty led tutorials per week. Prerequisite: SC/MATH 2131 3.00

A comprehensive introduction to the single-period mathematical risk theory. The course explores approaches to modeling and measuring (insurance) risks. Topics include (univariate) distribution theory: exponential dispersion models, elliptical distributions, (a,b,k) class, heavy-tailness; risk measurement: Value-at-Risk, Expected Shortfall, coherency; policy modifications: deductibles, (co)insurance, limits. The course ensures an adequate preparation for the C exam of the Society of Actuaries. Three lecture hours per week plus one hour of faculty led tutorials per week.
Coordinator: E. Furman (efurman@mathstat.yorku.ca)

MATH 4281 3.00 F
Risk Theory — Ruin and Credibility

Calendar copy: A comprehensive introduction to intermediate - level mathematical risk theory. The course on the one hand introduces a dynamic approach to risk measurement, and on the other develops the notion of prospective experience rating. Topics include probability of ruin, adjustment coefficient, Lunberg's inequality, credibility theory, simulation. The course ensures an adequate preparation for exam C of the Society of Actuaries. Prerequisite: SC/MATH 2131 3.00.

This course, together with MATH 4280 3.00, is part of the risk theory sequence of the B.A. Specialized Honours Math for Commerce Actuarial Stream Program. The course develops the necessary theoretical basis, which allows a student to employ modern techniques of modeling and measuring (actuarial) risks within the dynamic framework and applying various prospective experience ratemaking theories.

The topics include: (1) Ruin Theory: probability of ruin at finite and infinite horizons, adjustment coefficient, Lundberg's inequality, Cramer's asymptotic ruin, Maximum aggregate loss; (2) Credibility Theory: limited fluctuation credibility theory, greatest accuracy credibility theory, Buhlmann and Buhlmann-Straub models; (3) Simulation.

Students who complete this course will be adequately prepared to take the "Construction and Evaluation of Actuarial Model" exam of the Society of Actuaries (Exam C) if the student passes the sequence MATH 4280 3.00, MATH 4281 3.00, MATH 3131 3.00, MATH 3132 3.00 and MATH 4430 3.00 (or MATH 4431 3.00).

The text has not yet been chosen.
Coordinator: A. Kuznetsov
(kuznetsov@mathstat.yorku.ca**)**

MATH 4300 3.00 FW and 6.00 Y
Directed Readings

Calendar copy: A student may arrange to do independent study with a member of the Mathematics and Statistics Department. Such an arrangement must have prior approval of the department Chair. One term: 3 credits. Two terms: 6 credits.

Students may wish to pursue intensive work with a particular faculty member **on a topic of study not offered in a particular academic session**.

- Students may take independent reading courses only after having successfully completed 24 credits.
- The student and the faculty member must agree on a written description of the course, its content, and its method of evaluation at the time of enrolment in the course, and submit this description for approval according to the requirements of the unit teaching the course. Copies must be deposited with that unit, and the student and faculty member should each retain a copy.

MATH 4400 6.00 Y
The History of Mathematics

Calendar copy: Selected topics in the history of mathematics, discussed in full technical detail but with stress on the underlying ideas, their evolution and their context. Note: 36 credits required from mathematics courses without second digit 5, including at least 12 credits at or above the 3000 level. (12 of the 36 credits may be taken as corequisites.).

The aim is to give an overview of the development of mathematical thought from ancient times to the eighteenth century. This gives students a broader perspective and better understanding of mathematics. In each period of history, specific topics in algebra, geometry, number theory, combinatorics, trigonometry, mechanics, astronomy and/or analysis are discussed in complete mathematical detail in their original expositions. The discussion of each topic includes its historical and cultural contexts as well as its motivating applications. For example, the course begins with Egyptian arithmetic calculations using hieroglyphics and Babylonian geometric methods for solving quadratic equations. It concludes with the development of calculus.

This course is of interest to prospective teachers as most topics discussed are relevant to mathematics taught in high schools.

The grade will be determined by two hour exams and a two hour exam in the exam period each term as well as two papers.

The optional text is Victor Katz, *A History of Mathematics, an Introduction,* 3rd edition, Addison-Wesley, 2009.
Coordinator: S. O. Kochman (kochman@yorku.ca)

MATH 4430 3.00 W
Stochastic Processes
(same as: GS/MATH 6602 3.00)

Calendar copy: Basic Markov processes, Queueing Models, Diffusion processes, Stochastic Simulation and programming Prerequisite: SC/ MATH 2030 3.00.

In this course we begin with a review of probability theory (especially conditional expectation). Discrete Time Markov Chains and Queueing Models will be introduced along with applications in science and business. Diffusion processes and Brownian motion will be discussed including absorption problems. We will cover stochastic simulation and computational techniques for applications of these processes in different areas, such as performance modeling of service systems, population genetics and kinetic modeling. MATLAB or R software will be used for implementing stochastic processes.

The text for this course has not yet been determined.
Coordinator: J. Grigull (jgrigull@mathstat.yorku.ca)

MATH 4431 3.00
Probability Models

Calendar copy: This course introduces the theory and applications of several kinds of probabilistic models, including renewal theory, branching processes and martingales. Additional topics may include stationary processes, large deviations or models from the sciences. Prerequisite: SC/MATH 2030 3.00.

Note: This course will not be offered in FW 2014.

MATH 4630 3.00 F
Applied Multivariate Statistical Analysis
(same as: GS/MATH 6632 3.00)

Calendar copy: The course covers the basic theory of the multivariate normal distribution and its application to multivariate inference about a single mean, comparison of several means and multivariate linear regression. As time and interest permit, further related topics may also be covered. Prerequisites: SC/MATH 3131 3.00; SC/MATH 3033 3.00 or SC/MATH 3330 3.00; SC/MATH 2022 3.00 or SC/MATH 2222 3.00.

We will study methods of analysis for data which consist of observations on a number of variables. The primary aim will be interpretation of the data, starting with the multivariate normal distribution and proceeding to the standard multivariate inference theory. Sufficient theory will be developed to facilitate an understanding of the main ideas. This will necessitate a good background in matrix algebra, and some knowledge of vector spaces as well.

Computers will be used extensively, and familiarity with elementary use of R will be assumed. Topics covered will include multivariate normal population, inference about means and linear models, principal component analysis, canonical correlation analysis, and some discussion of discriminate analysis, and factor analysis and cluster analysis, if term permits.

The text will be the latest edition of R.A. Johnson and D.W. Wichern *Applied Multivariate Statistical Analysis* (Prentice Hall).
Coordinator: H. Massam (massamh@mathstat.yorku.ca)

MATH 4730 3.00 W
Experimental Design

Calendar copy: An examination of the statistical issues involved in ensuring that an experiment yields relevant information. Topics include randomized block, factorial, fractional factorial, nested, Latin square and related designs. Further topics as time permits. The emphasis is on applications. Prerequisite: SC/MATH 3033 3.00, or SC/MATH 3330 3.00, or permission of the course coordinator.

Experimental design is the process of planning an experiment so that appropriate data will be collected which may be analysed by statistical methods, resulting in valid and meaningful conclusions. This includes the choice of treatments, the required sample size, the random allocation of experimental units to treatments, the method of estimation, and a consideration of how the data will be analyzed once collected.

