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Cover design by: Susan Rainey
Guide for Returning Students

The Department has new requirements for all of its honours programs. However, if you began your studies at York in Winter 2008, 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 particular, the only upper level courses from the old program which have been phased out are MATH 3110, MATH 3210 and MATH 4010. You must see the Undergraduate Program Director in N505 Ross to discuss degree requirement equivalents to replace them. On the other hand, you have the option to complete your program by meeting the new requirements.

In the degree checklists at the back of this booklet, the old program requirements are listed before the new ones. Feel free to bring your questions to the Undergraduate Office.

Guide for New Students

The Department has new requirements for all of its honours programs. Since you are beginning your studies at York in September 2008, or later, 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 the Winter term of 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 are listed after the old ones. Feel free to bring your questions to the Undergraduate Office.

Guide for New Transfer Students

The Department has new requirements for all of its honours programs. Since you are beginning your studies at York in September 2008, or later, you must meet these new requirements. In particular, you do not have the option of completing your program by meeting the old requirements. You must see the Undergraduate Program Director in N505 Ross to discuss degree requirement equivalents and clarify your situation.
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 and Engineering. 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 Janice Grant, Administrative Assistant, in N503 Ross or Madeline Salzarulo, Program Secretary, in N502 Ross (416-736-5902), Monday–Friday, 10:30a.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: S. O. Kochman (Mathematics); H. Massam (Mathematics for Commerce); Huaxiong Huang (Applied Mathematics and Computational Mathematics); S. Chamberlin (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. 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, involves attempting to solve 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.

M. W. Wong, 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 Stephen Chamberlin (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 Math/Stats Lab, housed in S525 Ross (fifth floor 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, 1550, 1581, 2022, 2030, 2131, 2320, 2560, 3170, and 3330.

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 2011, this department is planning to offer the following courses:

   MATH 1013, 1014, 1019, 1021, 1025, 1090, 1131, 1190, 1300, 1310, 1505, 1510, 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 and Engineering 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 or MATH 1513 6.00; 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 and Engineering, 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 214 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, e-mail them at sos@yorku.ca, or phone them at 416-736-5383. 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

546 institutions and 4296 contestants across North America took part in the 71st William Lowell Putnam Mathematical Competition, held in December 2010. The York “team” had its best showing in several years, ranking 125th among the institution teams. These York students took valuable time from their studies at exam time, to compete in the venerable Putnam:

Coach: Professor Richard Ganong

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 February 2011, one team competed from York:

Amany Abdul-Baki, Rahila Amlany, Fei Guo, Tailia Manashirov, Farnaz Navid-Ehsani, Terry Ng, Peter Nguyen, Maninder Sarai, Weimin Yang.
Coach: Professor Jane Heffernan

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 and Engineering 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 Huaxiong Huang.

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 11.

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 B.Ed. 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 B.Ed. 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. For further information contact Walter Whiteley (whiteley@mathstat.yorku.ca). See also the Section on Mathematics teaching in the Careers section (page 10).

### 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 B.Sc. 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).

**Business and Society (BUSO)**

An interdisciplinary degree program in the Faculty of Liberal Arts and Professional Studies, called “Business and Society” (BUSO, for short), began in September 1999. The Program offers both BA and BA [Hons] degrees.

BUSO degree candidates who first entered BUSO in 2005-2006 or earlier can complete “Streams” in two of the participating disciplines. Those who choose Mathematics and Statistics as one of their two Streams must, in effect, concentrate either in Operations Research or in Applied Statistics (18 credits for Bachelor, 24 for Honours).

