## MATHEMATICS (MATH)

**MATH 00020**  **PRE-ALGEBRA**  **2 Credit Hours**
Course covers properties of whole numbers, fractions, decimals, percents, signed numbers and order of operations. Mental math and elementary algebraic thinking skills are emphasized. Use of calculators is not allowed. Course does not count toward graduation.

**Prerequisite:** 0-9 ALEKS math score.

**Schedule Type:** Emporium

**Contact Hours:** 2 other

**Grade Mode:** Standard Letter

**MATH 00021**  **BASIC ALGEBRA I**  **2 Credit Hours**
Course includes operations on integers, fractions, decimals and percents, and properties of real numbers. Introduction to variables, first degree equations and problem-solving with formulas. Equations and inequalities in one variable, linear equations, rate of change and slope, graphing in the cartesian plane. Course does not count toward graduation.

**Prerequisite:** Minimum 10 ALEKS math score.

**Pre/corequisite:** Minimum C grade in MATH 00020.

**Schedule Type:** Emporium

**Contact Hours:** 2 other

**Grade Mode:** Standard Letter

**MATH 00022**  **BASIC ALGEBRA II**  **2 Credit Hours**
Introduction to functions, systems of linear equations, exponents, polynomial operations, scientific notation. Factoring polynomials, solving quadratics by factoring, radicals and rational exponents. Course does not count toward graduation.

**Prerequisite:** Minimum 25 ALEKS math score; or minimum C grade in MATH 00021.

**Schedule Type:** Emporium

**Contact Hours:** 2 other

**Grade Mode:** Standard Letter

**MATH 00095**  **SPECIAL TOPICS IN MATHEMATICS**  **1-4 Credit Hours**
(Repeatable for credit) Topics in mathematics not covered in regular courses. Offered when opportunities and resources permit; the topic is announced when the course is scheduled. Course does not count toward graduation.

**Prerequisite:** None.

**Schedule Type:** Emporium

**Contact Hours:** 1-4 other

**Grade Mode:** Standard Letter

**MATH 10040**  **INTRODUCTORY STATISTICS PLUS (KMCR)**  **5 Credit Hours**
(Equivalent to MATH 10041) An introduction to statistical thinking and statistical methods. Emphasis is on statistical literacy, conceptual understanding and active learning in the classroom. No credit earned for this course if a student already earned credit for MATH 10040.

**Prerequisite:** Minimum 22 ACT math score; or minimum 530 SAT math score; or minimum 35 ALEKS Math score; or minimum C grade in MATH 00022; or any higher level MATH course.

**Schedule Type:** Lecture

**Contact Hours:** 5 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Mathematics and Critical Reasoning

**MATH 10041**  **INTRODUCTORY STATISTICS (KMCR)**  **4 Credit Hours**
(Equivalent to MATH 10040) An introduction to statistical thinking and statistical methods. Emphasis is on statistical literacy, conceptual understanding and active learning in the classroom. No credit earned for this course if a student already earned credit for MATH 10040.

**Prerequisite:** Minimum 22 ACT math score; or minimum 530 SAT math score; or minimum 35 ALEKS Math score; or minimum C grade in MATH 00022; or any higher level MATH course.

**Schedule Type:** Emporium

**Contact Hours:** 4 other

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Mathematics and Critical Reasoning

**MATH 10050**  **QUANTITATIVE REASONING PLUS (KMCR)**  **5 Credit Hours**
(Equivalent to MATH 10051) In the broadest sense mathematics should provide students the needed quantitative tools, logical reasoning and problem-solving skills, and a sense that quantitative modeling can be used to describe and understand developments in many areas of daily living. Since critical thinking is the primary objective and outcome for our course, in each area of concentration (numeracy, mathematical modeling, and probability and statistics) students will need to read and glean information from the problem situation, convert the information into a usable form, perform any needed routine calculations, make or draw a conclusion, and then communicate the result via explanation using quantitative reasoning by writing coherent statements and paragraphs. This course also provides just-in-time remediation to help students achieve the same learning outcomes as MATH 10051.

**Prerequisite:** ALEKS Math score between 25 and 34; or minimum C grade in MATH 00021.

**Schedule Type:** Lecture

**Contact Hours:** 5 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Mathematics and Critical Reasoning

**MATH 10051**  **QUANTITATIVE REASONING (KMCR)**  **4 Credit Hours**
(Equivalent to MATH 10050) In the broadest sense, mathematics should provide students the needed quantitative tools, logical reasoning and problem solving skills, and a sense that quantitative modeling can be used to describe and understand developments in many areas of daily living. Since critical thinking is the primary objective and outcome for this course, in each area of concentration (numeracy, mathematical modeling and probability and statistics), students will read and glean information from the problem situation, convert the information into a usable form, perform any needed routine calculations, make or draw a conclusion, and then communicate the result via explanation using quantitative reasoning by writing coherent statements and paragraphs.

**Prerequisite:** Minimum 22 ACT math score; or minimum 530 SAT math score; or minimum 35 ALEKS Math score; or minimum C grade in MATH 00022; or any higher level MATH course.

**Schedule Type:** Lecture

**Contact Hours:** 4 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Mathematics and Critical Reasoning
MATH 10675 ALGEBRA FOR CALCULUS BOOST (KMCR) 5 Credit Hours
(Equivalent to MATH 10775 and MATH 11010) Course includes an extensive and rich immersion into the structure of functions. Routine analysis includes discussion of domain, range, zeros, general function behavior (increasing, decreasing, extrema, etc.). Operations with functions, including addition, subtraction, multiplication, division, composition and inversion. Functions are studied as a tool to analyze rates of change in real-world scenarios. The emphasis is on linear, polynomial, exponential and rational functions, with an extensive problem-solving component. A two-week review of intermediate algebra skills is included in the course, as is extra time studying quadratic functions, absolute value functions, systems of equations and extended time on logarithms.
Prerequisite: Minimum 22 ACT math score; or minimum 530 SAT math score; or ALEKS math score between 35-44; or minimum C grade in MATH 00022.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 10771 BASIC MATHEMATICAL CONCEPTS I PLUS (KMCR) 5 Credit Hours
(Equivalent to MATH 14001) Course covers the development of the real-number system and its sub-systems, open sentences, numeration systems, modular arithmetic and some number theory concepts. Additional concepts covered include place value, logic, sets, algebra concepts and problem solving.
Prerequisite: Minimum 35 ALEKS math score; or minimum 22 ACT math score; or minimum 530 SAT math score; or minimum C grade in MATH 00022.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 10772 MODELING ALGEBRA PLUS (KMCR) 5 Credit Hours
(Equivalent to MATH 11009) Study of algebra arising in the context of real-world applications, including linear, polynomial, exponential and logarithmic models. Includes a review of factoring and functions. Course is intended for students not planning to take calculus. No credit earned toward a degree for this course if student already earned credit for MATH 11010.
Prerequisite: Minimum 35 ALEKS math score; or minimum 22 ACT math score; or minimum 530 SAT math score; or minimum C grade in MATH 00022.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 10773 ALGEBRA FOR CALCULUS STRETCH I 3 Credit Hours
Study of functions in general, factoring, negative and rational exponents; polynomial functions, including quadratic functions; and sequences and series. No credit earned for this course if a student already earned credit for MATH 12001. Students cannot earn credit toward a degree for both this course and either MATH 10775 or MATH 11010.
Prerequisite: Minimum 35 ALEKS math score; or minimum 22 ACT math score; or minimum 530 SAT math score; or minimum C grade in MATH 00022.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 10774 ALGEBRA FOR CALCULUS STRETCH II (KMCR) 3 Credit Hours
(Equivalent to MATH 10775 or MATH 11010) Course is continuation of MATH 10773. Study of rational expressions and functions, exponential and logarithmic functions and conic sections.
Prerequisite: Minimum C grade in MATH 10773.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 10775 ALGEBRA FOR CALCULUS PLUS (KMCR) 4 Credit Hours
(Equivalent to MATH 10675 or MATH 10775 or MATH 11010) Course includes an extensive and rich immersion into the structure of functions. Routine analysis includes discussion of domain, range, zeros, general function behavior (increasing, decreasing, extrema, etc.). Operations with functions, including addition, subtraction, multiplication, division, composition and inversion. Functions are studied as a tool to analyze rates of change in real-world scenarios. The emphasis is on linear, polynomial, exponential and rational functions, with an extensive problem-solving component. Skill review is included in the course, as is time studying quadratic functions, absolute value functions, systems of equations and extended time on logarithms.
Prerequisite: ALEKS math score between 45 and 54; or minimum C grade in MATH 10772.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 11008 EXPLORATIONS IN MODERN MATHEMATICS (KMCR) 3 Credit Hours
Topics from various branches of mathematics will be chosen to introduce the student to the wide varieties of ways in which mathematics affects everyday life.
Prerequisite: Minimum 35 ALEKS math score; or minimum 22 ACT math score; or minimum C grade in MATH 00022; or any higher MATH course.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning
MATH 11009  MODELING ALGEBRA (KMCR)  4 Credit Hours
(Equivalent to MATH 10772) Study of algebra arising in the context of
real-world applications, including linear, polynomial, exponential and
logarithmic models. Intended for students not planning to take calculus.
No credit earned toward a degree for this course if the student already
earned credit for MATH 11010.
Prerequisite: Minimum 45 ALEKS math score.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 11010  ALGEBRA FOR CALCULUS (KMCR)  3 Credit Hours
(Equivalent to MATH 10675 and MATH 10774 and MATH 10775) Course
includes an extensive and rich immersion into the structure of functions.
Routine analysis includes discussion of domain, range, zeros, general
function behavior (increasing, decreasing, extrema, etc.). Operations
with functions, including addition, subtraction, multiplication, division,
composition and inversion. Functions are studied as a tool to analyze
rates of change in real-world scenarios. Emphasis is on linear, polynomial,
exponential and rational functions, with an extensive problem-solving
component.
Prerequisite: Minimum 55 ALEKS math score; or minimum B grade in
MATH 10772 or MATH 11009.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer
Module Mathematics

