Mathematics and Computing Science (MATH, CPSC, and CSCI)

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The Department of Mathematics and Computing Science offers a broad range of courses, including introductory courses intended for students with little mathematical or computing science background; preparatory courses for students intending to enter fields requiring mathematics or computing science; and specialized courses for more advanced mathematics and computing science students.

Students can obtain a degree in Computing Science in one of two possible areas. A more traditional degree in Computing Science involving an emphasis in Mathematics is offered as a minor, concentration, major, or honors. This option has the designation CPSC. These programs are for students who are primarily interested in the technical aspects of Computing Science. Alternatively, students interested in applying the technical aspects of Computing Science to business can obtain a major in Computing Science and Business Administration. This option has the designation CSCI and is available as a major only. Note too that all computing science courses offered by this Department have a CSCI designation, whether applied to a CPSC or CSCI degree designation. Both of these Computing Science options have a Co-op option.

Details on the computing science programs are found below immediately following the detailed course descriptions for mathematics.

Co-operative Education Program (Co-op)

This program is designed for students in the honors or major programs who wish to gain relevant work experience while attending university. The general requirements for the Co-operative Education program can be found in the Faculty of Science regulations, Co-operative Education Section, of this *Calendar*. Interested students should contact the Department of Mathematics and Computing Science Co-op advisor before the end of their first year.

Credit for Duplicate Courses

No student who has received credit for an advanced mathematics or computing science course may later receive credit for a mathematics or computing science prerequisite to the course without permission of the Department. With renumbered or restructured courses, students are advised that they are not eligible to take a course for credit if they already have a credit for a comparable course, even if that course was taken at a different level or under a different number.

Upper Level Mathematics Course Offerings

In order to help major and honors students plan their course of study, each year during the second semester, the Department typically offers 400 level Mathematics courses:
(1) MATH 3405 and MATH 3406 are offered every year.
(2) MATH 3401, MATH 3402, MATH 4408, MATH 4409, MATH 4420, MATH 4421, MATH 4434, MATH 4436, and MATH 4437 are offered in academic years in which the fall term is an even numbered year.
(3) MATH 3456, MATH 3457, MATH 4426, MATH 4427, MATH 4430, MATH 4432, MATH 4441 and MATH 4442 are offered in academic years in which the fall term is an odd numbered year. Although every effort will be made to keep this schedule, no absolute guarantee can be made.

Mathematics (MATH)

Preparatory Courses
MATH 0010.1(.2)/0011.1(.2) and 0050.1(.2)/0051.1(.2) are accepted as the equivalent of Nova Scotia Grade 12 Mathematics. MATH 0010.1(.2)/0011.1(.2) are intended primarily for students entering natural sciences or mathematics, and include emphasis on trigonometry as well as algebra. MATH 0050.1(.2)/0051.1(.2) are for commerce and social science students who do not have Nova Scotia Grade 12 Mathematics or equivalent.

MATH 1210.1(.2)/2111.1(.2) are the first courses in calculus, and MATH 2310.1(.2)/2311.1(.2) combined form the natural calculus sequel.

MATH 2320.1(.2) provides an introduction to linear algebra, while further topics in linear algebra are covered in MATH 2321.1(.2).

Specialized Courses
Students may obtain a degree which has a special emphasis in one of the areas indicated below by choosing the majority of their optional courses from those listed following the area of selection:

Special Emphasis in Pure Mathematics:
MATH 2370.1(.2); 3401.1(.2); 3402.1(.2); 4420.1(.2); 4421.1(.2); 4426.1(.2); 4427.1(.2); 4430.1(.2); 4432.1(.2); 4436.1(.2); 4437.1(.2); 4441.1(.2); and 4442.1(.2).

Special Emphasis in Applied Mathematics:
MATH 2308.1(.2); 2309.1(.2); 2315.1(.2); 2316.1(.2); 3401.1(.2); 3402.1(.2); 3405.1(.2); 3406.1(.2); 4408.1(.2); 4409.1(.2); 3414.0; 3415.1(.2); 3416.1(.2); 3445.0; 3456.1(.2); and 3457.1(.2).

Students who lack the stated high school courses prerequisite for credit courses in mathematics or computing science are advised to enrol in MATH 0010.1(.2)/0011.1(.2) in Year 1.

Requirements for a Major in Mathematics

A major in mathematics is offered for students working towards the degrees of Bachelor of Arts and Bachelor of Science and for students of above average ability working towards the degrees of Bachelor of Arts (Honors) and Bachelor of Science (Honors).

The Departmental requirements for a major in mathematics are:
1. MATH 1210.1(.2)/1211.1(.2)
2. CSCI 1226.1(.2)/1227.1(.2)
3. MATH 2310.1(.2)/2311.1(.2)
4. MATH 2320.1(.2)/2321.1(.2)
5. A minimum of twenty-four (24) credit hours [eighteen (18) credit hours in case of double major] additional credits in mathematics courses numbered 1216 or 2305 or above, chosen by the student in consultation with the Department. At least twelve (12) credit hours [six (6) credit hours in case of double major] must be at the 3000 level or above.

Requirements for Honors in Mathematics

The honors program is designed for mathematics majors of above average ability. Mathematics majors in Year 2 with an overall quality point average of at least 2.50, and with a quality point average of at least 3.00 in their mathematics courses, should consider enrolling in the honors program, and are advised to consult with the Department before making a final decision.

The Departmental requirements for honors in mathematics are:
1. MATH 1210.1(.2)/1211.1(.2)
2. CSCI 1226.1(.2)/1227.1(.2)
3. MATH 2310.1(.2)/2311.1(.2)
4. MATH 2320.1(.2)/2321.1(.2)
5. A minimum of forty-two (42) credit hours [twenty-four (24) credit hours in case of double honors] additional credits in mathematics courses numbered 1216 or 2305 or above, chosen by the student in consultation with the Department. At least twenty-four (24) credit hours [twelve (12) credit hours in case of double honors] must be at the 3000 level or above.

Notes:
(i) Students must obtain formal Departmental approval of their program at the time of their declaration to enter the major or honors program, as well as for any subsequent changes.
(ii) Students taking a major or honors in mathematics are permitted credit for at most one of BIOL 2308.1(.2), ECON 2207.1(.2), MATH 1207.1(.2), MGSC 1207.1(.2), or PSYC 2350.1(.2); and shall not be permitted credit for any of these courses simultaneously with or subsequent to MATH 1216.1(.2) or 2316.1(.2).
(iii) Major and honors students in mathematics can use CSCI courses to satisfy Faculty of Science regulation 6e or 12b.

Requirements for a Minor in Mathematics

It is possible to minor in mathematics by completing the equivalent of thirty (30) credit hours in mathematics in addition to satisfying Faculty of Science regulations for a minor. These courses must include:
a. MATH 1210.1(.2), 1211.1(.2), 2310.1(.2), 2311.1(.2), 2320.1(.2), and 2321.1(.2) [eighteen (18) credit hours]
b. An additional twelve (12) credit hours in mathematics numbered 1200 or above.

Concentration in Mathematics (B.A.-General)

To obtain a concentration in Mathematics in partial fulfillment of the B.A. General degree (i.e., one with Double Arts Concentrations and a minimum of ninety (90) credit hours), a minimum of twenty-four (24) credit hours in MATH is required; also a minimum cumulative quality point average of 2.00 is required. Further details are available from the chairperson.

Requirements for a Double Major or Double Honors in Mathematics and Physics

Detailed requirements for these programs are found above in the Department of Astronomy and Physics.

Certificate in the Mathematical Sciences for Education

1. Introduction

The Certificate in the Mathematical Sciences for Education is intended to provide holders of a Bachelor of Education (B.Ed.) degree with a broad background in mathematics, statistics, and computing science, enabling them to teach high school mathematics courses effectively. Teachers who complete this program will have a deep understanding of the mathematics that they teach, and a familiarity with the various contexts in which their own university-bound students will use that mathematics. A teaching mehtods course is an integral part of this program.

