MATH 100
Introduction to the Profession
Introduces the student to the scope of mathematics as a profession, develops a sense of mathematical curiosity and problem solving skills, identifies and reinforces the student’s career choices, and provides a mechanism for regular academic advising. Provides integration with other first-year courses. Introduces applications of mathematics to areas such as engineering, physics, computer science, and finance. Emphasis is placed on the development of teamwork skills.
Lecture: 3 Lab: 0 Credits: 3  
Satisfies: Communications (C)

MATH 119
Geometry for Architects
Basic Euclidean and analytic geometry in two and three dimensions; trigonometry. Equations of lines, circles and conic sections; resolution of triangles; polar coordinates. Equations of planes, lines, quadratic surfaces. Applications. This course does not count toward any mathematics requirements in business, computer science, engineering, mathematics, or natural science degree programs.
Lecture: 3 Lab: 1 Credits: 3  
Satisfies: Communications (C)

MATH 122
Introduction to Calculus
Basic concepts of calculus of a single variable; limits, continuity, derivatives, and integrals. Applications. This course does not count toward any mathematics requirements in business, computer science, engineering, mathematics, or natural science degree programs.
Lecture: 3 Lab: 1 Credits: 3

MATH 130
Thinking Mathematically
This course allows students to discover, explore, and apply modern mathematical ideas. Emphasis is placed on using sound reasoning skills, visualizing mathematical concepts, and communicating mathematical ideas effectively. Classroom discussion and group work on challenging problems are central to the course. Topics from probability, statistics, logic, number theory, graph theory, combinatorics, chaos theory, the concept of infinity, and geometry may be included. This course does not count toward any mathematics requirements in business, computer science, engineering, mathematics, or natural science degree programs.
Lecture: 3 Lab: 0 Credits: 3  
Satisfies: Communications (C)

MATH 148
Preparation for Calculus
Review of algebra and analytic geometry. Functions, limits, derivatives. Trigonometry, trigonometric functions and their derivatives. Inverse functions, inverse trigonometric functions and their derivatives. Exponential and logarithmic functions. This course does not count toward any mathematics requirements in business, computer science, engineering, mathematics, or natural science degree programs.
Lecture: 4 Lab: 0 Credits: 4

MATH 151
Calculus I
Prerequisite(s): IIT Mathematics Placement score of 151 or MATH 149 with min. grade of C or MATH 151 with min. grade of C  
Lecture: 4 Lab: 1 Credits: 5  
Satisfies: Communications (C)

MATH 152
Calculus II
Prerequisite(s): MATH 149 with min. grade of C or MATH 151 with min. grade of C  
Lecture: 4 Lab: 1 Credits: 5  
Satisfies: Communications (C)

MATH 230
Introduction to Discrete Math
Sets, statements, and elementary symbolic logic; relations and digraphs; functions and sequences; mathematical induction; basic counting techniques and recurrence. Credit will not be granted for both CS 330 and MATH 230.
Lecture: 3 Lab: 0 Credits: 3

MATH 251
Multivariate and Vector Calculus
Prerequisite(s): MATH 152  
Lecture: 4 Lab: 0 Credits: 4

MATH 252
Introduction to Differential Equations
Prerequisite(s): MATH 152  
Lecture: 4 Lab: 0 Credits: 4