- **Operations Research**
  - calculus, or calculus with matrix algebra (MATH 1550 6.00 or MATH 1530 3.00 + 1540 3.00) or (MATH 1300 3.00 + 1310 3.00)
  - linear algebra (MATH 2221 3.0)
• either MATH 2560 3.00 or MATH 2565 3.00 if statistics was already taken in the student’s other Stream, then either MATH 2222 3.00 or 3 “further credits” in statistics
• operations research (MATH 3170 6.00)
• (Honours only) further operations research (MATH 4570 6.00)

- Applied Statistics
  - calculus with matrix algebra (MATH 1550 6.00 or MATH 1530 3.00 + 1540 3.00)
  - introductory statistics (MATH 2560 3.00 + MATH 2570 3.00)
  - regression analysis (MATH 3330 3.00)
  - applied statistics (MATH 3430 3.00 or MATH 3034 3.00)

BUSO degree candidates who first entered BUSO in 2006–2007 or later must follow new (different) streams.

Further information about BUSO can be obtained from the Office for New Students (103 Central Square) or from the Division of Social Science (S748 Ross). The Program Coordinator is Professor M. Peacock (S767 Ross) and fairly complete details of the program are posted on its website, www.yorku.ca/laps/socs/buso.

### Glendon College Mathematics Courses

The following is a selection of courses offered in 2011–2012 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 1190: GL/MATH 1650 3.00, Discrete Mathematics
- 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
- MATH 4010: GL/MATH 4240 6.00—Analyse Réelle

### 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.

A new Mathematics for Education BSc Program was implemented for the first time in 2007–2008. This 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:

- 6 credits in calculus
- 6 credits in linear algebra
- 6 credits in probability and statistics
- 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. It will also be online at www.math.yorku.ca/Careers/actuary.html. 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. A student needs to 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).

**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 calendar 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 H. Massam N630 Ross, 416-736-2100, ext. 66099, massamh@yorku.ca.

**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 3170 and MATH 4170—OR courses
2. MATH 2131 and MATH 3330—statistics courses
3. COSC/1020/1030 or COSC/1520/1530 or COSC/1540 or COSC/1550—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 as prerequisites.

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.

Coordinator: A. Szeto

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. Prerequisites: 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/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 1310 3.00, SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00.

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

Coordinator: J. Steprans

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.

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 W. K. Nicholson, Linear Algebra with Applications (McGraw-Hill Ryerson).

Coordinator: Y. Gao

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, SC/MATH 2025 3.00, SC/MATH 2225 3.00, GL/MATH/MODR 2650 3.00.

Note (from the Undergraduate Office): 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.

Coordinator: Hm. Zhu

2011-2012
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" of the previous paragraph.

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

Coordinators: Fall: G. Tourlakis Winter: R. Ganong

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.

Testing a new drug, pricing a derivative asset, determining 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" of the previous paragraph.

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

Coordinators: Fall: G. Tourlakis Winter: R. Ganong

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 textbook for the course is to be announced.

Coordinator: Y. Gao

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.

Coordinator: M. Zabrocki

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 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.


Coordinators: Fall: S. O. Kochman Winter: R. Ganong

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.


Coordinators: Fall: R. Ganong Winter: S. O. Kochman

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...
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: P. Olin

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.

Coordinator: S. Watson

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.

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.

Coordinator: Fall: H. Joshi

MATH 1532 3.00 FW
Statistics for Business and Society

Calendar Copy: An introduction to statistics with an emphasis on concepts and applications relevant to 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 or equivalents. Course credit exclusions: AK/MATH 1720 3.00; SC/NATS 1500 3.00.

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.

Coordinator: S. Wang

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.

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.

Coordinator: TBA

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 B.B.A. (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: E. Brettler

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: P. Olin Winter: H. Ku
### Mathematics and Statistics

#### 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 will be D.M. Bressoud, *A Radical Approach to Real Analysis*, 2nd ed. (Mathematical Association of America).

**Coordinator:** J. Stepáns

**MATH 2015 3.00 F**  
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 2310 3.00, GL/MATH/MODR 2670 3.00. GL/MATH/MODR 3200 3.00.

Other topics covered include curves and surfaces in Cartesian, cylindrical, and spherical polar coordinates; differential vector identities, Green’s theorem.


