MATHEMATICS (MATH)

MATH 110 Linear Algebra Units: 6.00
This course is intended for students who plan to pursue a Major or Joint Honours Plan in Mathematics or Statistics. Provides a thorough introduction to linear algebra up to and including eigenvalues and eigenvectors.
Learning Hours: 264 (72 Lecture, 24 Tutorial, 168 Private Study)
Requirements: Prerequisite None. Exclusion MATH 111/6.0; MATH 112/3.0; MATH 212/3.0. Recommended At least one 4U Mathematics course.
Offering Faculty: Faculty of Arts and Science

MATH 111 Linear Algebra Units: 6.00
An introduction to matrices and linear algebra. Emphasis on applications to biological and economic systems and to computer applications. Topics covered will include systems of equations, eigenvalues, recursions, orthogonality, regression analysis, and geometric transformations.
Learning Hours: 240 (72 Lecture, 168 Private Study)
Requirements: Prerequisite None. Exclusion MATH 110/6.0; MATH 112/3.0. Recommended At least one 4U Mathematics course.
Offering Faculty: Faculty of Arts and Science

MATH 112 Introduction to Linear Algebra Units: 3.00
A brief introduction to matrix algebra, linear algebra, and applications. Topics include systems of linear equations, matrix algebra, determinants, the vector spaces Rn and their subspaces, bases, co-ordinates, orthogonalization, linear transformations, eigenvectors, diagonalization of symmetric matrices, quadratic forms.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite None. Exclusion MATH 110/6.0; MATH 111/6.0. Recommended At least one 4U Mathematics course.
Course Equivalencies: MATH 110B/112 / APSC 174
Offering Faculty: Faculty of Arts and Science

MATH 120 Differential and Integral Calculus Units: 6.00
This course is intended for students who plan to pursue a Major or Joint Honours Plan in Mathematics, Statistics, or Physics. A thorough discussion of calculus, including limits, continuity, differentiation, integration, multivariable differential calculus, and sequences and series.
Learning Hours: 288 (72 Lecture, 24 Tutorial, 192 Private Study)
Requirements: Prerequisite None. Exclusion MATH 121/6.0; MATH 123/3.0; MATH 124/3.0; MATH 126/6.0. Recommended MHF4U and MCV4U or 4U AFIC or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 121 Differential and Integral Calculus Units: 6.00
Differentiation and integration with applications to biology, physics, chemistry, economics, and social sciences; differential equations; multivariable differential calculus.
NOTE Also offered online, consult Arts and Science Online (Learning Hours may vary).
NOTE Also offered at Bader College, UK (Learning Hours may vary).
Learning Hours: 240 (72 Lecture, 168 Private Study)
Requirements: Prerequisite None. Recommended MHF4U and MCV4U or equivalent, or 4U AFIC, or permission of the Department. Exclusion Maximum of 6.0 units from: MATH 120/6.0; MATH 121/6.0; MATH 123/3.0; MATH 124/3.0; MATH 126/6.0. Exclusion Maximum of one course from: MATH 121/6.0; MATH 130/3.0. Note This course is intended for students who wish to pursue a Major or Joint Honours Plan in a subject other than Mathematics or Statistics.
Course Equivalencies: MATH121; MATH121B;MATH122B
Offering Faculty: Faculty of Arts and Science

MATH 123 Differential and Integral Calculus I Units: 3.00
Differentiation and integration of elementary functions, with applications to physical and social sciences. Topics include limits, related rates, Taylor polynomials, and introductory techniques and applications of integration.
Requirements: Prerequisite Permission of the Department. Exclusion Maximum of one course from: MATH 120/6.0; MATH 121/6.0; MATH 123/3.0; MATH 126/6.0. Exclusion Maximum of one course from: MATH 123/3.0; MATH 130/3.0. Note This course is not intended for students pursuing a MATH or STAT Plan.
Offering Faculty: Faculty of Arts and Science

MATH 124 Differential and Integral Calculus II Units: 3.00
Topics include techniques of integration; differential equations, and multivariable differential calculus.
Learning Hours: 126 (36 Lecture, 12 Tutorial, 78 Private Study)
Requirements: Prerequisite MATH 123 or permission of the Department. Exclusion MATH 120; MATH 121; MATH 126. Note For students who have credit for a one-term course in calculus. Topics covered are the same as those in the Winter term of MATH 121.
Course Equivalencies: APSC172, MATH124
Offering Faculty: Faculty of Arts and Science

