MATHEMATICS AND ENGINEERING

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 281
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; 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  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 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 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 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
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 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