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: MATH 00020 with a minimum C grade.
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 MATH 00021 with a minimum C grade.
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 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 MATH 00022 with a minimum C grade; or any higher level MATH course.
Schedule Type: Emporium
Contact Hours: 4 other
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, Transfer Module Mathematics

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 MATH 00021 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 5 lecture
Grade Mode: Standard Letter
Attributes: Kent Core Mathematics and Critical Reasoning, TAG Mathematics, Transfer Module Mathematics

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 MATH 00022 with a minimum C grade; 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 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. 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 MATH 00022 with a minimum C grade.  
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, equality, properties of the real numbers, multiple representations of operations with numbers, and problem solving.  
Prerequisite: Minimum 35 ALEKS math score; or minimum 22 ACT math score; or minimum 530 SAT math score; or MATH 00022 with a minimum C grade.  
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 MATH 00022 with a minimum C grade.  
Schedule Type: Lecture  
Contact Hours: 5 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.  
Prerequisite: Minimum 22 ACT math score; or minimum ALEKS math score between 45 and 54; or MATH 10772 with a minimum C grade.  
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 MATH 00022 or any higher MATH course with a minimum C grade.  
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 or 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 MATH 10772 or MATH 11009 with a minimum B grade.  
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 10675 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 11022  TRIGONOMETRY (KMCR)  3 Credit Hours
Solution of triangles, trigonometric equations and identities.
Prerequisite: Minimum 67 ALEKS math score; or minimum C grade in MATH 10675 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 MATH 11022 with a minimum C grade.
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; vectors; parametric equations; sequences and series.
Prerequisite: MATH 12002 or MATH 12012 with a minimum C grade.
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: MATH 12011 with a minimum C grade.
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: Minimum C grade in MATH 12002 or MATH 12012 or MATH 12021.
Schedule Type: Lecture
Contact Hours: 4 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 MATH 11022 or MATH 12011 with a minimum C grade.
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
(Equivalent to 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 minimum C grade in MATH 00023 or any higher MATH course (except MATH 10041, MATH 10051, MATH 10057, 10058, 10081, 10083, 11005, 11016).
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: MATH 10771 or MATH 14001 with a minimum C grade.
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: MATH 12002 with a minimum C grade.
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, eigenvalues, eigenvectors.
Prerequisite: Minimum C grade in 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 MATH 12002 or MATH 11012 or MATH 12012 or MATH 12021.
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: Practical Experience
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: MATH 12003 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter
Attributes: TAG Mathematics

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 C grade in MATH 11009 or MATH 11010 or Math 11022, or ALEKS score of 78.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 23032  DISCRETE STRUCTURES FOR COMPUTER SCIENCE  3 Credit Hours
(Cross-listed with CS 23032) 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 C grade in MATH 11009 or MATH 11010 or Math 11022, or ALEKS score of 78.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 23001  LINEAR ALGEBRA  3 Credit Hours
Systems of linear equations and the associated matrix operations, linear transformations, vector spaces, bases, eigenvalues, eigenvectors.
Prerequisite: Minimum C grade in 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 30001  BASIC MATHEMATICS  3 Credit Hours
No prerequisites.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 30009  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 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 10675 or MATH 10775 or MATH 11010; or any course MATH 11012 to MATH 12022; 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: MATH 12003 with a minimum C grade.
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: MATH 12002 with a minimum C grade.
Pre/corequisite: MATH 21001 or MATH 32051 with a minimum C grade.
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: MATH 21001 and MATH 22005 with a minimum C grade.
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: MATH 12003 with a minimum C grade.
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: MATH 32051 with a minimum C grade; or MATH 21001 and
MATH 22005 with a minimum C grade.
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: MATH 12002 with a minimum C grade.
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: MATH 12002 with a minimum C grade.
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: MATH 12002 with a minimum C grade.
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: MATH 22005 or MATH 32051 with a minimum C grade.
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: MATH 40011 with a minimum C grade.
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. Students with 
statistics courses from other disciplines should consult with the 
Department of Mathematical Sciences for possible prerequisite overrides. 
Prerequisite: (MATH 21001 with a minimum C grade OR MATH 21002 
with a minimum C grade) AND (MATH 12022 with a minimum B grade OR 
MATH 20011 with a minimum C grade OR MATH 30011 with a minimum 
B grade OR MATH 40012 with a minimum C grade).

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. 
Students with statistics courses from other disciplines should consult with the 
Department of Mathematical Sciences for possible prerequisite overrides. 
Prerequisite: (MATH 21001 with a minimum C grade OR MATH 21002 
with a minimum C grade) AND (MATH 12022 with a minimum B grade OR 
MATH 20011 with a minimum C grade OR MATH 30011 with a minimum 
B grade OR MATH 40012 with a minimum C grade).