MATH 11012  INTUITIVE CALCULUS (KMCR)  3 Credit Hours
Course is designed to give an overview of differential and integral
calculus to business and life-science majors. Course does not include
trigonometric functions. No credit earned toward a degree for this course
if the student already earned credit for MATH 12002.
Prerequisite: Minimum 67 ALEKS math score; or minimum C grade in
MATH 10774 or MATH 10775 or MATH 11010.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer
Module Mathematics

MATH 12002  ANALYTIC GEOMETRY AND CALCULUS I (KMCR)  5
Credit Hours
Concepts of limit, continuity and derivative, and the indefinite and definite
integral for functions of one real variable. Maximization, related rates,
fundamental theorem of calculus. No credit earned toward a degree for
this course if the student already earned credit for MATH 12011 and
MATH 12012.
Prerequisite: Minimum 78 ALEKS math score; or minimum C grade in
MATH 11022.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer
Module Mathematics

MATH 12003  ANALYTIC GEOMETRY AND CALCULUS II  5 Credit
Hours
Continued study of techniques and applications of integration;
trigonometric, logarithmic and exponential functions; polar coordinates;
parametric equations; sequences and series.
Prerequisite: Minimum C grade in MATH 12002 or MATH 12012.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Transfer Module Mathematics

MATH 12011  CALCULUS WITH PRECALCULUS I (KMCR)  3 Credit
Hours
Introduction to differential calculus with a review of algebra and
trigonometry. Includes exponents, factoring, functions, graphs, tangent
lines, limits, continuity, derivatives and related rates. No credit earned
toward a degree for this course if the student already earned credit for
MATH 12002.
Prerequisite: Minimum 67 ALEKS math score.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer
Module Mathematics

MATH 12012  CALCULUS WITH PRECALCULUS II (KMCR)  3 Credit
Hours
Development of integral calculus and continued study of differential
calculus. Includes curve sketching optimization fundamental theorem of
calculus areas between curves, exponential and logarithmic functions.
No credit earned toward a degree for this course if student already earned
credit for MATH 12002.
Prerequisite: Minimum C grade in MATH 12011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer
Module Mathematics
MATH 12013 BRIEF CALCULUS II 3 Credit Hours
This is a condensed version of MATH 12003 to meet the needs of majors that do not require the full force of Math 12003. The course starts with integration by parts, approximating integrals, and applications of integrals. It follows with a brief introduction to series, parametric equations and polar coordinates, and finishes with vectors and geometry of space. No credit earned toward a degree for this course if student already earned credit for MATH 12003.
Prerequisite: MATH 12002 or MATH 12012 or MATH 12021 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 12021 CALCULUS FOR LIFE SCIENCES 4 Credit Hours
Differential and integral calculus using examples and problems in life sciences.
Prerequisite: Minimum 78 ALEKS math score; or minimum C grade in MATH 11022 or MATH 12011.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 12022 PROBABILITY AND STATISTICS FOR LIFE SCIENCES 3 Credit Hours
Probability and statistics with applications in medical and biological sciences.
Prerequisite: Minimum C grade in MATH 12002 or MATH 12012 or MATH 12021.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 14001 BASIC MATHEMATICAL CONCEPTS I (KMCR) 4 Credit Hours
(Exclusive of MATH 10771) Development of the real number system and its sub-systems, open sentences, numeration systems, modular arithmetic and some number theory concepts.
Prerequisite: Minimum 45 ALEKS math score; or any higher level MATH course (except MATH 10041, MATH 10051 or MATH 11008).
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 14002 BASIC MATHEMATICAL CONCEPTS II (KMCR) 4 Credit Hours
Basic concepts of probability, statistics and geometry.
Prerequisite: Minimum C grade in MATH 10771 or MATH 14001.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning

MATH 19002 TECHNICAL MATHEMATICS II 4 Credit Hours
Emphasizes advanced topics in algebra and trigonometry, analytic geometry, derivatives and integrals.
Prerequisite: None.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 19099 FIELD EXPERIENCE IN MATHEMATICS INSTRUCTION (ELR) 1 Credit Hour
(Repeatable for credit) Learning through tutoring. A supervised lab experience in providing explanations of mathematical concepts.
Prerequisite: Special approval.
Schedule Type: Lecture
Contact Hours: 1 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement

MATH 20011 DECISION-MAKING UNDER UNCERTAINTY 3 Credit Hours
An introductory course on applied statistics. The course provides a hands-on approach to understanding, quantification and decision-making under various forms of uncertainty. The main topics include visualization of uncertainty, probabilistic quantification of uncertainty, Bayesian and non-Bayesian ways of decision-making under uncertainty. Class activities incorporate active learning elements, including in-classroom computation with professional-grade software for statistical analysis and simulation.
Prerequisite: Minimum C grade in MATH 12002.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 20095 SPECIAL TOPICS IN MATHEMATICS 1-5 Credit Hours
(Repeatable for credit) Various special courses will be announced in the schedule of classes under this course number with different section numbers.
Prerequisite: Special approval.
Schedule Type: Lecture
Contact Hours: 1-5 lecture
Grade Mode: Standard Letter

MATH 21001 LINEAR ALGEBRA 3 Credit Hours
Systems of linear equations and the associated matrix operations, linear transformations, vector spaces, bases, eigenvectors.
Prerequisite: Minimum C grade in the following courses MATH 11012 or MATH 12002 or MATH 12012 or MATH 12021.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: TAG Mathematics

