

MATHEMATICS AND ENGINEERING

Department Head Professor J. A. Mingo

Chair of Undergraduate Studies A. Mansouri

Curriculum Chair A. Mansouri

Undergraduate Assistant J. Ng

Office Jeffery Hall, Room 310

Telephone (613) 533-2390

E-mail math.engineering@queensu.ca

Departmental Web Site <http://www.queensu.ca/mathstat/>
mthe (<http://www.queensu.ca/mathstat/mthe/>)

This plan was developed at Queen's in response to the need for engineers who possess the skills and insights of applied mathematicians. In the second and third years of the plan, half of the curriculum consists of honours courses in pure and applied mathematics; the balance consists of engineering courses in one of three sub-plans offered in cooperation with the departments of Mechanical, Electrical and Computer Engineering, and the School of Computing. The sub-plans are developed with appropriate applications of mathematics to engineering in the final year. The sub-plans are:

Options available:

- (M6) **Applied Mechanics:** (mechanics, dynamics, fluid mechanics, thermodynamics)
- (M9) **Computing and Communications:** (computer science, software design, communication, information systems, and electrical engineering)
- (M11) **Systems and Robotics:** (electrical and mechanical engineering, control, communications, information systems, robotics, and mechanics)

Programs

- Mathematics and Engineering, B.A.Sc. (Class of 2022) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-basc-class-2022/>)
- Mathematics and Engineering, B.A.Sc. (Class of 2023) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-basc-class-2023/>)
- Mathematics and Engineering, B.A.Sc. (Class of 2024) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-basc-class-2024/>)
- Mathematics and Engineering, Applied Mechanics (M6): Technical Electives (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-applied-mechanics-m6-technical-electives/>)

- Mathematics and Engineering, Computing and Communications (M9): Technical Electives (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-computing-communications-m9-technical-electives/>)
- Mathematics and Engineering, Systems and Robotics (M11): Technical Electives (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/mathematics-engineering/mathematics-engineering-systems-robotics-m11-technical-electives/>)

Courses

MTHE 212 Linear Algebra Units: 3.50

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.

Requirements: APSC174

Offering Faculty: Fac of Engineering Appl Sci

MTHE 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 engineering applications. Topics include symbolic logic; switching and logic circuits; set theory, equivalence relations and mappings; the integers and modular arithmetic; groups, cyclic groups, Lagrange's theorem, group quotients, group homomorphisms and isomorphisms; applications to error-control codes for noisy communication channels.

Requirements: APSC 174 and registered in BSCE or BASC

Offering Faculty: Faculty of Arts and Science

MTHE 224 Applied Math For Civil Eng. Units: 4.20

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.

Requirements: APSC 143, APSC 172, APSC 174

Offering Faculty: Faculty of Arts and Science

**MTHE 225 Ordinary Differential Equations Units: 3.50**

First order differential equations, linear differential equations with constant coefficients, and applications, Laplace transforms, systems of linear equations.

Requirements: APSC 171, APSC 172, APSC 174

Course Equivalencies: MATH225;MTHE225

Offering Faculty: Faculty of Arts and Science

MTHE 226 Differential Equations Units: 3.00

First order differential equations, linear differential equations with constant coefficients, and applications, Laplace transforms, systems of linear equations. (36/0/0/0/0) ~ COURSE DELETED IN 2008/09 ~

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: APSC 171, APSC 172, APSC 174

Offering Faculty: Faculty of Arts and Science

MTHE 228 Complex Analysis Units: 3.50

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.

Requirements: APSC 171, APSC 172, APSC 174,

Offering Faculty: Faculty of Arts and Science

MTHE 235 Diff Equations For Elec & Comp Units: 3.50

First order differential equations, linear differential equations with constant coefficients. Laplace transforms. Systems of linear differential equations. Introduction to numerical methods for ODEs. Examples involving the use of differential equations in solving circuits will be presented.

Requirements: APSC 171, APSC 172, APSC 174

Offering Faculty: Faculty of Arts and Science

MTHE 237 Differential Equations for Engineering Science Units: 3.25

Topics include models for dynamical systems, classification of differential equations, methods for solving differential equations, systems of equations and connections with Linear Algebra, stability of dynamical systems and Lyapunov's method, the Laplace Transform method, and numerical and computer methods.

Requirements: APSC 171, APSC 172, APSC 174

Offering Faculty: Faculty of Arts and Science

MTHE 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 MATH120 OR MATH126 OR MATH121 OR APSC172 OR MATH126

Offering Faculty: Faculty of Arts and Science

MTHE 267 Engineering Data Analysis Units: 3.50

Course is identical to STAT 367 with the exception that STAT 367 has one extra tutorial session. (38/0/0/4/0)~ COURSE DELETED IN 2009/10 ~

Offering Faculty: Faculty of Arts and Science

MTHE 280 Advanced Calculus Units: 3.50

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.