2. Admission

To gain entry to this program, students must have a B.Ed. (or equivalent). They must also have at least Grade 12 precalculus mathematics (or equivalent) before starting MATH 1210. (Among possible equivalents are MATH 1190 and some non-credit courses offered at Saint Mary's. **Note**: these do not form part of the Certificate Program.)

Precalculus mathematics is not a prerequisite for MATH 1202, CISY 1205, or MATH 1207.
Students must register in the actual program before starting courses.

3. Courses
Students must take at least thirty (30) credit hours as delineated below. Where the student has already obtained credit for one or more of these courses (or equivalents) as part of a program leading to an earlier certification by the Nova Scotia Department of Education, MATH or CSCI courses numbered 1200 or above and acceptable to the Department of Mathematics and Computing Science may be substituted. (Students should note that each individual's program must be approved ahead of time by the Registrar for Teacher Certification in order to be recognized for teacher certification in Nova Scotia.)

MATH 1202.1(.2)	Concepts and Topics in Mathematics
MATH 1203.1(.2)	Concepts in High School Mathematics
MATH 1207.1(.2)	Survey of Statistics
MATH 1210.1(.2)	Intro Calculus I
MATH 1211.1(.2)	Intro Calculus II
MATH 1216.1(.2)	Intro Mathematical Statistics
CSCI 1226.1(.2)	Introduction to Computing Science and Programming
MATH 2305.1(.2)	Discrete Mathematics I
MATH 2320.1(.2)	Linear Algebra I
EDUC 2523.1(.2)	Mathematics

4. To obtain the Certificate, a student in this program must achieve a minimum grade of C in all courses forming part of the certificate and hence have a minimum cumulative quality point average of 2.00.

5. The Department of Mathematics and Computing Science restriction on receiving credit for an advanced course, and then receiving credit for a course prerequisite to the advanced course, and the restriction on taking MATH 1207.1(.2) and MATH 1216.1(.2), do not apply to this Certificate program.

6. All courses must normally be taken at Saint Mary's University. In very exceptional circumstances, the Department of Mathematics and Computing Science may recommend to the Acting Dean of Education for one or more courses to be taken at another university on a Letter of Permission. Courses taken at or transferred from other universities must meet the program's requirement of a minimum grade of C.

7. A student who intends to use this program to obtain a license upgrade or other professional certification **MUST** obtain **prior** written approval from the appropriate authorities (in Nova Scotia, the Registrar for Teacher Certification). **The student is responsible for obtaining such approval**; Saint Mary's University takes no responsibility for the approval of individual programs of study.

IMPORTANT

In the 2004-2005 academic year, courses were renumbered from three digits to four. A new digit was added to the front of the sequence to indicate the year of study in which a student would normally enroll in a course. The last three digits represent the "old" course number – for example, MATH 0010.1(.2) was formerly MAT 010.1(.2).

Students are urged to be extremely careful not to register again for a course for which they have already earned credit. Academic Regulation 17(b) is extremely important to this matter.

IN THE CASES WHERE COURSES HAVE BEEN RENUMBERED, CHANGED IN LEVEL, OR WHERE A SIX (6) CREDIT HOUR COURSE (FORMERLY REFERRED TO AS "FULL COURSE") HAS BEEN SPLIT INTO TWO THREE (3) CREDIT HOUR COURSES (FORMERLY TERMED "HALF COURSES") OR VICE VERSA, A STUDENT WHO RECEIVED CREDIT RECOGNITION FOR THE ORIGINAL COURSE IS NOT ENTITLED TO REPEAT THE COURSE IN ITS NEW FORMAT OR ON ITS NEW LEVEL FOR ADDITIONAL CREDIT RECOGNITION.

Previous Course #'s	New Course #'s	Previous Course #'s	New Course #'s
MAT 010	MATH 0010	MAT 405	MATH 3405
MAT 011	MATH 0011	MAT 406	MATH 3406
MAT 050	MATH 0050	MAT 408	MATH 4408
MAT 051	MATH 0051	MAT 409	MATH 4409
MAT 190	MATH 1190	MAT 414	MATH 3414
MAT 202	MATH 1202	MAT 415	MATH 3415
MAT 207	MATH 1207	MAT 416	MATH 3416
MAT 210	MATH 1210	MAT 420	MATH 4420
MAT 211	MATH 1211	MAT 421	MATH 4421
MAT 212	MATH 1212	MAT 426	MATH 4426
MAT 216	MATH 1216	MAT 427	MATH 4427
MAT 301	MATH 2301	MAT 430	MATH 4430
MAT 303	MATH 2303	MAT 432	MATH 4432
MAT 305	MATH 2305	MAT 434	MATH 4434
MAT 308	MATH 2308	MAT 436	MATH 4436
MAT 309	MATH 2309	MAT 437	MATH 4437
MAT 310	MATH 2310	MAT 441	MATH 4441
MAT 311	MATH 2311	MAT 442	MATH 4442
MAT 315	MATH 2315	MAT 445	MATH 3445
MAT 320	MATH 2320	MAT 456	MATH 3456
MAT 321	MATH 2321	MAT 457	MATH 3457

MAT 370	MATH 2370	MAT 490-499	MATH 4490-4499
MAT 401	MATH 3401		
MAT 402	MATH 3402	MAT 500	MATH 4500

0010.1(.2) Precalculus I
Elementary set theory and the real number system. Factorization. Inequalities, absolute values, and interval notation. Techniques of solving a variety of equations and inequalities in a single variable. The Cartesian plane and representation of ordered pairs of real numbers. Elements of analytic geometry. Relations, functions, and graphs, with emphasis on the polynomial, exponential, logarithmic functions, and polynomial and rational equations.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: This is a preparatory course. It does not carry a credit value; therefore it cannot be counted in the number of credits required for a degree, diploma or certificate.

0011.1(.2) Precalculus II
Prerequisite: MATH 0010.1(.2).

Trigonometry, inverse trigonometric functions. Complex numbers. Matrices, determinants, and system of equations. System of inequalities. Sequences and series. Permutations, combinations, and the binomial theorem. Mathematical induction.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: This is a preparatory course. It does not carry a credit value; therefore it cannot be counted in the number of credits required for a degree, diploma or certificate.

0050.1(.2) Algebra for Commerce and the Social Sciences I
Elementary set theory and the real number system. Factorization. Inequalities, absolute values, and interval notation. Techniques of solving a variety of equations and inequalities in a single variable. The Cartesian plane and representation of ordered pairs of real numbers. Elements of analytic geometry. Relations, functions, and graphs, with emphasis on the polynomial, exponential, logarithmic functions, and polynomial and rational equations.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: This is a preparatory course. It does not carry a credit value; therefore it cannot be counted in the number of credits required for a degree, diploma or certificate.

0051.1(.2) Algebra for Commerce and the Social Sciences II
Prerequisite: MATH 0010.1(.2) or MATH 0050.1(.2) or equivalent.

Polynomials and rational functions. Matrices, determinants, and systems of equations. Systems of inequalities. Introduction to linear programming. Sequences and series. Permutations, combinations and the binomial theorem. Probability. Emphasis throughout on the skills needed to solve “word problems”.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: This is a preparatory course. It does not carry a credit value; therefore it cannot be counted in the number of credits required for a degree, diploma or certificate.

1190.1(.2) Pre-Calculus Review
Prerequisite: the equivalent of Nova Scotia precalculus Grade 12 or MATH 441 which is the prerequisite for MATH 1210.1(.2).

The following topics will be covered, in greater depth than in Grade 12 Mathematics courses: Manipulation of algebraic expressions. Solving equations and inequalities. Functions and relations including discussion of polynomials, rational functions, trigonometric functions, inverse trigonometric functions, logarithms, and exponentials. Analytic Geometry. Derivatives and integrals of simple functions.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Notes: (i) Students who have passed MATH 1190.1(.2) are exempted from writing the pre-test for MATH 1210.1(.2).
(ii) MATH 1190.1(.2) is given in the fall and summer of each year; MATH 1210.1(.2) is given in the winter of each year; and MATH 1211.1(.2) is given in the summer of each year. Thus, if you do not meet or exceed the standards set by the department as indicated on the pre-test, it is possible to take MATH 1190.1(.2) and still complete the Calculus in one calendar year.
(iii) Students receiving a grade of less than C are advised not to proceed with MATH 1210.1(.2).
(iv) This course does not count as one of the mathematics credits required for the degree of Bachelor of Science, or towards the requirements for a major or honors in mathematics and computing science. Students should be aware, therefore, that they may not be able to qualify for graduation by completing the minimum number of courses originally stipulated for their program.
(v) This is a credit course but can only be counted as an elective.