MATH 21002 APPLIED LINEAR ALGEBRA 3 Credit Hours
This is an introductory course in linear algebra. The goal of the course is to teach the math fundamentals of linear algebra in a way that focuses more on applications. The topics include systems of linear equations, matrix operations, vector spaces, eigenvalues and eigenvectors, singular value decompositions, and their applications.
Prerequisite: Minimum C grades in the following courses MATH 12002 or MATH 11012 or MATH 12012 or MATH 12021.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 21013 BRIEF CALCULUS II 3 Credit Hours
This is a condensed version of MATH 12003 to meet the needs of majors that do not require the full force of Math 12003. The course starts with integration by parts, approximating integrals, and applications of integrals. It follows with a brief introduction to series, parametric equations and polar coordinates, and finishes with vectors and geometry of space. No credit earned toward a degree for this course if student already earned credit for MATH 12003.
Prerequisite: MATH 12002 or MATH 12012 or MATH 12021 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 21092 COMPUTER PRACTICUM (ELR) 2 Credit Hours
(Repeatable for credit) Supervised work experience in a computer installation.
Prerequisite: None.
Schedule Type: Practicum or Internship
Contact Hours: 2 other
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement
MATH 22005  ANALYTIC GEOMETRY AND CALCULUS III  4 Credit Hours
Study of functions of several variables, including partial derivatives and multiple integrals.
Prerequisite: Minimum C grade in MATH 12003.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 23022  DISCRETE STRUCTURES FOR COMPUTER SCIENCE  3 Credit Hours
(Cross-listed with CS 23022) Discrete structures for computer scientists with a focus on: mathematical reasoning, combinatorial analysis, discrete structures, algorithmic thinking, applications and modeling. Specific topics include logic, sets, functions, relations, algorithms, proof techniques, counting, graphs, trees, Boolean algebra, grammars and languages.
Prerequisite: Minimum 55 Compass Algebra score and either minimum 540 SAT math score or minimum 23 ACT math score; or CS 10051 and minimum C grade in MATH 11010.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 30011  BASIC PROBABILITY AND STATISTICS  3 Credit Hours
Analysis and representation of data. Controlled experiments and observations. Measurement errors. Correlation and regression. Sampling. Probability models and tests of models. Inference. This course cannot be used to meet the mathematics requirements for a BA in Mathematics or a BS in Applied Mathematics or Mathematics.
Prerequisite: Minimum 67 ALEKS math score; or minimum C grade in MATH 10774 or MATH 10775 or MATH 11010; or any course MATH 10774 or MATH 10775 or MATH 11010; or any course MATH 20000 to MATH 49999.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 30055  MATHEMATICAL THEORY OF INTEREST  3 Credit Hours
A calculus-based introduction to the mathematics of finance. Limited to deterministic analysis of interest rates annuities bonds and immunization. Emphasizes the mathematical theory of the subject matter.
Prerequisite: Minimum C grade in MATH 12003.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 31011  PROOFS IN DISCRETE MATHEMATICS  3 Credit Hours
The study of discrete mathematical structures including sets, functions, and relations. The course includes an introduction to logical thinking with an emphasis on proof techniques. The course also emphasizes combinatorics topics such as recursion and counting.
Prerequisite: Minimum C grade in MATH 12002.
Pre/corequisite: Minimum C grade in MATH 21001 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 32044  ORDINARY DIFFERENTIAL EQUATIONS  3 Credit Hours
An introduction to ordinary differential equations and applications. Topics include solution methods, series solutions and singular points. Laplace transforms and linear systems. Applications include population dynamics, forced oscillations and resonance.
Prerequisite: Minimum C grade in MATH 21001 and MATH 22005.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: TAG Mathematics

MATH 32051  MATHEMATICAL METHODS IN THE PHYSICAL SCIENCES I  4 Credit Hours
Mathematics background beyond calculus I and II for upper-division courses in the physical sciences. Topics include complex numbers and arithmetic, linear algebra, partial differentiation and multiple integrals.
Prerequisite: Minimum C grade in MATH 12003.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 32052  MATHEMATICAL METHODS IN THE PHYSICAL SCIENCES II  4 Credit Hours
Additional mathematics background for upper-division courses in the physical sciences. Topics include vector analysis, Fourier series and transforms ordinary differential equations and partial differential equations.
Prerequisite: Minimum C grade in MATH 32051; or minimum C grade in MATH 21001 and MATH 22005.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 34001  FUNDAMENTAL CONCEPTS OF ALGEBRA  3 Credit Hours
Professionalized course in algebra for prospective secondary teachers. Postulational development of number system of algebra; other systems, related topics, applications. This course cannot be used to meet the mathematical requirements for a BA in Mathematics or a BS in either Applied Mathematics or Mathematics. No credit earned toward a degree for this course if a student already earned credit for MATH 41001.
Prerequisite: Minimum C grade in MATH 12002.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 34002  FUNDAMENTAL CONCEPTS OF GEOMETRY  3 Credit Hours
Professionalized course in geometry for secondary school teachers. Origin and development of the geometry of Euclid with modern refinements, topics, approaches. Other geometries, applications. This cannot be used to meet the mathematics requirement for a BA in Mathematics or a BS in either Applied Mathematics or Mathematics.
Prerequisite: Minimum C grade in MATH 12002.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
MATH 38001 HANDS-ON MATHEMATICS 3 Credit Hours
Students take turns learning a topic and then teach that topic to the class. No text is required; the students use web resources and materials supplied by the instructor. Many of the topics have a hands-on component. Some examples are two- and three-dimensional tiling problems, the Towers of Hanoi and other problems with an inductive solution, and ‘magic tricks’ with a basis in algebra, parity or modular arithmetic.
Prerequisite: Minimum C grade in MATH 12003.
Schedule Type: Seminar
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40011 PROBABILITY THEORY AND APPLICATIONS 3 Credit Hours
(Slashed with MATH 50011) Permutations and combinations, discrete and continuous distributions, random variables, conditional probabilities, Baye’s formula, mathematical expectation, law of large numbers, normal approximations, basic limit theorems.
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40012 THEORY OF STATISTICS 3 Credit Hours
(Slashed with MATH 50012) Sample spaces, continuous distributions, sampling distributions, point and interval estimation, hypothesis testing, types of error, level and power of tests, sequential and nonparametric methods.
Prerequisite: Minimum C grade in MATH 40011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40015 APPLIED STATISTICS 3 Credit Hours
(Slashed with MATH 50015) Course is based on classical linear regression techniques with an emphasis on real data using the principles of sound data analysis. Close attention is given to issues of interpretation, diagnostics, outliers and influential points, goodness of fit and model selection. Topics include simple and multiple linear regression, transformation and modifications of covariates and responses, design matrices, variable selection and logistic regression.
Prerequisite: Minimum C grade in both MATH 20011 and MATH 21001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40024 COMPUTATIONAL STATISTICS 3 Credit Hours
(Slashed with MATH 50024) This course is about the use of computational tools to manage, explore, summarize, and visualize data, as well as the computational underpinnings of fitting statistical models. It uses mostly the statistical computation language R, but also other languages like Python and Matlab. It also covers: simulation and random number generation, computationally intensive methods like the bootstrap and permutation tests, Expectation-Maximization and related algorithms, and dimensionality reduction via matrix decomposition.
Prerequisite: Minimum grade of C in both MATH 20011 and MATH 21001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40028 STATISTICAL LEARNING 3 Credit Hours
(Slashed with MATH 50028) This course is about the statistical foundations of modern machine learning techniques. The main focus is classification and prediction, using regression-based, tree-based, and kernel-based methods. Specific methods include logistic regression, classification and regression trees, random forests, and support vector machines. The course also includes an introduction to unsupervised and semi-supervised learning.
Prerequisite: Minimum grade of C in both MATH 40015 and MATH 40024.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40051 TOPICS IN PROBABILITY THEORY AND STOCHASTIC PROCESSES 3 Credit Hours
(Slashed with MATH 50051) Topics from conditional expectations, Markov chains, Markov processes, Brownian motion and Martingales and their applications to stochastic calculus.
Prerequisite: Minimum C grade in MATH 40011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 40055 ACTUARIAL MATHEMATICS I (ELR) (WIC) 4 Credit Hours
(Slashed with MATH 50055) Topics from survival models, stochastic analysis of annuities and life insurance and casualty models.
Prerequisite: Minimum C grade in MATH 30055 and MATH 40011.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 40056 ACTUARIAL MATHEMATICS II 4 Credit Hours
(Slashed with MATH 50056) Benefit premiums, benefit reserves and their analysis, decrement models, joint survivorship, risk models.
Prerequisite: Minimum C grade in MATH 40055.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 40059 STOCHASTIC ACTUARIAL MODELS 3 Credit Hours
(Slashed with MATH 50059) Designed to prepare students for the Society of Actuaries examination on actuarial mathematics.
Prerequisite: Minimum C grade in MATH 40011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 40093 VARIABLE TITLE WORKSHOP IN MATHEMATICS 1-6 Credit Hours
(Repeatable for credit) Studies special topics in mathematics. Not acceptable for credit toward a major or minor in math without approval of student’s adviser.
Prerequisite: Special approval.
Schedule Type: Workshop
Contact Hours: 1-6 other
Grade Mode: Satisfactory/Unsatisfactory
MATH 41001  MODERN ALGEBRA I (ELR) (WIC)  3 Credit Hours
(Slashed with MATH 51001) Basic properties of groups, subgroups, factor
groups. Basic properties of rings, integral domains and homomorphisms.
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051; and
minimum C grade in MATH 31011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 41002  MODERN ALGEBRA II (ELR) (WIC)  3 Credit Hours
(Slashed with MATH 51002) A continuation of MATH 41001, emphasizing
properties of rings, their ideals, polynomial ring extensions, fields, finite
degree extensions, roots of polynomials, constructability.
Prerequisite: Minimum C grade in MATH 41001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 41021  THEORY OF MATRICES  3 Credit Hours
(Slashed with MATH 51021) A rigorous study of the topics introduced in
matrix algebra. Topics included are vector space preliminaries, canonical
forms of matrices, diagonalizability criteria.
Prerequisite: Minimum C grade in MATH 21001 and MATH 22005.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 41038  INTERMEDIATE LOGIC  3 Credit Hours
(Slashed with MATH 51038; Cross-listed with CS 41038 and PHIL 41038)
A detailed, systematic study of symbolic logic for philosophy majors, mathematics majors, computer science majors,
and anyone else interested in advanced study in logic. The aim of the
course is twofold: first, to develop a facility in understanding and using
symbolic logic for various purposes, and second, to understand and
appreciate symbolic logic as an area of study in itself. Topics include the
distinction between syntactic, object-level proofs and semantic, meta-
level proofs, the distinction between axiomatic systems and natural
deduction systems of object-level proofs, various systems of modal logic,
and some non-classical logics.
Prerequisite: None.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 41045  METALOGIC  3 Credit Hours
(Slashed with MATH 51045; Cross-listed with CS 41045 and CS 51045
and PHIL 41045 and PHIL 51045) A detailed, systematic study of
metalogic for philosophy majors, mathematics majors, computer
science majors, and anyone else interested in advanced study in logic.
Topics include the soundness and completeness of the propositional
and predicate calculi, the decidability of propositional calculus, the
undecidability of predicate calculus, G"odel's incompleteness proof for
languages capable of expressing arithmetic, the co-extensionality of the
set of general recursive functions, abacus computable functions,
and Turing computable functions, and the philosophical motivations
for the Church-Turing Thesis that all computable functions are Turing
computable.
Prerequisite: PHIL 41038.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42001  ANALYSIS I (ELR) (WIC)  3 Credit Hours
(Slashed with MATH 52001) Topics include basic structure of the real
numbers, Cauchy sequences, convergence, completeness of the real
numbers, continuity, differentiation and Riemann integration.
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051 and
Minimum C grade in MATH 31011.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 42002  ANALYSIS II (ELR) (WIC)  3 Credit Hours
(Slashed with MATH 52002) Topics include further development of
integration theory, infinite series, uniform convergence, several variable
calculus and metric spaces.
Prerequisite: Minimum C grade in MATH 42001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 42011  MATHEMATICAL OPTIMIZATION  3 Credit Hours
(Slashed with MATH 52011) Analytic and numerical techniques for
location of extreme points of functions and calculus of variations. Both
constrained and unconstrained problems are considered.
Prerequisite: Minimum C grade in MATH 21001 and MATH 22005 or
32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42021  GRAPH THEORY AND COMBINATORICS  3 Credit Hours
(Slashed with MATH 52021) Fundamentals and applications of
combinatorial mathematics. Topics include traversability, colorability,
networks, inclusion and exclusion, matching and designs.
Prerequisite: Minimum C grade in MATH 12003 and MATH 21001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42024  NUMBERS AND GAMES  3 Credit Hours
(Slashed with MATH 52024) The study of partisan and impartial
combinatorial games; games as numbers; Grundy-Sprague theory.
Prerequisite: Minimum C grade in MATH 21001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42031  MATHEMATICAL MODELS AND DYNAMICAL SYSTEMS
  3 Credit Hours
(Slashed with MATH 52031) Formulation and analysis of mathematical
models for a variety of phenomena. Mathematical methods from
optimization dynamical systems and probability are developed and
applied. Modern software tools are utilized.
Prerequisite: Minimum C grade in MATH 32044 or MATH 32052.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
MATH 42039 MODELING PROJECTS (ELR) (WIC) 3 Credit Hours
(Slashed with MATH 52039) Individual and small-group projects concerned with the formulation and analysis of mathematical models in a variety of areas. Written and oral reports are required.
Prerequisite: Minimum C grade in MATH 42031.
Schedule Type: Seminar
Contact Hours: 3 other
Grade Mode: Standard Letter/IP
Attributes: Experiential Learning Requirement, Writing Intensive Course

