

Math Course Descriptions Fall 2010

Mathematics (MATH)

MATH 105 -- Mathematics in Modern Society (3 units)

Description: This course will examine how the mathematics learned in high school is applied to real life situations. Topics may include personal finance, statistics, elections, symmetry, and scheduling. Some of the applications may be how the site of the Olympic Games is chosen, why spirals occur in nature, and how statistical data is collected and how it can be used to mislead the public. The course is designed for elementary education majors, fine arts majors, humanities majors, and those social and behavioral science majors whose further courses do not require College Algebra as a prerequisite.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable score on UA Math Readiness Test.

Usually offered: Fall, Spring.

MATH 109 -- College Algebra with Data Analysis (4 units)

Description: College algebra course that emphasizes data analysis. Topics include functions, rates of change, linear functions, exponential & logarithmic functions, and systems of equations. Graphing calculators and spreadsheets will be used. This course may be used as a prerequisite for MATH 115A, 160, 113, or 263. It is not intended for students planning to take Math 124, and it will not serve as a prerequisite for that course. Credit will be allowed for only one of the following courses: Math 109, Math 110, or Math 112.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable score on UA Math Readiness Test.

MATH 109C -- Applied College Algebra with Data Analysis (3 units)

Description: College algebra course that emphasizes data analysis. Topics include functions, rates of change, linear functions, systems of equations, exponential & logarithmic functions, and quadratic functions. Graphing calculators and spreadsheets will be used. This course may be used as a prerequisite for MATH 115A, 160, 113, or 263. It is not intended for students planning to take MATH 124, and it will not serve as a prerequisite for that course. Credit will be allowed for only one of the following courses: MATH 109, MATH 109C, MATH 110, or MATH 112.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable placement.

Usually offered: Fall, Spring, Summer.

MATH 110 -- College Algebra (4 units)

Description: Topics include properties of functions and graphs, linear and quadratic equations, polynomial functions, rational functions, exponential and logarithmic functions with applications, sequences and series. Course includes an integrated review of important concepts in intermediate algebra. Students are expected to have a graphing calculator. Credit will be allowed for only one of the following courses: MATH 109, MATH 110, or MATH 112.

Registration in MATH courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): An acceptable score on UA Math Readiness Test.

Usually offered: Fall, Spring.

MATH 111 -- Plane Trigonometry (2 units)

Description: Topics include right triangle trigonometry, trigonometric functions and graphs, trig identities, inverse trig functions, law of sines, and law of cosines. Students are expected to have a graphing calculator. Not applicable to the mathematics major or minor. Students with credit in MATH 120R or MATH 120S obtain one unit of graduation credit for MATH 111. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): An acceptable score on the UA Math Readiness Test.

Usually offered: Fall, Spring.

MATH 112 -- College Algebra Concepts and Applications (3 units)

Description: Topics include properties of functions and graphs, linear and quadratic equations, polynomial functions, exponential and logarithmic functions with applications. Students are expected to have a graphing calculator. MATH 112 may be substituted for MATH 110 in any university requirement or prerequisite. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course. Credit allowed for only one of the following courses: MATH 109, MATH 110 or MATH 112.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable score on the UA Math Readiness Test. Credit allowed for only one of the following courses: MATH109, MATH 110 or MATH 112.

Usually offered: Fall, Spring.

MATH 113 -- Elements of Calculus (3 units)

Description: Introductory topics in differential and integral calculus. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Formerly MATH 123.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 109/110/112 or acceptable score on UA Math Readiness Test. Credit allowed for only one of the following courses: MATH 113, MATH 124, or MATH 125.

Usually offered: Fall, Spring.

MATH 115A -- Business Mathematics I (3 units)

Description: Probability, conditional probability, Bayes' Theorem, random variables, random sampling, compound interest, expected value, computer simulation, and spreadsheet functions. The course is based on an electronic text, with extensive use of spreadsheets, downloaded

data, and team reports on major business projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$20.

Prerequisite(s): MATH 109, MATH 110, MATH 112 or an acceptable score on the UA Math Readiness Test, MIS 111.

Usually offered: Fall, Spring.

MATH 115B -- Business Mathematics II (3 units)

Description: Variance, normal distributions, distribution of the sample mean, integration, differentiation, advanced spreadsheet functions, and computer simulation. The course is based on an electronic text, with extensive use of spreadsheets, downloaded data, and team reports on major business projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$20.

Prerequisite(s): MATH 115A.

Usually offered: Fall, Spring.

MATH 120R -- Calculus Preparation (4 units)

Description: Review of algebra and trigonometry; study of functions including polynomial, rational, exponential, logarithmic and trigonometric. For students who have high school credit in college algebra and trigonometry but have not attained a sufficient score on the UA Math Readiness Test to enter calculus. Students with credit in both MATH 110/112 and MATH 111 receive no credit for MATH 120R. Students with credit in MATH 111, but not MATH 110/112, receive three units of graduation credit for MATH 120R. Students with credit in MATH 110/112 but not MATH 111, will receive one unit of graduation credit for MATH 120R. Graphing calculators are required in this course. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable score on UA Math Readiness Test.