MATH 126 Differential and Integral Calculus Units: 6.00
Differentiation and integration of the elementary functions with applications to the social sciences and economics; Taylor polynomials; multivariable differential calculus.
Learning Hours: 240 (72 Lecture, 24 Tutorial, 144 Private Study)
Requirements: Prerequisite None. Exclusion Maximum of 6.0 units from: MATH 120/6.0; MATH 121/6.0; MATH 123/3.0; MATH 124/3.0; MATH 126/6.0. Exclusion Maximum of one course from: MATH 126/6.0; MATH 130/3.0. Note This course is primarily intended for students in the BAH program. Students in the BSCH, BCMPH or BCOM program should not enrol in this course.
Offering Faculty: Faculty of Arts and Science

MATH 130 Mathematics for Biochemistry and Life Sciences Units: 3.00
The course will have four topics, each approximately three weeks long. Topics include a review of functions, limits, and differentiation, antiderivatives, integration and fundamental theorem of calculus, differential equations, and probability.
Learning Hours: 120 (36 Lecture, 12 Tutorial, 72 Private Study)
Requirements: Prerequisite Registration in a BCHM or LISC Plan. Recommended 4U Calculus and Vectors (or equivalent). Exclusion MATH 121/6.0; MATH 123/3.0; MATH 126/6.0.
Offering Faculty: Faculty of Arts and Science

MATH 210 Rings and Fields Units: 3.00
Integers, polynomials, modular arithmetic, rings, ideals, homomorphisms, quotient rings, division algorithm, greatest common divisors, Euclidean domains, unique factorization, fields, finite fields.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite MATH 110/6.0 or MATH 111/6.0 or (MATH 112/3.0 and MATH 212/3.0) or (MATH 112/3.0 with permission of the Department). Exclusion MATH 211/6.0.
Offering Faculty: Faculty of Arts and Science

MATH 211 Algebraic Methods Units: 6.00
Algebraic techniques used in applied mathematics, statistics, computer science and other areas. Polynomials, complex numbers; least squares approximations; discrete linear systems; eigenvalue estimation; non-negative matrices - Markov chains; permutation groups; linear Diophantine equations; introduction to algebraic structures.
Learning Hours: 240 (72 Lecture, 168 Private Study)
Requirements: Prerequisite (MATH 120 or MATH 121 or MATH 124 or MATH 126) and (MATH 110 or MATH 111 or MATH 112). Exclusion MATH 210.
Offering Faculty: Faculty of Arts and Science

MATH 212 Linear Algebra ll Units: 3.00
Vector spaces, direct sums, linear transformations, eigenvalues, eigenvectors, inner product spaces, self-adjoint operators, positive operators, singular-value decomposition, minimal polynomials, Jordan canonical form, the projection theorem, applications to approximation and optimization problems.
Learning Hours: 120 (36 Lecture, 12 Tutorial, 72 Private Study)
Requirements: Prerequisite MATH 111 or MATH 112 or MTHE 217. Exclusion MATH 110. Equivalency MATH 312.
Offering Faculty: Faculty of Arts and Science

MATH 221 Vector Calculus Units: 3.00
Double and triple integrals, including polar and spherical coordinates. Parameterized curves and line integrals. Gradient, divergence, and curl. Green's theorem. Parameterized surfaces and surface integrals. Stokes' and Gauss' Theorems.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 120 or MATH 121 or MATH 124 or MATH 126. Exclusion MATH 280. Recommended Some linear algebra.
Offering Faculty: Faculty of Arts and Science

MATH 225 Ordinary Differential Equations Units: 3.00
An introduction to solving ordinary differential equations. Topics include first order differential equations, linear differential equations with constant coefficients, Laplace transforms, and systems of linear equations.
NOTE Some knowledge of linear algebra is assumed.
Learning Hours: 120 (36 Lecture, 12 Tutorial, 72 Private Study)
Requirements: Prerequisite MATH 120 or MATH 121 or MATH 124 or MATH 126. Exclusion MATH 231. Equivalency MATH 232/3.0.
Offering Faculty: Faculty of Arts and Science

MATH 228 Complex Analysis Units: 3.00
Complex arithmetic, complex plane. Differentiation, analytic functions. Elementary functions. Contour integration, Cauchy's Theorem, and Integral Formula. Taylor and Laurent series, residues with applications to evaluation of integrals.
Learning Hours: 120 (36 Lecture, 12 Tutorial, 72 Private Study)
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 112) and (MATH 120 or MATH 121 or MATH 124). Exclusion MATH 326; PHYS 312; PHYS 317.
Offering Faculty: Faculty of Arts and Science