We will study various experimental situations in this course, considering how the principles of design can be applied to each to create a design that is appropriate to the objectives of the experiment. We will examine appropriate procedures for the analysis of the resulting data, including the underlying assumptions and limitations of the procedures.

Students will use the statistical software SAS for data analysis.

The final grade will be based on assignments, a midterm test, and a final exam.
Coordinator: Y. Wu (wuyh@mathstat.yorku.ca)

MATH 4731 3.00 W
Sampling: Design and Analysis

Calendar copy: Topics include: sampling weights and design effects in complex surveys; imputation and weighting methods for nonresponse; variance estimation in complex surveys; effects of complex sampling design on categorical data analysis and on regression analysis. Prerequisites: SC/MATH 3430 3.00 or permission of the course director.

This course concentrates on the statistical aspects of analyzing complex sample surveys obtained by using the basic sampling designs of simple random sampling, stratification, and cluster sampling with equal and unequal probabilities of selection. The use of sampling weights and design effects will be discussed as well as what to do if there is nonresponse. Several methods for estimating variances of various statistics will be described as well as how to perform chi-squared tests and regression analyses using data from complex surveys.

The text has not been chosen yet.

The final grade may be based on assignments (10%), a midterm test (30%) and a final exam (60%).
Coordinator: P. Peskun (peskun@mathstat.yorku.ca)

MATH 4830 3.00
Time Series and Spectral Analysis

Calendar copy: Treatment of discrete sampled data involving correlation, convolution, spectral density estimation, frequency, domain filtering, and Fast Fourier Transforms. Three lecture hours. One term. Three credits. Prerequisites: AK/AS/SC/CSE 1540 3.00 or equivalent programming experience; AS/SC/MATH 2015 3.00; AS/SC/MATH 2271 3.00. Course credit exclusions: AK/AS/SC/CSE 3451 4.00, AK/AS/SC/CSE 3451 3.00, AS/SC/MATH 4130B 3.00, AS/SC/MATH 4930C 3.00.

Note: This course will not be offered in FW 2014.

MATH 4930A 3.00
Topics in Applied Statistics:
Statistical Quality Control

Calendar copy: This course provides a comprehensive coverage of the modern practice of statistical quality control from basic principles to state-of-the-art concepts and applications. Prerequisite: SC/MATH 3330 3.00 or SC/MATH 3033 3.00. Corequisite: SC/MATH 4730 3.00.

Note: This course will not be offered in FW 2014.

MATH 4931 3.00 W
Simulation and the Monte Carlo Method

Calendar copy: Introduction to systems, models, simulation and Monte Carlo methods. Random number generation. Random variate generation. Monte Carlo integration and variance reduction techniques. Applications to queuing systems and networks. Prerequisite: SC/MATH 3330 3.00 and LE/CSE 1560 3.00 and SC/MATH 2030. Course credit exclusion: LE/SC/CSE 3408 3.00, SC/MATH 4930B 3.00. Prior to Summer 2013: Prerequisite: SC/MATH 3330 3.00 or SC/MATH 3033 3.00. Course credit exclusion: SC/CSE 3408 3.00. Prior to Fall 2009: Prerequisite: AK/AS/SC/MATH 3330 3.00 or AS/SC/MATH 3033 3.00. Course credit exclusion: AK/AS/SC/CSE 3408 3.00 (formerly COSC).

The term "Monte Carlo" refers to a broad class of numerical algorithms which rely on repeated random sampling. Since its beginnings in the late 1940s at the Los Alamos National Laboratory, Monte Carlo has continued to gain in importance in scientific use. The continued growth of computing power coupled with a drastic decrease in price in the last decade, means that Monte Carlo methods are now more practical than ever.

In this course, we will discuss what Monte Carlo methods are, and we will look at their varied applications. The three main topics we will cover are (a) "basic" Monte Carlo integration, (b) Markov chain Monte Carlo, and © bootstrap methodology. Applications will be taken from various sciences, including statistics, operations research, and actuarial science.

The hope is that a significant portion of the course will be spent in the computer lab, using the statistical software R to perform Monte Carlo simulations. Previous experience with computing will be an asset, but is not required.

Coordinator: H. Jankowski (hkj@mathstat.yorku.ca)

Summary of Degree Requirements BA and BA (Hons)

The following is *not* intended to be a complete list of the many requirements of which you should be aware. For that, see the main York Calendar and/or an advisor. Moreover, the regulations that apply to you vary according to the year you entered York.

All students must fulfill the following requirements:

General Education Requirements: Pre Fall 2009 — Faculty of Arts

1000-level course (6 credits) in NATS or BIOL, CHEM, EATS or PHYS. 9 credit 1000-level HUMA Foundations course, plus a 9 credit 2000-level SOSC Foundations course (or 2000-level HUMA and 1000-level SOSC). (The requirement is different for students who entered York before 1997.)

General Education Requirements: Admitted FW 2009 and later

Students in the BA, BA Honours and iBA Honours programs must take a total of 24 credits from the following areas: Humanities, Modes of Reasoning, Natural Science, Social Science. Of these 24 credits, students must complete the following minimum requirements: at least six credits from Humanities, Natural Science and Social Science (with no more than nine credits in each counting towards the general education requirement).

Elective Courses:

All students majoring in a program in this department must take at least 18 credits[1] *outside the department* which are *not required* in their programs. (E.g., CSE 1540 is *not* an elective in the Applied Mathematics BA program.)

Degree Program Selection:

Each student must choose a departmental program (see the following three pages and also the section "Programs" near the front of this minicalendar), in which to complete one of the following degrees:

Specialized Honours Program Honours Double Major[2] Program Honours Major Program
Honours Major/Minor[3] Program Bachelor Program

"Residence" Requirement[4], Course Requirements:

Bachelor Programs:	At least 90 credits must be completed. 30 must be from York University. *"Major" requirement:* At least half of the required Major credits must be "in-Faculty". At least 18 must be in courses at the 3000 level or higher. 12 of these 18 must be in the Major.

Honours Degrees:	At least 120 credits must be completed. 30 must be from York University. *"Major" requirement:* At least half of each Major's or Minor's required credits must be "in-Faculty". At least 36 credits must be at the 3000 level or higher. 18 of these must be at the 4000 level (of which 12 must be in the Major).

GPA Requirements:

Bachelor Programs: A credit-weighted grade-point average (c.w.g.p.a.) of at least 4.0, over all courses taken, is required to graduate. At most 12 credits may be taken beyond the required 90, to raise the g.p.a. above 4.0 (and they must be above the 1000 level).

Honours Programs: An overall cumulative c.w.g.p.a. of at least 5.0 must be maintained.

[1] Not applicable to Honours Double Major or Honours Major/Minor candidates, unless both subjects are offered by this department (Mathematics, Applied Mathematics, Statistics, Mathematics for Education).
[2] Choose two different Honours programs (e.g., Mathematics and Economics, or Mathematics and Statistics).
[3] Choose one Honours Major and a distinct Honours Minor.
[4] Requirements that a certain number of your courses must "live" in your Faculty and/or department.