MATH 42041 ADVANCED CALCULUS 3 Credit Hours
(Slashed with MATH 52041) The calculus and applications of scalar and vector functions of several variables. Vector differential and integral calculus. Applications to field theories, electricity and magnetism and fluid flow.
Prerequisite: Minimum C grade in MATH 21001; and MATH 22005 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42043 PARTIAL DIFFERENTIAL EQUATIONS 3 Credit Hours
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42045 PARTIAL DIFFERENTIAL EQUATIONS 3 Credit Hours
(Slashed with MATH 52045) An introduction to Fourier series, Fourier transforms and partial differential equations. Wave, heat and potential equations of mathematical physics. Additional topics include Green’s functions and the Method of Characteristics for wave equations.
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42048 COMPLEX VARIABLES 3 Credit Hours
(Slashed with MATH 52048) Algebra of complex numbers, analytic functions, mappings, Cauchy integral theory, residue theory and applications.
Prerequisite: Minimum C grade in MATH 22005 or MATH 32051.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42201 NUMERICAL COMPUTING I 3 Credit Hours
(Cross-listed with CS 42201 and CS 52201; slashed with MATH 52201). An introduction to numerical methods and software for solving many common scientific computing problems. Linear systems, least-squares data fitting, nonlinear equations and systems, and optimization problems.
Prerequisite: Minimum C grade in all the following: MATH 12003; and MATH 21001 or MATH 32051; and CS 13001 or (CS 13011 and CS 13012).
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 42202 NUMERICAL COMPUTING II 3 Credit Hours
(Cross-listed with CS 42202) (Slashed with CS 52202 and MATH 52202) A continuation of MATH 42201. Topics include interpolation, numerical differentiation and integration, and numerical solution of ordinary differential equations.
Prerequisite: Minimum C grade in MATH 42201; and minimum C grade in MATH 32044 or MATH 32052.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 45011 DIFFERENTIAL GEOMETRY 3 Credit Hours
(Slashed with MATH 55011) Analytic and metric differential geometry of curves and surfaces.
Prerequisite: Minimum C grade in MATH 22005.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 45021 EUCLIDEAN GEOMETRY 3 Credit Hours
(Slashed with MATH 55021) Geometry of Euclid extended to advanced topics of the triangle, quadrilaterals and circles: cross-ratio, groups, constructions, geometric generalizations; inversion.
Prerequisite: Minimum C grade in MATH 21001.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 46001 ELEMENTARY TOPOLOGY 3 Credit Hours
(Slashed with MATH 56001) Metric spaces, introduction to topological spaces, separation axioms.
Prerequisite: Minimum C grade in MATH 22005.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 47011 THEORY OF NUMBERS 3 Credit Hours
(Slashed with MATH 57011) Divisibility properties of the integers, prime numbers, congruences, quadratic reciprocity, Diophantine equations, number theoretic functions, simple continued fractions, rational approximations.
Prerequisite: Minimum C grade in MATH 12003.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 48001 HISTORY OF MATHEMATICS 3 Credit Hours
(Slashed with MATH 58001) Survey of the development of algebra, geometry, calculus, number theory.
Prerequisite: Minimum C grade in one course MATH 23022 or higher.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 49995 SELECTED TOPICS IN MATHEMATICS AND ITS APPLICATIONS 1-4 Credit Hours
(Repeatable for credit) Various special courses will be announced in the schedule of classes under this course number with different section numbers.
Prerequisite: Special approval.
Schedule Type: Lecture
Contact Hours: 1-4 lecture
Grade Mode: Standard Letter
MATH 49996  INDIVIDUAL STUDY  1-4 Credit Hours  
(Repeatable for credit) Individual investigation in mathematics.  
Prerequisite: Special approval.  
Schedule Type: Individual Investigation  
Contact Hours: 1-4 other  
Grade Mode: Standard Letter  