MATH 231 Differential Equations Units: 3.00
An introduction to ordinary differential equations and their applications. Intended for students concentrating in Mathematics or Statistics.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 212) and (MATH 120 or MATH 121 or MATH 124). Exclusion MATH 225; MATH 226; MATH 232.
Offering Faculty: Faculty of Arts and Science

MATH 272 Applications of Numerical Methods Units: 3.00
An introductory course on the use of computers in science. Topics include: solving linear and nonlinear equations, interpolation, integration, and numerical solutions of ordinary differential equations. Extensive use is made of MATLAB, a high level interactive numerical package.
Learning Hours: 120 (36 Lecture, 12 Laboratory, 12 Tutorial, 60 Private Study)
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 212) and (CISC 101 or CISC 121) Corequisite (MATH 225 or MATH 231 or MATH 232). Exclusion CISC 271; PHYS 213; PHYS 313.
Offering Faculty: Faculty of Arts and Science

MATH 280 Advanced Calculus Units: 3.00
Limits, continuity, C^1 and linear approximations of functions of several variables. Multiple integrals and Jacobians. Line and surface integrals. The theorems of Green, Stokes, and Gauss.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 112) and (MATH 120 or MATH 121 or MATH 124). Exclusion MATH 221.
Offering Faculty: Faculty of Arts and Science

MATH 281 Introduction to Real Analysis Units: 3.00
Taylor's theorem, optimization, implicit and inverse function theorems. Elementary topology of Euclidean spaces. Sequences and series of numbers and functions. Pointwise and uniform convergence. Power series.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite MATH 120 or MATH 121 or MATH 124.
Offering Faculty: Faculty of Arts and Science

MATH 310 Group Theory Units: 3.00
Permutation groups, matrix groups, abstract groups, subgroups, homomorphisms, cosets, quotient groups, group actions, Sylow theorems.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 210.
Course Equivalencies: MATH310, MATH313
Offering Faculty: Faculty of Arts and Science

MATH 311 Elementary Number Theory Units: 3.00
Congruences; Euler's theorem; continued fractions; prime numbers and their distribution; quadratic forms; Pell's equation; quadratic reciprocity; introduction to elliptic curves.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 210 or MATH 211.
Offering Faculty: Faculty of Arts and Science

MATH 314 Representations of the Symmetric Group Units: 3.00
The symmetric group consists of all permutations of a finite set or equivalently all the bijections from the set to itself. This course explores how to map the symmetric group into a collection of invertible matrices. To handle, count, and manipulate these objects, appropriate combinatorial tools are introduced.
Learning Hours: 132 (36 Lecture, 96 Lecture)
Requirements: Prerequisite MATH 210 or MATH 211.
Offering Faculty: Faculty of Arts and Science

MATH 326 Functions of a Complex Variable Units: 3.00
Complex numbers, analytic functions, harmonic functions, Cauchy's Theorem, Taylor and Laurent series, calculus of residues, Rouche's Theorem.
Learning Hours: 120 (36 Lecture, 12 Tutorial, 72 Private Study)
Requirements: Prerequisite MATH 281. Exclusion MATH 228; PHYS 312; PHYS 317.
Offering Faculty: Faculty of Arts and Science

MATH 328 Real Analysis Units: 3.00
Metric spaces, topological spaces, compactness, completeness, contraction mappings, sequences and series of functions, uniform convergence, normed linear spaces, Hibert space.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 281.
Offering Faculty: Faculty of Arts and Science

MATH 335 Mathematics of Engineering Systems Units: 3.00
Signal Spaces (Linear Spaces, Banach and Hilbert spaces; Distributions and Schwartz space of signals). Discrete and Continuous Fourier Transforms, Laplace and Z transforms. Linear input/output systems and their stability analysis. Frequency-domain and time-domain analysis of linear time-invariant systems. Applications to modulation of communication signals, linear filter design, and digital sampling.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite MATH 281/3.0 and (MATH 228/3.0 or MATH 326/3.0).
Offering Faculty: Faculty of Arts and Science

MATH 337 Stochastic Models in Operations Research Units: 3.00
Some probability distributions, simulation, Markov chains, queuing theory, dynamic programming, inventory theory.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (MATH 120 or MATH 121 or MATH 124) and (MATH 231 or MATH 225).
Offering Faculty: Faculty of Arts and Science