**Coordinator:** M. Haslam

**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 the most recent edition of W.K. Nicholson, *Linear Algebra with Applications* (McGraw-Hill Ryerson).

**Coordinator:** R. Burns

**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.

The text will be will be Pitman, *Probability*, 1st ed. (Springer-Verlag, 1993).

**Coordinator:** T. Salisbury ([salt@yorku.ca](mailto:salt@yorku.ca))

**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.

Generations of Engineers and Scientists used pen and paper to perform numerical and symbolic computations. In the case of numerical computations, effective algorithms were invented for finding the roots of functions, minimization problems, and statistical analysis. The calculations in these algorithms are
laborious and had to be done by hand, and tools such as the abacus, log books, the shift rule, and eventually, mechanical calculators, were employed to ease the workload, and to ensure that errors were kept to a minimum. In some cases, teams of people worked in the financial world or with engineers as human calculators, solely to perform, check and recheck calculations for accuracy.

The Electronic Computer introduced methods and means to efficiently and accurately perform numerical calculations. Symbolic Computations, however, were more difficult to implement on the computer, and were done solely by hand until fairly recent times. The cancellation and factorization of terms and symbols in mathematical expressions often follow algebraic rules that are different from those followed by numbers and are generally much more difficult to implement on the computer. Programs such as Maple or Mathematica, however, made it possible to perform symbolic computations with some level of efficiency by machine. In this course we shall explore symbolic computations in select areas of Mathematics by using Maple.

The course will take place in the Gauss Laboratory (S110 Ross). I shall guide you through a number of worksheets, introducing and reinforcing concepts and techniques in Maple. There will be a focus on writing procedures towards the end of the course.

Mathematically we shall cover the basic mathematical ideas with a focus on developing your skills in Maple and Maple programming. Topics will include Basic Mathematical and Basic Algebra, Simple Functions and Calculus with Maple, Data Structures in Maple, Applications, Procedures, Looping and Conditional Statements in Maple, Recurrence and Iteration in Maple, and Non-linear recursions. If there is time, then a short introduction to differential equations and some applications.

Some computing experience in CSE1540 or CSE1560 is an asset.

Coordinator: B. van Rensburg

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. In addition, this course considers maximum likelihood and Bayesian estimation (time permitting). The topics considered in this course require knowledge of univariate and multivariate calculus.

Coordinator: H. Jankowski

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.

Note: This course is expected to be offered beginning September 2012 and should be offered every second year after that.

MATH 2221 3.00 F
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.

Linear algebra is that branch of mathematics which finds more application, in other fields and other branches of mathematics, than perhaps any other branch except calculus. Fields in which linear algebra is essential include the physical sciences, engineering, computer science, economics, and, increasingly, the management and social sciences.

This course and MATH 2222 (see below) together provide a standard full-year introduction to linear algebra. While our focus will not be excessively theoretical, students will be introduced to proofs and expected to develop skills in understanding and applying concepts as well as results. Applications will be left mainly for MATH 2222.

The textbook has not been chosen as this calendar goes to press.

Note that MATH 1540 may not be taken for credit by anyone who is taking, or anyone who has passed, MATH 2221.

Coordinator: E. Brettler

MATH 2222 3.00 W
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.

This course is a continuation of either MATH 1025 3.00 or MATH 2221 3.00, and requires knowledge of the topics discussed in those courses.
The text is likely to be H. Anton, Elementary Linear Algebra (Wiley).

**Mathematics and Statistics**

**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

**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 yet to be chosen.

**Coordinator:** M. Haslam

**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:** H. Jankowski

**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 2131 3.00; SC/MATH 1021 3.00 or SC/MATH 2221 3.00.

Note: A proposal is under review as of this writing, to eliminate the listed prerequisite of MATH 2131. The instructor will waive that prerequisite for Winter 2012.

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:** T. Salisbury (salt@yorku.ca)
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/MATH 1014 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/MODR 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, 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 (O, 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. Notes: 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 grading scheme has not been determined as this supplemental calendar goes to press. The text will be the most recent edition of K.H. Rosen, Discrete Mathematics and its Applications (McGraw-Hill).