MATH 49998  RESEARCH (ELR)  1-15 Credit Hours  
(Repeatable for credit) Research in mathematics.  
Prerequisite: Special approval.  
Schedule Type: Research  
Contact Hours: 1-15 other  
Grade Mode: Satisfactory/Unsatisfactory-IP  
Attributes: Experiential Learning Requirement  

MATH 50011  PROBABILITY THEORY AND APPLICATIONS  3 Credit Hours  
(Slashed with MATH 40011) Permutations and combinations, discrete  
and continuous distributions, random variables, conditional probabilities,  
Baye’s formula, mathematical expectation, law of large numbers, normal  
approximations, basic limit theorems.  
Prerequisite: Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50012  THEORY OF STATISTICS  3 Credit Hours  
(Slashed with MATH 40012) Sample spaces, continuous distributions,  
sampling distributions, point and interval estimation, hypothesis testing,  
types of error, level and power of tests, sequential and nonparametric  
methods.  
Prerequisite: MATH 40011 or MATH 50011 and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50015  APPLIED STATISTICS  3 Credit Hours  
(Slashed with MATH 40015) Course is based on classical linear regression  
techniques with an emphasis on real data using the principles of sound  
data analysis. Close attention is given to issues of interpretation,  
diagnostics, outliers and influential points, goodness of fit and model  
selection. Topics include simple and multiple linear regression,  
transformation and modifications of covariates and responses, design  
matrices, variable selection and logistic regression.  
Prerequisite: Applied Mathematics or Pure Mathematics major; and  
Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50024  COMPUTATIONAL STATISTICS  3 Credit Hours  
(Slashed with MATH 40024) This course is about the use of  
computational tools to manage, explore, summarize, and visualize data,  
as well as the computational underpinnings of fitting statistical models.  
It uses mostly the statistical computation language R, but also other  
languages like Python and Matlab. It also covers: simulation and random  
number generation, computationally intensive methods like the bootstrap  
and permutation tests, Expectation-Maximization and related algorithms,  
and dimensionality reduction via matrix decomposition.  
Prerequisite: Applied Mathematics or Pure Mathematics major; and  
Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50028  STATISTICAL LEARNING  3 Credit Hours  
(Slashed with MATH 40028) This course is about the statistical  
foundations of modern machine learning techniques. The main focus  
is classification and prediction, using regression-based, tree-based, and  
kernel-based methods. Specific methods include logistic regression,  
classification and regression trees, random forests, and support vector  
machines. The course also includes an introduction to unsupervised and  
semi-supervised learning.  
Prerequisite: MATH 40015 or 50015 and MATH 40024 or 50024; Applied  
Mathematics or Pure Mathematics major; and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50051  TOPICS IN PROBABILITY THEORY AND STOCHASTIC  
PROCESSES  3 Credit Hours  
(Slashed with MATH 40051) Topics from conditional expectations,  
Markov chains, Markov processes, Brownian Motion and Martingales and  
their applications to stochastic calculus.  
Prerequisite: MATH 50011 and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 50055  ACTUARIAL MATHEMATICS I  4 Credit Hours  
(Slashed with MATH 40055) Topics from survival models, stochastic  
analysis of annuities and life insurance and casualty models.  
Prerequisite: MATH 30055 and MATH 50011; and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 4 lecture  
Grade Mode: Standard Letter  

MATH 50056  ACTUARIAL MATHEMATICS II  4 Credit Hours  
(Slashed with MATH 40056) Benefit premiums, benefit reserves and their  
analysis; decrement models, joint survivorship, risk models.  
Prerequisite: MATH 50055 and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 4 lecture  
Grade Mode: Standard Letter  

MATH 50059  STOCHASTIC ACTUARIAL MODELS  3 Credit Hours  
(Slashed with MATH 40059) Designed to prepare students for the Society  
of Actuaries examination on actuarial mathematics.  
Prerequisite: Minimum C grade in MATH 50011 and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 51001  MODERN ALGEBRA I  3 Credit Hours  
(Slashed with MATH 41001) Basic properties of groups, subgroups, factor  
groups. Basic properties of rings, integral domains and homomorphisms.  
Prerequisite: MATH 21001 and MATH 22005 and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

