MATHEMATICS AND STATISTICS

Courses

MATH 110 Linear Algebra Units: 6.00
For students intending a medial or major concentration in Mathematics or Statistics. Provides a thorough introduction to linear algebra up to and including eigenvalues and eigenvectors.
LEARNING HOURS 264 (72L;24T;168P).
Requirements: Prerequisite None. Exclusion MATH 111; MATH 112; MATH 212. 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 (72L;168P).
Requirements: Prerequisite None. Exclusion MATH 110; MATH 112. 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 (36L;84P).
Requirements: Prerequisite None. Exclusion MATH 110; MATH 111. 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
A thorough discussion of calculus, including limits, continuity, differentiation, integration, multivariable differential calculus, and sequences and series.
LEARNING HOURS 288 (72L;24T;192P).
Requirements: Prerequisite None. Exclusion MATH 121; MATH 123; MATH 124; MATH 126. Recommended MHF4U and MCV4U or equivalent, or 4U AFIC, or MATH P06, or permission of the Department. Note This course is intended for students who wish to pursue a Major or Medial Plan in a subject other than Mathematics or Statistics.
Course Equivalencies: MATH121; MATH121B;MATH122B
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 the Bader International Study Centre.
Learning Hours may vary.
LEARNING HOURS 262 (48L;11G;72O).
Requirements: Prerequisite None. Exclusion MATH 120; MATH 123; MATH 124; MATH 126. Recommended MHF4U and MCV4U or equivalent, or 4U AFIC, or MATH P06, or permission of the Department. Note This course is intended for students who wish to pursue a Major or Medial Plan in a subject other than Mathematics or Statistics.
Course Equivalencies: MATH121; MATH121B;MATH122B
Offering Faculty: Faculty of Arts and Science

MATH 122 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 MATH 120; MATH 121; MATH 126. Note This course is not intended for students pursuing a MATH or STAT Plan.
Offering Faculty: Faculty of Arts and Science

MATH 123 Differential and Integral Calculus II Units: 3.00
Topics include techniques of integration; differential equations, and multivariable differential calculus.
LEARNING HOURS 126 (36L;12T;78P).
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 124 Differential and Integral Calculus II Units: 3.00
Topics include techniques of integration; differential equations, and multivariable differential calculus.
LEARNING HOURS 126 (36L;12T;78P).
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 (72L;24T;144P).
Requirements: Prerequisite None. Exclusion MATH 120; MATH 121; MATH 123; MATH 124; MATH 126. 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 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.
NOTE Students with MATH 112/3.0 may ask for admission with the permissions of the Department.
LEARNING HOURS 132 (36L;12T;84P)
Requirements: MATH110
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 (72L;168P)
Requirements: Pre MATH120;121;122;124;126
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 (36L;12T;72P).
Requirements: MATH111 or MATH 112 or MTHE 217. Exclusion MATH 110. Equivalency MATH 312.
Offering Faculty: Faculty of Arts and Science

MATH 217  Algebraic Structures  Units: 3.50
The purpose of the course is to provide an introduction to abstract algebraic systems, and to illustrate the concepts with applications to communication engineering. Topics covered are: symbolic logic, switching and logic circuits; set theory and mappings; equivalence relations; the integers; introduction to Boolean algebras; group theory, groups, subgroups, cyclic groups, cosets and Lagrange's theorem, quotient groups, homomorphisms and isomorphisms; applications to error-control codes, binary block codes for noisy communication channels, nearest neighbor decoding, code error detection/correction capabilities, group (linear) codes, coset decoding, generator and parity check matrices, syndrome decoding; basic properties of rings and fields. (30/0/0/12/0)
Requirements: MATH118 OR APSC174
Offering Faculty: Faculty of Arts and Science

MATH 221  Vector Calculus  Units: 3.00
LEARNING HOURS 120 (36L;84P)
RECOMMENDATION Some linear algebra.
Requirements: MATH120 OR MATH121 OR MATH126 OR APSC172 OR MATH122 OR MATH124
Offering Faculty: Faculty of Arts and Science

MATH 224  Applied Math For Civil Eng.  Units: 4.50
The course will discuss the application of linear differential equations with constant coefficients, and systems of linear equations within the realm of civil engineering. Additionally, the course will explore relevant data analysis techniques including: graphical and statistical analysis and presentation of experimental data, random sampling, estimation using confidence intervals, linear regression, residuals and correlation. (54/0/0/0)
Requirements: (APSC171 AND APSC172) OR (APSC142 AND APSC172) OR (APSC142 AND APSC174) OR (APSC171 AND APSC174)
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 (36L;12T;72P).
Requirements: (MATH128 AND MATH118) OR (MATH128 AND MATH129) OR (MATH12## AND MATH11##) OR (APSC171 AND APSC172) OR (APSC171 AND APSC174) OR (APSC171 AND APSC174)
Offering Faculty: Faculty of Arts and Science