Faculty of Science
Summary of Degree Requirements BSc and BSc (Hons)
(Pre FW 12/13)

The following is *not* intended to be a complete list of the many requirements of which you should be aware. For that, see the main York Calendar or the FSE Calendar.
All candidates must complete the following (in addition to 1000-level MATH requirements):

- *(Lab requirements)* 12 credits chosen from (BIOL 1010 6.0 or BIOL 1410 6.0), (CHEM 1000 3.0 and CHEM 1001 3.0), (EATS 1010 3.0 and EATS 1011 3.0), (MATH 2041+2042)[1], (PHYS 1410 6.0 or PHYS 1010 6.0)
- 12 credits of "General Education" courses — at least 3 credits in each of two approved areas outside Science. See Section IV of the FSE Calendar.
- at least 3, and in some cases 6, CSE credits — see individual program requirements on the next three pages.

Degree Program Selection:

Each student must choose a departmental program (see subsequent pages and also the section "Programs" near the front of this minicalendar), in which to complete one of the following degrees:

Specialized Honours Program | Honours Double Major[2] Program | Bachelor Program

Honours Major/Minor Program | Honours Major Program

Total Credit Requirements:

Bachelor Program	At least 90 credits must be completed. At least 66 must be in SC courses, of which at least 24 must be at the 1000 level. At least 18 must be in courses at the 3000 level or higher.
Honours Program	At least 120 credits must be completed. At least 90 must be in SC courses, of which at least 24 must be at the 1000 level. At least 42 must be in courses at the 3000 level or higher.

GPA Requirements for Bachelor Programs:

For students admitted to York University for 2001/2002 and subsequent years, the Senate of York University will require a minimum cumulative credit-weighted grade-point average (c.c.w.g.p.a.), computed over *all* courses, of 4.0, for eligibility to graduate in an undergraduate Bachelor program.

GPA Requirements for Honours Programs:

To "declare":	At least 24 credits passed, and a minimum c.c.w.g.p.a. of at least 5.0[3] over all courses completed.
To proceed:	Each year, a c.c.w.g.p.a. of at least 5.0[3] over all courses.
To graduate:	For students admitted to York University for 1999/2000 and subsequent years, a minimum c.c.w.g.p.a., computed over *all* courses, of 5.0[3] is required, for eligibility to graduate in an undergraduate Honours degree program.
Note:	A maximum of 6 credits from 1000-level College courses may be counted towards a BSc or BSc (Hons) degree.

"In-department" and "in-Faculty" credit are important, and potentially complex, issues. Any student concerned about these should consult with an advisor.

[1] If MATH 2041 + 2042 is chosen, the student must also ensure that (s)he takes a total of at least 24 1000-level science (SC) credits. These 24 may NOT include any of: CHEM 1500, CHEM 1520, MATH 1500, MATH 1510, MATH 1515, PHYS 1510, nor any NATS courses.
[2] Choose two different Honours Majors (e.g., Mathematics and Physics, or Applied Mathematics and Statistics).
[3] Honours Double Major with Biology also requires 6.0 over SC courses.

NOTE: Programs Starting between September 2008 and May 2012

The following old mathematics and statistics program descriptions apply to all students (including transfer students) who entered York between September 2008 and May 2012. In particular, these students may not use the older Pre Fall/Winter 08/09 programs described in the 2011–2012 Undergraduate Supplemental Calendar. Transfer students should consult with the Undergraduate Program Director to determine which courses are required to complete their program.

Note that careful planning is necessary to insure that prerequisites of a required MATH course are taken previously.

MATH 1513 6.0 may be substituted for MATH 1300 3.0.

MATH 1013 3.0 + MATH 1014 3.0 may be substituted for MATH 1300 3.0 + MATH 1310 3.0 although this is not recommended.

Students who have taken MATH 1530 3.0 or MATH 1550 6.0 may not take MATH 1300 3.0, but will be considered to have credit for MATH 1300 3.0 and may take MATH 1310 3.0.

Applied Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs

(Post FW 07/08)

(Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 35 for BSc, BSc (Hons).
Note: *See also the "areas of concentration" listed on page 7, when choosing upper-year courses.*

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐		
MATH 2001 3.0	☐	MATH 2041 3.0	☐	MATH 2270 3.0	☐	MATH 3001 3.0	☐
MATH 3241 3.0	☐	MATH 3242 3.0	☐	MATH 3410 3.0	☐		
MATH 3260 3.0 *or* MATH 3170 6.0			☐				
12 additional credits selected from MATH courses (without second digit "5") at the 4000 level.							☐

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2041 3.0	☐	MATH 2270 3.0	☐	MATH 3241 3.0	☐
MATH 3242 3.0 *or* MATH 3260 3.0 *or* MATH 3170 6.0			☐				
12 additional credits selected from MATH courses (without second digit "5") at the 4000 level.			☐				

Honours Minor BA or BSc (with another subject as Major):

MATH 1021 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐	CSE 1560 3.0	☐
MATH 2310 3.0	☐						
6 credits chosen from: MATH 2041 3.0; MATH 2270 3.0; either MATH 2022 3.0 or MATH 2222 3.0.							☐
12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including at least one of MATH 3170 6.0, MATH 3241 3.0 *or* MATH 3260 3.0.			☐				

Applied Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (continued) (Post FW 07/08)

(Pre FW 12/13)

BA Program:

Mathematics/Statistics Core ☐ CSE 1560 3.0 ☐ MATH 2041 3.0 ☐

MATH 2270 3.0 ☐ MATH 3241 3.0 ☐ MATH 3260 3.0 *or* MATH 3170 6.0 ☐

6 or 3 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher to make the total of such courses at least 12. ☐

BSc Program:

Mathematics/Statistics Core ☐

CSE 1560 3.0 ☐ MATH 2041 3.0 ☐ MATH 2270 3.0 ☐ MATH 3241 3.0 ☐

MATH 3260 3.0 *or* MATH 3170 6.0 ☐

Computational Mathematics
Specialized Honours BSc (FW 08/09 and FW 09/10)

Important: For a summary of Faculty degree requirements, see page 35.

The only degree currently offered in Computational Mathematics is Specialized Honours BSc. Students must complete the courses in the first box below and the courses in one of the three areas of concentration appearing further down this page. Students must complete at least 54 credits from MATH courses (without second digit "5").

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Computational Mathematics Core:

CSE 1020 3.0	☐	CSE 1030 3.0	☐	CSE 2031 3.0	☐	MATH 2041 3.0	☐
MATH 3090 3.0	☐	MATH 4090 3.0	☐				

Applied and Industrial Mathematics:

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
MATH 2042 3.0	☐	MATH 2270 3.0	☐	MATH 3241 3.0	☐	MATH 3242 3.0	☐
MATH 4141 3.0	☐						

Financial Mathematics

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
ECON 1000 3.0	☐	ECON 1010 3.0	☐	MATH 2280 3.0	☐	MATH 3170 6.0	☐
MATH 4143 3.0	☐						

Actuarial Mathematics:

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
MATH 2280 3.0	☐	MATH 3280 6.0	☐	MATH 3330 3.0	☐	MATH 4143 3.0	☐
MATH 4280 3.0	☐	MATH 4430 3.0 *or* MATH 4431 3.0			☐		

See next page for Computational Mathematics Specialized Honours BSc (Post FW 09/10).