1202.1(.2) Concepts and Topics in Mathematics
Prerequisite: Nova Scotia Academic Grade 12 Mathematics (or equivalent)

This course will deal with fundamental concepts and topics in Mathematics, including the axioms of arithmetic and algebra, the integer, rational, and real systems, sets and logic.

Note: This course is intended to provide the necessary MATH background for elementary teachers.

Classes 3 hrs. and recitation 1.5 hrs. a week. 1 semester.

1203.1(.2) Concepts in High School Mathematics
Prerequisites MATH 1202.1(.2) and Nova Scotia Grade XII Pre-Calculus MATH or equivalent.

This course will deal with the mathematical background of topics such as algebra, geometry, probability, and statistics that are in the Nova Scotian junior high and high school curriculum. This course, in conjunction with MATH 1202 and other courses, is intended to provide the necessary MATH background for junior high school teachers. The material will be covered in significantly greater depth than would actually be taught in the school classroom.

Classes 3 hrs. a week plus recitations 1.5 hrs. a week. 1 semester.

1207.1(.2) Survey of Statistics
Prerequisite: The equivalent of Nova Scotia Precalculus Mathematics 12 or Mathematics 12 Academic.

This course provides an introduction to statistics accessible for students in any discipline. The emphasis will be on developing a practical approach to data analysis rather than on mathematical theory. Topics will include exploratory data analysis, elementary probability theory, confidence intervals, hypothesis testing, ANOVA, and regression. As well, students will be introduced to the use of computers in data analysis.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Notes: (i) Students who do not pass at least one of the two pre-tests in this course will be required to withdraw from this course. These students are advised to take MATH 0050.1(.2) before attempting MATH 1207.1(.2) again.
(ii) No credit will be given for this course simultaneously with or subsequent to credit given for BIOL 1308.1(.2), ECON 1207.1(.2), ECON 3303.1(.2), MATH 1216.1(.2), MGSC 1207.1(.2), MGSC 2303.1(.2), or PSYC 2305.0.

1210.1(.2) Introductory Calculus I
Prerequisite: The equivalent of Nova Scotia Grade Precalculus Mathematics 12 or MATH 441.

Topics will include: functions, limits, continuity, derivatives, the chain rule, implicit differentiation, inverse functions, exponential and logarithmic functions, the mean value theorem, indeterminate forms, L'Hôpital's Rule, curve sketching, maximum and minimum problems, antiderivatives, area under a curve.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: Students who do not meet or exceed the standards set by the department as indicated on at least one of the two pre-tests in this course will be required to withdraw from this course and will be eligible to re-register only after successful completion of MATH 1190.1(.2).

1211.1(.2) Introductory Calculus II
Prerequisite: MATH 1210.1(.2).

Topics will include: area under a curve, the definite integral, the fundamental theorem of calculus, applications such as volume, work, inverse trigonometric functions, techniques of integration, L'Hôpital's Rule, improper integrals, arc length, surface area, parametric equations, polar coordinates, simple differential equations, approximate integration.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

1212.1(.2) Calculus II for Engineers
Prerequisite: MATH 1210.1(.2).

Applications of integration: area between curves, volumes of revolution, work, average value of function. Techniques of integration: integration by parts, trigonometric integral, trigonometric substitutions, partial fractions, substitutions. More applications of integration: separable differential equations arc length, area of surface of revolution, applications to engineering such as moments, center of mass, hydrostatic pressure and force, applications to Economics and Biology. Parametrically defined curves, tangents, arc length, polar coordinates, areas and length in polar coordinates. Sequences and series, the integral test, and the comparison test, alternating series, absolute convergence. Power series, Taylor and MacLaurin series. The binomial series, approximation by Taylor polynomials.

Classes 3 hours plus recitations 11/2 hours a week. 1 semester.

Note: Since this course replaces MATH 1211.1(.2) for Engineering students only, these students cannot receive a credit for both MATH 1211.1(.2) and MATH 1212.1(.2).

1216.1(.2) Introduction to Mathematical Statistics
Prerequisite: MATH 1210.1(.2).

This course provides a mathematically rigorous introduction to statistics, based on calculus. Introductory probability theory is covered, including probability distributions and densities, random variables, the central limit theorem, and counting methods. Statistical inference is then covered, including estimation and confidence intervals, hypothesis tests and the role of the likelihood function. Specific methodologies are discussed, including goodness-of-fit tests, regression, analysis of variance and nonparametric methods. As well, students will be introduced to the use of computers in data analysis.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

2301.1(.2) Linear Algebra for Engineers
Prerequisite: MATH 1211.1(.2)/1212.1(.2).

Geometric vectors in three dimensions, dot product, norm cosine formulas, Schwartz inequality, cross product. Equations of lines and planes, normal vectors. Complex numbers, the complex plane, real and imaginary parts, complex conjugate, magnitude and phase, Euler's formula, roots of unity, the elementary complex functions: sine, cosine, exponential and logarithm. Systems of equations, Gaussian elimination using matrices, row echelon form, applications. Matrix algebra, matrix multiplication, matrix inverse, application to networks and graphs. Determinants and Cramers rule. Linear independence, bases, dimensions and rank. Linear transformations: definition and examples, null space and range. Eigenvalues and eigenvectors, applications, diagnolization of symmetric matrices. Inner product spaces, least squares problems, orthonormal sets, Gram-Schmidt orthogonalization process.

Classes 3 hours plus recitation 1 1/2 hours a week. 1 semester.

Note: Students cannot receive credit for both MATH 2301.1(.2) and MATH 2320.1(.2).

2303.1(.2) Differential Equations for Engineers
Prerequisite: MATH 1212.1(.2) and 2301.1(.2). Students must co-register in MATH 2311.1(.2).

First order differential equations: separable equations; exact equations; integral equations; integrating factors; linear differential equations; modelling electric circuits. Second order differential equations: homogeneous linear equations; constant coefficient equations; Euler-Cauchy equations; Wronskian; non-homogeneous equations; undetermined coefficients; variation of parameters; modelling forced oscillations and resonance modelling electric circuits phasor methods for particular solutions. Power series solutions. Legendre's equation. Laplace transform, inverse transform. Linearity; transforms of derivatives and integral; s-shifting; t-shifting; unit step. Differentiation and integration of Laplace Transforms. Partial fractions method for inverse Laplace Transform. Applications to systems of differential equations, convolutions, the delta function, impulse response, transfer function. Periodic driving functions and Laplace Transforms. Fourier series; even and odd functions; half range expressions; Complex Fourier series; applications to systems driven by various periodic functions (e.g., square, wave, saw tooth, etc.) The line spectrum.

Classes 3 hours plus recitation 1 1/2 hours a week. 1 semester.

2305.1(.2) Survey of Discrete Mathematics
Prerequisite: MATH 1210.1(.2)/1211.1(.2).
This course provides an overview of a number of topics in discerete mathematics including sets, set operations, logic, proof techniques such as mathematical induction and proof of contradiction, elementary counting techniques and combinatories as well as applications.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

Note: No credit will be given for this course simultaneously with or subsequent to MATH 1205.1(.2).

2308.1(.2) Numerical Analysis I
Prerequisite: MATH 1210.1(.2)/1211.1(.2).

A discussion of errors in numerical analysis. Theoretical and practical considerations of numerical procedures in non-linear equations in one variable, including polynomial equations, in systems of linear equations, and systems of non-linear equations. A brief discussion of vectors, matrices and norms.

2309.1(.2) Numerical Analysis II
Prerequisite: MATH 3308.1(.2).