MATH 227  Vector Analysis  Units: 3.00
Review of multiple integrals. Differentiation and integration of vectors; line, surface and volume integrals; gradient, divergence and curl; conservative fields and potential. Spherical and cylindrical coordinates, solid angle. Green's and Stokes' theorems, the divergence theorem. (36/0/0/0/0)
Requirements: (MATH128 AND MATH118) OR (MATH128 AND MATH129) OR (APSC171 AND APSC174) OR (APSC171 AND APSC172) OR (MATH120 AND MATH110) OR (MATH120 AND MATH111) OR (MATH120 AND MATH112)
Offering Faculty: Faculty of Arts and Science

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MATH 228 Complex Analysis Units: 3.00
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 (36L;12T;84P).
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 235 Diff Equations For Elec & Comp Units: 3.00
First order differential equations, linear differential equations with constant coefficients. Laplace transforms. Systems of linear differential equations. Examples involving the use of differential equations in solving circuits will be presented. (30/0/0/6/0)
Requirements: (MATH128 AND MATH118) OR (MATH128 AND MATH129) OR (APSC171 AND APSC172) OR (APSC171 AND APSC174) OR (MATH120 AND MATH111#)
Offering Faculty: Faculty of Arts and Science

MATH 239 Applied Math Modeling Units: 3.00
A survey of important mathematical techniques used to model processes in a variety of fields. Topics include multivariable calculus and optimization, game theory, discrete-time dynamical systems, and dynamic optimization. Examples will be drawn from several areas including biology, economics, and medicine. (18/9/5/4/0) ~ COURSE DELETED IN 2008/09 ~
Requirements: APSC172 OR MATH120 OR MATH121 OR MATH125 OR MATH126 OR APSC172 OR MATH126
Course Equivalencies: MATH239, MATH339
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 (36L;12Lb;12T;60P).
Requirements: Prerequisite (MATH120 AND MATH110) OR (MATH120 AND MATH111) OR (MATH120 AND APSC174) OR (APSC172 AND MATH110) OR (APSC172 AND MATH111) OR (APSC172 AND APSC174) OR (MATH120 AND MATH112) OR (APSC172 AND MATH112)
Offering Faculty: Faculty of Arts and Science

MATH 280 Advanced Calculus Units: 3.00
Limits, continuity, C1 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 (36L;12T;84P).
Requirements: (MATH120 AND MATH110) OR (MATH120 AND MATH111) OR (MATH120 AND APSC174) OR (APSC172 AND MATH110) OR (APSC172 AND MATH111) OR (APSC172 AND APSC174) OR (MATH120 AND MATH112) OR (APSC172 AND MATH112)
Offering Faculty: Faculty of Arts and Science

MATH 281 Introduction to Real Analysis Units: 3.00
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 (36L;96P).
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 (36L;84P).
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 (36L;96L).
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 (36L;12T;72P).
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, Hilbert space.
LEARNING HOURS 132 (36L;96P).
Requirements: Prerequisite MATH 281.
Offering Faculty: Faculty of Arts and Science

MATH 334 Mathematical Methods for Engineering and Physics Units: 3.00
Banach and Hilbert spaces of continuous- and discrete-time signals; spaces of continuous and not necessarily continuous signals; continuous-discrete Fourier transform; continuous-continuous Fourier transform; discrete-continuous Fourier transform; discrete-discrete Fourier transform; transform inversion using Fourier series and Fourier integrals.
LEARNING HOURS 132 (36L;12T;84P).
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 212) and MATH 281. Exclusion PHYS 312; PHYS 316.
Offering Faculty: Faculty of Arts and Science

MATH 335 Mathematics of Engineering Systems Units: 3.00
LEARNING HOURS 132 (36L;12T;84P).
Requirements: Prerequisite MATH 334 and (MATH 228 or MATH 326). Exclusion PHYS 312. Equivalency MATH 236.
Course Equivalencies: MATH236, MATH335
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 (36L;84P).
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 (36L;12T;70P).
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 (36L;84P).
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 (36L;96P).
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 (36L;12G;72P).
Requirements: Prerequisite MATH 221 and MATH210 OR (MATH221 AND MATH211) OR (MATH210 AND MATH280) OR (MATH231
AND MATH211) OR (MATH210 AND MATH281) OR (MATH231
AND MATH211) OR (MATH280 AND MATH210) OR (MATH280
AND MATH211)
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 (12L;84P).
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 108 (36L;72P).
Requirements: Prerequisite ([MATH 120 or MATH 121 or
MATH 124 or MATH 126] and MATH 384 and [STAT 268 or
STAT 351]) 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 (36L;84P).
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 (36L;84P).
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 (36L;84P).
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 (36L;84P).
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
LEARNING HOURS 120 (36L;84P).
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 Nullstellensatz, the dictionary between ideals and affine varieties, and projective geometry.
LEARNING HOURS 132 (36L;96P).
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 (36L;96P).
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 (36L;84P).
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 (36L;96P).
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 (36L;84P).
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 (36L;12G;84P).
Requirements: Prerequisite (MATH 231 and MATH 328) 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 (36L;84P).
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-dual 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 435 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 (36L;96P).
Requirements: Prerequisite MATH 231 and MATH 280. Recommended MATH 328 or MATH 334 or MATH 338 or PHYS 312.
Offering Faculty: Faculty of Arts and Science