Computational Mathematics (Post FW 09/10)
Specialized Honours BSc (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 35.

The only degree currently offered in Computational Mathematics is Specialized Honours BSc. Students must complete the courses in the first box below and the courses in one of the two areas of concentration appearing further down this page.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Computational Mathematics Core:

CSE 1020 3.0	☐	CSE 1030 3.0	☐	CSE 2031 3.0	☐	MATH 2041 3.0	☐
MATH 2131 3.0	☐	MATH 2270 3.0	☐	MATH 3090 3.0	☐	MATH 3241 3.0	☐
MATH 3242 3.0	☐	MATH 3271 3.0	☐	MATH 4090 3.0	☐		

Applied and Industrial Mathematics:

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
MATH 3170 6.0	☐	MATH 4141 3.0	☐	MATH 4170 6.0	☐		

Financial Mathematics

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
ECON 1000 3.0	☐	ECON 1010 3.0	☐	MATH 2280 3.0	☐	MATH 2281 3.0	☐
MATH 3330 3.0	☐	MATH 4143 3.0	☐	MATH 4430 3.0 *or* MATH 4431 3.0			☐

International Dual Degree Mathematics Statistics BSc, BSc (Specialized Hons) Programs (Post FW 07/08)[1] (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 35.

Note: This program requires a *Specified General Education Requirement*. See box at bottom of this page.

Mathematics/Statistics Core:							
MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:							
Mathematics/Statistics Core			☐				
CSE 1530 3.0	☐	CSE 1560 3.0	☐	PHYS 1410 6.0	☐	MATH 2001 3.0	☐
MATH 2270 3.0	☐	MATH 2320 3.0	☐	MATH 3020 6.0	☐	MATH 3170 6.0	☐
MATH 3241 3.0	☐	MATH 3271 3.0	☐	MATH 3410 3.0	☐		
9 additional credits selected from MATH courses at the 4000 level.					☐		

Bachelor Program:							
Mathematics/Statistics Core			☐				
CSE 1530 3.0	☐	CSE 1560 3.0	☐	PHYS 1410 6.0	☐	MATH 2001 3.0	☐
MATH 2270 3.0	☐	MATH 2320 3.0	☐	MATH 3020 6.0	☐	MATH 3170 6.0	☐
MATH 3241 3.0	☐	MATH 3271 3.0	☐	MATH 3410 3.0	☐		

In lieu of the Faculty's General Education Requirement, students of this program MUST take the appropriate courses.

Students whose home university is York University

AP/IT 1000 6.0	☐	Any Faculty-approved General Education course 3.0	☐
Lingua e Cultura Italiana 3.0 (offered by the University of L'Aquila)	☐		

Students whose home university is University of L'Aquila

Lingua Inglese 1, 2 (offered by the University of L'Aquila)	☐	HUMA 1220 9.0	☐

[1] For an up-to-date list of equivalent courses offered at the University of L'Aquila, contact the Department of Mathematics and Statistics.

Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 35 for BSc, BSc (Hons).

Mathematics/Statistics Core[1]:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Pure Mathematics 4000 Level Courses:

4000 6.0/3.0	4001 6.0	4020 6.0	4030 3.0	4080 6.0	4110 3.0	4120 3.0
4130 3.0	4140 3.0	4150 3.0	4160 3.0	4170 6.0	4210 3.0	4230 3.0
4250 6.0	4280 3.0	4290 3.0	4300 6.0/3.0	4430 3.0	4431 3.0	4630 3.0
4730 3.0						

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2001 3.0	☐	MATH 3001 3.0	☐	MATH 3010 3.0	☐
MATH 3020 6.0 *or* both MATH 3131 3.0 and MATH 3132 3.0					☐		
6 credits chosen from the Pure Math 4000 Level Courses above					☐		
6 additional credits selected from MATH courses (without second digit "5") at the 4000 level, including either MATH 4001 6.0 *or* MATH 4020 6.0 if neither was taken above.			☐				
15 additional credits selected from MATH courses (without second digit "5").					☐		

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2001 3.0	☐	MATH 3001 3.0	☐	MATH 3010 3.0	☐
MATH 3020 6.0 *or* both MATH 3131 3.0 and MATH 3132 3.0					☐		
6 credits chosen from the Pure Math 4000 Level Courses above.					☐		
6 additional credits selected from MATH courses (without second digit "5") at the 4000 level.					☐		

Honours BA or BSc Minor (with another subject as Major):

MATH 1300 3.0	☐	MATH 1310 3.0	☐	MATH 1021 3.0	☐	MATH 2022 3.0	☐
MATH 2310 3.0	☐						
3 credits chosen from: MATH 1019 3.0, MATH 1090 3.0, MATH 1190 3.0, MATH 1200 3.0, MATH 2030 3.0, MATH 2320 3.0							☐
12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher							☐

See next page for Mathematics BA or BSc Programs.

[1] In all Mathematics Honours programs, MATH 1021 3.0 and/or MATH 2022 3.0 may be replaced by other linear algebra courses, but if the grade obtained in any such replacement is below A then one of the following courses must be taken above and beyond the normal Honours requirements: MATH 1019 3.0, MATH 1090 3.0, MATH 1190 3.0 or MATH 2320 3.0.

Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (continued) (Post FW 07/08) (Pre FW 12/13)

Bachelor BA or BSc Program:

MATH 1300 3.0	☐	MATH 1310 3.0	☐	MATH 1021 3.0[2]	☐	MATH 2022 3.0[3]	☐
MATH 2310 3.0	☐	CSE 1560 3.0	☐				

3 credits chosen from:
MATH 1019 3.0, MATH 1090 3.0, MATH 1190 3.0, MATH 1200 3.0, MATH 2030 3.0, MATH 2320 3.0. ☐

12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher. ☐

[2] MATH 2221 3.0 or MATH 1025 3.0 will be accepted in lieu of MATH 1021 3.0 in this program.
[3] MATH 2222 3.0 will be accepted in lieu of MATH 2022 3.0 in this program.

Mathematics for Commerce BA and BA (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Mathematics for Commerce may not be taken jointly with another subject in a Double Major honours program. For a summary of Faculty degree requirements, see page 34.[1]

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Actuarial Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2001 3.0	☐	MATH 2131 3.0	☐	MATH 2270 3.0	☐
MATH 2280 3.0	☐	MATH 2281 3.0	☐	MATH 3131 3.0	☐	MATH 3132 3.0	☐
MATH 3280 3.0	☐	MATH 3281 3.0	☐	MATH 3330 3.0	☐	MATH 4280 3.0	☐
MATH 4130B 3.0	☐	MATH 4143 3.0	☐	MATH 4281 3.0	☐		
MATH 4430 3.0 *or* MATH 4431 3.0			☐				

Honours Actuarial Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 2280 3.0	☐	MATH 3131 3.0	☐
MATH 3280 3.0 + 3281 3.0[2]			☐☐	MATH 3330 3.0	☐	MATH 4280 3.0	☐
MATH 4430 3.0 *or* MATH 4431 3.0			☐				
6 additional credits selected from MATH courses at the 4000 level.					☐		

Honours Operations Research Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 3170 6.0	☐	MATH 3330 3.0	☐
MATH 4170 6.0	☐	MATH 3034 3.0 *or* MATH 3430 3.0			☐		
6 additional credits selected from MATH courses at the 4000 level.					☐		

See next page for Mathematics for Commerce BA Honours Minor (with another subject as Major) and BA Bachelor Programs.