Coordinator: B. van Rensburg

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, SS/OMIS 1000 3.00, AS/POLS 3300 6.00, GL/POLS 2610 3.00, HH/PSYC 2020 6.00, HH/PSYC 2121 3.00, GL/SOCI 2610 3.00, SS/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 (most likely Excel).

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, 6th 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: W. Liu

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, SS/OMIS 1000 3.00.
Three lectures per week. 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.

**Coordinator: A. Wong**

**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/POLS 3300 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.


**Coordinator: S. Chamberlin**

**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.

Prerequisites: SC/MATH 1581 3.00; SC/MATH 1580 3.00. Course credit exclusions: AP/SC/GEOG 2420 3.00, HH/KINE 3150 3.00, GL/MATH/MODR 1620 3.00, AS/POLS 3300 6.00, GL/POLS 2620 3.00, HH/PSYC 2020 6.00, HH/PSYC 2022 3.00, GL/SOCI 2620 3.00.

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., 2010); 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.

It will be possible (but not preferable) to use the 6th edition of the textbook. The previous 6th edition of the text did not include the chapter on insurance. This material can be downloaded from the publisher’s website.

A substantial component of the course will consist of an introduction to spreadsheets since much of the material can be particularly well treated with this tool. We will use Microsoft EXCEL in particular, but the basic MATH concepts are common to all spreadsheets. EXCEL is available for both PC and Macintosh. EXCEL will be used to simplify and illuminate equation-solving, amortization of loans and mortgages, bond schedules, depreciation tables, life and mortality tables. With the help of notes and class instruction, students will be introduced to the spreadsheet and to its use in mathematics of finance. There will be some in-class demonstrations of the software but students will need individual accounts on the Mathematics Department MOODLE server to access some of the homework problems and to develop some competence with EXCEL.

The grading scheme for the course has not been determined, but it will likely involve a mid-term and a final examination.

Each student will also need a hand-held calculator which has power and logarithm functions. Specifically, it must be able, given values of x and y, to compute x to the power y.

The course should be especially interesting to students of business and economics. The emphasis will be on practical problems. 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 wish a more advanced treatment of the material should not take this course, but enrol instead in MATH 2280 3.00. In particular, this includes:

- **Honours Mathematics for Commerce students in the Actuarial Stream. MATH 2280 3.00** is a required course for this program.
- students who are contemplating a career in the actuarial profession. They should take MATH 2280 3.00, followed by MATH 3280 3.00 and MATH 3281 3.00.

The pair of half-courses MATH 1581/2581 is equivalent to the full course MATH 2580 which is no longer offered. Roughly speaking, MATH 1581 contains all of the easy material from MATH 2580 while MATH 2581 deals with the ‘complications’.

**Coordinator: D. Pelletier**

**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
Mathematics and Statistics

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: P. Gibson

MATH 3010 3.00 F
Vector Integral Calculus

Calendar copy: Integrality 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

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

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.

Algebra is the study of algebraic systems, that is, sets of elements endowed with certain operations. A familiar example is the set of integers with the operations of addition and multiplication.

Algebra is used in almost every branch of mathematics; indeed, it has simplified the study of mathematics by indicating connections between seemingly unrelated topics. In addition, the success of the methods of algebra in unravelling the structure of complicated systems has led to its use in many fields outside of mathematics.

One aim of this course is to help students learn to write clear and concise proofs, read mathematical literature, and communicate mathematical ideas effectively, both orally and in writing.

Students should have a thorough understanding of elementary sets and functions, and of basic logic, such as can be obtained from courses like MATH 1190, or from many mathematics books. Reviewing those utterly basic foundations of mathematics before the course starts would be wise.

The text has not yet been chosen.

Coordinator: TBA

MATH 3034 3.00 W
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.