MATH 338 Fourier Methods for Boundary Value Problems Units: 3.00
Methods and theory for ordinary and partial differential equations; separation of variables in rectangular and cylindrical coordinate systems; sinusoidal and Bessel orthogonal functions; the wave, diffusion, and Laplace's equation; Sturm-Liouville theory; Fourier transform.
Learning Hours: 118 (36 Lecture, 12 Tutorial, 70 Private Study)
Requirements: Prerequisite (MATH 221 or MATH 280) and (MATH 225 or MATH 231 or MATH 232) and (MATH 110 or MATH 111). Exclusion PHYS 312; PHYS 316.
Offering Faculty: Faculty of Arts and Science

MATH 339 Evolutionary Game Theory Units: 3.00
This course highlights the usefulness of game theoretical approaches in solving problems in the natural sciences and economics. Basic ideas of game theory, including Nash equilibrium and mixed strategies; stability using approaches developed for the study of dynamical systems, including evolutionary stability and replicator dynamics; the emergence of co-operative behaviour; limitations of applying the theory to human behaviour.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (MATH 120 or MATH 121 or MATH 124) and (MATH 110 or MATH 111 or MATH 112). Equivalency MATH 239. Recommended MATH 110 or MATH 111.
Course Equivalencies: MATH239, MATH339
Offering Faculty: Faculty of Arts and Science

MATH 341 Differential Geometry Units: 3.00
Introductory geometry of curves/surfaces: directional/covariant derivative; differential forms; Frenet formulas; congruent curves; surfaces in R3: mappings, topology, intrinsic geometry; manifolds; Gaussian/mean curvature; geodesics, exponential map; Gauss-Bonnet Theorem; conjugate points; constant curvature surfaces.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 110 and MATH 280.
Offering Faculty: Faculty of Arts and Science

MATH 381 Mathematics with a Historical Perspective Units: 3.00
A historical perspective on mathematical ideas focusing on a selection of important and accessible theorems. A project is required.
Learning Hours: 120 (36 Lecture, 12 Group Learning, 72 Private Study)
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 212) and (MATH 120 or MATH 121 or MATH 126).
Offering Faculty: Faculty of Arts and Science

MATH 382 Mathematical Explorations Units: 3.00
Elementary mathematical material will be used to explore different ways of discovering results and mastering concepts. Topics will come from number theory, geometry, analysis, probability theory, and linear algebra. Much class time will be used for problem solving and presentations by students.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (MATH 221 or MATH 225 or MATH 231 or MATH 280 or MATH 232/3.0) and (MATH 210 or MATH 211).
Offering Faculty: Faculty of Arts and Science

MATH 384 Mathematical Theory of Interest Units: 3.00
Interest accumulation factors, annuities, amortization, sinking funds, bonds, yield rates, capital budgeting, contingent payments. Students will work mostly on their own; there will be a total of six survey lectures and six tests throughout the term, plus opportunity for individual help.
Learning Hours: 102 (12 Lecture, 84 Private Study)
Requirements: Prerequisite Level 3 or above and (MATH 120 or MATH 121 or MATH 124 or MATH 126).
Offering Faculty: Faculty of Arts and Science

MATH 385 Life Contingencies Units: 3.00
Measurement of mortality, life annuities, life insurance, premiums, reserves, cash values, population theory, multi-life functions, multiple-decrement functions. The classroom meetings will be primarily problem-solving sessions, based on assigned readings and problems.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite ([MATH 120/6.0 or MATH 121/6.0 or MATH 124/3.0 or MATH 126/6.0] and MATH 384/3.0 and [STAT 268/3.0 or STAT 252/3.0]) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 386 Our Number System - an Advanced Perspective Units: 3.00
Integers and rationals from the natural numbers; completing the rationals to the reals; consequences of completeness for sequences and calculus; extensions beyond rational numbers, real numbers, and complex numbers.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 281.
Offering Faculty: Faculty of Arts and Science

MATH 387 Elementary Geometry - an Advanced Perspective Units: 3.00
In-depth follow-up to high school geometry: striking new results/connections; analysis/proof of new/familiar results from various perspectives; extensions (projective geometry, e.g.); relation of classical unsolvable constructions to modern algebra; models/technology for geometric exploration.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (Level 3 or above and [MATH 221 or MATH 280 or MATH 281]) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 401 Graph Theory Units: 3.00
An introduction to graph theory, one of the central disciplines of discrete mathematics. Topics include graphs, subgraphs, trees, connectivity, Euler tours, Hamiltonian cycles, matchings, independent sets, cliques, colourings, and planarity. Given jointly with MATH 801.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 210 or MATH 211. Recommended Experience with abstract mathematics and mathematical proof, and a good foundation in linear algebra.
Offering Faculty: Faculty of Arts and Science