[1] In an honours program, three full courses at the 4000 level are required. Students must plan ahead to ensure they have the prerequisites for six *more* credits at the 4000 level, in MATH or another subject.
[2] This may be replaced by MATH 3280 6.0.

Mathematics for Commerce BA and BA (Hons) Programs (continued) (Post FW 07/08) (Pre FW 12/13)

Honours Minor (with another subject as Major):

CSE 1520 3.0	☐	MATH 1550 6.0 *or* (MATH 1530 3.0 + 1540 3.0)	☐				
MATH 1021 3.0	☐	MATH 1581 3.0	☐	MATH 2560 3.0	☐	MATH 2570 3.0	☐
MATH 3170 6.0	☐	MATH 3330 3.0	☐	MATH 3034 3.0 *or* MATH 3430 3.0			☐

Bachelor Program:

CSE 1520 3.0	☐	CSE 1530 3.0	☐	MATH 1550 6.0 *or* (MATH 1530 3.0 + 1540 3.0)			☐
MATH 2221 3.0	☐	MATH 2222 3.0	☐	MATH 2560 3.0	☐	MATH 2570 3.0	☐
MATH 1581 3.0 + 2581 3.0[1]			☐☐	MATH 3330 3.0	☐	MATH 3170 6.0	☐
One of: MATH 3034 3.0 *or* MATH 3430 3.0			☐				

[1] This may be replaced by MATH 2580 6.0.

Mathematics for Education BSc (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 35.

Note: This program may be taken as a double major, or as a minor with a program in other Faculties.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐		
3 credits chosen from: MATH 2001 3.0, MATH 2131 3.0, MATH 2270 3.0, MATH 2280 3.0					☐		
MATH 3050 6.0	☐	MATH 3090 3.0	☐	MATH 4100 3.0	☐	MATH 4400 6.0	☐
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher.							☐

Honours Major, Double Major or Major/Minor:

Mathematics/Statistics Core	☐	CSE 1560 3.0	☐	MATH 4100 3.0	☐
18 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher (MATH 3050 6.0, MATH 4400 6.0 and one of MATH 3090 3.0 or MATH 4090 3.0 recommended).			☐		

Proof-based requirement: at least 3 credits, which may be within the choices above, selected from:

MATH 2001 3.0	MATH 3020 6.0	MATH 3050 6.0		MATH 3001 3.0
MATH 3140 6.0	MATH 3260 3.0	MATH 4160 3.0	☐	

Honours Minor (with another subject as Major):

3 CSE credits (CSE 1560 3.0 recommended)			☐				
MATH 1021 3.0	☐	MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐
MATH 1310 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐		
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including MATH 4100 3.0 or MATH 4400 6.0.							☐
3 credits, which may be within the choices above, selected from proof-based courses approved by the director (such as MATH 2001 3.0, MATH 3020 6.0, MATH 3050 6.0, MATH 3140 6.0, MATH 3260 3.0, MATH 4160 3.0).							☐

Mathematics for Education BA (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 34.

Note: This program may be taken as a double major, or as a minor with a program in other Faculties.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:

Mathematics/Statistics Core ☐ CSE 1560 3.0 ☐

3 credits chosen from: MATH 2001 3.0, MATH 2131 3.0, MATH 2270 3.0, MATH 2280 3.0 ☐

MATH 3050 6.0	☐	MATH 3090 3.0	☐	MATH 4100 3.0	☐	MATH 4400 6.0	☐

9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including 3 credits at the 4000 level. ☐

Honours Major, Double Major or Major/Minor:

Mathematics/Statistics Core ☐ CSE 1560 3.0 ☐ MATH 4100 3.0 ☐

18 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including 9 credits at the 4000 level (MATH 3050 6.0, MATH 4400 6.0 and one of MATH 3090 3.0 or MATH 4090 3.0 recommended). ☐

Proof-based requirement: at least 3 credits, which may be within the choices above, selected from:

MATH 2001 3.0	MATH 3020 6.0	MATH 3050 6.0	MATH 3001 3.0
MATH 3140 6.0	MATH 3260 3.0	MATH 4160 3.0 ☐	

Honours Minor (with another subject as Major):

3 CSE credits (CSE 1560 3.0 recommended) ☐

MATH 1021 3.0	☐	MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐
MATH 1310 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐		

9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher, with at least 6 credits at the 4000 level, including MATH 4100 3.0 or MATH 4400 6.0. ☐

3 credits, which may be within the choices above, selected from proof-based courses approved by the director (such as MATH 2001 3.0, MATH 3020 6.0, MATH 3050 6.0, MATH 3140 6.0, MATH 3260 3.0, MATH 4160 3.0). ☐

Statistics BA and BA (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 34.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐		
MATH 2001 3.0	☐	MATH 2131 3.0	☐	MATH 3001 3.0	☐	MATH 3330 3.0	☐
MATH 3034 3.0	☐	MATH 3131 3.0	☐	MATH 3132 3.0	☐	MATH 3430 3.0	☐
12 additional credits selected from MATH courses with third digit "3" at the 4000 level.					☐		
6 additional credits selected from MATH courses (without second digit "5").					☐		

Honours Major, Double Major or Major/Minor:

Mathematics/Statistics Core[1]			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 3330 3.0	☐	MATH 3131 3.0	☐
MATH 3132 3.0	☐	MATH 3034 3.0 *or* MATH 3430 3.0			☐		
12 additional credits selected from MATH courses with third digit "3" at the 4000 level.					☐		

Honours Minor (with another subject as Major):

MATH 1021 3.0[2]	☐	MATH 1131 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 2022 3.0[1]	☐	MATH 2030 3.0	☐	MATH 2131 3.0	☐		
9 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.					☐		

Bachelor Program:

Mathematics/Statistics Core[1]			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 3131 3.0	☐	MATH 3330 3.0	☐
3 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.					☐		
3 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher.							☐

[1] MATH 2222 3.0 will be accepted in lieu of MATH 2022 3.0 in this program, but is not recommended.
[2] MATH 2221 3.0 will be accepted in lieu of MATH 1021 3.0 in this program, but is not recommended.