This course is a continuation of MATH 3330 3.00, Regression Analysis, or of MATH 3033 3.00, Classical Regression Analysis. The focus is on categorical data analysis, including contingency tables, logistic regression, log-linear models and generalized linear models. Students will use the statistical software SAS to analyze data.

The text is A. Agresti, An Introduction to Categorical Data Analysis, 2nd ed. (Wiley).

Coordinator: S. Chamberlin

MATH 3050 6.00 Y
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.

In modern geometries, the rich interplay of synthetic methods (constructive and visual), groups of transformations, analytic methods, dynamic geometry computer programs and axioms presents a rich mix of problems and methods to be explored. Through multiple mathematical and pedagogical approaches we will introduce these geometries in their classical and modern 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), and (iii) teaching geometry (iv) teaching mathematics with multiple representations. The formal prerequisites are minimal: familiarity with linear algebra and some mathematical maturity. Other background will be developed as needed. We will expect students to join in group work, to work with and build physical models in class, to use a dynamic geometry program, Geometer’s SketchPad, and to develop their own geometric questions and projects.

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

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 from the sciences and/or business applications. Case studies and simulations through modelling and representation of data. Implementation, efficiency and application of numerical and stochastic algorithms.

Coordinator: TBA

MATH 3100 3.00
Famous Problems in Mathematics

Calendar copy: An attempt to foster an appreciation of the history, the personalities and some of the content of different areas of mathematics, by means of a study of some specific problems which have exercised the minds of mathematicians. Prerequisites: At least 12 credits from 2000-level mathematics courses without second digit 5, or permission of the course coordinator.

Note: This course will not be offered in FW 2011.

The problems will range from ancient to recent times, and will be selected from the fields of algebra, analysis, geometry, number theory, set theory, and foundations of mathematics. The course will deal with mathematical ideas in the context of mathematical techniques. Philosophical issues in the development of mathematics will also be discussed.

MATH 3110 3.00
Introduction to Mathematical Analysis

Calendar copy: Proofs in calculus and analysis. Topics include sets, functions, axioms for R, applications of the completeness axiom, countability, sequences and their limits, monotone sequences, limits of functions, continuity. Prerequisite: SC/MATH 1310 3.00 or SC/MATH 1014 3.00. Prerequisites or corequisites: SC/MATH 2310 3.00 or SC/MATH 2010 3.00 or SC/MATH 2015 3.00; SC/MATH 1021 3.00 or SC/MATH 2221 3.00 or SC/MATH 1025 3.00. Course credit exclusion: SC/MATH 1010 3.00.

Note: This course is no longer offered.

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.

In this course, we first consolidate and extend some notions acquired in MATH 2131. We then introduce the basic concepts of statistical inference and apply them to various examples. For estimation, we study the notions of unbiasedness, sufficiency and consistency. Confidence regions are derived for parameters in various classical problems. For hypothesis testing, we define the notions of most powerful, uniformly most powerful and likelihood ratio tests. We prove the Neyman-Pearson lemma and give several examples of testing problems.

Coordinator: X. Gao

2011-2012
MATH 3312 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 testing statistical hypotheses, Bayesian methods, nonparametric statistics, linear models, etc.

Coordinator: H. Massam

MATH 3140 6.00
Number Theory and Theory of Equations

Calendar copy: A study of topics in number theory and theory of equations using relevant methods and concepts from modern algebra, such as Abelian groups, unique factorization domains and field extensions. Prerequisite: SC/MATH 2022 3.00 or SC/MATH 2222 3.00 or permission of the course coordinator.

Note: This course will not be offered in 2011.

Number theory, “the queen of mathematics” (as Gauss called it), is a fascinating subject in which easily-stated problems, understandable to anybody who can add and multiply integers, have occupied amateurs and professionals alike throughout the ages. One of the earliest problems (going back at least 4000 years) must have been that of solving the "Pythagorean" equations \( x^2 + y^2 = z^2 \) for integers \( x, y, z \). Presenting the solutions in this case is not very difficult (and we shall deal with it early in the course), but it becomes a famous and very difficult problem if we replace the squares by \( n \)th powers, with an arbitrary natural number \( n \). The absence of any nontrivial solutions for \( n > 2 \) is known as "Fermat’s Last Theorem", a proof of which was published only in 1994, after centuries of intensive research and with the use of many powerful techniques of modern mathematics.