Usually offered: Fall, Spring.

MATH 124 -- Calculus I with Applications (5 units)

Description: Introduction to calculus with an emphasis on understanding and problem solving. Concepts are presented graphically and numerically as well as algebraically. Elementary functions, their properties and uses in modeling; the key concepts of derivative and definite integral; techniques of differentiation, using the derivative to understand the behavior of functions; applications to optimization problems in physics, biology and economics. A graphing calculator is required in this course. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 120R, or MATH 110/112 and MATH 111, or an acceptable score on the UA Math Readiness Test. Credit allowed for only one of the following courses: MATH 113, MATH 124, or MATH 125.

Usually offered: Fall, Spring.

MATH 125 -- Calculus I (3 units)

Description: An accelerated version of MATH 124. Introduction to calculus with an emphasis on understanding and problem solving. Concepts are presented graphically and numerically as well as algebraically. Elementary functions, their properties and uses in modeling; the key concepts of derivative and definite integral; techniques of differentiation, using the derivative to understand the behavior of functions; applications to optimization problems in physics, biology and economics. A graphing calculator is required for this course. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Math Readiness Test. Credit will not be given for this course if the student has credit in a higher level math course; these students will be dropped from the course. Students with unusual circumstances can petition the Mathematics Department for exemption from this rule. This policy does not infringe on the student's rights granted by the university policy on repeating a course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Acceptable score on UA Math Readiness Test. Credit allowed for only one of the following courses: MATH 113, MATH 124, or MATH 125.

Usually offered: Fall, Spring.

MATH 129 -- Calculus II (3 units)

Description: Continuation of MATH 124 or MATH 125. Techniques of symbolic and numerical integration, applications of the definite integral to geometry, physics, economics, and probability; differential equations from a numerical, graphical, and algebraic point of view; modeling using differential equations, approximations by Taylor series. A graphing calculator is required for this course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 124 or MATH 125. Credit allowed for only one of the following: MATH 129 or MATH 250A.

Usually offered: Fall, Spring.

MATH 160 -- Basic Statistics (3 units)

Description: Organizing data: displaying distributions, measures of center, measures of spread, scatterplots, correlation, regression, and their interpretation. Design of experiments: simple random samples and their sampling distribution, models from probability, normal distributions, and normal approximations. Statistical inference: confidence intervals and hypothesis testing, t procedures and chi-square tests. Not intended for those who plan further studies in statistics. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Mathematics Readiness Test.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 109/110/112 or an acceptable score on the UA Math Readiness Test. Credit allowed for only one of the following: MATH 160 or MATH 263.

Usually offered: Fall, Spring.

MATH 196A -- Tutoring in the Schools (1 unit)

Description: This course is designed to introduce the mathematics teaching profession to

mathematically talented college students. Students are given opportunities to observe and tutor in middle and high school mathematics classrooms. Additionally, class time will be dedicated to developing tutor techniques, examining learning styles, and exploring various methods of instruction. Readings, reflections, discussions, and group work will facilitate student understanding of the teaching and learning of mathematics. Students with a math placement level of calculus or higher will be given preference in the application process

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

Prerequisite(s): Students must apply for the course. The application can be found at <http://crr.math.arizona.edu>. Students with a math placement level of calculus or higher will be given preference in the application process.

Usually offered: Fall, Spring.

MATH 199 -- Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 199H -- Honors Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 202 -- Introduction to Symbolic Logic (3 units)

Description: Truth-functional logic and quantification theory; deductive techniques and translation into symbolic notation.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: PHIL 202; PHIL is home department.

Usually offered: Fall.

MATH 215 -- Introduction to Linear Algebra (3 units)

Description: Vector spaces, linear transformations and matrices. There is some emphasis on the writing of proofs.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Prerequisite(s): MATH 129 or MATH 250A.

Usually offered: Fall, Spring.

MATH 223 -- Vector Calculus (4 units)

Description: Vectors, differential and integral calculus of several variables.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Prerequisite(s): MATH 129 or MATH 250A.

Usually offered: Fall, Spring.

MATH 243 -- Discrete Mathematics in Computer Science (3 units)

Description: Set theory, logic, discrete structures; induction and recursion; graphs and networks; techniques of proof.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Prerequisite(s): MATH 129 or MATH 250A.

Usually offered: Fall, Spring.

MATH 250A -- Calculus and Differential Equations I (3 units)

Description: Integral calculus with applications, techniques of integration, solving first order differential equations using separation of variables, introduction to autonomous first order differential equations. The sequence MATH 250A-250B substitutes for the pair of courses MATH 129-254 or the pair MATH 129-355; however, MATH 250A alone does not substitute for MATH 129.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): A score of 4 or 5 on the "AB" Advanced Placement Calculus Exam, consent of instructor. Credit allowed for only one of the following: MATH 250A or MATH129.