MATH 300
Perspectives in Analysis
The course is focused on selected topics related to fundamental concepts and methods of classic analysis and their applications with emphasis on various problem-solving strategies, visualization, mathematical modeling, and interrelation of different areas of mathematics.
Prerequisite(s): MATH 252 and MATH 251  
Lecture: 3 Lab: 0 Credits: 3
MATH 332
Elementary Linear Algebra
Systems of linear equations; matrix algebra, inverses, determinants, eigenvalues, and eigenvectors, diagonalization; vector spaces, basis, dimension, rank and nullity; inner product spaces, orthonormal bases; quadratic forms.
Prerequisite(s): MATH 251*. An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MATH 333
Matrix Algebra and Complex Variables
Vectors and matrices; matrix operations, transpose, rank, inverse; determinants; solution of linear systems; eigenvalues and eigenvectors. The complex plane; analytic functions; contour integrals; Laurent series expansions; singularities and residues.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 350
Introduction to Computational Mathematics
Study and design of mathematical models for the numerical solution of scientific problems. This includes numerical methods for the solution on linear and nonlinear systems, basic data fitting problems, and ordinary differential equations. Robustness, accuracy, and speed of convergence of algorithms will be investigated including the basics of computer arithmetic and round-off errors.
Same as MMAE 350.
Prerequisite(s): (CS 104 or CS 105 or CS 115) and MATH 251 and MATH 252
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 374
Probability and Statistics for Electrical and Computer Engineers
This course focuses on the introductory treatment of probability theory including: axioms of probability, discrete and continuous random variables, random vectors, marginal, joint, conditional and cumulative probability distributions, moment generating functions, expectations, and correlations. Also covered are sums of random variables, central limit theorem, sample means, and parameter estimation. Furthermore, random processes and random signals are covered. Examples and applications are drawn from problems of importance to electrical and computer engineers. Credit only granted for one of MATH 374, MATH 474, and MATH 475.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 380
Introduction to Mathematical Modeling
This course provides an introduction to problem-driven (as opposed to method-driven) applications of mathematics with a focus on design and analysis of models using tools from all parts of mathematics.
Prerequisite(s): (CS 104 or CS 105 or CS 115) and MATH 251 and MATH 252* and MATH 332, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 400
Real Analysis
Real numbers, continuous functions; differentiation and Riemann integration. Functions defined by series.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 402
Complex Analysis
Analytic functions, conformal mapping, contour integration, series expansions, singularities and residues, and applications. Intended as a first course in the subject for students in the physical sciences and engineering.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 405
Introduction to Iteration and Chaos
Functional iteration and orbits, periodic points and Sharkovsky's cycle theorem, chaos and dynamical systems of dimensions one and two. Julia sets and fractals, physical implications.
Prerequisite(s): (MATH 251 and MATH 252 and MATH 332) or (MATH 252 and MATH 333 and MATH 251)
Lecture: 3 Lab: 0 Credits: 3

MATH 410
Number Theory
Divisibility, congruencies, distribution of prime numbers, functions of number theory, diophantine equations, applications to encryption methods.
Prerequisite(s): MATH 230
Lecture: 3 Lab: 0 Credits: 3

MATH 420
Geometry
The course is focused on selected topics related to fundamental ideas and methods of Euclidean geometry, non-Euclidean geometry, and differential geometry in two and three dimensions and their applications with emphasis on various problem-solving strategies, geometric proof, visualization, and interrelation of different areas of mathematics. Permission of the instructor is required.
Lecture: 3 Lab: 0 Credits: 3

MATH 425
Statistical Methods
Concepts and methods of gathering, describing and analyzing data including basic statistical reasoning, basic probability, sampling, hypothesis testing, confidence intervals, correlation, regression, forecasting, and nonparametric statistics. No knowledge of calculus is assumed. This course is useful for students in education or the social sciences. This course does not count for graduation in any mathematics programs. Credit not given for both MATH 425 and MATH 476.
Lecture: 3 Lab: 0 Credits: 3
MATH 426
Statistical Tools for Engineers
Descriptive statistics and graphs, probability distributions, random sampling, independence, significance tests, design of experiments, regression, time-series analysis, statistical process control, introduction to multivariate analysis. Same as CHE 426. Credit not given for both Math 426 and CHE 426.
Lecture: 3 Lab: 0 Credits: 3

MATH 430
Applied Algebra
Introduction to groups, homomorphisms, group actions, rings, field theory. Applications, including constructions with ruler and compass, solvability by radicals, error correcting codes.
Prerequisite(s): MATH 230 or MATH 332*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 431
Computational Algebraic Geometry
Systems of polynomial equations and ideals in polynomial rings; solution sets of systems of equations and algebraic varieties in affine n-space; effective manipulation of ideals and varieties, algorithms for basic algebraic computations; Groebner bases; applications. Credit may not be granted for both MATH 431 and MATH 530.
Prerequisite(s): MATH 332 and MATH 230
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 435
Linear Optimization
Introduction to both theoretical and algorithmic aspects of linear optimization: geometry of linear programs, simplex method, anticycling, duality theory and dual simplex method, sensitivity analysis, large scale optimization via Dantzig-Wolfe decomposition and Benders decomposition, interior point methods, network flow problems, integer programming. Credit may not be granted for both MATH 435 and MATH 535.
Prerequisite(s): MATH 332
Lecture: 3 Lab: 0 Credits: 3

MATH 453
Combinatorics
Permutations and combinations; pigeonhole principle; inclusion-exclusion principle; recurrence relations and generating functions; enumeration under group action.
Prerequisite(s): MATH 230
Lecture: 3 Lab: 0 Credits: 3