Number theory has many modern applications, particularly in cryptography. Any system to secure the flow of potentially sensitive information (encoded on credit cards, or in e-mail communication, for example) makes heavy use of number theory.

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.

This course deals with standard optimization techniques used in Operations Research. These techniques are widely used in managerial decision making, and also lead to interesting mathematical theory. We shall investigate problem formulation, underlying theory, applications, and practical implementation. The main topics include:

(a) Linear Programming, including the simplex algorithm, duality theory, sensitivity analysis;
(b) Network Problems, including the transportation algorithm, network flows, assignment problem, shortest-path problems, critical path scheduling;
(c) Integer Programming, including solution by the branch-and-bound method;
(d) Dynamic Programming.
The text will be determined later.

Students who have not taken the prerequisite courses need the permission of the course instructor to enrol.

Coordinator: S. Watson

MATH 3210 3.00
Principles of Mathematical Analysis

Calendar copy: Rigorous presentation, with proofs, of fundamental concepts of analysis: limits, continuity, differentiation, integration, fundamental theorem, power series, uniform convergence. Prerequisite: At least one of the following four courses or course combinations: 1) SC/MATH 2010 3.00, 2) SC/MATH 3110 3.00, 3) SC/MATH 2310 3.00 and SC/MATH 1010 3.00, 4) SC/MATH 2015 3.00 and SC/MATH 1010 3.00.

Note: This course is no longer offered.

MATH 3241 3.00 F
Numerical Methods I
(same as CSE 3211 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 3211 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
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

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.

A first course in graph theory. After considering introductory material on graphs and properties of graphs, we shall look at trees, circuits and cycles. Graph embeddings, labelings and colourings, with some applications, will also be covered.

The text will be R. Wilson, Introduction to Graph Theory, 4th ed. (Addison Wesley).

Coordinator: A. Weiss

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 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.

The course will be based on the three archetypical equations from mathematical physics: the wave equation, Laplace's equation, and the heat equation. Using these equations in various contexts as examples and motivation, the basic mathematical techniques for solving second order partial differential equations will be developed.

Coordinator: P. Gibson

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

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. Three lecture hours per week plus one hour of faculty led tutorials per week.

Coordinator: E. Furman
**Mathematics and Statistics**

**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 2131 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:** Y. Wu

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**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 215 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.

The final grade will be based on term work (60%) and a final exam worth 40%.

**Coordinator:** TBA

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

**Coordinator:** P. Peskun

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**MATH 3500 6.00**

**Mathematics in the History of Culture**

(same as HUMA3990 A 6.00)

Calendar copy: An introduction to the history of mathematical ideas from antiquity to the present, with emphasis on the role of these ideas in other areas of culture such as philosophy, science and the arts.

**Note:** This course will not be offered in FW 2011.

**Note:** This course is a major course for ITEC and STCS students. It counts for “Group C” credit in the ITEC program.

Note that this is a web-based course. Course lectures are available from the web site and course discussion takes place on web forum. The course mark is based on written essay-type tests and participation in the on-line discussion forum.

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2011-2012
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, class tests, and a final examination, probably three class tests, and a final examination, weighted in a way favourable to students.

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

This is the last of a three course sequence in real analysis (preceded by MATH 2001 and 3001) intended for honours majors. The course provides an essential basis for further mathematical study in a number of areas, including functional analysis, probability and harmonic analysis. Apart from the particular mathematical content, the course aims to train students to compose and to write rigorous mathematical arguments clearly and unambiguously. In addition there will be an opportunity for students to present mathematical theorems and proofs verbally to their peers. The course will treat the following topics: complex numbers, metric spaces and topology, sequences and series of functions, functions of several variables, Lebesgue measure and integration on the real line, Hilbert space, and Fourier analysis.