MATH 436 Topics in Applied Mathematics Units: 3.00
Subject matter to vary from year to year. Given jointly with MATH 837.
LEARNING HOURS 132 (36L;96P).
Requirements: Prerequisite Permission of the Department.
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  
**Offering Faculty:** Faculty of Arts and Science

MATH 595  Independent Study  Units: 6.00  
**Offering Faculty:** Faculty of Arts and Science

MATH 603  Mathematics  Units: 6.00  
**Offering Faculty:** Faculty of Arts and Science

MATH 620  Diff. & Int. Calculus  Units: 6.00  
**Offering Faculty:** Faculty of Arts and Science

MATH 800  Seminar  Units: 3.00  
Students are expected to participate in a weekly seminar in which they are required to present material on a topic that relates to their research.  
**Offering Faculty:** Faculty of Arts and Science

MATH 801  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. (Offered jointly with MATH-401.*)  
**Offering Faculty:** Faculty of Arts and Science

MATH 802  Enumerative Combinatorics  Units: 3.00  
Enumerative combinatorics is concerned with counting the number of elements of finite sets with prescribed conditions. The techniques covered include inclusion-exclusion, bijective proofs, double-counting arguments, recurrence relations, and generating functions. (Offered jointly with MATH-402.) Three term hours; lectures.  
**Offering Faculty:** Faculty of Arts and Science

MATH 806  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. (Offered jointly with MATH 406.*) Three term-hours, fall or winter; lectures.  
**Offering Faculty:** Faculty of Arts and Science

MATH 812  Topics In Number Theory  Units: 3.00  
Subject matter may vary from year to year. Three term-hours, fall or winter; lectures.  
**Offering Faculty:** Faculty of Arts and Science

MATH 813  Introduction to Algebraic Geometry  Units: 3.00  
An introduction to the study of systems of polynomial equations in one or more variables. Topics covered include the Hilbert basis theorem, the Nullstellensatz, the dictionary between ideals and affine varieties, and projective geometry (Offered jointly with MATH 413).  
**Offering Faculty:** Faculty of Arts and Science

MATH 818  Number Theory & Cryptography  Units: 3.00  
Time estimates for arithmetic and elementary number theory algorithms (division algorithm, Euclidean algorithm, congruences), modular arithmetic, finite fields, quadratic residues. Design of simple cryptographic systems; public key, RSA systems. Primality and factoring: pseudoprimes, Pollard's rho-method, index calculus. Elliptic curve cryptography. Offered jointly with MATH-418. Three term hours, fall or winter; lectures.  
**Offering Faculty:** Faculty of Arts and Science

MATH 823  Ordinary Diff. Equations  Units: 3.00  
**Offering Faculty:** Faculty of Arts and Science

MATH 827  Deterministic Dynamical System  Units: 3.00  
Topics include: global properties of flows and diffeomorphisms; invariant sets and dynamics; bifurcations of fixed and periodic points; stability and chaos. (Offered jointly with MATH-427.*) Three term-hours, fall or winter; lectures.  
**Offering Faculty:** Faculty of Arts and Science

MATH 829  Functional Analysis  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. (Offered jointly with MATH 429.) Three term hours; lectures.  
**EXCLUSION:** MATH -429  
**Offering Faculty:** Faculty of Arts and Science

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MATH 830 Modern Control Theory Units: 3.00
This course covers core topics in discrete and continuous
time modern control theory: controllability, observability
and minimal realizations; Lyapunov stability; the linear
quadratic regulator and design of robust controllers; state
estimation via Luenberger and deterministic Kalman-
Bucy filters. Laboratory experiments illustrate design
considerations in implementing the lecture material. Students
are required to identify a high order under-actuated torsion
disc system; perform model verification experiments; design
and implement robust linear feedback controllers; design
and implement nonlinear sliding mode controllers; study
implementation issues for observers and Kalman-Bucy filters;
depending on instructor, some nonlinear control strategies
may be implemented. (Offered jointly with MATH-430.*)
Three term hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 833 Continuum Mechanics Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 834 Optimization Theory with Applications to
Machine Learning Units: 3.00
Theory of convex sets and functions; separation theorems;
primal-dual properties; geometric treatment of optimization
problems; algorithmic procedures for solving constrained
optimization programs; applications of optimization theory to
machine learning. (Offered jointly with MATH/MTHE 434.)
EXCLUSIONS: MTHE/MATH 434
Offering Faculty: Faculty of Arts and Science