MATH 454
Graph Theory and Applications
Directed and undirected graphs; paths, cycles, trees, Eulerian cycles, matchings and coverings, connectivity, Menger's Theorem, network flow, coloring, planarity, with applications to the sciences (computer, life, physical, social) and engineering.
Prerequisite(s): (MATH 230 and MATH 251) or (MATH 252 and MATH 230)
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 461
Fourier Series and Boundary-Value Problems
Prerequisite(s): MATH 251 and MATH 252
Lecture: 3 Lab: 0 Credits: 3

MATH 474
Probability and Statistics
Elementary probability theory including discrete and continuous distributions, sampling, estimation, confidence intervals, hypothesis testing, and linear regression. Credit not granted for both MATH 474 and MATH 475.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 475
Probability
Elementary probability theory; combinatorics; random variables; discrete and continuous distributions; joint distributions and moments; transformations and convolution; basic theorems; simulation. Credit not granted for both MATH 474 and MATH 475.
Prerequisite(s): MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 476
Statistics
Estimation theory; hypothesis tests; confidence intervals; goodness-of-fit tests; correlation and linear regression; analysis of variance; nonparametric methods.
Prerequisite(s): MATH 475
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 477
Numerical Linear Algebra
Fundamentals of matrix theory; least squares problems; computer arithmetic; conditioning and stability; direct and iterative methods for linear systems; eigenvalue problems. Credit may not be granted for both MATH 477 and MATH 577.
Prerequisite(s): MATH 350 or MMAE 350
Lecture: 3 Lab: 0 Credits: 3

MATH 478
Numerical Methods for Differential Equations
Polynomial interpolation; numerical integration; numerical solution of initial value problems for ordinary differential equations by single and multi-step methods, Runge-Kutta, Predictor-Corrector; numerical solution of boundary value problems for ordinary differential equations by shooting method, finite differences and spectral methods. Credit may not be granted for both MATH 478 and MATH 578.
Prerequisite(s): MATH 350 or MMAE 350
Lecture: 3 Lab: 0 Credits: 3
MATH 481
Introduction to Stochastic Processes
This is an introductory, undergraduate course in stochastic processes. Its purpose is to introduce students to a range of stochastic processes which are used as modeling tools in diverse fields of applications, especially in risk management applications for finance and insurance. The course covers basic classes of stochastic processes: Markov chains and martingales in discrete time; Brownian motion; and Poisson process. It also presents some aspects of stochastic calculus.
Prerequisite(s): (MATH 332 and MATH 475) or (MATH 475 and MATH 333)
Lecture: 3 Lab: 0 Credits: 3

MATH 483
Design and Analysis of Experiments
Review of elementary probability and statistics; analysis of variance for design of experiments; estimation of parameters; confidence intervals for various linear combinations of the parameters; selection of sample sizes; various plots of residuals; block designs; Latin squares; one, two, and 2^k factorial designs; nested and cross factor designs; regression; nonparametric techniques.
Prerequisite(s): MATH 476
Lecture: 3 Lab: 0 Credits: 3

MATH 484
Regression and Forecasting
Simple linear regression; multiple linear regression; least squares estimates of parameters; hypothesis testing and confidence intervals in linear regression models; testing of models, data analysis, and appropriateness of models; linear time series models; moving average, autoregressive and/or ARIMA models; estimation, data analysis, and forecasting with time series models; forecasting errors and confidence intervals. Credit may not be granted for both MATH 484 and MATH 564.
Prerequisite(s): MATH 474 or MATH 476
Lecture: 3 Lab: 0 Credits: 3
Satisfies: Communications (C)

MATH 485
Introduction to Mathematical Finance
This is an introductory course in mathematical finance. Technical difficulty of the subject is kept at a minimum while the major ideas and concepts underlying modern mathematical finance and financial engineering are explained and illustrated. The course covers the binomial model for stock prices and touches on continuous time models and the Black-Scholes formula.
Prerequisite(s): MATH 475
Lecture: 3 Lab: 0 Credits: 3

MATH 486
Mathematical Modeling I
The course provides a systematic approach to modeling applications from areas such as physics and chemistry, engineering, biology, and business (operations research). The mathematical models lead to discrete or continuous processes that may be deterministic or stochastic. Dimensional analysis and scaling are introduced to prepare a model for study. Analytic and computational tools from a broad range of applied mathematics will be used to obtain information about the models. The mathematical results will be compared to physical data to assess the usefulness of the models. Credit may not be granted for both MATH 486 and MATH 522.
Prerequisite(s): MATH 251 and MATH 332 and MATH 252
Lecture: 3 Lab: 0 Credits: 3