Coordinator: F. Gibson

MATH 4010 6.00 Y
Real Analysis


Note: This course is no longer offered.

MATH 4020 6.00 Y
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.

This course aims to broaden and deepen the student’s knowledge and understanding of modern abstract algebra by building on the material of MATH 3020 6.00.

The text has not been chosen, but may be T. Hungerford, Abstract Algebra, An Introduction, 2nd ed. (Brooks/Cole). Additional readings will be supplied to the class as needed.

The final grade will be based on assignments, probably three class tests, and a final examination, weighted in a way favourable to students.

Student should consult this web page around 15 August for further information: www.math.yorku.ca/~ganong/menu.html

Coordinator: R. Ganong (ganong@yorku.ca)

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 2011.
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 2011.

Unlike a geometrician, who will consider only non-distorting transformations of geometric objects, such as reflections and rotations, a topologist studies properties that are invariant under bending, stretching, compressing, etc. Hence, a circle is considered topologically equivalent not to an ellipse, but even to a triangle or a square! While this seems mathematically rough and disturbing, a second look quickly reveals how fine and powerful a tool topological equivalences (called homeomorphisms) are, since they turn out to be able to distinguish such seemingly similar objects as open, closed and half-open intervals of the same length! The main purpose of this course is to study so-called topological spaces, and those properties which are invariant under homeomorphisms and isotopies. To get a feel for the latter concept, perform the following (rather theoretical) experiment: Using both of your hands, make linked rings with your thumbs and index fingers, and now assume that your whole body is made of very elastic material, so that its shape may be changed at will, by bending, stretching and compressing it as much as you like (but tearing and gluing is forbidden). Question: can you move your hands apart without separating the joined fingertips? Surprisingly, the answer turns out to be positive!

Topology is an integral part of modern mathematics, just like geometry, algebra and analysis. It has many applications to almost all mathematical fields and is increasingly used in other subjects, such as physics and economics. The course will present basic constructions and concepts of general topology, such as separation axioms, compactness, connectedness, metrizability, as well as the fundamentals of homotopy theory.

The course can be used to fulfill the Pure Mathematics Honours requirement.

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

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 the 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: W. Whiteley

MATH 4130B 3.00 W
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: S. Wang

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.

Note: This course will not be offered in FW 2011.
Mathematics and Statistics

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

We start with some parametric models and show how censored data can be incorporated in the analysis. Then we proceed to nonparametric methods and discuss Kaplan-Meier and Actuarial estimators. Semiparametric models, proportional hazards model and time dependent covariates will also be discussed. The computer will be extensively used, and familiarity with elementary use of S+ and SAS will be assumed.

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 2310 3.00; six credits from 3000-level mathematics courses without second digit 5; or permission of the course coordinator. Course credit exclusion: AS/MATH 3170 6.00; or permission of the instructor.

Coordinator: A. Kuznetsov

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

MATH 4143 3.00 W
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 2010 3.00 or SC/MATH 2030 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: A. Kuznetsov

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, queueing 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 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.

**Coordinators: Fall: N. Madras Winter: M. Chen**

**MATH 4230 3.00 F**

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.

This course will cover classical and modern nonparametric methods. The first part of the course surveys general rank statistics, one-sample, two-sample, and k-sample problems, Kolmogorov-Smirnov statistics, tests of independence, and relative efficiencies. The second part of the course will introduce density estimation, the bootstrap and jackknife, and nonparametric regression, time-permitting. Additional topics may also be considered.

The text for this course has not yet been determined.

**Coordinator: H. Jankowski**

**MATH 4280 3.00 F**

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.

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**Coordinator: E. Furman**

**MATH 4281 3.00 W**

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, Lundberg'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).


Prerequisite: MATH 2131 3.00.