Theoretical and practical considerations of numerical procedures in function approximations including splines, interpolation and least squares and in numerical integration.

2310.1(.2) Intermediate Calculus I
Prerequisite: MATH 1210.1(.2)/1211.1(.2).

This course consists of the study of the " - " definition of limits and continuity; the least upper bound axiom; completeness of the real line; the intermediate value theorem; and the monotone convergence theorem. This course also provides an introduction to compactness in various forms. Infinite sequences and series are discussed from a more rigorous perspective than MAT 1211. These ideas are extended to two-dimensions and to the complex numbers. Additional topics may include: elementary asymptotics; the big-Oh nation; power series as generating functions; uniform convergence and uniform continuity; and Riemann sums and integration.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

2311.1(.2) Intermediate Calculus II
Prerequisite: MATH 2310.1(.2) or both MATH 1212.1(.2) and 2301.1(.2).

Limits and continuity of functions of several variables, partial derivatives, and the chain rule.

irectional derivatives and gradient vector, the total differential, tangent planes and normals to a surface, higher order partial derivatives, extrema of functions of two variables. The double integrals, iterated integrals, double integrals in polar coordinates, applications of double integrals, the triple integral, triple integrals in cylindrical and spherical coordinates, applications of triple integrals vector fields, divergence and curl of vector fields, line integrals, path-independent line integrals. Green's theorem, Stokes theorem, and the divergence theorem.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

2315.1(.2) Introduction to Probability Theory
Prerequisite: MATH 1210.1(.2).

This course covers the probability theory which underlies fundamental statistical concepts. It assumes a good knowledge of first-year calculus, and may cover the following topics: probability, conditional probability, Bayes' Theorem, random variables, order statistics, discrete distributions, continuous distributions, expected values, moments, and special distributions including the Poisson, normal, binomial, exponential, and gamma distributions.

Classes 3 hrs. plus recitation 1 1/2 hrs. a week. 1 semester.

2320.1(.2) Linear Algebra I
Prerequisite: MATH 1210.1(.2)/1211.1(.2).

This course presents the basic concepts and techniques of linear algebra, including Gaussian elimination, matrix algebra, vector spaces, determinants, eigenvalues, eigenvectors, diagonalization and linear transformations, together with various applications and computational methods.

Classes 3 hrs. plus recitation 1.5 hrs. a week. 1 semester.

Note: Students cannot receive credit for both MATH 3320.1(.2) and MATH 2301.1(.2).

2321.1(.2) Linear Algebra II
Prerequisite: MATH 2320.1(.2).

This course continues MATH 2320.1(.2) with further concepts and theory of linear algebra. Topics include inner product spaces, orthogonality, Gram-Schmidt Process, linear transformations and their matrix representation, change of basis and similarity, further study of eigenvalues and eigenvectors, canonical forms, with applications to linear differential equations and quadratic forms.

Classes 3 hrs. plus recitation 1.5 hrs. a week. 1 semester.

2370.1(.2) Problem-Solving Seminar

3401.1(.2) Sequences, Series and Improper Integrals
Prerequisite: MATH 2311.1(.2).

Infinite sequences and series, convergence tests, grouping and rearrangements, sequences and series of functions, pointwise and uniform convergence, power series, double sequences and series, differentiation under the integral sign, improper single and double integrals, functions defined by improper integrals, Fourier series and transforms.

3402.1(.2) Vector Calculus
Prerequisite: MATH 2311.1(.2) and 2320.1(.2).

Topology of Rn, open sets, closed sets, cluster points, compactness, connectedness, completeness. Transformations, linear transformations, continuity, Extreme and Intermediate Value Theorems, uniform continuity of transformations, differentiability of transformations. The chain rule, Taylor's Theorem, Implicit and Inverse function theorems, maxima and minima, the method of Lagrange multipliers. Multiple Integrals: existence, properties, change of variables theorem and evaluation of multiple integrals. A review of vector field theory, line and surface integrals, the integral theorems of Green and Strokes, the divergence theorem.

3405.1(.2) Differential Equations I
Prerequisite: MATH 2311.1(.2) or permission of instructor.

First order differential equations, linear differential equations with constant coefficients, Laplace transforms, linear differential equations with variable coefficients (series solutions), applications.

Note: Students cannot receive credit for both MATH 2303.1(.2) and MATH 3405.1(.2).

3406.1(.2) Differential Equations II
Prerequisite: MATH 2311.1(.2); MATH 2303.1(.2) or MATH 3405.1(.2); MATH 2301.1(.2) or MATH 2320.1(.2). Students who do not meet these exact prerequisites may be permitted to take this course with permission of instructor.

Theory of systems of linear differential equations, linear systems with constant coefficients, solution by matrix methods, applications. Nonlinear differential equations: existence and uniqueness of solutions, stability and the phase plane, Liapunov Method, various equations occurring in applications are qualitatively analyzed, chaos, and bifurcation.

3414.0 Statistical Simulation Theory

3415.1(.2) Mathematical Statistics
Prerequisite: MATH 2311.1(.2) and a course in the Pascal computer programming language.

This course studies mathematical foundations of statistics, including both parametric and non-parametric inferences. Emphasis is placed on the properties of random variables and their distributions. The estimation of parameters by using sample statistics and tests of related hypotheses are included. Applications to computer science are studied.

3416.1(.2) Mathematical Probability
Prerequisite: MATH 2311.1(.2) or permission of instructor.

The aim of the course is to introduce students to mathematical (non-measure-theoretic) foundations of probability and elements of stochastic processes. The topics include conditional probabilities, conditional distributions, characteristic functions, limit theorems, Markov chains and Markov processes, birth and death processes and elementary queuing theory.

3445.0 Introduction to Operations Research

3456.1(.2) Introduction to Applied Mathematics I
Prerequisite: MATH 2303.1(.2) or 3405.1(.2).

Pointwise and uniform convergence of sequences and series of functions. Tests for uniform convergence, continuity, integral, and differentiability of functions defined by sequences and series. Pointwise and uniform convergence of improper integrals depending on a parameter. Tests for uniform convergences of improper integrals, consequences of uniform convergence of improper integrals, Gamma and Beta functions. Series solutions of Bessel, Legendre, and hypergeometric equations and their elementary properties. Two point boundary value problems, Green's functions, Sturm-Liouville problems, eigenfunction expansions. Fourier series and Fourier integrals.

3457.1(.2) Introduction to Applied Mathematics II
Prerequisite: MATH 3456.1(.2).

Classification of partial differential equations, linear and quasilinear first order equations, method of Lagrange. Classification and solutions of second order linear partial differential equations, the canonical forms. Modeling of wave, heat, and Laplace equations. Separation of variables, Green's functions, and Integral Transform methods. Existence and uniqueness theorems, numerical methods.

4408.1(.2) Advanced Numerical Analysis I
Prerequisite: MATH 2309.1(.2) or permission of instructor.

Theoretical and practical considerations of numerical analysis in the eigenvalue-eigenvector problem and in the solutions of ordinary differential equations.

4409.1(.2) Advanced Numerical Analysis II
Prerequisite: MATH 4408.1(.2).

Theoretical and practical considerations of numerical analysis in the solutions of ordinary and partial differential equations.

4420.1(.2) Abstract Algebra I
Prerequisite: MATH 2321.1(.2) or permission of instructor.

The study of algebraic structures, such as groups, rings, fields, posets, graphs, or universal algebras. The major emphasis will be on derivation of theory, with inclusion of applications and examples.

4421.1(.2) Abstract Algebra II
Prerequisite: MATH 4420.1(.2) or permission of instructor.

The further study of algebraic structures and their applications.

4426.1(.2) Introduction to Combinatorics
Prerequisite: MATH 2311.1(.2) or 2320.1(.2) or permission of instructor.

This course will introduce the student to various enumeration techniques and will include such topics as permutations and combinations, recurrence relations and generating functions. Various finite structures and their applications will also be studied.

4427.1(.2) Computational Methods in Graph Theory
Prerequisite: MATH 2311.1(.2) or 2320.1(.2) or permission of instructor.