MATH 487
Mathematical Modeling II
The formulation of mathematical models, solution of mathematical equations, interpretation of results. Selected topics from queuing theory and financial derivatives.
Prerequisite(s): MATH 252
Lecture: 3 Lab: 0 Credits: 3

MATH 488
Ordinary Differential Equations and Dynamical Systems
Boundary-value problems and Sturm-Liouville theory; linear system theory via eigenvalues and eigenvectors; Floquet theory; nonlinear systems: critical points, linearization, stability concepts, index theory, phase portrait analysis, limit cycles, and stable and unstable manifolds; bifurcation; and chaotic dynamics.
Prerequisite(s): MATH 252 and MATH 251
Lecture: 3 Lab: 0 Credits: 3

MATH 489
Partial Differential Equations
First-order equations, characteristics. Classification of second-order equations. Laplace’s equation; potential theory. Green’s function, maximum principles. The wave equation: characteristics, general solution. The heat equation: use of integral transforms.
Prerequisite(s): MATH 461
Lecture: 3 Lab: 0 Credits: 3

MATH 491
Reading and Research
Independent reading and research. **Instructor permission required.**
Credit: Variable
Satisfies: Communications (C)

MATH 497
Special Problems
Special problems.
Credit: Variable
Satisfies: Communications (C)
Lecture: MATH 522
will be compared to physical data to assess the usefulness of
obtain information about the models. The mathematical results
introduced to prepare a model for study. Analytic and computational
deterministic or stochastic. Dimensional analysis and scaling are
models lead to discrete or continuous processes that may be
biology, and business (operations research). The mathematical
applications from areas such as physics and chemistry, engineering,

Prerequisite(s): MATH 400
Lecture: 3 Lab: 0 Credits: 3

MATH 501
Applied Analysis II
Bounded Linear Operators on a Hilbert Space; Spectrum of Bounded
Linear Operators; Fourier Series; Linear Differential Operators
and Green's Functions; Distributions and the Fourier Transform;
Differential Calculus and Variational Methods.
Prerequisite(s): MATH 500
Lecture: 3 Lab: 0 Credits: 3

MATH 512
Partial Differential Equations
Basic model equations describing wave propagation, diffusion
and potential functions; characteristics, Fourier transform, Green
function, and eigenfunction expansions; elementary theory of partial
differential equations; Sobolev spaces; linear elliptic equations;
energy methods; semigroup methods; applications to partial
differential equations from engineering and science.
Prerequisite(s): MATH 461 or MATH 489
Lecture: 3 Lab: 0 Credits: 3

MATH 515
Ordinary Differential Equations and Dynamical Systems
Basic theory of systems of ordinary differential equations;
equilibrium solutions, linearization and stability; phase portraits
analysis; stable unstable and center manifolds; periodic orbits,
homoclinic and heteroclinic orbits; bifurcations and chaos;
nonautonomous dynamics; and numerical simulation of nonlinear
dynamics.
Prerequisite(s): MATH 252
Lecture: 3 Lab: 0 Credits: 3

MATH 519
Complex Analysis
Analytic functions, contour integration, singularities, series,
conformal mapping, analytic continuation, multivalued functions.
Prerequisite(s): MATH 402
Lecture: 3 Lab: 0 Credits: 3

MATH 522
Mathematical Modeling
The course provides a systematic approach to modeling
applications from areas such as physics and chemistry, engineering,
biology, and business (operations research). The mathematical
models lead to discrete or continuous processes that may be
deterministic or stochastic. Dimensional analysis and scaling are
introduced to prepare a model for study. Analytic and computational
tools from a broad range of applied mathematics will be used to
obtain information about the models. The mathematical results
will be compared to physical data to assess the usefulness of
the models. Credit may not be granted for both MATH 486 and
MATH 522.
Lecture: 3 Lab: 0 Credits: 3

MATH 523
Case Studies and Project Design in Applied Mathematics
The goal of the course is for students to learn how to use applied
mathematics methods and skills to analyze real-world problems and
to communicate their results in a non-academic setting. Students
will work in groups of 2 or 3 to study and analyze problems and then
provide useful information to a potential client. The time distribution
is flexible and includes discussions of problems, presentation
of needed background material and the required reports, and
presentations by the teams. Several small projects will be examined
and reported on.
Prerequisite(s): MATH 522 and CHEM 511
Lecture: 6 Lab: 0 Credits: 6