Statistics BSc and BSc (Hons) Programs (Post FW 07/08) (Pre FW 12/13)

Important: For a summary of Faculty degree requirements, see page 35.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐		
MATH 2001 3.0	☐	MATH 2131 3.0	☐	MATH 3001 3.0	☐	MATH 3330 3.0	☐
MATH 3034 3.0	☐	MATH 3131 3.0	☐	MATH 3132 3.0	☐	MATH 3430 3.0	☐
12 additional credits selected from MATH courses with third digit "3" at the 4000 level.							☐
6 additional credits selected from MATH courses (without second digit "5").					☐		

Honours Major or Major/Minor:

Mathematics/Statistics Core[1]			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 3330 3.0	☐	MATH 3131 3.0	☐
MATH 3132 3.0	☐	MATH 3034 3.0 *or* MATH 3430 3.0			☐		
12 additional credits selected from MATH courses with third digit "3" at the 4000 level.							☐

Honours Double Major:

Mathematics/Statistics Core[1]			☐	CSE 1560 3.0	☐		
MATH 2131 3.0	☐	MATH 3330 3.0	☐	MATH 3131 3.0	☐	MATH 3132 3.0	☐
6 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.					☐		

Honours Minor (with another subject as Major):

MATH 1021 3.0[2]	☐	MATH 1131 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 2022 3.0[1]	☐	MATH 2030 3.0	☐	MATH 2131 3.0	☐		
9 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.							☐

Bachelor Program:

Mathematics/Statistics Core[1]			☐				
CSE 1560 3.0	☐	MATH 2131 3.0	☐	MATH 3131 3.0	☐	MATH 3330 3.0	☐
3 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.					☐		

[1] MATH 2222 3.0 will be accepted in lieu of MATH 2022 3.0 in this program, but is not recommended.
[2] MATH 1025 3.0 or MATH 2221 3.0 will be accepted in lieu of MATH 1021 3.0 in this program, but is not recommended.

Summary of Degree Requirements BSc and BSc (Hons) (Post FW 11/12)

Degree Program Selection:

Each student must choose a departmental program (see subsequent pages and also the section "Programs" near the front of this minicalendar), in which to complete one of the following degrees: Specialized Honours Program; Honours Double Major.[1] Program; Bachelor Program; Honours Major/Minor Program; and, Honours Major Program

The following is *not* intended to be a complete list of the many requirements of which you should be aware. For that, see the main York Calendar.

Degree Option/Requirement	Minimum Credit Requirement
A. General Education Requirements	
Non-science Requirement	12 credits in human enquiry outside of science disciplines. See the Non-Science Requirement section of the relevant York University Calendar for details.
Mathematics	6 credits at 1000 level; satisfied within the major or minor requirements in all Mathematics and Statistics programs.
Computer Science	3 credits at 1000 level; satisfied by program requirements except Minor in Mathematics and Minor in Statistics.
Foundational Science	6 credits from SC/BIOL 1000 3.00, SC/BIOL 1001 3.00 (or SC/BIOL 1010 6.00), SC/CHEM 1000 3.00, SC/CHEM 1001 3.00, SC/PHYS 1410 6.00 or SC/PHYS 1010 6.00.
B. Major or Minor Requirements	
	See relevant program checklist on subsequent pages.
C. Science Breadth Requirement Outside the Major Program	
90 credit BSC (Bachelor) degree	24 credits in science disciplines outside the major, of which 3 credits must be at the 2000 level or above, which may include: · science credits in the General Education requirements that are not in the major; and · science credits required by the major that are not in the major discipline. Check program specification in the relevant York University Calendar for guidance.
120 credit Specialized Honours BSc and Honours BSc degrees *Not applicable to double major and major/minor programs, if the second major or the minor is another science discipline.*	24 credits in science disciplines outside the major, of which 3 credits must be at the 2000 level or above, which may include: · science credits in the General Education requirements that are not in the major; and; · science credits required by the major that are not in the major discipline. Check program specification in the relevant York University Calendar for guidance.
D. Upper Level Requirements Not Implemented Within the Program Specification	
90 credits BSc (Bachelor) degree	Minimum of 18 credits must be at the 3000 level or above.
120 credit Specialized Honours BSc and Honours BSc degrees	Minimum of 42 credits must be at the 3000 level or above.
E. Elective Requirements	
90 credit BSc (Bachelor) degree	Additional elective credits, as required, for an overall total of 90 credits.
120 credit Specialized Honours BSc and Honours BSc degrees	Additional elective credits, as required, for an overall total of 120 credits.
F. Standing Requirements	
90 credit BSc (Bachelor) degree	A minimum overall grade point average of 4.00 © is required in order to be eligible to graduate.
120 credit Specialized Honours BSc and Honours BSc degrees	To graduate in an Honours program requires successful completion of all Faculty requirements and departmental required courses and a minimum cumulative credit-weighted grade point average of 5.00 ©+) over all courses completed, subject to the following exception. In addition, a minimum cumulative credit-weighted grade point average of 5.00 ©+) over all biology courses completed is required to graduate in an Honours Double Major program where biology is the other major.
Residency Requirement	
	A minimum of 30 courses credits and at least half (50 percent) of the course credits required in each undergraduate degree program major/minor must be taken at York University.

[1] Choose two different Honours Majors (e.g., Mathematics and Physics, or Applied Mathematics and Statistics).

NOTE: Programs Starting in September 2012 or Later

The following new mathematics and statistics program descriptions apply to all students (including transfer students) who enter York in September 2012 or later. In particular, these students may not use the older programs described on the preceding pages. Transfer students should consult with the Undergraduate Program Director to determine which courses are required to complete their program.

Note that careful planning is necessary to insure that prerequisites of a required MATH course are taken previously.

MATH 1013 3.0 + MATH 1014 3.0 may be substituted for MATH 1300 3.0 + MATH 1310 3.0 although this is not recommended.

Students who have taken MATH 1530 3.0 or MATH 1550 6.0 may not take MATH 1300 3.0, but will be considered to have credit for MATH 1300 3.0 and may take MATH 1310 3.0.

Applied Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (Post FW 11/12)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 49 for BSc, BSc (Hons).

Note: *See also the "areas of concentration" listed on page 7, when choosing upper-year courses.*

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2001 3.0	☐
MATH 2031 1.0	☐	MATH 2041 3.0	☐	MATH 2270 3.0	☐	MATH 3001 3.0	☐
MATH 3241 3.0	☐	MATH 3242 3.0	☐	MATH 3243 1.0	☐	MATH 3271 3.0	☐
MATH 3260 3.0 *or* MATH 3170 6.0			☐	MATH 3410 3.0	☐	MATH 4090 3.0	☐
9 additional credits selected from MATH courses (without second digit "5") at the 4000 level.							☐

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2031 1.0	☐
MATH 2041 3.0	☐	MATH 2270 3.0	☐	MATH 3241 3.0	☐	MATH 3243 1.0	☐
MATH 3242 3.0 *or* MATH 3260 3.0 *or* MATH 3170 6.0			☐	MATH 3271 3.0	☐	MATH 4090 3.0	☐
9 additional credits selected from MATH courses (without second digit "5") at the 4000 level.			☐				

Honours BA or BSc Minor (with another subject as Major):

MATH 1021 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐	CSE 1560 3.0	☐
MATH 2310 3.0	☐	6 credits chosen from: MATH 2041 3.0; MATH 2270 3.0; either MATH 2022 3.0 or MATH 2222 3.0.					☐
12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including at least one of MATH 3170 6.0, MATH 3241 3.0 *or* MATH 3260 3.0.[1]							☐

[1] Beginning FW 14/15, this requirement changes to: 12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including at least 6 credits selected from MATH 3090 3.0, MATH 3171 3.0, MATH 3172 3.0, MATH 3241 3.0, MATH 3242 3.0, MATH 3260 3.0, MATH 3271 3.0 or MATH 3410 3.0.