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: MATH 40015 and MATH 40024 with a minimum C grade.  
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: MATH 40011 with a minimum C grade.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter

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: MATH 30055 and MATH 40011 with a minimum C grade.  
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: MATH 40055 with a minimum C grade.  
Schedule Type: Lecture  
Contact Hours: 4 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: MATH 22005 or MATH 32051 with a minimum C grade; and 
MATH 31011 with a minimum C grade.  
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: MATH 21001 and MATH 22005 with a minimum C grade.  
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 and PHIL 51038) 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. A or B.S.) major or Mathematics minor.
Prerequisite: Junior standing; and Actuarial Mathematics major, Applied Mathematics major, Applied Mathematics minor, Applied Statistics minor, Mathematics (B).
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 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 ChurchTuring 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: MATH 22005 or MATH 32051 with a minimum C grade; and MATH 31011 with a minimum C grade.
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: MATH 42001 with a minimum C grade.
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 MATH 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: MATH 12003 and MATH 21001 with a minimum C grade.
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: MATH 32044 or MATH 32052 with a minimum C grade.
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: MATH 42031 with a minimum C grade.
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: MATH 21001 with a minimum C grade; and 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: MATH 32044 or MATH 32052 with a minimum C grade.
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: MATH 22005 or MATH 32051 with a minimum C grade.
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 52001; 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 and CS 52202) (Slashed with MATH 52202) A continuation of MATH 42201. Topics include interpolation, numerical differentiation and integration, and numerical solution of ordinary differential equations.
Prerequisite: MATH 42201 with a minimum C grade; and MATH 32044 or MATH 32052 with a minimum C grade.
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: MATH 22005 with a minimum C grade.
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: MATH 21001 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 45022 LINEAR GEOMETRY 3 Credit Hours
(Slashed with MATH 55022) Using transformations as a tool to study geometry and to differentiate between different kinds of geometry. Linear algebra methods applied to geometry.
Prerequisite: MATH 21001 with a minimum C grade.
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: MATH 22005 with a minimum C grade.
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: MATH 12003 with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 47021 HISTORY OF MATHEMATICS 3 Credit Hours
(Slashed with MATH 57021) Survey from Babylonian and Egyptian mathematics to 20th century mathematics with emphasis on the development of algebra, geometry, calculus, number theory.
Prerequisite: MATH 23002 or higher with a minimum C grade.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 49992 INTERNSHIP IN MATHEMATICS (ELR) 1-3 Credit Hours
Supervised work experience and training in the mathematical sciences. Since this work will be outside the department a report and final presentation will be required.
Prerequisite: Special Approval.
Schedule Type: Practical Experience
Contact Hours: 0 lecture, 0 lab, 3-9 other
Grade Mode: Satisfactory/Unsatisfactory-IP
Attributes: Experiential Learning Requirement

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 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; and 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) Topics from investment risk, mean variance analysis, CAPM, financial derivatives, binomial pricing model, stochastic calculus, Black-Scholes pricing model, and Greeks.
Prerequisite: MATH 40011 or 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; and applied mathematics or pure mathematics major; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

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

MATH 51038 INTERMEDIATE LOGIC 3 Credit Hours
(Cross-listed with CS 41038 and PHIL 41038 and PHIL 51038) 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: Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 51045 METALOGIC 3 Credit Hours
(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, 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
Prerequisite: Graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 52001 ANALYSIS I 3 Credit Hours
(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.
Prerequisite: Applied mathematics or pure mathematics major; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 52002 ANALYSIS II 3 Credit Hours
(Slashed with MATH 42002) Topics include further development of integration theory infinite series, uniform convergence, several variable calculus and metric spaces.
Prerequisite: MATH 42001 or MATH 52001; and applied mathematics or pure mathematics major; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 52011 MATHEMATICAL OPTIMIZATION 3 Credit Hours
(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.
Prerequisite: MATH 21001 and MATH 22005; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 52021 GRAPH THEORY AND COMBINATORICS 3 Credit Hours
(MATH 42021) Fundamentals and applications of combinatorial mathematics. Topics include transversability, colorability, networks, inclusion and exclusion, matching and designs.
Prerequisite: MATH 12003 and MATH 21001; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

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

MATH 52031 MATHEMATICAL MODELS AND DYNAMICAL SYSTEMS 3 Credit Hours
(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.
Prerequisite: MATH 32044; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