This course discusses various graph theoretic algorithms and their application to different problems. Topics to be discussed will be chosen from the following: the connector problem, the shortest path problem, the Chinese Postman problem and Euler trails, matchings and their applications to the personnel and optimal assignment problems, colouring problems (with reference to timetabling) and flows in networks.

4430.1(.2) Set Theory
Prerequisite: MATH 2311.1(.2) or 2320.1(.2).

Basic set theory will be developed using one of the widely accepted axiom systems. Alternate systems will be discussed. The topics will include: set operations, cardinality, ordered sets, well ordering, cardinal and ordinal numbers, and the axiom of choice.

4432.1(.2) Elementary Topology
Prerequisite: MATH 2311.1(.2) and 2321.1(.2); MATH 4430.1(.2) is recommended.

This course will begin with a study of the topology of metric spaces. Topics will include bounded and totally bounded sets, completeness and fixed point theorems. Following this, abstract topological spaces will be studied.

4434.1(.2) Geometry
Prerequisite: MATH 2320.1(.2) or 4420.1(.2) or permission of instructor.

Many important ideas of modern mathematics, such as the axiomatic method, emerged from the study of geometry. This course examines topics in geometry from Euclid to the present day, which may include axiomatic geometry, constructive geometry, inversive geometry, projective geometry, non-Euclidean geometry, and combinatorial geometry.

Note: No credit will be given for this course subsequent to a directed study course on geometry [MATH 4490.1(.2)].

4436.1(.2) Theory of Functions of a Complex Variable I
Prerequisite: MATH 2310.1(.2) and 2311.1(.2).

The complex plane. Elementary transformations and mappings, analytic functions, infinite series and uniform convergence. Differentiation and integration in the complex plane, residue. Harmonic functions, entire and merimorphic functions. Some principles of conformal mapping theory.

Note: No credit will be given for this course simultaneously with or subsequent to MATH 4435.0.

4437.1(.2) Theory of Functions of a Complex Variable II
Prerequisite: MATH 4436.1(.2).

A continuation of MATH 4436.1(.2). Further study of analytic functions and conformal mapping theory.

Note: No credit will be given for this course simultaneously with or subsequent to MATH 4435.0.

4441.1(.2) Real Analysis I
Prerequisite: MATH 2310.1(.2) and 2311.1(.2).

Sets, functions and relations, the real number field, the least upper bound axiom, countability, sequences and subsequences, accumulation points, metric spaces, continuous functions, uniform continuity, monotone and inverse functions, compactness and connectedness, series of functions, uniform convergence, integration and differentiation of series of functions.

Note: No credit will be given for this course simultaneously with or subsequent to MATH 4440.0.

4442.1(.2) Real Analysis II
Prerequisite: MATH 4441.1(.2).

Further topics on metric spaces. Baire category theorem, the space of continuous functions, fixed points and integral equations, Arzela-Accoli theorem, the Stone-Weierstrass theorem, Picard existence theorem for differential equations, Riemann Integrability, sets of measure zero, Lebesgue Theorem.

Note: No credit will be given for this course simultaneously with or subsequent to MATH 4440.0.

4490.1(.2) to 4499.1(.2) Directed Study in Mathematics
Prerequisite: permission of instructor.

This course is intended to supplement or provide an alternative to the regular mathematics courses in order to meet the special needs and interests of students. The course provides an opportunity to study a particular subject in detail and requires from the student some measure of independence and initiative.

4500.0 Thesis
Prerequisite: permission of Department.

Research project in the mathematical sciences carried out by the student under the supervision of any member of the Department. The student will submit a thesis and present it orally. This course is open to 4th year honors students.

Directed study 6 hrs. a week. 2 semesters.

Computing Science (CPSC)

Co-ordinator P. Muir

Preparatory Courses
CSCI 1226.1(.2)/CSCI 1227.1(.2) is intended to be the first pair of courses for all students who intend to pursue further studies in computing science.

Requirements for a Concentration in Computing Science

A concentration in computing science is offered for students working towards the degree of Bachelor of Science. The Departmental requirements for a concentration in computing science are:

1. CSCI 1226.1(.2) and 1227.1(.2)
2. CSCI 2327.1(.2) and 2328.1(.2)
3. CSCI 2341.1(.2) and 2342.1(.2)
4. MATH 1210.1(.2) and 1211.1(.2)
5. Twelve (12) additional credit hours in CSCI courses numbered 2306 or above.
6. Additional Faculty of Science regulations: 3(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities; 3(c) twelve (12) credit hours in Arts/Economics; 3(e) twenty-four (24) credit hours in other sciences (not MATH or CSCI); and 3(f) twelve (12) credit hour free electives.

Requirements for a Major in Computing Science

A major in computing science is offered for students working towards the degree of Bachelor of Science. The Departmental requirements for a major in computing science are:

1. CSCI 1226.1(.2) and 1227.1(.2)
2. CSCI 2327.1(.2) and 2328.1(.2)
3. CSCI 2341.1(.2) and 2342.1(.2)
4. Six (6) credit hours chosen from CSCI 3428.1(.2), 3430.1(.2), 3431.1(.2), and 3451.1(.2)
5. MATH 1210.1(.2) and 1211.1(.2)
6. MATH 2305.1(.2), 2308.1(.2), 1216.1(.2), and 2320.1(.2)
7. Six (6) additional credit hours in MATH numbered 2306 or above.
8. Twelve (12) additional credit hours in CSCI courses numbered 2306 or above, at least six (6) credit hours which are at the 3000 level or above.
9. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 6(c) twelve (12) credit hours in Arts/Economics, 6(e) twenty-four (24) in other sciences (not MATH or CSCI), 6(f) eighteen (18) credit hours free electives.

Requirements for a Double Major in Computing Science and Mathematics

1. MATH 1210.1(.2) and MATH 1211.1(.2)
2. CSCI 1226.1(.2) and CSCI 1227.1(.2)
3. MATH 2310.1(.2) and MATH 2311.1(.2)
4. MATH 2320.1(.2) and MATH 2321.1(.2)
5. CSCI 2327.1(.2) and CSCI 2328.1(.2)
6. CSCI 2341.1(.2) and CSCI 2342.1(.2)

7. MATH 2305.1(.2), MATH 2308.1(.2), and MATH 1216.1(.2)
8. Six (6) credit hours chosen from CSCI 3428.1(.2), CSCI 3430.1(.2), CSCI 3431.1(.2) and CSCI 3451.1(.2)
9. Nine (9) additional credit hours in MATH courses numbered 2306 or above, at least one (1.0) of which is at the 3000 level or above.
10. Twelve (12) additional credit hours in CSCI courses numbered 2306 or above, at least six (6) of which are at the 3000 level or above.
11. Six (6) additional credit hours in MATH or CSCI courses numbered 2306 or above.
12. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 6(c) twelve (12) credit hours in Arts/Economics, 7(b) twelve (12) credit hours in other sciences (not MATH or CSCI), 7(c) twelve (12) credit hours free electives.

Requirements for a Double Major in Computing Science and a subject other than Mathematics.

1.-7. Same as for Major in Computing Science (above).
8. Six (6) additional credit hours in CSCI courses numbered 2306 or above.
9. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 7(a), (c) forty-eight (48) additional credit hours, with a minimum of thirty-six (36) credit hours in the other major subject. [(Twelve (12) credit MATH hours are used to satisfy Faculty of Science regulation 7(b).]

Requirements for an Honors in Computing Science

The honors program is designed for majors in computing science of above average ability. Majors in the second year with an overall quality point average of at least 2.50 and with a quality grade point average of at least 3.00 in their CSCI and MATH courses should consider enrolling in the honors program and are advised to consult with the Department before making a final decision. The Departmental requirements for honors in computing science are:

1. CSCI 1226.1(.2) and 1227.1(.2)
2. CSCI 2327.1(.2) and 2328.1(.2)
3. CSCI 2341.1(.2) and 2342.1(.2)
4. CSCI 3428.1(.2), 3430.1(.2), 3431.1(.2), and 3451.1(.2)
5. MATH 1210.1(.2) and 1211.1(.2)
6. MATH 2305.1(.2), 2308.1(.2), 1216.1(.2), and 2320.1(.2)
7. Twelve (12) additional credit hours in MATH numbered 2306 or above.
8. Twenty-four (24) additional credit hours in CSCI courses numbered 2306 or above, at least twelve (12) credit hours of which are at the 3000 level or above.
9. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 6(c) two (2.0) credits in Arts/Economics, 12(b) eighteen (18) credit hours in other sciences (not MATH or CSCI).