MATH 51002  MODERN ALGEBRA II  3 Credit Hours  
(Slashed with MATH 41002) A continuation of MATH 51001, emphasizing  
properties of rings, their ideals, polynomial ring extensions, fields, finite  
degree extensions, roots of polynomials, constructibility.  
Prerequisite: MATH 41001 or MATH 51001; Applied Mathematics or Pure  
Mathematics major; and Graduate standing.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 51021</td>
<td>THEORY OF MATRICES</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 41021) A rigorous study of the topics introduced in matrix algebra. Topics included are: canonical forms of matrices, diagonalizability criteria. <strong>Prerequisite:</strong> MATH 21001 and MATH 22005 and Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 51038</td>
<td>INTERMEDIATE LOGIC</td>
<td>3</td>
<td>Lecture</td>
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<td>(Cross-listed with CS 41038 and PHIL 41038 and PHIL 51038; slashed with MATH 41038) A detailed, systematic study of symbolic logic for philosophy majors, mathematics majors, computer science majors, and anyone else interested in advanced study in logic. The aim of the course is twofold: first, to develop a facility in understanding and using symbolic logic for various purposes, and second, to understand and appreciate symbolic logic as an area of study in itself. Topics include the distinction between syntactic, object-level proofs and semantic, meta-level proofs, the distinction between axiomatic systems and natural deduction systems of object-level proofs, various systems of modal logic and some non-classical logics. <strong>Prerequisite:</strong> Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 51045</td>
<td>METALOGIC</td>
<td>3</td>
<td>Lecture</td>
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<td>(Cross-listed with CS 41045 and CS 51045 and PHIL 41045 and PHIL 51045; slashed with MATH 41045) A detailed, systematic study of metalogic for philosophy majors, mathematics majors, computer science majors, and anyone else interested in advanced study in logic. Topics include the soundness and completeness of the propositional and predicate calculus, the decidability of propositional calculus, the undecidability of predicate calculus, Gödel's incompleteness proof for languages capable of expressing arithmetic, the co-extensionality of the set of general recursive functions, abacus computable functions, and Turing computable functions, and the philosophical motivations for the Church-Turing Thesis that all computable functions are Turing computable. <strong>Prerequisite:</strong> Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52001</td>
<td>ANALYSIS I</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42001) Topics include basic structure of the real numbers, Cauchy sequences, convergence, completeness of the real numbers, continuity, differentiation and Riemann integration. <strong>Prerequisite:</strong> Applied Mathematics or Pure Mathematics major; and Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52002</td>
<td>ANALYSIS II</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42002) Topics include further development of integration theory infinite series, uniform convergence, several variable calculus and metric spaces. <strong>Prerequisite:</strong> MATH 42001 or MATH 52001; Applied Mathematics or Pure Mathematics major; and Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52011</td>
<td>MATHEMATICAL OPTIMIZATION</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42011) Analytical and numerical techniques for location of extreme points of functions and calculus of variations. Both constrained and unconstrained problems are considered. <strong>Prerequisite:</strong> MATH 21001 and MATH 22005; Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52021</td>
<td>GRAPH THEORY AND COMBINATORICS</td>
<td>3</td>
<td>Lecture</td>
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<td>(MATH 42021) Fundamentals and applications of combinatorial mathematics. Topics include transversability, colorability, networks, inclusion and exclusion, matching and designs. <strong>Prerequisite:</strong> MATH 12003 and MATH 21001 and Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52024</td>
<td>NUMBERS AND GAMES</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42024) The study of partisan and impartial combinatorial games; games as numbers; Grundy-Sprague theory. <strong>Prerequisite:</strong> Graduate standing and special approval. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52031</td>
<td>MATHEMATICAL MODELS AND DYNAMICAL SYSTEMS</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42031) Formulation and analysis of mathematical models for a variety of phenomena. Mathematical methods from optimization, dynamical systems and probability are developed and applied. Modern software tools are utilized. <strong>Prerequisite:</strong> MATH 32044 and Graduate standing. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52039</td>
<td>MODELING PROJECTS</td>
<td>3</td>
<td>Seminar</td>
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<td>(Slashed with MATH 42039) Individual and small-group projects concerned with the formulation and analysis of mathematical models in a variety of areas. Written and oral reports required. <strong>Prerequisite:</strong> Minimum C grade in MATH 52031; and Graduate standing. <strong>Schedule Type:</strong> Seminar <strong>Contact Hours:</strong> 3 other <strong>Grade Mode:</strong> Standard Letter</td>
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<tr>
<td>MATH 52040</td>
<td>ADVANCED CALCULUS</td>
<td>3</td>
<td>Lecture</td>
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<td>(Slashed with MATH 42040) The calculus and applications of scalar and vector functions of several variables. Vector differential and integral calculus. Applications to field theories, electricity and magnetism and fluid flow. <strong>Prerequisite:</strong> MATH 21001 and MATH 22005. <strong>Schedule Type:</strong> Lecture <strong>Contact Hours:</strong> 3 lecture <strong>Grade Mode:</strong> Standard Letter</td>
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</table>
MATH 52045  PARTIAL DIFFERENTIAL EQUATIONS  3 Credit Hours
(Slashed with MATH 42045) Introduction to Fourier series, Fourier
transforms and partial differential equations. Wave, heat and potential
equations of mathematical physics. Additional topics include Green's
functions and the Method of Characteristics for wave equations.
**Prerequisite:** Applied Mathematics or Pure Mathematics major; and
Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 52048  COMPLEX VARIABLES  3 Credit Hours
(Slashed with MATH 42048) Algebra of complex numbers, analytic
functions, mappings, Cauchy integral theory, residue theory and
applications.
**Prerequisite:** Applied Mathematics or Pure Mathematics major; and
Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 52201  NUMERICAL COMPUTING I  3 Credit Hours
(Cross-listed with CS 42201 and CS 52201; slashed with MATH 42201)
An introduction to numerical methods and software for solving many
common scientific computing problems. Linear systems, least-square
data fitting, nonlinear equations and systems and optimization problems.
**Prerequisite:** Applied Mathematics or Pure Mathematics major; and
Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 52202  NUMERICAL COMPUTING II  3 Credit Hours
(Cross-listed with CS 42202 and CS 52202; slashed with MATH 42202)
A continuation of MATH 52201. Topics include interpolation, numerical
differentiation and integration, and numerical solution of ordinary
differential equations.
**Prerequisite:** MATH 42201 or 52201; Applied Mathematics or Pure
Mathematics major; and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 55011  DIFFERENTIAL GEOMETRY  3 Credit Hours
(Slashed with MATH 45011) Analytic and metric differential geometry of
curves and surfaces.
**Prerequisite:** MATH 22005 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 55021  EUCLIDEAN GEOMETRY  3 Credit Hours
(Slashed with MATH 45021) Geometry of Euclid extended to advanced
topics of the triangle, quadrilaterals and circles: crossratio, groups,
constructions, geometric generalizations; inversion.
**Prerequisite:** MATH 21001 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 55022  LINEAR GEOMETRY  3 Credit Hours
(Slashed with MATH 45022) Use of transformations as a tool to study
geometry and to differentiate between different kinds of geometry. Linear
algebra methods applied to geometry.
**Prerequisite:** MATH 21001 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 56001  ELEMENTARY TOPOLOGY  3 Credit Hours
(Slashed with MATH 46001) Metric spaces, introduction to topological
spaces, separation axioms.
**Prerequisite:** MATH 22005 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 57011  THEORY OF NUMBERS  3 Credit Hours
(Slashed with MATH 47011) Divisibility properties of the integers, prime
numbers, congruencies, quadratic reciprocity, Diophantine equations,
number theoretic functions, simple continued fractions, rational
approximations.
**Prerequisite:** MATH 12003 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 57021  HISTORY OF MATHEMATICS  3 Credit Hours
(Slashed with MATH 47021) Survey from Babylonian and Egyptian
mathematics to 20th-century mathematics with emphasis on the
development of algebra, geometry, calculus, number theory.
**Prerequisite:** MATH 21001 and Graduate standing.
**Schedule Type:** Lecture
**Contact Hours:** 3 lecture
**Grade Mode:** Standard Letter

MATH 57091  SELECTED TOPICS IN MATHEMATICS AND ITS
APPLICATIONS  1-3 Credit Hours
(Repeatable for credit) Various special courses will be announced in the
schedule of classes under this course number with different section
numbers.
**Prerequisite:** Graduate standing and special approval.
**Schedule Type:** Seminar
**Contact Hours:** 1-3 other
**Grade Mode:** Standard Letter

MATH 59893  VARIABLE TITLE WORKSHOP IN MATHEMATICS  1-6
Credit Hours
(Repeatable for credit) Studies in special topics in pure and applied
mathematics.
**Prerequisite:** Graduate standing and special approval.
**Schedule Type:** Workshop
**Contact Hours:** 1-6 other
**Grade Mode:** Satisfactory/Unsatisfactory
MATH 60052  PROBABILITY II  3 Credit Hours
(Slashed with MATH 70052) Characteristic functions, the central limit problem, conditional expectations, Martingale theory, Brownian motion.
Prerequisite: MATH 60051 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 60061  MATHEMATICAL STATISTICS I  4 Credit Hours
Prerequisite: MATH 42002 or MATH 52002 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 60062  MATHEMATICAL STATISTICS II  3 Credit Hours
Prerequisite: MATH 60061 and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 60070  FINANCIAL MATHEMATICS  3 Credit Hours
(Slashed with MATH 70070) Topics from replication of trading strategies, arbitrage, completeness, Martingale representation theorem, fundamental theorem of finance, stochastic differential equations, Black and Scholes formula of option pricing.
Prerequisite: MATH 50051 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 60091  SEMINAR IN STATISTICS AND PROBABILITY  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in statistics and probability.
Prerequisite: Graduate standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter

MATH 60093  VARIABLE TITLE WORKSHOP IN MATHEMATICS  1-3 Credit Hours
(Repeatable for credit) Studies of special topics in mathematics. Not acceptable for credit toward a graduate degree in mathematics without approval of the student's adviser.
Prerequisite: Graduate standing and special approval.
Schedule Type: Workshop
Contact Hours: 1-3 other
Grade Mode: Satisfactory/Unsatisfactory

MATH 60094  COLLEGE TEACHING OF MATHEMATICS  1 Credit Hour
(Repeatable for credit) Techniques and problems in the teaching of college-level mathematics. Student presentations of mathematical papers and colloquia will be included.
Prerequisite: Graduate standing.
Schedule Type: Lecture
Contact Hours: 1 lecture
Grade Mode: Standard Letter

MATH 60151  ABSTRACT ALGEBRA I  4 Credit Hours
(Slashed with MATH 71061) Advanced topics in group theory including Sylow Theorems, finite Abelian groups, divisible groups and related concepts. Includes one hour problem session each week.
Prerequisite: Graduate standing and special approval.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 61052  ABSTRACT ALGEBRA II  3 Credit Hours
(Slashed with MATH 71052) Advanced topics, commutative ring theory and field theory, including polynomial rings, unique factorization domains, matrix rings, Galois theory.
Prerequisite: MATH 61051 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 61091  SEMINAR IN ALGEBRA  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in algebra.
Prerequisite: Graduate standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Satisfactory/Unsatisfactory