MATH 52039 MODELING PROJECTS 3 Credit Hours
(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.
Prerequisite: MATH 52031 with a minimum C grade; and graduate standing.
Schedule Type: Seminar
Contact Hours: 3 other
Grade Mode: Standard Letter
MATH 52041  ADVANCED CALCULUS  3 Credit Hours  
(Slashed with MATH 42041) 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: MATH 21001 and MATH 22005.  
Schedule Type: Lecture  
Contact Hours: 3 lecture  
Grade Mode: Standard Letter  

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; and 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: One course MATH 23022 or higher; 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 60051 PROBABILITY I 4 Credit Hours
(Slashed with MATH 70051) Distribution functions, measure theory, random variables, expectation, independence, convergence, concepts, law of large numbers.
Prerequisite: MATH 40011 or MATH 42002 or MATH 50011 or MATH 52002; and graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

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 61051 ABSTRACT ALGEBRA I 4 Credit Hours
(Slashed with MATH 71051) 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
(Slashed with MATH 72261) Discretization methods for ordinary
differential equations and systems. Initial value and boundary value
problems. Numerical implementation software and analysis.
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
(Slashed with MATH 72263) (Cross-listed with CS 62263 and CS 72263)
Construction and analysis of iterative methods for large systems of linear
algebraic equations. Jacobi, Gauss-Seidel, SOR. Polynomial acceleration
methods, conjugate gradients. Multi-grid methods.
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) (Slashed with 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 COMPUTATIONAL AND APPLIED
MATHEMATICS  1-3 Credit Hours
(Repeatable for credit) (Slashed with MATH 72291) Seminar on current
research in computational and applied Mathematics
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: 3 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 67091  SEMINAR IN NUMBER THEORY  1-3 Credit Hours  
(Repeatable for credit) (Slashed with MATH 77091) Seminar on current research in number theory.  
Prerequisite: Graduate standing; and special approval.  
Schedule Type: Seminar  
Contact Hours: 1-3 other  
Grade Mode: Standard Letter  

MATH 67095  SELECTED TOPICS IN MATHEMATICS  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: Graduate Standing; and special approval.  
Schedule Type: Lecture  
Contact Hours: 1-4 lecture, 0 lab, 0 other  
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 67299  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) Characteristic functions, the central limit problem, conditional expectations, Martingale theory, Brownian motion.  
Prerequisite: MATH 60011 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) Distribution functions, measure theory, random variables, expectation, independence, convergence, concepts, law of large numbers.  
Prerequisite: MATH 40011 or MATH 70061 or MATH 70062; 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: 1-3
Grade Mode: Satisfactory/Unsatisfactory

MATH 70095 SELECTED TOPICS IN STATISTICS AND PROBABILITY 1-3 Credit Hours
(Repeatably for credit) Topics vary with each offering and complement topics covered in MATH 70051, MATH 70052, MATH 70061 and MATH 70062.
Prerequisite: Doctoral standing; and special approval.
Schedule Type: Lecture
Contact Hours: 1-3
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: MATH 71001; and doctoral standing.
Schedule Type: Lecture
Contact Hours: 3
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
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
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
Grade Mode: Standard Letter

MATH 71051 ABSTRACT ALGEBRA I 4 Credit Hours
(Repeatably for credit) 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
Grade Mode: Standard Letter

MATH 71052 ABSTRACT ALGEBRA II 3 Credit Hours
(Repeatably for credit) 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
Grade Mode: Standard Letter

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

MATH 71095 SELECTED TOPICS IN ALGEBRA 1-3 Credit Hours
(Repeatably 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: 3
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
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
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
Grade Mode: Standard Letter

MATH 72042 METHODS OF APPLIED MATHEMATICS II 3 Credit Hours
(Repeatably for credit) 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
Grade Mode: Standard Letter
MATH 72051  FUNCTIONS OF A REAL VARIABLE I  4 Credit Hours
(Slashed with MATH 62051) Introduction to modern concepts of real
analysis including metric spaces, measure and integration theory.
Prerequisite: MATH 42002 or MATH 52002; and doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