Requirements for a Double Honors in Computing Science and Mathematics

1. MATH 1210.1(.2) and MATH 1211.1(.2)
2. CSCI 1226.1(.2) and CSCI 1227.1(.2)
3. MATH 2310.1(.2) and 2311.1(.2)
4. MATH 2320.1(.2) and MATH 2321.1(.2)
5. CSCI 2327.1(.2) and CSCI 2328.1(.2)
6. CSCI 2341.1(.2) and CSCI 2342.1(.2)
7. MATH 2305.1(.2), MATH 2308.1(.2), and MATH 1216.1(.2)
8. CSCI 3428.1(.2), CSCI 3430.1(.2), CSCI 3431.1(.2) and CSCI 3451.1(.2)
9. Twenty-one (21) additional credit hours in MATH courses numbered 2306 or above, at least twelve (12) credit hours of which are at the 3000 level or above.
10. Eighteen (18) additional credit hours in CSCI courses numbered 2306 or above, at least twelve (12) of which are at the 3000 level or above.
11. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 6(c) twelve (12) credit hours in Arts/Economics, 12(b) six (6) credit hours in other sciences (not MATH or CSCI).

Requirements for a Double Honors in Computing Science and a subject other than Mathematics

1.-6. Same as Computing Science Honors (above).
7. Six (6) additional credit hours in MATH courses numbered 2306 or above.
8. Six (6) additional credit hours in CSCI courses numbered 2306 or above.
9. Additional Faculty of Science regulations: 6(a) three (3) credit hours in English [ENGL 1205.1(.2)] and three (3) credit hours in Humanities, 6(c) twelve (12) credit hours in Arts/Economics, 12(c) forty-two (42) additional credit hours in the other honors subject. [Six (6) credit hours in MATH are used to satisfy Faculty of Science regulation 12(b).]

Notes: (i) Students must obtain formal Departmental approval of their program at the time of their declaration to enter the major or honors program, as well as for any subsequent changes.
(ii) Students taking a concentration, major, or honors in computing science are permitted credit for at most one of MATH 1207.1(.2), BIOL 2308.1(.2), ECON 2207.1(.2), MGSC 1207.1(.2), or PSYC 2350.1(.2), and shall not be permitted credit for any of these courses simultaneously with or subsequent to MATH 1216.1(.2).
(iii) Courses with MATH or CSCI designation cannot be used to satisfy requirements 6(e) or 12(b) of the Faculty of Science regulations regarding Science electives outside the discipline.
(iv) Related courses to a maximum of nine (9) credit hours offered by other Departments may be allowed for

CSCI credit, with approval of the Department of Mathematics and Computing Science.
(v) Students pursuing a major in Computing Science can also complete a minor in Mathematics by taking MATH 2310.1(.2) and MATH 2311.1(.2), under requirement **7**, of the major degree, and by taking MATH 2321.1(.2) and three (3) additional credit hours in MATH, under requirement **9**, of the major degree, Faculty of Science regulation **6(f)** on free electives.
(vi) Students pursuing an honours in Computing Science can also complete a minor in Mathematics by taking MATH 2310.1(.2), MATH 2311.1(.2), MATH 2321.1(.2) and three (3) additional credit hours in MATH, under requirement **7,** of the honours degree.

Requirements for a Minor in Computing Science

It is possible to obtain a minor in computing science by completing thirty (30) credit hours in CSCI in addition to satisfying the Faculty of Science regulations for a minor. These courses must include:

1. CSCI 1226.1(.2) and 1227.1(.2) [six (6) credit hours]
2. CSCI 2327.1(.2), CSCI 2328.1(.2), CSCI 2341.1(.2), and CSCI 2342.1(.2)
3. Twelve (12) additional credit hours in CSCI courses numbered 2306 or above.

Computing Science and Business Administration (CSCI)

Co-ordinator P. Muir

This is an interdisciplinary four year degree combining Computing Science courses, taught in the Department of Mathematics and Computing Science, with a selection of courses taught in the Faculty of Commerce. This program is designed to meet the increasing demand for people with a solid technical knowledge of Computing Science who also understand the application of this technology to business problems.

To declare this program as a major, students should consult with the Co-ordinator of Computing Science in the Department of Mathematics and Computing Science. Students must complete the one hundred and twenty (20) credit hours as listed below. Due to restrictions associated with the prerequisite structure, please note that certain courses should be taken by the end of the period indicated so that the program can be completed in four years.

1. Computing Science courses [thirty-six (36) credit hours]
1.1 *CSCI 1226.1(.2) and *CSCI 1227.1(.2) (first year) [six (6) credit hours]
1.2 *CSCI 2327.1(.2), *CSCI 2328.1(.2), *CSCI 2341.1(.2), and *CSCI 2342.1(.2) (second year) [twelve (12) credit hours]
1.3 *six (6) additional CSCI credit hours in third year
1.4 *twelve (12) additional CSCI credit hours in fourth year
The credits referred to in 1.3 and 1.4 must be numbered 2306.1(.2) or above and at least twelve (12) of these credit hours must be at the 3000 level or above. With the approval of the Program Co-ordinator, students may be allowed to take up to nine (9) computing science credit hours given by other departments.

2. Mathematics and Statistics courses [fifteen (15) credit hours]
2.1 *MATH 2110.1(.2) and *MATH 1211.1(.2) (first year) [six (6) credit hours]
2.2 *MATH 2305.1(.2) and *MATH 2320.1(.2) (third year) [six (6) credit hours]
2.3 *CISY 1207.1(.2) or MATH 1216.1(.2) (second year) [three (3) credit hours]

3. Commerce courses [forty-two (42) credit hours]
3.1 *MGMT 1281.1(.2) (first year or first term of second year) [three (3) credit hours]
3.2 *MGMT 2383.1(.2) and *MGMT 2384.1(.2) (third year) [six (6) credit hours]
3.3 *MGMT 4489.1(.2) (fourth year) [three (3) credit hours]
3.4 *ACCT 2241.1(.2) and *ACCT 2242.1(.2) (second year) [six (6) credit hours]
3.5 *ACCT 3332.1(.2) (third year) [three (3) credit hours]
3.6 *ACCT 3323.1(.2) (fourth year) [three (3) credit hours]
3.7 *FINA 2360.1(.2) and *FINA 3361.1(.2) (third year) [six (6) credit hours]
3.8 *MKTG 2270.1(.2) (third year) [three (3) credit hours]
3.9 *CISY 4425.1(.2) (fourth year) [three (3) credit hours]
3.10 *ECON 1201.1(.2) and *ECON 1202.1(.2) (first year preferably or second year) [six (6) credit hours]

4. Other courses [twenty-seven (27) credit hours]
4.1 ENGL 1205.1(.2) and three (3) credit hours in humanities [six (6) credit hours]
4.2 Arts and/or Economics courses that satisfy regulation 6(e) of the Faculty of Science, except only six (6) credit hours are required
4.3 Science electives that satisfy regulation 6(e) of the Faculty of Science, except only twelve (12) credit hours are required
4.4 Free elective [three (3) credit hours]

Notes: (i) Courses marked with an asterisk (*) are considered as major courses for the purposes of regulation 9 of the Faculty of Science.
(ii) All electives are to be at the 1000 level or above.
(iii) Credit will not be given for any introductory computing course if taken subsequent to CSCI 1226.1(.2).
(iv) Credit will not be given for MGSC 1205.1(.2), MGSC 1206.1(.2) or other preparatory or introductory courses if taken subsequent to, or concurrent with MATH 1210.1(.2) or MATH 1211.1(.2).
(v) For students in this program, MATH 1210.1(.2) can replace MGSC 1205.1(.2) or MGSC 1206.1(.2) as a prerequisite for other commerce courses.