MATH 835 Mathematical Biology Units: 3.00
This is a course in advanced mathematical methods used
to construct models of biological phenomena in ecology,
epidemiology, and evolutionary biology. The course will focus
on population models, starting with individual-based models
based on assumptions on the distribution of individual traits,
then scaling up to stochastic models for small populations
and deterministic models for large populations.
Offering Faculty: Faculty of Arts and Science

MATH 836 Lagrangian Mechanics. Dynamics &
Control Units: 3.00
Configuration space, generalized coordinates, Euler-Lagrange
equations. Forces: dissipative, potential. Simple mechanical
control systems: modeling, linearization about equilibrium
points, linear controllability tests; equivalence with kinematic
systems and trajectory generation. (Offered jointly with
MATH 439). Three term hours, fall or winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 837 Topics In Applied Mathematics Units: 3.00
Subject matter may vary from year to year. Three term-hours,
fall or winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 838 Topics In Mathematical Biology Units: 3.00
Subject matter may vary from year to year. Three term-hours,
fall or winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 844 Differentiable Manifolds Units: 3.00
Calculus on manifolds; transversality; Sard's Theorem;
immersions and submersions; intersection theory; Jordan
curve theorem; Lefschetz fixed point theorem; Poincaré-
Hopf Theorem. (Offered jointly with MATH-444.*) Three term-
hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 845 Differential Geometry Units: 6.00
Offering Faculty: Faculty of Arts and Science

MATH 848 Topics In Graph Theory Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 860 Probability Theory Units: 6.00
Offering Faculty: Faculty of Arts and Science

MATH 862 Stochastic Processes Units: 6.00
Offering Faculty: Faculty of Arts and Science

MATH 865 Stochastic Processes Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 872 Control Of Stochastic Systems Units: 3.00
Stabilization and optimization of controlled dynamical
systems under probabilistic uncertainty. Topics include:
review of probability, controlled Markov chains, martingale
and Lyapunov methods for stochastic stability, dynamic
programming, partially observed models and non-linear
filtering, the Kalman Filter, average cost problems, learning
and computational methods, decentralized stochastic control,
and stochastic control in continuous-time. (Offered jointly
with MTHE- 472.) Three term hours, fall or winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 873 Num. Lin. & Nonlin. Algebra II Units: 3.00
Offering Faculty: Faculty of Arts and Science
MATH 874 Information Theory Units: 3.00
An introduction to the fundamental principles of the theory of communication. Topics include: information measures, entropy, mutual information, divergence; modeling of information sources, discrete memoryless sources, Markov sources, entropy rate, source redundancy; fundamentals of lossless data compression, block encoding, variable-length encoding, Kraft inequality, design of Shannon-Fano and Huffman codes; fundamentals of channel coding, channel capacity, noisy channel coding theorem, channels with memory, lossless information transmission theorem; continuous-alphabet sources and channels, differential entropy, capacity of discrete-time and band-limited continuous-time Gaussian channels; rate-distortion theory, lossy data compression, rate-distortion theorem, lossy information transmission theorem. Offered jointly with MATH-474). Three term hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 877 Data Compression And Source Co Units: 3.00
Fundamentals of the theoretical and practical (algorithmic) aspects of lossless and lossy data compression. Topics include: adaptive Huffman coding, arithmetic coding, the fundamental performance limits of universal lossless coding, Lempel-Ziv and related dictionary based methods, the Burrows-Wheeler transform, elements of Kolmogorov complexity theory, rate-distortion theory, scalar and vector quantization, applications to speech and image coding. Offered jointly with MATH-477*).
Offering Faculty: Faculty of Arts and Science

MATH 880 Foundations Of Mathematics I Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 883 Mathematical Logic Units: 6.00
Offering Faculty: Faculty of Arts and Science

