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)

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

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: 3.50
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’, 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

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, Rouche’s Theorem.

Requirements: MTHE 280 or MATH 280 and MTHE
Offering Faculty: Faculty of Arts and Science

MTHE 328  Real Analysis  Units: 3.00

Requirements: MTHE 281 and Must be enrolled
Offering Term: W
Offering Faculty: Fac of Engineering Appl Sci
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
Requirements: MTHE 326 or MTHE 228
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: MTHE 351 or 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; Sturm-Liouville 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
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: Pre Req APSC 200 (or APSC 202)
Offering Faculty: Faculty of Arts and Science

MTHE 406  Introduction To Coding Theory  Units: 3.00
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: pseudoprimates, 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  Control Theory  Units: 4.00
This course covers core topics in both classical and modern control theory. Overview of classical control theory using frequency methods. Linear and nonlinear controlled differential systems and their solutions. Stabilization and stability methods via Lyapunov analysis or linearization. Controllability, observability, minimal realizations, feedback stabilization, observer design. Optimal control theory, the linear quadratic regulator, dynamic programming.
Requirements: PREREQ: MTHE 237, MTHE 212, MTHE 326 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  
Topic: An Introduction to Stochastic Differential Equations  
(with Applications to Mathematical Finance and Engineering)  
The aim of this course is to provide a rigorous introduction  
to the theory of stochastic calculus and stochastic differential  
equations, and to survey some of its most important  
applications, especially in Mathematical Finance. The  
Itô stochastic integral and its associated “Itô Calculus”  
will be derived in the general framework of continuous  
semimartingales, leading to a detailed treatment of stochastic  
differential equations (SDEs) and their properties. The theory  
thus developed will be applied to selected problems in  
Mathematical Finance (option pricing and hedging, trading  
strategies and arbitrage) and Engineering (boundary-value  
problems, filtering, optimal control). Numerical aspects of  
SDEs will also be discussed.  
Requirements: PRE-REQ: MTHE 328 and MTHE 351 or  
permission of the instructor  
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 or 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  
Offering Faculty: Faculty of Arts and Science  

MTHE 457  Statistical Learning  Units: 3.00  
Introduction to the theory and application of statistical  
algorithms. Topics include classification, smoothing,  
model selection, optimization, sampling, supervised and  
unsupervised learning.  
Requirements: MTHE 351 Must be enrolled in  
Offering Term: W  
Offering Faculty: Fac of Engineering Appl Sci  

MTHE 472  Optimization and Control of Stochastic  
Systems  Units: 3.50  
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 permission of the instructor  
Offering Faculty: Faculty of Arts and Science  

MTHE 474  Information Theory  Units: 3.50  
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 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.  
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