Applied Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (Post FW 11/12) (continued)

Bachelor BA or BSc Program:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2031 1.0	☐
MATH 2041 3.0	☐	MATH 2270 3.0	☐	MATH 3241 3.0	☐	MATH 3243 1.0	☐
MATH 3260 3.0 *or* MATH 3170 6.0[1]			☐				
6 or 3 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher to make the total of such courses at least 12 credits.[2]							☐

[1] Beginning FW 14/15, this requirement changes to: MATH 3271 3.0.

[2] Beginning FW 14/15, this requirement changes to: 6 additional credits selected from MATH 3090 3.0, MATH 3171 3.0, MATH 3172 3.0, MATH 3242 3.0, MATH 3260 3.0, MATH 3410 3.0, MATH 4090 3.0, MATH 4141 3.0, or MATH 4161 3.0.

Computational Mathematics
Specialized Honours BSc (Post FW 11/12)

Important: For a summary of Faculty degree requirements, see page 49.

The only degree currently offered in Computational Mathematics is Specialized Honours BSc. Students must complete the courses in the first box below and the courses in one of the two areas of concentration appearing further down this page.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Computational Mathematics Core:

CSE 1020 3.0	☐	CSE 1030 3.0	☐	CSE 2031 3.0	☐	MATH 2031 1.0	☐
MATH 2041 3.0	☐	MATH 2131 3.0	☐	MATH 2270 3.0	☐	MATH 3090 3.0	☐
MATH 3241 3.0	☐	MATH 3242 3.0	☐	MATH 3243 1.0	☐	MATH 3271 3.0	☐
MATH 4090 3.0	☐						

Applied and Industrial Mathematics:

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
MATH 3171 3.0 + 3172 3.0[1]			☐	MATH 4141 3.0	☐	MATH 4170 6.0	☐

Financial Mathematics

Mathematics/Statistics Core			☐	Computational Mathematics Core			☐
ECON 1000 3.0	☐	ECON 1010 3.0	☐	MATH 2280 3.0	☐	MATH 2281 3.0	☐
MATH 3330 3.0	☐	MATH 4143 3.0	☐	MATH 4430 3.0 *or* MATH 4431 3.0			☐

3 additional credits selected from MATH courses (without second digit "5") at the 4000 level to make the total of such courses at least 12 credits. ☐

[1] This may be replaced by MATH 3170 6.0.

International Dual Degree Mathematics Statistics
BSc, BSc (Specialized Hons) Programs (Post FW 11/12)[1]

Important: For a summary of Faculty degree requirements, see page 49.

Note: This program requires a *Specified General Education Requirement*. See box at bottom of this page.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Major:

Mathematics/Statistics Core			☐				
CSE 1530 3.0	☐	CSE 1560 3.0	☐	PHYS 1410 6.0	☐	MATH 2001 3.0	☐
MATH 2270 3.0	☐	MATH 2320 3.0	☐	MATH 3020 6.0	☐	MATH 3171 3.0 + 3172 3.0[2]	☐
MATH 3241 3.0	☐	MATH 3271 3.0	☐	MATH 3410 3.0	☐		
12 additional credits selected from MATH courses at the 4000 level.					☐		

Bachelor Program:

Mathematics/Statistics Core			☐				
CSE 1530 3.0	☐	CSE 1560 3.0	☐	PHYS 1410 6.0	☐	MATH 2001 3.0	☐
MATH 2270 3.0	☐	MATH 2320 3.0	☐	MATH 3020 6.0	☐	MATH 3171 3.0 + 3172 3.0[2]	☐
MATH 3241 3.0	☐	MATH 3271 3.0	☐	MATH 3410 3.0	☐		

In lieu of the Faculty's General Education Requirement, students of this program MUST take the appropriate courses.

Students whose home university is York University

AP/IT 1000 6.0	☐	Any Faculty-approved General Education course 3.0	☐
Lingua e Cultura Italiana 3.0 (offered by the University of L'Aquila)	☐		

Students whose home university is University of L'Aquila

Lingua Inglese 1, 2 (offered by the University of L'Aquila)	☐	HUMA 1220 9.0	☐

[1] For an up-to-date list of equivalent courses offered at the University of L'Aquila, contact the Department of Mathematics and Statistics.
[2] This may be replaced by MATH 3170 6.0.

Mathematics BA, BA (Hons), BSc, BSc (Hons) Programs (Post FW 11/12)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 49 for BSc, BSc (Hons).

Mathematics/Statistics Core[1]:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2001 3.0	☐
MATH 2031 1.0	☐	MATH 3001 3.0	☐	MATH 3010 3.0	☐	MATH 4011 3.0	☐
Either both MATH 3021 3.0 and MATH 3022 3.0 *or* both MATH 3131 3.0 and MATH 3132 3.0					☐	MATH 4021 3.0	☐
MATH 4200 3.0	☐						
3 additional credits selected from MATH courses (without second digit "5") at the 4000 level.					☐		
15 additional credits selected from MATH courses (without second digit "5").					☐		

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2001 3.0	☐
MATH 2031 1.0	☐	MATH 3001 3.0	☐	MATH 3010 3.0	☐	MATH 4011 3.0	☐
Either both MATH 3021 3.0 and MATH 3022 3.0 *or* both MATH 3131 3.0 and MATH 3132 3.0					☐	MATH 4021 3.0	☐
3 additional credits selected from MATH courses (without second digit "5") at the 4000 level.					☐	MATH 4200 3.0	☐

Honours BA or BSc Minor (with another subject as Major):

MATH 1300 3.0	☐	MATH 1310 3.0	☐	MATH 1021 3.0	☐	MATH 2022 3.0	☐
MATH 2310 3.0	☐						
3 credits chosen from: MATH 1019 3.0, MATH 1090 3.0, MATH 1190 3.0, MATH 1200 3.0, MATH 2030 3.0, MATH 2320 3.0						☐	
12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher						☐	

Bachelor BA or BSc Program:

CSE 1560 3.0	☐	MATH 1021 3.02	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐
MATH 1310 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2031 1.0	☐
MATH 2310 3.0	☐	MATH 3010 3.0	☐				
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher.						☐	

[1] In all Mathematics Honours programs, MATH 1021 3.0 and/or MATH 2022 3.0 may be replaced by other linear algebra courses, but if the grade obtained in any such replacement is below A then one of the following courses must be taken above and beyond the normal Honours requirements: MATH 1019 3.0, MATH 1090 3.0, MATH 1190 3.0 or MATH 2320 3.0.