**Coordinator: A. Kuznetsov**

**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.)

Note: This course may not be offered in 2012/2013. Third year students who plan to take the course should do so in 2011-2012.

The aim of this course is to give an overview of the development of mathematical thought from ancient times to the eighteenth century. This will give students a broader perspective and better understanding of mathematics. In each period of history, specific topics in algebra, analysis and/or geometry will be discussed in complete mathematical detail. No attempt will be made to include every interesting development. The discussion of each topic will include its historical and cultural contexts as well as its motivating applications. For example, the course will begin with arithmetic calculations using hieroglyphics and geometric methods of the Babylonians for solving quadratic equations. It will end 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 course grade will be determined by a combination of attendance, two papers, two tests and a final exam.


Coordinator: S. O. Kochman

MATH 4430 3.00
Stochastic Processes


Note: This course will not be offered in FW 2011.

In this course, we begin with review of probability theory (especially conditional expectation). We introduce transition probability matrices for discrete-time Markov chains. We then cover the following topics: first step analysis, the long-run behaviour of Markov chains which includes classification of states and basic limit theorems, Poisson processes, Birth and death process and its limiting behaviour, and finally Brownian motion.


MATH 4431 3.00W
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.

Probability theory has been used to describe and analyze many kinds of real-world phenomena. This course will investigate several classes of probability models, including the following:

- Renewal processes are used to model an event that occurs repeatedly at random times, such as the failure of a machine component. The focus of study is on the long-run average behaviour of such processes.
- Branching processes are a class of simple population growth models. One important question is how the distribution of the number of offspring of one parent can be used to predict the probability that the population eventually dies out. Generating functions will be introduced and used to derive results.
- Martingales are models of “fair games”. They have been used to study stock market behaviour and are an important theoretical tool for a wide variety of probability problems.

Coordinator: H. Ku

MATH 4630 3.00 W
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. Familiarity with elementary use of SAS will be assumed.

Topics covered will include multivariate normal population, inference about means and linear models, principal component analysis, factor analysis and some discussion of discriminant analysis, and canonical correlation analysis and cluster analysis, if time permits.


Coordinator: H. Massam

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.

Note: This course will not be offered in FW 2011.

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 analysed 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.

MATH 4830 3.00 F
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 3.00, AK/AS/SC/CSE 3451 4.00, AS/SC/MATH 4130B 3.00, AS/SC/MATH 4930C 3.00. Coordinator: TBA

MATH 4930A 3.00 W
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.

This course presents the modern approach to quality through the use of statistical methods. The primary focus will be on the control chart, whose use in modern-day business and industry is of tremendous value. Various control charts will be discussed, including EWMA and CUSUM charts. Time permitting, the important interrelationship between statistical process control and experimental design for process improvement will be discussed.

Coordinator: P. Peskun

MATH 4930B 3.00 W
Topics in Applied Statistics:
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 generation and variance reduction techniques. Applications to queueing systems and networks. Prerequisite: SC/MATH 3330 3.00 or SC/MATH 3033 3.00. Course credit exclusion: SC/CSE 3408 3.00. Note: This course will not be offered in FW 2011.

The role of simulation and Monte Carlo methods in all the sciences has increased in importance during the past several years. These methods are at the heart of rapidly developing subdisciplines of computational sciences in physics and chemistry, for example, as well as being fundamental tools of computational statistics. The growing power of computers and the evolving simulation methodology have led to the recognition of computation as a third approach for advancing the natural sciences and statistics, together with theory and traditional experimentation.

This course examines the role and discusses the use of simulation and Monte Carlo methods, especially in computational statistics. Topics to be discussed include: random numbers and pseudorandom number generation; random variate generation from nonuniform distributions; Monte Carlo integration and variance reduction techniques; Markov chain Monte Carlo (MCMC) including the basic Metropolis-Hastings algorithm and a variation, the Gibbs sampler; resampling methods including the jackknife and the bootstrap; statistical applications.