(vi) For students in this program, CSCI 1227.1(.2) can replace CISY 1225.1(.2) as a prerequisite for other commerce courses. However, a knowledge of the topics covered in CISY 1225.1(.2) will be assumed in other courses.

IMPORTANT

In the 2004-2005 academic year, courses were renumbered from three digits to four. A new digit was added to the front of the sequence to indicate the year of study in which a student would normally enroll in a course. The last three digits represent the "old" course number – for example, CSCI 1226.1(.2) was formerly CSC 226.1(.2).

Students are urged to be extremely careful not to register again for a course for which they have already earned credit. Academic Regulation 17(b) is extremely important to this matter.

IN THE CASES WHERE COURSES HAVE BEEN RENUMBERED, CHANGED IN LEVEL, OR WHERE A SIX (6) CREDIT HOUR COURSE (FORMERLY REFERRED TO AS "FULL COURSE") HAS BEEN SPLIT INTO TWO THREE (3) CREDIT HOUR COURSES (FORMERLY TERMED "HALF COURSES") OR VICE VERSA, A STUDENT WHO RECEIVED CREDIT RECOGNITION FOR THE ORIGINAL COURSE IS NOT ENTITLED TO REPEAT THE COURSE IN ITS NEW FORMAT OR ON ITS NEW LEVEL FOR ADDITIONAL CREDIT RECOGNITION.

Previous Course #'s	New Course #'s	Previous Course #'s	New Course #'s
CSC 101		CSC 434	CSCI 4434
CSC 102		CSC 451	CSCI 3451
CSC 226	CSCI 1226	CSC 452	CSCI 4452
CSC 227	CSCI 1227	CSC 461	CSCI 3461
CSC 301	CSCI 2301	CSC 462	CSCI 3462
CSC 327	CSCI 2327	CSC 463	CSCI 4463
CSC 328	CSCI 2328	CSC 465	CSCI 3465
CSC 341	CSCI 2341	CSC 471	CSCI 4471
CSC 342	CSCI 2342	CSC 474	CSCI 4474
CSC 355	CSCI 2355	CSC 475	CSCI 4475
CSC 421	CSCI 3421	CSC 476	CSCI 4476
CSC 423	CSCI 4423	CSC 482	CSCI 3482
CSC 426	CSCI 3426	CSC 491	CSCI 4491
CSC 428	CSCI 3428	CSC 499	CSCI 4499
CSC 430	CSCI 3430	CSC 500	CSCI 4500
CSC 431	CSCI 3431		

1226.1(.2) Introduction to Computing Science and Programming
Prerequisite: There is no formal prerequisite for this course; however, some prior experience with analytical thinking is highly recommended.

This course is designed to introduce the student to some of the key concepts in computing science and simultaneously provide introductory hands-on experience using a modern programming language. General topics will include a brief history of computing; the place of hardware, software, and policies in any computing environment; a high-level view of the components of a computing system; and the tools one can expect to find in any programming environment. Programming language topics will include input/output; simple data types; operators and expressions; looping and decision-making control constructs; subprograms and parameter passing; overall program structure and programming style considerations. Problem-solving and program-design strategies will include divide-and-conquer and top-down design with step-wise refinement. Students will design algorithms with data input and output to solve particular problems, and later implement those solutions as computer programs in the current programming language of choice.

Classes 3 hrs. and lab 3 hrs. a week. 1 semester.

1227.1(.2) Intermediate Programming and Problem Solving
Prerequisite: CSCI 1226.1(.2).

This course is designed to extend the student's knowledge of, and provide additional hands-on experience with, the programming language encountered in CSCI 226, in the context of the structured data types provided by that language, and within the larger contexts of object-oriented programming and more complex problem-solving situations. Techniques for managing file input and output in the current language will also be studied. A number of classical algorithms and data structures for the storage and manipulation of information of various kinds in a computer's internal memory will be studied. The student will acquire the knowledge that comes from actually implementing a non-trivial abstract data type and the experience that comes from having to make use, as a client programmer, of an abstract type that has already been implemented.

Classes 3 hrs. and lab 3 hrs. a week. 1 semester.

2301.1(.2) Data Structures and Numerical Methods for Engineers
Prerequisites: CSCI 1226.1(.2) or EGNE 1204.1(.2)

This class introduces students to system analysis and software techniques. Topics covered include data structures such as stacks, queues, multiple linked lists, searching and sorting algorithms, and their implementation in an object-oriented programming language. Students use linear algebra and numerical methods in engineering examples, while leaning to implement properly structured solutions.

Note: This course is intended only for Engineering students. Computing Science students (CPSC or CSCI) should take CSCI 2341.1(.2) and CSCI 2342.1(.2) instead. No credit will be given for this course simultaneously with or subsequent to CSCI 2341.1(.2).

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

2327.1(.2) Digital Logic and Assembly Level Machine Organization
Prerequisite: CSCI 1227.1(.2).

This course considers data representation, digital logic and computer organization at the assembly language level. Data will be represented as sequences of symbols and interpreted as numbers (binary, signed, unsigned, decimal, etc.) or text. The student will be introduced to the concept of computation at the digital logic level by studying devices for storing data, transferring data, and making decisions based on data patterns. Such devices will include flip-flops, registers, tristates, bus structures, multiplexers, comparators, and adders. The fetch-execute cycle of a processor, as well as the structure and addressing modes of machine instructions, will be considered. Students will obtain experience in the assembly language of a particular processor.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

2328.1(.2) Computer Architecture
Prerequisite: CSCI 2327.1(.2).

This course builds on the experience obtained in CSCI 2327. The fetch-execute cycle of a processor is considered in more detail by examining the data path and the control unit. The abstract view of the memory system is refined by discussing storage systems, the memory hierarchy, cache memories, and the concept of virtual memory. The course will examine the input/output subsystem of a computer that serves as an interface with peripheral devices. In particular, interrupt and synchronization mechanisms will be considered. Some basic principles of data communications will also be discussed with examples of communications protocols including the TCP/IP protocol. Alternative computer architectures will be discussed briefly.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

2341.1(.2) Algorithmic Foundations of Computing Science
Prerequisite: CSCI 1227.1(.2).

This course provides an introduction to some of the fundamental theoretical concepts in computing science. These theoretical concepts will be applied to some programming problems. The course will introduce the basis for evaluating algorithms. This basis will be used to analyze various searching and sorting algorithms. Students will be introduced to the concept of lower-bound time requirements for specific problems. Examples of various problem solving strategies such as greedy algorithms, divide-and-conquer, and backtracking will be discussed. Context free languages will be studied using BNF notations and derivation trees.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

2342.1(.2) Data Structures and Algorithms
Prerequisite: CSCI 2341.1(.2).

This course provides an introduction to data structures and associated algorithms. Students will build on the theoretical and programming skills developed in CSCI 1226/1227 and CSCI 2341 through a systematic study of some of the fundamental computing science concepts. The course will use the basis for evaluating algorithms, established in CSCI 2341, to study various data structures and related operations. The data structures that will be studied in this course include lists, stacks, queues, hash tables, binary trees, and binary search trees. The operations on these data structures include creation, destruction, insertions, deletions, searching, and sorting. Contiguous and linked designs and corresponding implementations of these data structures will be studied. Students will be expected to create some of the data structures as well as use a library of existing data structures. The advantages and disadvantages of using these data structures will be studied. External data storage structures, file structures, and relational databases will also be briefly reviewed.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

2355.1(.2) Internet Technologies and Web Programming
Prerequisite: CSCI 1227.1(.2).

This course will discuss a number of fundamental architectures, protocols and scripting languages for displaying and transferring data of various kinds in the context of the Internet and the World Wide Web. Students will gain experience with web programming concepts and techniques.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

3421.1(.2) Data Communications and Networking

3426.1(.2) Distributed Systems

3428.1(.2) Software Engineering
Prerequisite: CSCI 2342.1(.2).