MATH 525
Statistical Models and Methods
Concepts and methods of gathering, describing and analyzing
data including statistical reasoning, basic probability, sampling,
hypothesis testing, confidence intervals, correlation, regression,
forecasting, and nonparametric statistics. No knowledge of calculus
is assumed. This course is useful for graduate students in education
or the social sciences. This course does not count for graduation in
any mathematics program. Credit given only for one of the following:
MATH 425, MATH 476, or MATH 525.
Lecture: 3 Lab: 0 Credits: 3

MATH 530
Applied and Computational Algebra
Basics of computation with systems of polynomial equations, ideals
in polynomial rings; solving systems of equations by Groebner
bases; introduction to elimination theory; algebraic varieties in affine
n-space; Zariski topology; dimension, degree, their computation and
theoretical consequences.
Prerequisite(s): MATH 532 or MATH 332
Lecture: 3 Lab: 0 Credits: 3

MATH 532
Linear Algebra
Matrix algebra, vector spaces, norms, inner products and
orthogonality, determinants, linear transformations, eigenvalues and
eigenvectors, Cayley-Hamilton theorem, matrix factorizations (LU,
QR, SVD).
Prerequisite(s): MATH 332
Lecture: 3 Lab: 0 Credits: 3

MATH 535
Optimization I
Introduction to both theoretical and algorithmic aspects of linear
optimization: geometry of linear programs, simplex method,
anticycling, duality theory and dual simplex method, sensitivity
analysis, large scale optimization via Dantzig-Wolfe decomposition
and Benders decomposition, interior point methods, network flow
problems, integer programming. Credit may not be given for both
MATH 435 and MATH 535.
Prerequisite(s): MATH 332
Lecture: 3 Lab: 0 Credits: 3
MATH 540
Probability
Random events and variables, probability distributions, sequences of random variables, limit theorems, conditional expectations, and martingales.
Prerequisite(s): MATH 475 with min. grade of C and MATH 400 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

MATH 542
Stochastic Processes
This is an introductory course in stochastic processes. Its purpose is to introduce students into a range of stochastic processes, which are used as modeling tools in diverse field of applications, especially in the business applications. The course introduces the most fundamental ideas in the area of modeling and analysis of real World phenomena in terms of stochastic processes. The course covers different classes of Markov processes: discrete and continuous-time Markov chains, Brownian motion, and diffusion processes. It also presents some aspects of stochastic calculus with emphasis on the application to financial modeling and financial engineering.
Prerequisite(s): (MATH 332 or MATH 333) and MATH 475
Lecture: 3 Lab: 0 Credits: 3

MATH 543
Stochastic Analysis
This course will introduce the student to modern finite dimensional stochastic analysis and its applications. The topics will include: a) an overview of modern theory of stochastic processes, with focus on semimartingales and their characteristics, b) stochastic calculus for semimartingales, including Ito formula and stochastic integration with respect to semimartingales, c) stochastic differential equations (SDE’s) driven by semimartingales, with focus on stochastic SDE’s driven by Levy processes, d) absolutely continuous changes of measures for semimartingales, e) some selected applications.
Prerequisite(s): MATH 540
Lecture: 3 Lab: 0 Credits: 3

MATH 544
Stochastic Dynamics
This course is about modeling, analysis, simulation and prediction of dynamical behavior of complex systems under random influences. The mathematical models for such systems are in the form of stochastic differential equations. It is especially appropriate for graduate students who would like to use stochastic methods in their research, or to learn these methods for long term career development. Topics include white noise and colored noise, stochastic differential equations, random dynamical systems, numerical simulation, and applications to scientific, engineering and other areas.
Prerequisite(s): MATH 540
Lecture: 3 Lab: 0 Credits: 3

MATH 545
Stochastic Partial Differential Equations
This course introduces various methods for understanding solutions and dynamical behaviors of stochastic partial differential equations arising from mathematical modeling in science, engineering, and other areas. It is designed for graduate students who would like to use stochastic methods in their research or to learn such methods for long term career development. Topics include the following: Random variables; Brownian motion and stochastic calculus in Hilbert spaces; Stochastic heat equation; Stochastic wave equation; Analytical and approximation techniques; Stochastic numerical simulations via Matlab; and applications to science, engineering, and other areas.
Prerequisite(s): MATH 540 or MATH 543 or MATH 544
Lecture: 3 Lab: 0 Credits: 3

MATH 546
Introduction to Time Series
Properties of stationary, random processes; standard discrete parameter models, autoregressive, moving average, harmonic; standard continuous parameter models. Spectral analysis of stationary processes, relationship between the spectral density function and the autocorrelation function; spectral representation of some stationary processes; linear transformations and filters. Introduction to estimation in the time and frequency domains.
Prerequisite(s): MATH 475 or ECE 511
Lecture: 3 Lab: 0 Credits: 3