Requirements: Prerequisites: APSC 172, APSC 174

Exclusions: MATH 221, MTHE 227 (MATH 227)

Offering Faculty: Faculty of Arts and Science

MTHE 281 Introduction To Real Analysis Units: 3.50

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.

Requirements: APSC 172, APSC 174, MTHE 280

Offering Faculty: Faculty of Arts and Science

MTHE 326 Functions of a Complex Variable Units: 3.50

Complex numbers, analytic functions, harmonic functions, Cauchy's Theorem, Taylor and Laurent series, calculus of residues, Rouché's Theorem.

Requirements: MTHE 280 or MATH 280 and MTHE

Offering Faculty: Faculty of Arts and Science

MTHE 332 Introduction To Control Units: 4.00

Geometric modelling, 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.

Requirements: MTHE 326 or MATH 326

Offering Faculty: Faculty of Arts and Science

MTHE 333 Control-Robotics Lab I Units: 1.00

This laboratory introduces the use of motion control devices such as optical encoders, pulse width amplifiers and armature controlled DC servo motors. The experiments complement the analytical and theoretical work on control taken in other third year courses. Students design and implement proportional, proportional-derivative, and proportional-integral-derivative controllers.

Requirements: COREQ: MTHE 332

Offering Faculty: Faculty of Arts and Science

MTHE 334 Math Methods For Engrg & Phys Units: 3.50

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.

Requirements: PREREQ: MTHE 212 (MATH 212), MTHE 281 (MATH 281) and registered in BSCE or BASC.

Offering Faculty: Faculty of Arts and Science

MTHE 335 Math Of Engineering Systems Units: 3.50

Linear input/output systems and their stability. Frequency-domain and time-domain analysis. Continuous and discrete time-modeling. Fourier, Laplace, and Z-transforms. Sampling and the discrete-time Fourier transform. Application to modulation of communications signals, filter design, and digital sampling.

Requirements: MTHE 334 or MATH 334 and MTHE

Offering Faculty: Faculty of Arts and Science

MTHE 337 Intro. To Operations Research Units: 3.00

Some probability distributions, simulation, Markov chains, queuing theory, dynamic programming, inventory theory.

Requirements: PREREQ: APSC 174, MTHE 367 and permission of the instructor. Must also be registered in BSCE or BASC.

Offering Faculty: Faculty of Arts and Science

MTHE 338 Fourier Methods for Boundary Value Problems Units: 3.50

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; SturmLiouville theory; Fourier transform techniques.

Requirements: Prereq: MTHE 227 (MATH 227) or

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: PREREQ: APSC 172 or MATH 120 (or MATH121) and APSC 174 or MATH 110 (or MATH 111) and must be registered in BSCE or BASC.

Offering Faculty: Faculty of Arts and Science

MTHE 351 Probability I Units: 3.50

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, timetofailure models, binary communication channels with Gaussian noise.

Requirements: MTHE 280

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: STAT 251 or MTHE 351 or STAT 3

Offering Faculty: Faculty of Arts and Science

MTHE 367 Engineering Data Analysis Units: 3.50

Exploratory data analysis -- graphical and statistical analysis and presentation of experimental data. Random sampling. Probability and probability models for discrete and continuous random variables. Process capability. Normal probability graphs. Sampling distribution of means and proportions. Statistical Quality Control and Statistical Process Control. Estimation using confidence intervals. Testing of hypothesis procedures for means, variances and proportions -- one and two samples cases. Linear regression, residuals and correlation. ANOVA. Use of statistical software.

Requirements: APSC 171 and APSC 172

Offering Faculty: Faculty of Arts and Science



MTHE 393 Engineering Design and Practice for Mathematics and Engineering Units: 4.00

This is a project-based design course where methods of applied mathematics are used to solve a complex open-ended engineering problem. The projects involve using system theoretic methods for modelling, analysis, and design applied to engineering problems arising in a variety of engineering disciplines. Students will work in teams and employ design processes to arrive at a solution. The course will include elements of communications, economic analysis, impacts of engineering, professionalism, and engineering ethics.

Requirements: PreReq APSC 200 (or APSC 202)

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: MATH 212 or MTHE 217 or MATH 2

Offering Faculty: Faculty of Arts and Science

MTHE 418 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. Simple cryptographic systems; public key, RSA. Primality and factoring; pseudoprimes, Pollard's rho-method, index calculus. Elliptic curve cryptography.

Requirements: MATH 210 or MATH 212 or MTHE 2

Offering Faculty: Faculty of Arts and Science

MTHE 430 Modern Control Theory Units: 4.00

This course covers core topics in modern control theory: Linearization, existence and uniqueness of trajectories for nonlinear and linear systems, the transition matrix, controllability, observability, minimal realizations, feedback stabilization, linear state observers, optimal control theory, the linear quadratic regulator, dynamic programming.