MATH 62041  METHODS OF APPLIED MATHEMATICS I  3 Credit Hours
Prerequisite: MATH 51021 and MATH 52041 and MATH 52045 and MATH 52048 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62042  METHODS OF APPLIED MATHEMATICS II  3 Credit Hours
(Slashed with MATH 72042) Continuation of MATH 62041. Integral equations and Green's functions (Fredholm alternative, compact operators, distributions, weak solutions). Wave phenomena (dispersion, KdV equation). Stability and bifurcation (linearized stability analysis, turning points, Hopf bifurcation).
Prerequisite: MATH 62041 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62051  FUNCTIONS OF A REAL VARIABLE I  4 Credit Hours
(Slashed with MATH 72051) Introduction to modern concepts of real analysis, including metric spaces, measure and integration theory.
Prerequisite: MATH 42002 or MATH 52002 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 62052  FUNCTIONS OF A REAL VARIABLE II  3 Credit Hours
(Slashed with MATH 72052) A continuation of MATH 62051. Included are basic topics in functional analysis and Hilbert space theory.
Prerequisite: MATH 62051 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
MATH 62151  FUNCTIONS OF A COMPLEX VARIABLE I  4 Credit Hours
(Slashed with MATH 72151) Topological properties of the complex plane; analytic, entire, meromorphic functions; analytic continuation; conformal mappings; Picard's Theorem; Riemann surfaces.
Prerequisite: MATH 52002 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 62152  FUNCTIONS OF A COMPLEX VARIABLE II  3 Credit Hours
(Slashed with MATH 72152) Topological properties of the complex plane; analytic, entire, meromorphic functions; analytic continuation; conformal mappings; Picard's Theorem; Riemann surfaces.
Prerequisite: MATH 62151 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62203  COMPUTATIONAL FINANCE  3 Credit Hours
(Slashed with MATH 72203) Basic numerical methods, (numerical linear algebra, nonlinear equations, curve fitting, ODEs, integration, Monte-Carlo methods), numerical solution of PDEs (stability, convergence, Black-Scholes, American options, SDEs) probabilistic methods.
Prerequisite: MATH 22005 and MATH 21001 and MATH 32044 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62251  NUMERICAL ANALYSIS I  4 Credit Hours
(Slashed with MATH 72251) Floating point computation, rounding error analysis, conditioning, interpolation (polynomial, trigonometric, spline). Numerical quadrature (Newton-Cotes, Gauss), extrapolation, Romberg integration.
Prerequisite: MATH 42002 or MATH 52002 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 62252  NUMERICAL ANALYSIS II  3 Credit Hours
(Slashed with MATH 72252) Numerical solution of linear systems of equations (LU factorization, error analysis). Least squares, orthogonalization methods. Algebraic eigenvalue problems, QR algorithm, singular value decomposition.
Prerequisite: MATH 41021 or MATH 51021; and MATH 62251 or MATH 72251; and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62261  NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS  3 Credit Hours
Prerequisite: MATH 32044; and MATH 42202 or MATH 52202; and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62262  NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS  3 Credit Hours
(Slashed with MATH 72262) Derivation and analysis of discrete methods (finite differences, finite elements) for the numerical solution of elliptic, hyperbolic and parabolic partial differential equations.
Prerequisite: MATH 42045 or MATH 52045; and MATH 42202 or MATH 52202; and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62263  NUMERICAL SOLUTION OF LARGE SPARSE LINEAR SYSTEMS  3 Credit Hours
Prerequisite: MATH 41021 or MATH 51021; and MATH 42202 or MATH 52202; and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62264  NUMERICAL SOLUTION OF NONLINEAR SYSTEMS  3 Credit Hours
(Cross-listed with CS 62264 and CS 72264 and MATH 72264) Construction and analysis of numerical methods for systems of nonlinear algebraic equations and optimization problems. Numerical implementation and software.
Prerequisite: MATH 42041 or MATH 52041; and MATH 42202 or MATH 52202; and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 62291  SEMINAR IN NUMERICAL ANALYSIS  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in numerical analysis.
Prerequisite: Graduate standing and special approval.
Schedule Type: Seminar
Contact Hours: 3 other
Grade Mode: Standard Letter

MATH 62391  SEMINAR IN MEASURE THEORY  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in measure theory.
Prerequisite: Graduate standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter

MATH 62491  SEMINAR IN NONLINEAR ANALYSIS  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in nonlinear analysis.
Prerequisite: Graduate standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter

MATH 64091  SEMINAR IN MATHEMATICS EDUCATION  3 Credit Hours
(Repeatable for credit) Studies in geometry, algebra, mathematics for junior and senior high school. Mathematics content professionalized for teachers.
Prerequisite: MATH 34001 and Graduate standing.
Schedule Type: Seminar
Contact Hours: 3 other
Grade Mode: Standard Letter
MATH 66051  INTRODUCTION TO TOPOLOGY I  4 Credit Hours
(Slashed with MATH 76051) Set theory, topological spaces, continuity, product spaces, quotient spaces, separation axioms, compactness and metrizability.
Prerequisite: Graduate standing and special approval.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 66052  INTRODUCTION TO TOPOLOGY II  3 Credit Hours
(Slashed with MATH 76052) Geometric topology, including connectedness, continua, homotopy, the plane and 2 manifolds.
Prerequisite: MATH 76051 and Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 67098  RESEARCH  1-15 Credit Hours
(Repeatable for credit) Research or individual investigation. Credits are applied toward degree requirements with approval if letter grade of "S" is given.
Prerequisite: Graduate standing.
Schedule Type: Research
Contact Hours: 1-15 other
Grade Mode: Standard Letter

MATH 67199  THESIS I  2-6 Credit Hours
Thesis student must register for a total of 6 hours, 2 to 6 hours in a single semester distributed over several semesters if desired.
Prerequisite: Graduate standing.
Schedule Type: Masters Thesis
Contact Hours: 2-6 other
Grade Mode: Satisfactory/Unsatisfactory-IP

MATH 67199  THESIS II  2 Credit Hours
Thesis students must continue registration each semester until all degree requirements are met.
Prerequisite: MATH 67199 and Graduate standing.
Schedule Type: Masters Thesis
Contact Hours: 2 other
Grade Mode: Satisfactory/Unsatisfactory-IP

MATH 70051  PROBABILITY I  4 Credit Hours
(Slashed with MATH 60051) Distribution functions, measure theory, random variables, expectation, independence, convergence, concepts, law of large numbers.
Prerequisite: MATH 40011 or MATH 50011; or MATH 42002 or MATH 52002; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 70052  PROBABILITY II  3 Credit Hours
(Slashed with MATH 60052) Characteristic functions, the central limit problem, conditional expectations, Martingale theory, Brownian motion.
Prerequisite: MATH 60051 or MATH 70051 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 70061  MATHEMATICAL STATISTICS I  4 Credit Hours
Prerequisite: MATH 42002 or MATH 52002.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 70062  MATHEMATICAL STATISTICS II  3 Credit Hours
Prerequisite: MATH 60061 or MATH 70061 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 70070  FINANCIAL MATHEMATICS  3 Credit Hours
(Slashed with MATH 60070) Topics from replication of trading strategies, arbitrage completeness, Martingale presentation theorem, fundamental theorem of finance, stochastic differential equations, Black and Scholes formula of option pricing.
Prerequisite: MATH 50051 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 70091  SEMINAR IN STATISTICS AND PROBABILITY  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in statistics and probability.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Seminar
Contact Hours: 3 other
Grade Mode: Standard Letter

MATH 70095  SELECTED TOPICS IN STATISTICS AND PROBABILITY  1-3 Credit Hours
(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 70051, MATH 70052, and MATH 60062.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter
MATH 71001  STRUCTURE OF RINGS AND ALGEBRAS I  3 Credit Hours
Advanced topics in ring theory, including Artinian rings, Noetherian rings, advanced commutative ring theory.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 71002  STRUCTURE OF RINGS AND ALGEBRAS II  3 Credit Hours
Advanced topics in ring theory including an introduction to homological algebra. Includes Dedekind domains, regular rings, torsion theory.
Prerequisite: MATH 71001 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 71011  ADVANCED GROUP THEORY  3 Credit Hours
Advanced topics in group theory. Topics include permutation arguments, coprime actions, transfer theorems, nonsimplicity criteria. Properties of families of groups: solvable, p solvable, nilpotent, p groups.
Prerequisite: MATH 61051 or MATH 71051; and MATH 61052 or MATH 71052; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 71012  CHARACTERS OF FINITE GROUPS  3 Credit Hours
Development of characters of finite groups, their properties, orthogonality relations, integrality conditions. Applications include Burnside's paqb theorem and existence of Frobenius kernels in Frobenius groups.
Prerequisite: MATH 61051 or MATH 71051; and MATH 61052 or MATH 71052; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 71051  ABSTRACT ALGEBRA I  4 Credit Hours
(Slashed with MATH 61051) Advanced topics in group theory, including Sylow theorems, finite Abelian groups, divisible groups and related concepts. Includes one-hour problem session each week.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 71052  ABSTRACT ALGEBRA II  3 Credit Hours
(Slashed with MATH 61052) Advanced topics, commutative ring theory and field theory, including polynomial rings, unique factorization, domains, matrix rings, Galois theory.
Prerequisite: MATH 61051 or MATH 71051 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 71091  SEMINAR IN ALGEBRA  1-3 Credit Hours
(Repeatable for credit) (Slashed with MATH 61091) Seminar on current research in algebra.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Satisfactory/Unsatisfactory