MATH 884 Data Networks Units: 3.00
This course covers performance models for data networking, delay models and loss models; analysis of multiple access systems, routing, and flow control; multiplexing; priority systems; satellite multiple access, wireless networking, wireless sensor networks. Knowledge of networking protocols is not required. (Offered jointly with MATH 484.) Three term hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 891 Core Course In Analysis I Units: 3.00
This course provides basic knowledge in real and complex analysis at the graduate level on the following topics: Lebesgue measure and integration theory; elementary Hilbert space theory; examples of Banach space techniques. Three term-hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 892 Core Course In Analysis II Units: 3.00
This course provides basic knowledge in real and complex analysis at the graduate level on the following topics: basic theory of Fourier transforms; basic elements of spectral theory and Banach algebras; complex analysis. Three term-hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 893 Core Course In Algebra I Units: 3.00
This course provides basic knowledge in algebra at the graduate level on the following topics: elementary theory of groups; elementary theory of rings and modules; Galois theory. Three term-hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 894 Core Course In Algebra II Units: 3.00
This course provides basic knowledge in algebra at the graduate level on the following topics: representation theory of finite groups through characters; advanced theory of modules; advanced theory of rings. Three term-hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 895 Core Course In Prob. Theory Units: 3.00
This course provides basic knowledge in probability at the graduate level. Topics will include: basic notions and concepts of Probability Theory; characteristic functions; law of large numbers and central limit theorem; martingales; stochastic processes. Three term-hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 896 Core Mathematical Statistics I Units: 3.00
This course provides basic knowledge in mathematical statistics at the graduate level. Topics will include: Classical and Bayesian inference, Multivariate Gaussian distribution and its applications in Statistics; decision theory; basic techniques of non-parametric estimation. Three term-hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

MATH 897 Core Mathematical Statistics II Units: 3.00
This course provides basic knowledge in mathematical statistics at the graduate level. Topics will include: Weak convergence in metric spaces; Delta method; Method of moments; M-estimation; Asymptotic normality and efficiency; Likelihood ratio test; U statistics; Bootstrap; Applications in statistics.
Offering Faculty: Faculty of Arts and Science

MATH 898 Master's Project Units: 6.00
Offering Faculty: Faculty of Arts and Science

MATH 899 Master's Thesis Research Units: 6.00
Offering Faculty: Faculty of Arts and Science
MATH 901 Research Institute Course Units: 3.00
Advanced topics course, normally offered in the summer term, by a research institute in Canada or abroad can be taken for credit with the permission of the Supervisor and Coordinator of Graduate Studies and in cooperation with Institute organizers. Grades are assigned on a PASS - FAIL basis.
Offering Faculty: Faculty of Arts and Science

MATH 902 Topics In Algebra Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 903 Topics In Algebra Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 905 Topics In Algebra Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 912 Topics In Number Theory Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 913 Topics In Number Theory Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 915 Topics In Number Theory Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 916 Group Representations IIb Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 920 Topological Vector Spaces Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 921 Vector Lattices & Integration Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 922 Topics In Analysis Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 923 Topics In Analysis Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 924 Topics In Analysis Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 925 Topics In Analysis Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 926 Measure & Integration Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 928 Abstract Harmonic Analysis Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 930 Quantum Mechanics Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 932 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 933 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 935 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 936 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 937 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 938 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 939 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 940 Topics In Applied Mathematics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 942 Topics In Topology & Geometry Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 943 Topics In Topology & Geometry Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 944 Topics In Topology & Geometry Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 945 Topics In Topology & Geometry Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 950 Pontragin's Maximum Principle Units: 3.00
Offering Faculty: Faculty of Arts and Science
MATH 972  Topics In Communication Theory  Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 973  Topics In Communication Theory  Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 975  Topics In Communication Theory  Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

MATH 986  Philosophy Of Mathematics  Units: 3.00
Offering Faculty: Faculty of Arts and Science

MATH 999  Ph. D. Thesis Research  Units: 6.00
Offering Faculty: Faculty of Arts and Science

STAT 252  Introductory Applied Probability  Units: 3.00
NOTE STAT 252 is a new course for STAT Minors and Medials.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite MATH 120 or MATH 121 or MATH 122 or MATH 124. Exclusion STAT 268; STAT 351.
Offering Faculty: Faculty of Arts and Science

STAT 263  Introduction to Statistics  Units: 3.00
A basic course in statistical methods with the necessary probability included. Topics include probability models, random variables, distributions, estimation, hypothesis testing, elementary nonparametric methods.
NOTE Also offered online, consult Arts and Science Online (Learning Hours may vary).
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite None. Exclusion BIOL 243; CHEE 209; COMM 162; ECON 250; GPHY 247; KNPE 251; NURS 323; PHED 251; POLS 385; PSYC 202; SOCY 211; STAM 200; STAT 267; STAT 367. One-Way Exclusion May not be taken with or after STAT 269. Recommended An Ontario 4U mathematics course or equivalent.
Offering Faculty: Faculty of Arts and Science

STAT 268  Statistics and Probability I  Units: 3.00
Basic ideas of probability theory such as random experiments, probabilities, random variables, expected values, independent events, joint distributions, conditional expectations, moment generating functions. Main results of probability theory including Chebyshev's inequality, law of large numbers, central limit theorem. Introduction to statistical computing.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite (MATH 120 or MATH 121 or MATH 122 or MATH 124). Corequisite (MATH 221 or MATH 280). Exclusion STAT 252; STAT 351.
Offering Faculty: Faculty of Arts and Science