MATH 402 Enumerative Combinatorics Units: 3.00
Enumerative combinatorics is concerned with counting the number of elements of a finite set. The techniques covered include inclusion-exclusion, bijective proofs, double-counting arguments, recurrence relations, and generating functions. Given jointly with MATH 802.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 210 or MATH 211. Recommended Experience with abstract mathematics and mathematical proof, and a good foundation in linear algebra.
Offering Faculty: Faculty of Arts and Science

MATH 406 Introduction to Coding Theory Units: 3.00
Construction and properties of finite fields. Polynomials, vector spaces, block codes over finite fields. Hamming distance and other code parameters. Bounds relating code parameters. Cyclic codes and their structure as ideals. Weight distribution. Special codes and their relation to designs and projective planes. Decoding algorithms.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 210.
Offering Faculty: Faculty of Arts and Science

MATH 413 Introduction to Algebraic Geometry Units: 3.00
An introduction to the study of systems of polynomial equations in one or many variables. Topics covered include the Hilbert basis theorem, the Nullstellenstaz, the dictionary between ideals and affine varieties, and projective geometry.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 210.
Offering Faculty: Faculty of Arts and Science

MATH 414 Introduction to Galois Theory Units: 3.00
An introduction to Galois Theory and some of its applications.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 310.
Offering Faculty: Faculty of Arts and Science

MATH 418 Number Theory and Cryptography Units: 3.00
Time estimates for arithmetic and elementary number theory algorithms (division algorithm, Euclidean algorithm, congruences), modular arithmetic, finite fields, quadratic residues. Simple cryptographic systems; public key, RSA. Primality and factoring: pseudoprimes, Pollard's rho-method, index calculus. Elliptic curve cryptography.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 210 or (MATH 211 with permission of the Department).
Offering Faculty: Faculty of Arts and Science

MATH 421 Fourier Analysis Units: 3.00
An exploration of the modern theory of Fourier series: Abel and Cesàro summability; Dirichlet's and Fejér's kernels; term by term differentiation and integration; infinite products; Bernoulli numbers; the Fourier transform; the inversion theorem; convolution of functions; the Plancherel theorem; and the Poisson summation theorem.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 281 or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 427 Introduction to Deterministic Dynamical Systems Units: 3.00
Topics include: global properties of flows and diffeomorphisms, Invariant sets and dynamics, Bifurcations of fixed and periodic points; stability and chaos. Examples will be selected by the instructor. Given jointly with MATH 827.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (MATH 231 and MATH 328) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 429 Functional Analysis and Quantum Mechanics Units: 3.00
A generalization of linear algebra and calculus to infinite dimensional spaces. Now questions about continuity and completeness become crucial, and algebraic, topological, and analytical arguments need to be combined. We focus mainly on Hilbert spaces and the need for Functional Analysis will be motivated by its application to Quantum Mechanics.
Learning Hours: 132 (36 Lecture, 12 Group Learning, 84 Private Study)
Requirements: Prerequisite ([MATH 110 or MATH 111 or MATH 112] and MATH 281) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 433 Continuum Mechanics with Applications Units: 3.00
Continuum mechanics lays the foundations for the study of the mechanical behavior of materials. After a review of vector and tensor analysis, the kinematics of continua are introduced. Conservation of mass, balance of momenta and energy are presented with the constitutive models. Applications are given in elasticity theory and fluid dynamics. NOTE This is the MATH version of MTHE 433 in FEAS.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite (MATH 231 and MATH 280) or permission of the Instructor.
Offering Faculty: Faculty of Arts and Science

MATH 434 Optimization Theory with Applications to Machine Learning Units: 3.00
Theory of convex sets and functions; separation theorems; primal-duel properties; geometric treatment of optimization problems; algorithmic procedures for solving constrained optimization programs; engineering and economic applications.
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 212) and MATH 281.
Offering Faculty: Faculty of Arts and Science

MATH 436 Partial Differential Equations Units: 3.00
Quasilinear equations: Cauchy problems, method of characteristics; Cauchy-Kovalevski theorem; generalized solutions; wave equation, Huygens' principle, conservation of energy, domain of dependence; Laplace equation, boundary value problems, potential theory, Green's functions; heat equation, maximum principle.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite MATH 231/3.0 and MATH 280/3.0. Recommended MATH 328/3.0 or MATH 338/3.0.
Offering Faculty: Faculty of Arts and Science