MATH 71095  SELECTED TOPICS IN ALGEBRA  1-3 Credit Hours
(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 71002, MATH 71051 and MATH 71052.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter

MATH 72001  FUNCTIONAL ANALYSIS I  3 Credit Hours
A study of principles of linear analysis in the setting of normed linear spaces and topological vector spaces.
Prerequisite: MATH 72052 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72002  FUNCTIONAL ANALYSIS II  3 Credit Hours
A study of principles of linear analysis in the setting of normed linear spaces and topological vector spaces.
Prerequisite: MATH 72001 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72041  METHODS OF APPLIED MATHEMATICS I  3 Credit Hours
Prerequisite: MATH 51021 and MATH 52041 and MATH 52045 and MATH 52048 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72042  METHODS OF APPLIED MATHEMATICS II  3 Credit Hours
(Slashed with MATH 62042) Continuation of MATH 72041. Integral equations and Green's functions (Fredholm alternative, compact operators, distributions, weak solutions). Wave phenomena (dispersion, KdV equation). Stability and bifurcation (linearized stability analysis, turning points, Hopf bifurcation).
Prerequisite: MATH 62041 or MATH 72041 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
MATH 72095 SELECTED TOPICS IN REAL ANALYSIS 1-3 Credit Hours
(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 72002, MATH 72051 and MATH 72052.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter

MATH 72151 FUNCTIONS OF A COMPLEX VARIABLE I 4 Credit Hours
(Slashed with MATH 62151) Topological properties of the complex plane; analytic, entire, meromorphic functions; analytic continuation; conformal mappings; Picard's theorem; Riemann surfaces.
Prerequisite: MATH 52002; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 72152 FUNCTIONS OF A COMPLEX VARIABLE II 3 Credit Hours
(Slashed with MATH 62152) Topological properties of the complex plane; analytic, entire, meromorphic functions; analytic continuation; conformal mappings; Picard's theorem; Riemann surfaces.
Prerequisite: MATH 72151; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72195 SELECTED TOPICS IN COMPLEX ANALYSIS 1-3 Credit Hours
(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 72151 and MATH 72152.
Prerequisite: Special approval and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter

MATH 72203 COMPUTATIONAL FINANCE 3 Credit Hours
(Slashed with MATH 62203) Basic numerical methods, (numerical linear algebra, nonlinear equations, curve fitting, ODEs, integration, Monte Carlo methods) numerical solution of PDEs (stability, convergence, Black Scholes, American options, SDEs) probabilistic methods.
Prerequisite: MATH 22005 and MATH 21001 and MATH 32044 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72251 NUMERICAL ANALYSIS I 4 Credit Hours
(Slashed with MATH 62251) Floating point computation, rounding error analysis, conditioning, interpolation (polynomial, trigonometric spline). Numerical quadrature (Newton-Cotes, Gauss), extrapolation, Romberg integration.
Prerequisite: MATH 42002 or MATH 52002 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 72252 NUMERICAL ANALYSIS II 3 Credit Hours
(Slashed with MATH 62252) Numerical solution of linear systems of equations (LU factorization, error analysis). Least squares, orthogonalization methods. Algebraic eigenvalue problems, QR algorithm, singular value decomposition.
Prerequisite: MATH 41021 or MATH 51021; and MATH 62251 or MATH 72251; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72261 NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 3 Credit Hours
Prerequisite: MATH 32044; and MATH 42202 or MATH 52202; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72262 NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS 3 Credit Hours
(Slashed with MATH 62262) Derivation and analysis of discrete methods (finite differences, finite elements) for the numerical solution of elliptic, hyperbolic and parabolic partial differential equations.
Prerequisite: MATH 42045 or MATH 52045; and MATH 42202 or MATH 52202; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72263 NUMERICAL SOLUTION OF LARGE SPARSE LINEAR SYSTEMS 3 Credit Hours
Prerequisite: MATH 41021 or MATH 51021; and MATH 42202 or MATH 52202; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72264 NUMERICAL SOLUTION OF NONLINEAR SYSTEMS 3 Credit Hours
(Slashed with MATH 62264) (Cross-listed with CS 62264 and CS 72264) Construction and analysis of numerical methods for systems of nonlinear algebraic equations and optimization problems. Numerical implementation and software.
Prerequisite: MATH 42041 or MATH 52041; and MATH 42202 or MATH 52202; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 72291 SEMINAR IN NUMERICAL ANALYSIS 1-3 Credit Hours
(Repeatable for credit) Seminar on current research in numerical analysis.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter
MATH 72295  SELECTED TOPICS IN NUMERICAL ANALYSIS  1-3
Credit Hours
(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 72251 and MATH 72252.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter

MATH 72391  SEMINAR IN MEASURE THEORY  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in measure theory.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter

MATH 72491  SEMINAR IN NONLINEAR ANALYSIS  1-3 Credit Hours
(Repeatable for credit) Seminar on current research in nonlinear analysis.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Seminar
Contact Hours: 1-3 other
Grade Mode: Standard Letter

MATH 76051  INTRODUCTION TO TOPOLOGY I  4 Credit Hours
(Flushed with MATH 66051) Set theory, topological spaces, continuity, product spaces, quotient spaces separation axiom, compactness and metrizability.
Prerequisite: Doctoral standing and special approval.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 76052  INTRODUCTION TO TOPOLOGY II  3 Credit Hours
Geometric topology, including connectedness, continua, homotopy, the plane and 2 manifolds.
Prerequisite: MATH 66051 or MATH 76051 and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 77011  ALGEBRAIC NUMBER THEORY  3 Credit Hours
Number fields and Dedekind domains; conjugates, norm and trace, discriminant, integral bases; arithmetic or quadratic and cyclotomic number fields; theory of ideals and class group; Dirichlet's theorem on units.
Prerequisite: MATH 57011; and MATH 61052 or MATH 71052; and Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 77012  ANALYTIC NUMBER THEORY  3 Credit Hours
Multiplicative functions and summatory functions, Riemann's Zeta function and the prime number theorem, L-functions and Dirichlet's theorem on primes in arithmetic progressions, asymptotic formula for partitions.
Prerequisite: MATH 57011 and MATH 62151 or MATH 72151.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 77098  RESEARCH I  1-15 Credit Hours
(Repeatable for credit) Research or individual investigation. Credits are applied toward degree requirements with approval if letter grade of "S" is given.
Prerequisite: Doctoral standing.
Schedule Type: Research
Contact Hours: 1-15 other
Grade Mode: Satisfactory/Unsatisfactory

MATH 87098  RESEARCH  1-15 Credit Hours
(Repeatable for credit) Research or individual investigation for doctoral students who have not yet passed their candidacy examinations. Credits earned may be applied toward degree if department approves.
Prerequisite: Doctoral standing.
Schedule Type: Research
Contact Hours: 1-15 other
Grade Mode: Satisfactory/Unsatisfactory
MATH 87199 DISSERTATION I 15 Credit Hours
(Repeatable for credit) Doctoral dissertation, for which registration in at least two semesters is required first of which will be semester in which dissertation work is begun and continuing until the completion of 30 hours.
Prerequisite: Admission to Doctoral candidacy and Doctoral standing.
Schedule Type: Dissertation
Contact Hours: 15 other
Grade Mode: Satisfactory/Unsatisfactory-IP

MATH 87299 DISSERTATION II 15 Credit Hours
(Repeatable for credit) Continuing registration required of doctoral students who have completed the initial 30 hours of dissertation and continuing until all degree requirements are met.
Prerequisite: MATH 87199 and Doctoral standing.
Schedule Type: Dissertation
Contact Hours: 15 other
Grade Mode: Satisfactory/Unsatisfactory-IP