MATH 548
Mathematical Finance I
This is an introductory course in mathematical finance. Technical difficulty of the subject is kept at a minimum by considering a discrete time framework. Nevertheless, the major ideas and concepts underlying modern mathematical finance and financial engineering are explained and illustrated.
Prerequisite(s): MATH 474 or MATH 475
Lecture: 3 Lab: 0 Credits: 3

MATH 550
Topology
Topological spaces, continuous mappings and homeomorphisms, metric spaces and metrizability, connectedness and compactness, homotopy theory.
Prerequisite(s): MATH 556
Lecture: 3 Lab: 0 Credits: 3

MATH 553
Discrete Applied Mathematics I
A graduate-level introduction to modern graph theory through existential and algorithmic problems, and the corresponding structural and extremal results from matchings, connectivity, planarity, coloring, Turan-type problems, and Ramsey theory. Proof techniques based on induction, extremal choices, and probabilistic methods will be emphasized with a view towards building an expertise in working in discrete applied mathematics.
Prerequisite(s): MATH 454
Lecture: 3 Lab: 0 Credits: 3
MATH 554
Discrete Applied Mathematics II
A graduate-level course that introduces students in applied mathematics, computer science, natural sciences, and engineering, to the application of modern tools and techniques from various fields of mathematics to existential and algorithmic problems arising in discrete applied math. Probabilistic methods, entropy, linear algebra methods, Combinatorial Nullstellensatz, and Markov chain Monte Carlo, are applied to fundamental problems like Ramsey-type problems, intersecting families of sets, extremal problems on graphs and hypergraphs, optimization on discrete structures, sampling and counting discrete objects, etc.
Prerequisite(s): MATH 454 or MATH 553
Lecture: 3 Lab: 0 Credits: 3

MATH 555
Tensor Analysis
Development of the calculus of tensors with applications to differential geometry and the formulation of the fundamental equations in various fields.
Prerequisite(s): MATH 332 and MATH 400
Lecture: 3 Lab: 0 Credits: 3

MATH 556
Metric Spaces
Point-set theory, compactness, completeness, connectedness, total boundedness, density, category, uniform continuity and convergence, Stone-Weierstrass theorem, fixed point theorems.
Prerequisite(s): MATH 400
Lecture: 3 Lab: 0 Credits: 3

MATH 557
Probabilistic Methods in Combinatorics
Graduate level introduction to probabilistic methods, including linearity of expectation, the deletion method, the second moment method and the Lovasz Local Lemma. Many examples from classical results and recent research in combinatorics will be included throughout, including from Ramsey Theory, random graphs, coding theory and number theory.
Lecture: 3 Lab: 0 Credits: 3

MATH 563
Mathematical Statistics
Theory of sampling distributions; principles of data reduction; interval and point estimation, sufficient statistics, order statistics, hypothesis testing, correlation and linear regression; introduction to linear models. Credit given only for one of MATH 425, MATH 476, MATH 525, or MATH 563.
Prerequisite(s): MATH 474 or MATH 475
Lecture: 3 Lab: 0 Credits: 3

MATH 564
Applied Statistics
Simple linear regression; multiple linear regression; least squares estimates of parameters; hypothesis testing and confidence intervals in linear regression models; testing of models, data analysis, and appropriateness of models; linear time series models; moving average, autoregressive and/or ARIMA models; estimation, data analysis, and forecasting with time series models; forecasting errors and confidence intervals. Credit may not be granted for both MATH 484 and MATH 564.
Prerequisite(s): MATH 474 or MATH 476 or MATH 563
Lecture: 3 Lab: 0 Credits: 3

MATH 565
Monte Carlo Methods in Finance
In addition to the theoretical constructs in financial mathematics, there are also a range of computational/simulation techniques that allow for the numerical evaluation of a wide range of financial securities. This course will introduce the student to some such simulation techniques, known as Monte Carlo methods, with focus on applications in financial risk management. Monte Carlo and Quasi Monte Carlo techniques are computational sampling methods which track the behavior of the underlying securities in an option or portfolio and determine the derivative’s value by taking the expected value of the discounted payoffs at maturity. Recent developments with parallel programming techniques and computer clusters have made these methods widespread in the finance industry.
Prerequisite(s): MATH 474 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