MATH 72052  FUNCTIONS OF A REAL VARIABLE II  3 Credit Hours
(Slashed with MATH 62052). A continuation of MATH 72051. Included are
basic topics in functional analysis and Hilbert space theory.
Prerequisite: MATH 62051 or MATH 72051; 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: Doctoral standing; and special approval.
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
(Slashed with MATH 62261) Discretization methods for ordinary
differential equations and systems. Initial value and boundary value
problems. Numerical implementation software and analysis.
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
(Slashed with MATH 62263) (Cross-listed with CS 62263 and CS 72263)
Construction and analysis of iterative methods for large systems of linear
algebraic equations. Jacobi, Gauss-Seidel, SOR. Polynomial acceleration
methods, conjugate gradients. Multi-grid methods.
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
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tr>
<td>MATH 72264</td>
<td>NUMERICAL SOLUTION OF NONLINEAR SYSTEMS</td>
<td>3</td>
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<td>(Slashed with MATH 62264) (Cross-listed with CS 62264 and CS 72264)</td>
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<td>Prerequisite:</td>
<td>MATH 42041 or MATH 52041; and MATH 42202 or MATH 52202; and doctoral standing.</td>
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<tr>
<td>MATH 72291</td>
<td>SEMINAR IN COMPUTATIONAL AND APPLIED MATHEMATICS</td>
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<td></td>
<td>(Repeatable for credit) (Slashed with Math 62291) Seminar on current research in numerical analysis.</td>
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<tr>
<td>Prerequisite:</td>
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<td>Schedule Type:</td>
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<td>Contact Hours:</td>
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<tr>
<td>MATH 72295</td>
<td>SELECTED TOPICS IN NUMERICAL ANALYSIS</td>
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<td>(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 72251 and MATH 72252.</td>
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<tr>
<td>Prerequisite:</td>
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<td>Grade Mode:</td>
<td>Standard Letter</td>
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<tr>
<td>MATH 72391</td>
<td>SEMINAR IN MEASURE THEORY</td>
<td>1-3</td>
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<td>(Repeatable for credit) Seminar on current research in measure theory.</td>
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<td>Schedule Type:</td>
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<td>Contact Hours:</td>
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<td>Grade Mode:</td>
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<tr>
<td>MATH 72491</td>
<td>SEMINAR IN NONLINEAR ANALYSIS</td>
<td>1-3</td>
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<td>(Repeatable for credit) Seminar on current research in nonlinear analysis.</td>
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<td>Prerequisite:</td>
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<td>Contact Hours:</td>
<td>1-3 other</td>
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<td>Grade Mode:</td>
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<tr>
<td>MATH 76051</td>
<td>INTRODUCTION TO TOPOLOGY I</td>
<td>4</td>
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<td>(Slashed with MATH 66051) Set theory, topological spaces, continuity, product spaces, quotient spaces separation axioms, compactness and metrizability.</td>
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<td>Prerequisite:</td>
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<td>Schedule Type:</td>
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<td>Contact Hours:</td>
<td>4 lecture</td>
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<td>Standard Letter</td>
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<tr>
<td>MATH 76052</td>
<td>INTRODUCTION TO TOPOLOGY II</td>
<td>3</td>
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<td>Geometric topology, including connectedness, continua, homotopy, the plane and 2 manifolds.</td>
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<td>Prerequisite:</td>
<td>MATH 66051 or MATH 76051; and doctoral standing.</td>
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<td>Contact Hours:</td>
<td>3 lecture</td>
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<tr>
<td>MATH 76095</td>
<td>SELECTED TOPICS IN TOPOLOGY</td>
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<td>(Repeatable for credit) Topics vary with each offering and complement topics covered in MATH 76051 and MATH 76052.</td>
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<td>Prerequisite:</td>
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<td>Contact Hours:</td>
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<td>Standard Letter</td>
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<tr>
<td>MATH 77011</td>
<td>ALGEBRAIC NUMBER THEORY</td>
<td>3</td>
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<td>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.</td>
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<tr>
<td>Prerequisite:</td>
<td>MATH 57011 and MATH 61052 or MATH 71052; and doctoral standing.</td>
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<tr>
<td>MATH 77091</td>
<td>SEMINAR IN NUMBER THEORY</td>
<td>1-3</td>
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<td>(Repeatable for credit) (Slashed with MATH 67091) Seminar on current research in number theory.</td>
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<td>Contact Hours:</td>
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<td>MATH 77095</td>
<td>SELECTED TOPICS IN MATHEMATICS</td>
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<td>(Repeatable for credit) Course topic varies with each offering.</td>
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<tr>
<td>MATH 77098</td>
<td>RESEARCH I</td>
<td>1-15</td>
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<td>(Repeatable for credit) Research or individual investigation. Credits are applied toward degree requirements with approval if letter grade of &quot;S&quot; is given.</td>
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<td>Contact Hours:</td>
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<td>Grade Mode:</td>
<td>Standard Letter</td>
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<tr>
<td>MATH 77195</td>
<td>SELECTED TOPICS IN NUMBER THEORY</td>
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<td>(Repeatable for credit) Content varies with each offering and complements topics covered in MATH 77011 and MATH 77012.</td>
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<tr>
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</table>
MATH 77198  RESEARCH II  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: Standard Letter

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