Requirements: PREREQ: MTHE 237 (MATH 237), MTHE 212 (MATH 212) or MTHE 312 (MATH 312), MTHE 326 (MATH 326), MTHE 332 (MATH 332), or permission of the instructor. Must be registered in BSCE or BASC.

Offering Faculty: Faculty of Arts and Science

MTHE 433 Continuum Mechanics with Applications Units: 3.00

Continuum mechanics lays the foundations for the study of the mechanical behavior of solids and fluids. After a review of vector and tensor analysis, the kinematics of continua are introduced. Emphasis is given to the concepts of stress, strain and deformation. The fundamental laws of conservation of mass, balances of (linear and angular) momentum and energy are presented together with the constitutive models. Applications of these models are given in the theory of linearized elasticity and fluid dynamics.

Requirements: Pre-requisites MTHE 237, MTHE 280, or permission of the instructor

Offering Faculty: Faculty of Arts and Science

MTHE 434 Optimization Theory with Applications to Machine Learning Units: 3.50

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.

Requirements: MTHE 281, MTHE 212

Offering Faculty: Fac of Engineering Appl Sci

MTHE 437 Topics In Applied Mathematics Units: 3.50

Subject matter to vary from year to year. Given jointly with MATH 837*.

Offering Faculty: Faculty of Arts and Science

MTHE 439 Lagrangian Mechanics, Dynamics

Control Units: 3.50

Geometric modelling, 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.

Requirements: MTHE 280 or MATH 280 and MTHE

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: PREREQUISITES: MTHE 353 (STAT 353), MTHE 312 (MATH 312); or MTHE 338 (MATH 338), STAT 251; or STAT 261, MATH 321; or permission of the instructor. Must be registered in a BSCE or BASC Academic Program.

Offering Faculty: Faculty of Arts and Science

MTHE 455 Stochastic Processes & Applications Units: 3.50

Markov chains, birth and death processes, random walk problems, elementary renewal theory, Markov processes, Brownian motion and Poisson processes, queuing theory, branching processes.

Requirements: MTHE 353 (STAT 353) or one of STAT 251, MTHE 351 (STAT 351), ELEC 326 with permission of the instructor

Offering Faculty: Faculty of Arts and Science

MTHE 472 Control Of Stochastic Systems Units: 3.00

This course concerns the 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 and stochastic stability; martingale methods for stability and stochastic learning; dynamic programming and optimal control for finite horizons, infinite horizons, and average cost problems; partially observed models, non-linear filtering and Kalman Filtering; linear programming and numerical methods; reinforcement learning and stochastic approximation methods; decentralized stochastic control, and continuous-time stochastic control.

Requirements: MTHE 351 or STAT 351 and MTHE

Offering Faculty: Faculty of Arts and Science

MTHE 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.

Requirements: PREREQUISITES: STAT 251 or MTHE 351 (STAT 351) or ELEC 326. Must be registered in a BSCE or BASC Academic Program.

Offering Faculty: Faculty of Arts and Science

MTHE 477 Data Compression & Source Codi 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.

Requirements: MTHE 474 or MATH 474 and regis

Offering Faculty: Faculty of Arts and Science

MTHE 478 Topics In Communication Theory Units: 3.00

Subject matter will vary from year to year. Possible subjects include: constrained coding and applications to magnetic and optical recording; data compression; theory and practice of error-control coding; design and performance analysis of communication networks; and other related topics.

Requirements: Permission of the instructor and must be registered in a BSCE or BASC Academic Program.

Offering Faculty: Faculty of Arts and Science

MTHE 484 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.

Requirements: MTHE 455 or STAT 455 and regis

Offering Faculty: Faculty of Arts and Science

**MTHE 493 Engineering Math Project Units: 7.50**

This is the capstone design course for Mathematics and Engineering. Students must work in groups, with a typical group size being between two and four members. Projects are selected early in the year from a list put forward by Mathematics and Engineering faculty members who will also supervise the projects. There is a heavy emphasis on engineering design and professional practice. All projects must be open-ended and design oriented, and students are expected to undertake and demonstrate, in presentations and written work, a process by which the design facets of the project are approached. Projects must involve social, environmental, and economic factors, and students are expected to address these factors comprehensively in presentations and written work. Students are assessed individually and as a group on their professional conduct during the course of the project.

Requirements: Must be registered in BASC

Offering Faculty: Faculty of Arts and Science

MTHE 494 Mathematics and Engineering Seminar Units: 3.00

This is a seminar and course, with an emphasis on communication skills and professional practice. A writing module develops technical writing skills. Students give an engineering presentation to develop their presentation skills. Seminars are given by faculty from the Mathematics and Engineering program, by Mathematics and Engineering alumni on the career paths since completing the program, and by visiting speakers on a variety of professional practice matters, on topics such as workplace safety, workplace equity and human rights, and professional organizations. Open to Mathematics and Engineering students only.

Requirements: Must be registered in BASC

Offering Faculty: Faculty of Arts and Science