Mathematics for Commerce BA and BA (Hons) Programs (Post FW 11/12)

Mathematics for Commerce may not be taken jointly with another subject in a Double Major honours program. For a summary of Faculty degree requirements, see page 34.[1]

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours Actuarial Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2001 3.0	☐	MATH 2031 1.0	☐	MATH 2131 3.0	☐
MATH 2270 3.0	☐	MATH 2280 3.0	☐	MATH 2281 3.0	☐	MATH 3131 3.0	☐
MATH 3132 3.0	☐	MATH 3280 3.0	☐	MATH 3281 3.0	☐	MATH 3330 3.0[2]	☐
MATH 4280 3.0	☐	MATH 4130B 3.0[2]	☐	MATH 4143 3.0	☐	MATH 4281 3.0	☐
MATH 4430 3.0 *or* MATH 4431 3.0			☐				

Honours Actuarial Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2031 1.0	☐	MATH 2131 3.0	☐	MATH 2280 3.0	☐
MATH 3131 3.0	☐	MATH 3280 3.0 + 3281 3.0			☐☐	MATH 3330 3.0	☐
MATH 4280 3.0	☐	MATH 4430 3.0 *or* MATH 4431 3.0			☐		
6 additional credits selected from MATH courses at the 4000 level.					☐		

Honours Operations Research Stream:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2031 1.0	☐	MATH 2131 3.0	☐	MATH 3171 3.0 + 3172 3.0[3]	☐
MATH 3330 3.0	☐	MATH 4170 6.0	☐	MATH 4330 3.0 *or* MATH 3430 3.0			☐
6 additional credits selected from MATH courses at the 4000 level.					☐		

Honours Minor (with another subject as Major):

CSE 1520 3.0	☐	MATH 1550 6.0 *or* (MATH 1530 3.0 + 1540 3.0)			☐		
MATH 1021 3.0	☐	MATH 1581 3.0	☐	MATH 2560 3.0	☐	MATH 2570 3.0	☐
MATH 3171 3.0 + 3172 3.0[3]	☐	MATH 3330 3.0	☐	MATH 3034 3.0 *or* MATH 3430 3.0			☐

Bachelor Program:

CSE 1520 3.0	☐	CSE 1530 3.0	☐	MATH 1550 6.0 *or* (MATH 1530 3.0 + 1540 3.0)			☐
MATH 2221 3.0	☐	MATH 2222 3.0	☐	MATH 2560 3.0	☐	MATH 2570 3.0	☐
MATH 1581 3.0 + 2581 3.0			☐☐	MATH 3330 3.0	☐	MATH 3170 6.0	☐
One of: MATH 4330 3.0 *or* MATH 3430 3.0			☐				

[1] In an honours program, three full courses at the 4000 level are required. Students must plan ahead to ensure they have the prerequisites for six *more* credits at the 4000 level, in MATH or another subject.

[2] This course is part of the 'Applied Statistics' Validation by Educational Experience (VEE) requirements of the Canadian Institute of Actuaries. In addition to it, students should take the following courses as electives: AP/ECON 1000 3.0, AP/ECON 1010 3.0 for the 'Economics' VEE and AP/ECON 2300 3.0, AP/ECON 2350 3.0, AP/ECON 4400 3.0, AP/ECON 4410 3.0 for the 'Corporate Finance' VEE. To be granted VEE credit from the Canadian Institute of Actuaries, students must achieve a grade of B or higher in each VEE requirement.

[3] This may be replaced by MATH 3170 6.00.

Mathematics for Education BA (Hons), BSc (Hons) Programs (Post FW 11/12)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 49 for BSc, BSc (Hons).

Note: This program may be taken as a double major, or as a minor with a program in other Faculties.

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core	☐	CSE 1560 3.0	☐	MATH 2031 1.0	☐
3 credits chosen from: MATH 2001 3.0, MATH 2131 3.0, MATH 2270 3.0 *or* MATH 2280 3.0	☐				
MATH 3050 6.0 *or* MATH 3052 6.0	☐	MATH 3090 3.0	☐	MATH 4100 3.0	☐
MATH 4400 6.0	☐				
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including 3 credits at the 4000 level.	☐				

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core	☐	CSE 1560 3.0	☐	MATH 2031 1.0	☐
MATH 3050 6.0 or MATH 3052 6.0	☐	MATH 4100 3.0	☐		
12 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including 9 credits at the 4000 level (MATH 4400 6.0 and one of MATH 3090 3.0 or MATH 4090 3.0 recommended).	☐				

Honours BA Minor (with another subject as Major):

3 CSE credits (CSE 1560 3.0 recommended)	☐						
MATH 1021 3.0	☐	MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐
MATH 1310 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐		
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher, with at least 6 credits at the 4000 level, including MATH 4100 3.0 or MATH 4400 6.0.	☐						
3 credits, which may be within the choices above, selected from proof-based courses approved by the director (such as MATH 2001 3.0, MATH 3020 6.0, MATH 3050 6.00 *or* MATH 3052 6.0, MATH 3140 6.0, MATH 3260 3.0, MATH 4160 3.0).	☐						

Honours BSc Minor (with another subject as Major):

3 CSE credits (CSE 1560 3.0 recommended)	☐						
MATH 1021 3.0	☐	MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐
MATH 1310 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐		
9 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher including MATH 4100 3.0 or MATH 4400 6.0.	☐						
3 credits, which may be within the choices above, selected from proof-based courses approved by the director (such as MATH 2001 3.0, MATH 3020 6.0, MATH 3050 6.0 *or* MATH 3052 6.0, MATH 3140 6.0, MATH 3260 3.0, MATH 4160 3.0).	☐						

Statistics BA, BA (Hons), BSc and BSc (Hons) Programs (Post FW 11/12)

Important: For a summary of Faculty degree requirements, see page 34 for BA, BA (Hons) and page 49 for BSc, BSc (Hons).

Mathematics/Statistics Core:

MATH 1131 3.0	☐	MATH 1200 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 1021 3.0	☐	MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2310 3.0	☐

Specialized Honours BA or BSc Major:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2001 3.0	☐
MATH 2031 1.0	☐	MATH 2131 3.0	☐	MATH 3001 3.0	☐	MATH 3131 3.0	☐
MATH 3132 3.0	☐	MATH 3330 3.0	☐	MATH 3430 3.0	☐	MATH 4330 3.0	☐
MATH 4730 3.0	☐	MATH 4939 3.0	☐				
3 additional credits selected from MATH courses with third digit "3" at the 4000 level.					☐		
9 additional credits selected from MATH courses (without second digit "5").					☐		

Honours BA or BSc Major, Double Major or Major/Minor:

Mathematics/Statistics Core			☐	CSE 1560 3.0	☐	MATH 2031 1.0	☐
MATH 2131 3.0	☐	MATH 3131 3.0	☐	MATH 3132 3.0	☐	MATH 3330 3.0	☐
MATH 3430 3.0	☐	MATH 4330 3.0	☐	MATH 4730 3.0	☐	MATH 4939 3.0	☐
3 additional credits selected from MATH courses with third digit "3" at the 4000 level.					☐		

Honours BA or BSc Minor (with another subject as Major):

MATH 1021 3.0	☐	MATH 1131 3.0	☐	MATH 1300 3.0	☐	MATH 1310 3.0	☐
MATH 2022 3.0	☐	MATH 2030 3.0	☐	MATH 2131 3.0	☐	MATH 3131 3.0	☐
MATH 3330 3.0	☐	MATH 3430 3.0	☐	MATH 4330 3.0	☐	MATH 4730 3.0	☐

Bachelor BA or BSc Program:

Mathematics/Statistics Core			☐				
CSE 1560 3.0	☐	MATH 2031 1.0	☐	MATH 2131 3.0	☐	MATH 3131 3.0	☐
MATH 3330 3.0	☐						
3 additional credits selected from MATH courses with third digit "3" at the 3000 level or higher.					☐		
3 additional credits selected from MATH courses (without second digit "5") at the 3000 level or higher.							☐