MATH 437 Topics in Applied Mathematics Units: 3.00
Subject matter to vary from year to year. Given jointly with MATH 837.
Learning Hours: 132 (36 Lecture, 96 Private Study)
Requirements: Prerequisite Permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 439 Lagrangian Mechanics, Dynamics, and Control Units: 3.00
Geometric modeling, including configuration space, tangent bundle, kinetic energy, inertia, and force. Euler-Lagrange equations using affine connections. The last part of the course develops one of the following three applications: mechanical systems with nonholonomic constraints; control theory for mechanical systems; equilibria and stability.
Learning Hours: 132 (36 Lecture, 12 Tutorial, 84 Private Study)
Requirements: Prerequisite (MATH 231 and [MATH 280 or MATH 281]) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 472 Optimization and Control of Stochastic Systems Units: 3.00
Optimization, control, and stabilization of dynamical systems under probabilistic uncertainty with applications in engineering systems and applied mathematics. Topics include controlled and control-free Markov chains, stochastic stability, martingale methods for stability, stochastic learning, dynamic programming, optimal control for finite and infinite horizons, average cost problems, partially observed models, non-linear and Kalman filtering, linear programming and numerical methods, reinforcement learning and stochastic approximation methods, decentralized and continuous time stochastic control.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 281/3.0 and (STAT 252/3.0 or STAT 268/3.0).
Offering Faculty: Faculty of Arts and Science

MATH 474 Information Theory Units: 3.00
Topics include: information measures, entropy, mutual information, modeling of information sources, lossless data compression, block encoding, variable-length encoding, Kraft inequality, fundamentals of channel coding, channel capacity, rate-distortion theory, lossy data compression, rate-distortion theorem. Given jointly with MATH 874.
Learning Hours: 140 (36 Lecture, 104 Private Study)
Requirements: Prerequisite STAT 268/3.0 or STAT 252/3.0. Recommended STAT 353/3.0.
Offering Faculty: Faculty of Arts and Science

MATH 477 Data Compression and Source Coding: Theory and Algorithms Units: 3.00
Topics include: arithmetic coding, universal lossless coding, Lempel-Ziv and related dictionary based methods, rate distortion theory, scalar and vector quantization, predictive and transform coding, applications to speech and image coding.
Learning Hours: 120 (36 Lecture, 84 Private Study)
Requirements: Prerequisite MATH 474/3.0. Recommended STAT 353/3.0.
Offering Faculty: Faculty of Arts and Science

MATH 497 Topics in Mathematics IV Units: 3.00
An important topic in mathematics not covered in any other courses.
Requirements: Note The prerequisite can vary depending on specific course content, please consult the Instructor or visit the Department of Mathematics and Statistics webpage for more information.
Offering Faculty: Faculty of Arts and Science

MATH 498 Topics in Mathematics V Units: 3.00
An important topic in mathematics not covered in any other courses.
Requirements: Note The prerequisite can vary depending on specific course content, please consult the Instructor or visit the Department of Mathematics and Statistics webpage for more information.
Offering Faculty: Faculty of Arts and Science

MATH 499 Topics In Mathematics Units: 3.00
Important topics in mathematics not covered in any other courses.
Requirements: Prerequisite Permission of the Department.
Offering Faculty: Faculty of Arts and Science

MATH 594 Independent Study Units: 3.00
Exceptionally qualified students entering their third- or fourth-year may take a program of independent study provided it has been approved by the Department or Departments principally involved. The Department may approve an independent study program without permitting it to be counted toward a concentration in that Department. It is, consequently, the responsibility of students taking such programs to ensure that the concentration requirements for their degree will be met.
NOTE Requests for such a program must be received one month before the start of the first term in which the student intends to undertake the program.
Requirements: Prerequisite Permission of the Department or Departments principally involved.
Offering Faculty: Faculty of Arts and Science

MATH 595 Independent Study Units: 6.00
Exceptionally qualified students entering their third- or fourth-year may take a program of independent study provided it has been approved by the Department or Departments principally involved. The Department may approve an independent study program without permitting it to be counted toward a concentration in that Department. It is, consequently, the responsibility of students taking such programs to ensure that the concentration requirements for their degree will be met.
NOTE Requests for such a program must be received one month before the start of the first term in which the student intends to undertake the program.
Requirements: Prerequisite Permission of the Department or Departments principally involved.
Offering Faculty: Faculty of Arts and Science