MATH 566
Multivariate Analysis
Random vectors, sample geometry and random sampling, generalized variance, multivariate normal and Wishart distributions, estimation of mean vector, confidence region, Hotelling’s T-square, covariance, principal components, factor analysis, discrimination, clustering.
Prerequisite(s): MATH 532 and MATH 564 and MATH 563
Lecture: 3 Lab: 0 Credits: 3

MATH 567
Advanced Design of Experiments
Various type of designs for laboratory and computer experiments, including fractional factorial designs, optimal designs and space filling designs.
Prerequisite(s): MATH 474 or MATH 476
Lecture: 3 Lab: 0 Credits: 3

MATH 568
Topics in Statistics
Categorical data analysis, contingency tables, log-linear models, nonparametric methods, sampling techniques.
Prerequisite(s): MATH 563
Lecture: 3 Lab: 0 Credits: 3
Mathematics (MATH)

MATH 569
Statistical Learning
The wealth of observational and experimental data available provides great opportunities for us to learn more about our world. This course teaches modern statistical methods for learning from data, such as regression, classification, kernel methods, and support vector machines.
Prerequisite(s): (MATH 474 or MATH 475) and MATH 350
Lecture: 3 Lab: 0 Credits: 3

MATH 571
Data Preparation and Analysis
This course surveys industrial and scientific applications of data analytics with case studies including exploration of ethical issues. Students will learn how to prepare data for analysis, perform exploratory data analysis, and develop meaningful data visualizations. They will work with a variety of real world data sets and learn how to prepare data sets for analysis by cleaning and reformatting. Students will also learn to apply a variety of different data exploration techniques including summary statistics and visualization methods.
Prerequisite(s): MATH 570* or CSP 570*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MATH 572
Data Science Practicum
In this project-oriented course, students will work in small groups to solve real-world data analysis problems and communicate their results. Innovation and clarity of presentation will be key elements of evaluation. Students will have an option to do this as an independent data analytics internship with an industry partner.
Prerequisite(s): SCI 522 and (CSP 571 or MATH 571)
Lecture: 3 Lab: 3 Credits: 6

MATH 573
Reliable Mathematical Software
Many mathematical problems cannot be solved analytically or by hand in a reasonable amount of time; so, turn to mathematical software to solve these problems. Popular examples of general-purpose mathematical software include Mathematica, MATLAB, the NAG Library, and R. Researchers often find themselves writing mathematical software to demonstrate their new ideas or using mathematical software written by others to solve their applications. This course covers the ingredients that go into producing mathematical software that is efficient, robust, and trustworthy. Students will write their own packages or parts of packages to practice the principles of reliable mathematical software.
Lecture: 1 Lab: 0 Credits: 0

MATH 574
Bayesian Computational Statistics
Rigorous introduction to the theory of Bayesian statistical inference and data analysis including prior and posterior distributions, Bayesian estimation and testing, Bayesian computation theories and methods, and implementation of Bayesian computation methods using popular statistical software.
Lecture: 3 Lab: 0 Credits: 3

MATH 577
Computational Mathematics I
Fundamentals of matrix theory; least squares problems; computer arithmetic, conditioning and stability; direct and iterative methods for linear systems; eigenvalue problems. Credit may not be granted for both Math 577 and Math 477. Prerequisite: An undergraduate numerical course, such as MATH350 or instructor’s consent.
Prerequisite(s): MATH 350
Lecture: 3 Lab: 0 Credits: 3

MATH 578
Computational Mathematics II
Polynomial interpolation; numerical solution of initial value problems for ordinary differential equations by single and multi-step methods, Runge-Kutta, Predictor-Corrector; numerical solution of boundary value problems for ordinary differential equations by shooting method, finite differences and spectral methods. Credit may not be granted for both MATH 578 and MATH 478. Prerequisite: An undergraduate numerical course, such as MATH350 or instructor’s consent.
Prerequisite(s): MATH 350
Lecture: 3 Lab: 0 Credits: 3

MATH 579
Complexity of Numerical Problems
This course is concerned with a branch of complexity theory. It studies the intrinsic complexity of numerical problems, that is, the minimum effort required for the approximate solution of a given problem up to a given error. Based on a precise theoretical foundation, lower bounds are established, i.e. bounds that hold for all algorithms. We also study the optimality of known algorithms, and describe ways to develop new algorithms if the known ones are not optimal.
Prerequisite(s): MATH 350
Lecture: 3 Lab: 0 Credits: 3

MATH 581
Finite Element Method
Various elements, error estimates, discontinuous Galerkin methods, methods for solving system of linear equations including multigrid. Applications.
Prerequisite(s): MATH 350 or MATH 489
Lecture: 3 Lab: 0 Credits: 3