STAT 269  Statistics and Probability II  Units: 3.00
Basic techniques of statistical estimation such as best unbiased estimates, moment estimates, maximum likelihood. Bayesian methods. Hypotheses testing. Classical distributions such as the t-distribution, F-distribution, beta distribution. These methods will be illustrated by simple linear regression. Statistical computing.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite (MATH 221 or MATH 280) and (STAT 252 or STAT 268 or STAT 351) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 351  Probability I  Units: 3.00
Probability theory; probability models; random variables; jointly distributed random variables; transformations and generating functions. Inequalities and limit laws. Distributions: binomial, Poisson, exponential, gamma, normal. Applications: elementary stochastic processes, time-to-failure models, binary communication channels with Gaussian noise.
LEARNING HOURS 120 (36L;12T;72P).
Requirements: Prerequisite None. Corequisite (MATH 221 or MATH 280). Exclusion STAT 252; STAT 268.
Offering Faculty: Faculty of Arts and Science

STAT 353  Probability II  Units: 3.00
Intermediate probability theory as a basis for further study in mathematical statistics and stochastic processes; probability measures, expectations; modes of convergence of sequences of random variables; conditional expectations; independent systems of random variables; Gaussian systems; characteristic functions; Law of large numbers, Central limit theory; some notions of dependence.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite (STAT 252 or STAT 268 or STAT 351) and (MATH 110 or MATH 111 or MATH 112) and MATH 281.
Offering Faculty: Faculty of Arts and Science
STAT 356  Probability For Elec. Engrs.  Units: 3.50  
Requirements: APSC171 OR MATH128  
Offering Term: W  
Offering Faculty: Fac of Engineering Appl Sci  

STAT 361  Applied Methods in Statistics I  Units: 3.00  
A detailed study of simple and multiple linear regression, residuals and model adequacy. The least squares solution for the general linear regression model. Analysis of variance for regression and simple designed experiments; analysis of categorical data.  
LEARNING HOURS 120 (36L;84P).  
Requirements: Prerequisite (MATH 110 or MATH 111 or MATH 112) and (STAT 252 or STAT 268 or STAT 351) and (STAT 263 or STAT 269) or permission of the Department. Exclusion ECON 351.  
Offering Faculty: Faculty of Arts and Science  

STAT 362  R for Data Science  Units: 3.00  
Introduction to R, data creation and manipulation, data import and export, scripts and functions, control flow, debugging and profiling, data visualization, statistical inference, Monte Carlo methods, decision trees, support vector machines, neural network, numerical methods.  
LEARNING HOURS 118 (36L;12G;70P).  
Requirements: Prerequisite (STAT 252 or STAT 263 or STAT 268 or STAT 351) and (MATH 110 or MATH 111 or MATH 120 or MATH 121 or MATH 124 or MATH 126 or [MATH 112 and MATH 212]) or permission of the Department.  
Offering Faculty: Faculty of Arts and Science  

STAT 363  Fundamental Statistical Infere  Units: 3.00  
Requirements: (STAT251 AND STAT261) OR (STAT251 AND STAT264) OR (STAT251 AND STAT265) OR STAT269  
Course Equivalencies: STAT363; STAT463  
Offering Faculty: Faculty of Arts and Science  

STAT 367  Engineering Data Analysis  Units: 4.00  
Requirements: (MATH128 AND MATH129) OR COMM161 OR (APSC171 AND APSC172) OR MATH12##  
Offering Faculty: Faculty of Arts and Science  

STAT 454  Statistical Spectrum Estimation  Units: 3.00  
Many systems evolve with an inherent amount of randomness in time and/or space. The focus of this course is on developing and analyzing methods for analyzing time series. Because most of the common time-domain methods are unreliable, the emphasis is on frequency-domain methods, i.e. methods that work and expose the bias that plagues most time-domain techniques. Slepian sequences (discrete prolate spheroidal sequences) and multi-taper methods of spectrum estimation are covered in detail. (12/0/0/12/12)~ COURSE NOT OFFERED IN 2010-2011 ~  
Requirements: (STAT353 AND MATH312) OR (MATH338 AND STAT251) OR (STAT261 AND MATH321)  
Offering Faculty: Faculty of Arts and Science  

STAT 455  Stochastic Processes and Applications  Units: 3.00  
LEARNING HOURS 120 (36L;12T;72P).  
Requirements: Prerequisite STAT 353.  
Offering Faculty: Faculty of Arts and Science  

STAT 456  Bayesian Analysis  Units: 3.00  
An introduction to Bayesian analysis and decision theory; elements of decision theory; Bayesian point estimation, set estimation, and hypothesis testing; special priors; computations for Bayesian analysis. Given Jointly with STAT 856.  
LEARNING HOURS 120 (36L;84P).  
Requirements: Prerequisite STAT 463 or permission of the Department.  
Offering Faculty: Faculty of Arts and Science  