In this course, students will obtain experience in the development of large scale software systems. The software life-cycle will be studied in detail. Issues of software documentation, reliability, and maintenance will be discussed. Several strategies for specification (formal and informal), design (functional, top-down, object-oriented, etc.), implementation, and verification and validation will be considered. The course will involve a major project that will expose students to the stages of the software life-cycle. Students should expect to work in teams.

3430.1(.2) Principles of Programming Languages
Prerequisite: CSCI 2342.1(.2) and MATH 2305.1(.2).

This course is designed to introduce the student to some of the key concepts underlying all programming languages by comparing and contrasting major programming language paradigms such as procedural, functional, logic, object-oriented, and parallel. Topics may include history and evolution of programming languages; programming language design goals, the place of programming languages in the programming environment; virtual machines; data representation, manipulation and sharing; type checking; storage management; control structures; language mechanisms that support modularity; syntax and semantics. The laboratory component will provide hands-on experience with several different languages from different paradigms.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

3431.1(.2) Operating Systems
Prerequisite: CSCI 2328.1(.2).

Students will study various aspects of operating systems with emphasis on the following topics: history, evolution, and philosophies; tasking and processes; process coordination and synchronization; scheduling and dispatch; physical and virtual memory organization; device management; file systems and naming; security and protection; communications and networking; distributed operating systems; and real-time concerns. Examples of two or more operating systems will be used to gain some systems programming experience.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

3451.1(.2) Theory of Computation
Prerequisite: CSCI 2341.1(.2) and MATH 2305.1(.2).

This course provides an introduction to some of the fundamental theoretical concepts in computing science. Students will be introduced to the concepts of decidable, P, NP, NP-complete, and NP-hard problems. Two classes of languages of interest to computing scientists, namely, regular and context free languages, and corresponding automata for recognizing these langauges, will also be studied. A brief discussion on the semantics of programming languages will be included. The concept of automata will be further extended using Turing machines. Turing machines will be used to explore the concept of decidability along with examples of decidable and undecidable problems.

3461.1(.2) Database Systems
Prerequisite: CSCI 2342.1(.2) and MATH 2305.1(.2).

This course provides an introduction to the design, implementation, use and maintenance of databases. Topics will include: data models such as the entity-relationship model, the relational model, and the object-oriented model; relational languages such as relational algebra, relational calculus, and SQL; the theory of normal forms of database design; use of indexes for efficient date retrieval; and database implementation using a commercial database management system. Other topics may be included, such as query optimization, database control, and distributed database systems.

3462.1(.2) File Structures
Prerequisite: CSCI 2342.1(.2) and MATH 2305.1(.2).

This course provides the student with the tools and techniques required to organize and efficiently maintain data on a secondary storage devices. The course will consider the implementation and performance of structures such as fields, records and buffers; primary and secondary indexes; multi-level indexes and B-trees; indexed sequential files; and hash structures. Also included will be some discussion of advanced sort and merge algorithms for secondary storage.

3465.1(.2) Object-Oriented Programming
Prerequisite: CSCI 2342.1(.2) and MATH 2305.1(.2).

This course provides and introduction to object-oriented analysis, design, and programming. Emphasis will be on the creation of reusable software. The object-oriented approach to software development will be compared and contrasted with other approaches, such as the classical "structured" approach. Students will gain hands-on experience by programming in a suitable object-oriented programming language.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

3482.1(.2) Artificial Intelligence
Prerequisite: CSCI 2342.1(.2), MATH 1216.1(.2), and MATH 2305.1(.2).

This course provides a general introduction to artificial intelligence (AI). The course will consider philosophical, mathematical, experimental, and implementation aspects of such topics as problem solving, searching, game playing, genetic algorithms, learning, neutral networks, natural language processing, vision, knowledge representation, logic, expert systems, reasoning under uncertainty, fuzzy sets, planning, and robotics. In addition to a theoretical introduction, students will also gain experience using one or more of the popular AI tools.

4423.1(.2) Cryptography
Prerequisite: CSCI 2342.1(.2), MATH 2305.1(.2), and MATH 2320.1(.2).

This course provides an introduction to various aspects of data security. Possible topics: classical encryption methods such as Vignere and Vernan ciphers; the Data Encryption Standard; key distribution methods and public key encryption; and authentication using digital signatures. Applications of these methods in the design of protocols for data privacy and security will also be studied.

4434.1(.2) Programming Language Translation

4452.1(.2) Algorithm Analysis
Prerequisite: CSCI 2342.1(.2) and MATH 2305.1(.2).

This course will build on the concepts of algorithm analysis introduced in CSCI 2341. Some of the key techniques of efficient algorithm design that will be discussed: divide and conquer; greedy methods; dynamic programming; graph traversal; and change of representation. Measuring algorithm performance and lower bounds for various problems will be studied. An introduction to complexity theory-P, NP, polynomial time reducibility, and NP-completeness- will also be provided

4463.1(.2) Numerical Software Engineering I
Prerequisite: CSCI 2342.1(.2) and MATH 2308.1(.2).

This course will study the software development process in the area of numerical software. Emphasis will be placed on software development and implementation aspects of a variety of numerical algorithms. The course will also examine a substantial number of software packages including some which are currently available in some of the large commercial software libraries, as well as a number of published software packages which have yet to appear in libraries and even a few experimental codes which have not yet appeared in the literature. The main project in the course will be the development of a large software package by the class working in programming teams in a selected area of numerical algorithms. Other projects to be undertaken during the course include the modification of one or more existing mathematical software packages and the critical analysis of several existing software packages. A number of assignments related to the software packages considered will also be given.

Classes 3 hrs. and recitation 1 1/2 hrs. a week. 1 semester.

4471.1(.2) Computer Graphics
Prerequisite: MATH 2310.1(.2) and 2320.1(.2); CSCI 2328.1(.2) and 2342.1(.2).

This course provides an overview of the principles and methodologies of computer graphics, including the representation, manipulation, and display of two- and three-dimensional objects. Subtopics may include characteristics of display devices (i.e., raster, vector); representing primitive objects (lines, curves, and surfaces) and composite objects; two- and three-dimensional transformations (translation, rotation, scaling); hidden lines and surfaces; shading and colouring; interactive graphics and the user interface; animation techniques.

Classes 3 hrs. and recitations 1 1/2 hrs. a week. 1 semester.

4474.1(.2) Information Retrieval

4475.1(.2) Human Computer Interaction
Prerequisite: CSCI 2342.1(.2).

The objective of this course is to teach students how to design, prototype, and evaluate user interfaces using a variety of methods. Topics covered include the following: human capabilities; interface technology; interface design methods; and interface evaluation.

4476.1(.2) Computer Vision and Digital Image Processing
Prerequisite: CSCI 2342.1(.2).

This course provides an introduction to the concepts used in computer vision and digital image processing. Computer vision techniques extract information from an image, while image processing techniques modifies the image for viewing by the human eye. Topics covered include the following: sampling and resolution, image processing, edge detection, segmentation, discrete image transforms, restoration and enhancement, and image compression.

4477.1(.2) Data Mining
Prerequisite: CSCI 2342.1(.2).

Data mining refers to a family of techniques used to detect interesting knowledge in data. With the availability of large databases to store, manage and assimilate data, the new thrust of data mining lies at the intersection of database systems, artificial intelligence and algorithms that efficiently analyze data. The course will use concepts from pattern recognitions, statistics, data anlysis and machine learning. The size of databases and high complexity of techniques present many interesting computational challenges.

4491.1(.2) to 4499.1(.2) Special Topics in Computing Science
Prerequisite: permission of instructor.

This course covers advanced topics in computing science chosen according to the interests of the students and instructor, and requires some measure of independence and initiative from the student.

Seminar 3 hrs. a week. 1 semester.

4500.0 Research Thesis
Prerequisite: honors standing and permission of the thesis committee.

Research project in computing science carried out by the student under the supervision of any member of the Department. The student will submit a thesis and present it orally.