MATH 582
Mathematical Finance II
This course is a continuation of Math 485/548. It introduces the student to modern continuous time mathematical finance. The major objective of the course is to present main mathematical methodologies and models underlying the area of financial engineering, and, in particular, those that provide a formal analytical basis for valuation and hedging of financial securities.
Prerequisite(s): (MATH 485 or MATH 548) and (MATH 481 or MATH 542)
Lecture: 3 Lab: 0 Credits: 3
MATH 586
Theory and Practice of Fixed Income Modeling
The course covers basics of the modern interest rate modeling and fixed income asset pricing. The main goal is to develop a practical understanding of the core methods and approaches used in practice to model interest rates and to price and hedge interest rate contingent securities. The emphasis of the course is practical rather than purely theoretical. A fundamental objective of the course is to enable the students to gain a hands-on familiarity with and understanding of the modern approaches used in practice to model interest rate markets.
Prerequisite(s): (MATH 481* or MATH 542) and (MATH 485 or MATH 548), An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MATH 587
Theory and Practice of Modeling Risk and Credit Derivatives
This is an advanced course in the theory and practice of credit risk and credit derivatives. Students will get acquainted with structural and reduced form approaches to mathematical modeling of credit risk. Various aspects of valuation and hedging of defaultable claims will be presented. In addition, valuation and hedging of vanilla credit derivatives, such as credit default swaps, as well as vanilla credit basket derivatives, such as collateralized credit obligations, will be discussed.
Prerequisite(s): MATH 582
Lecture: 3 Lab: 0 Credits: 3

MATH 589
Numerical Methods for Partial Differential Equations
This course introduces numerical methods, especially the finite difference method for solving different types of partial differential equations. The main numerical issues such as convergence and stability will be discussed. It also includes introduction to the finite volume method, finite element method and spectral method.
Prerequisite: An undergraduate numerical course such as MATH 350 and MATH 489 or consent of instructor.
Prerequisite(s): MATH 350 and MATH 489
Lecture: 3 Lab: 0 Credits: 3

MATH 590
Meshfree Methods
Fundamentals of multivariate meshfree radial basis function and moving least squares methods; applications to multivariate interpolation and least squares approximation problems; applications to the numerical solution of partial differential equations; implementation in Matlab.
Lecture: 3 Lab: 0 Credits: 3

MATH 591
Research and Thesis M.S.
Prerequisite: Instructor permission required.
Credit: Variable

MATH 592
Internship in Applied Mathematics
The course is for students in the Master of Applied Mathematics program who have an approved summer internship at an outside organization. This course can be used in place of Math 523 subject to the approval of the director of the program.
Lecture: 0 Lab: 6 Credits: 6

MATH 593
Seminar in Applied Mathematics
Current research topics presented in the department colloquia and seminars.
Lecture: 1 Lab: 0 Credits: 0

MATH 594
Professional Master's Project
The course is part of the capstone experience for students in the Master of Applied Mathematics program. Students will work in groups of 2 or 3 to study and analyze a real-world problem.
Credit: Variable

MATH 597
Reading and Special Projects
(Credit: Variable)
Credit: Variable

MATH 599
TA Training
This course provides the foundation of how to teach mathematics in the context of introductory undergraduate courses. The course is designed to encourage participation and cooperation among the graduate students, to help them prepare for a career in academia, and to help convey the many components of effective teaching.
Lecture: 1 Lab: 0 Credits: 0

MATH 601
Advanced Topics in Combinatorics
Course content is variable and reflects current research in combinatorics.
Prerequisite(s): MATH 554
Lecture: 3 Lab: 0 Credits: 3

MATH 602
Advanced Topics in Graph Theory
Course content is variable and reflects current research in graph theory.
Prerequisite(s): MATH 554
Lecture: 3 Lab: 0 Credits: 3

MATH 603
Advanced Topics in Computational Mathematics
Course content is variable and reflects current research in computational mathematics.
Prerequisite(s): MATH 578
Lecture: 3 Lab: 0 Credits: 3

MATH 604
Advanced Topics in Applied Analysis
Course content is variable and reflects current research in applied analysis.
Prerequisite(s): MATH 501
Lecture: 3 Lab: 0 Credits: 3
MATH 605
Advanced Topics in Stochastics
Course content is variable and reflects current research in stochastic.
Prerequisite(s): MATH 544
Lecture: 3 Lab: 0 Credits: 3

MATH 691
Research and Thesis Ph.D.
(Credit: Variable)
Credit: Variable