STAT 457  Statistical Learning II  Units: 3.00  
Introduction to the theory and application of statistical algorithms. Topics include classification, smoothing, model selection, optimization, sampling, supervised and unsupervised learning. Given jointly with STAT 857.  
LEARNING HOURS 120 (36L;84P).  
Requirements: Prerequisite STAT 361 or ECON 351 or permission of the Department.  
Offering Faculty: Faculty of Arts and Science
STAT 462 Statistical Learning I Units: 3.00
A working knowledge of the statistical software R is assumed. Classification; spline and smoothing spline; regularization, ridge regression, and Lasso; model selection; tree-based methods; resampling methods; importance sampling; Markov chain Monte Carlo; Metropolis-Hasting algorithm; Gibbs sampling; optimization. Given jointly with STAT 862.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite ([STAT 361 or ECON 351] and STAT 362) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 463 Fundamentals of Statistical Inference Units: 3.00
Decision theory and Bayesian inference; principles of optimal statistical procedures; maximum likelihood principle; large sample theory for maximum likelihood estimates; principles of hypotheses testing and the Neyman-Pearson theory; generalized likelihood ratio tests; the chi-square, t, F and other distributions.
LEARNING HOURS 132 (36L;96P).
Requirements: Prerequisite STAT 269. Equivalency STAT 363. Recommended STAT 353.
Course Equivalencies: STAT363; STAT463
Offering Faculty: Faculty of Arts and Science

STAT 464 Discrete Time Series Analysis Units: 3.00
Autocorrelation and autocovariance, stationarity; ARIMA models; model identification and forecasting; spectral analysis. Applications to biological, physical and economic data.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite STAT 361 or ECON 351 or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 465 Quality Management Units: 3.00
An overview of the statistical and lean manufacturing tools and techniques used in the measurement and improvement of quality in business, government and industry today. Topics include management and planning tools, Six Sigma approach, statistical process charting, process capability analysis, measurement system analysis and factorial and fractional factorial design of experiments.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite (STAT 263 or STAT 269) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 466 Statistical Programming with SAS and Applications Units: 3.00
Introduction to the basic knowledge in programming, data management, and exploratory data analysis using SAS software: data manipulation and management; output delivery system; advanced text file generation, statistical procedures and data analysis, macro language, structure query language, and SAS applications in clinical trial, administrative financial data.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite (STAT 263 or STAT 269) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 471 Sampling and Experimental Design Units: 3.00
Simple random sampling; Unequal probability sampling; Stratified sampling; Cluster sampling; Multi-stage sampling; Analysis of variance and covariance; Block designs; Fractional factorial designs; Split-plot designs; Response surface methodology; Robust parameter designs for products and process improvement. Offered jointly with STAT 871.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite ([STAT 361 or ECON 351] and STAT 463) or permission of the Department. Equivalency STAT 362.
Offering Faculty: Faculty of Arts and Science

STAT 473 Generalized Linear Models Units: 3.00
An introduction to advanced regression methods for binary, categorical, and count data. Major topics include maximum-likelihood method, binomial and Poisson regression, contingency tables, log linear models, and random effect models. The generalized linear models will be discussed both in theory and in applications to real data from a variety of sources. Given jointly with STAT 873.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite ([STAT 361 or ECON 351] and STAT 463) or permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 474 Survival Analysis Units: 3.00
Introduces the theory and application of survival analysis: survival distributions and their applications, parametric and nonparametric methods, proportional hazards models, counting process and proportional hazards regression, planning and designing clinical trials. Given jointly with STAT 886.
LEARNING HOURS 120 (36L;84P).
Requirements: Prerequisite ([STAT 361 or ECON 351] and STAT 463) or permission of the Department. Recommended STAT 462.
Offering Faculty: Faculty of Arts and Science
STAT 499  Topics in Statistics  Units: 3.00
An important topic in statistics not covered in any other courses.
Requirements: Prerequisite Permission of the Department. Exclusion STAT 505.
Offering Faculty: Faculty of Arts and Science

STAT 506  Topics in Statistics II  Units: 3.00
An important topic in probability or statistics not covered in any other course.
LEARNING HOURS 132 (24;108P).
Requirements: Prerequisite Permission of the Department.
Offering Faculty: Faculty of Arts and Science

STAT 507  Statistical Learning  Units: 3.00
Introduction to the theory and application of statistical algorithms. Topics may include classification, smoothing, model selection, optimization, sampling, supervised and unsupervised learning. Offered jointly with STAT-457. Exclusion: STAT-456
Offering Faculty: Faculty of Arts and Science

STAT 508  Statistical Spectrum Estimate  Units: 3.00
Many systems evolve with an inherent amount of randomness in time and/or space. The focus of this course is on developing and analyzing methods for analyzing time series. Because most of the common time--domain methods are unreliable, the emphasis is on frequency--domain methods, i.e. methods that work and expose the bias that plagues most time--domain techniques. Slepian sequences (discrete prolate spheroidal sequences) and multi--taper methods of spectrum estimation are covered in detail. (Offered jointly with STAT-454*) Three term-hours, fall; lectures.
Offering Faculty: Faculty of Arts and Science

STAT 509  Topics In Probability  Units: 3.00
A review of probability models and introduction to applied stochastic processes. Topics may include Markov chains, birth and death processes, random walk problems, elementary renewal theory, Markov processes, Brownian motion and Poisson processes, queuing theory. (Offered jointly with STAT-455*) Three term-hours, fall or winter; lectures.
Offering Faculty: Faculty of Arts and Science

STAT 510  Bayesian Analysis  Units: 3.00
This course is an introduction to Bayesian analysis and decision theory. Topics covered will include: elements of decision theory; Bayesian point estimation, set estimation, and hypothesis testing; special priors; computations for Bayesian analysis. Offered jointly with STAT-456. Exclusion: STAT-456
Offering Faculty: Faculty of Arts and Science
STAT 866 Statistical SAS Programming Units: 3.00
Introduction to the basic knowledge in programming, data management, and exploratory data analysis using SAS software: data manipulation and management; output delivery system; advanced text file generation, statistical procedures and data analysis, macro language, structure query language, and SAS applications in clinical trial, administrative financial data. Offered jointly with STAT 466.
Offering Faculty: Faculty of Arts and Science

STAT 871 Sampling and Experimental Design Units: 3.00
Simple random sampling; Unequal probability sampling; Stratified sampling; Cluster sampling; Multi-stage sampling; Analysis of variance and covariance; Block designs; Fractional factorial designs; Split-plot designs; Response surface methodology; Robust parameter designs for products and process improvement. (Offered jointly with STAT-471.) Three term hours; lectures.
Offering Faculty: Faculty of Arts and Science

STAT 873 Generalized Linear Models Units: 3.00
An introduction to advanced regression methods for binary, categorical, and count data. Major topics include maximum-likelihood method, binomial and Poisson regression, contingency tables, log linear models, and random effect models. The generalized linear models will be discussed both in theory and in applications to real data from a variety of sources.(Offered jointly with STAT-473*.)
Offering Faculty: Faculty of Arts and Science

STAT 886 Survival Analysis Units: 3.00
Introduces the theory and application of survival analysis: survival distributions and their applications, parametric and nonparametric methods, proportional hazards models, counting process and proportional hazards regression, planning and designing clinical trials. (Offered jointly with STAT-486*.) Three term-hours, winter; lectures.
Offering Faculty: Faculty of Arts and Science

STAT 888 Master’s Practicum Units: 6.00
Under the guidance of the supervisor, students will carry out a practicum project in a health research group/site and practise biostatistical methods and data analysis, or conduct methodology research in a biostatistical project. Students will summarize the results of the project in a written report that will be reviewed and orally defended.
Offering Faculty: Faculty of Arts and Science

STAT 898 Master’s Project Units: 6.00
Offering Faculty: Faculty of Arts and Science

STAT 899 Master’s Thesis Units: 6.00
Offering Faculty: Faculty of Arts and Science

STAT 952 Topics In Probability Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

STAT 953 Topics In Probability Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

STAT 955 Topics In Probability Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

STAT 963 Topics In Statistics Units: 3.00
Subject matter will vary from year to year. Three term-hours, Fall or winter; Seminar or reading course.
Offering Faculty: Faculty of Arts and Science

BIOM 300 Modeling Techniques in Biology Units: 3.00
Modeling will be presented in the context of biological examples drawn from ecology and evolution, including life history evolution, sexual selection, evolutionary epidemiology and medicine, and ecological interactions. Techniques will be drawn from dynamical systems, probability, optimization, and game theory with emphasis put on how to formulate and analyze models.
LEARNING HOURS 120 (36L;84P)
Requirements: Prerequisite (MATH 120 or MATH 121 or MATH 124) and (MATH 110 or MATH 111 or MATH 112).
Offering Faculty: Faculty of Arts and Science

BIOM 800 Modeling In Ecology/Evolution Units: 3.00
Modeling will be presented in the context of biological examples drawn from ecology and evolution, including life history evolution, sexual selection, evolutionary epidemiology and medicine, and ecological interactions. Techniques will be drawn from dynamical systems, probability, optimization, and game theory with emphasis put on how to formulate and analyze models. Three term hours; winter. T.B.A.
Offering Faculty: Faculty of Arts and Science