Usually offered: Fall.

MATH 250B -- Calculus and Differential Equations II (3 units)

Description: First order differential equations and modeling, approximations and series, second order differential equations, linear and nonlinear autonomous systems. The sequence MATH 250A-250B substitutes for the pair of courses MATH 129-254 or the pair MATH 129-355; however, MATH 250B alone does not substitute for MATH 254 or MATH 355.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 250A. Credit allowed for only one of the following: MATH 250B, MATH 254, or MATH 355.

Usually offered: Spring.

MATH 254 -- Introduction to Ordinary Differential Equations (3 units)

Description: Solution methods for ordinary differential equations, qualitative techniques; includes matrix methods approach to systems of linear equations and series solutions.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Prerequisite(s): MATH 129. Credit allowed for only one of these courses: MATH 254, MATH 355 or MATH 250B.

Usually offered: Fall, Spring.

MATH 263 -- Introduction to Statistics and Biostatistics (3 units)

Description: Organizing data; distributions, measures of center and spread, scatterplots, nonlinear models and transformations, correlation, regression. Design of experiments: models from probability, discrete and continuous random variables, normal distributions, sampling distributions, the central limit theorem. Statistical inference; confidence intervals and test of significance, t procedures, inference for count data, two-way tables and chi-square procedures, inference for regression, analysis of variance. Registration in math courses numbered 125 or below, 160, and 263, requires all students, including transfer students with or without college level math credit, to take the UA Mathematics Readiness Test.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 109/110/112 or an acceptable score on the UA Math Readiness Test.

Credit allowed for only one of MATH 160 or MATH 263.

Usually offered: Fall, Spring.

MATH 293 -- Internship (1-10 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or government establishment.

Grading: [Alternative grades](#) are awarded for this course: S P F.

Usually offered: Fall, Spring, Summer.

MATH 294A -- Problem-Solving Laboratory (1 unit)

Description: The practical application, on an individual basis, of previously studied theory and the collection of data for future theoretical interpretation.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring.

MATH 299 -- Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 299H -- Honors Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 302A -- Understanding Elementary Mathematics (A) (3 units)

Description: Development of a basis for understanding the common processes in elementary mathematics related to whole numbers, fractions, integers, and probability.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 105 or MATH 109/110/112 or acceptable score on the UA Math Readiness Test. This course is for elementary education majors only.

Usually offered: Fall, Spring.

MATH 302B -- Understanding Elementary Mathematics (B) (3 units)

Description: Development of a basis for understanding the common processes in elementary mathematics related to estimation, graphing of functions, measurement, geometry, and data analysis.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 302A; for elementary education majors only.

Usually offered: Fall, Spring.

MATH 303 -- Explorations in Integrated Science (4 units)

Description: Students will learn to integrate knowledge and research approaches from multiple scientific disciplines through four laboratory- and lecture- based modules. Module topics currently include: protein synthesis and folding, biological motion, multiscale modeling, and entropy. Students will use MATLAB and other computer software to analyze data collected in the course. This is a [Writing Emphasis Course](#).

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$150.

Prerequisite(s): MATH 124 or MATH 125. Satisfaction of the [Mid-Career Writing Assessment \(MCWA\)](#).

Typical structure: 3 hours lecture, 3 hours laboratory.

Identical to: MCB 303; MCB is home department.

Usually offered: Fall, Spring.

[MATH 315](#) -- Introduction to Number Theory and Modern Algebra (3 units)

Description: Divisibility properties of integers, primes, congruencies, quadratic residues, number-theoretic functions.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Equivalent to: [MATV315](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 315 or MATV 315

Prerequisite(s): MATH 323 or consent of instructor.

Usually offered: Spring.

[MATH 322](#) -- Mathematical Analysis for Engineers (3 units)

Description: Complex functions and integration, line and surface integrals, Fourier series, partial differential equations.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 250B or MATH 254 or MATH 355. Credit allowed for only one of the following: MATH 322 or MATH 422.

Usually offered: Fall, Spring.

[MATH 323](#) -- Formal Mathematical Reasoning and Writing (3 units)

Description: Elementary real analysis as an introduction to abstract mathematics and the use of mathematical language. Elementary logic and quantifiers; manipulations with sets, relations and functions, including images and pre-images; properties of the real numbers; supreme and infimum; other topics selected from cardinality, the topology of the real line, sequence and limits of sequences and functions; the emphasis throughout is on proving theorems. This is a [Writing Emphasis Course](#).

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV323](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 323 or MATV 323

Prerequisite(s): MATH 215. Satisfaction of the [Mid-Career Writing Assessment \(MCWA\)](#).

Usually offered: Fall, Spring.

MATH 330 -- Topics in Geometry (3 units)

Description: Topics to be selected from 2- and 3-dimensional combinatorial geometry, Euclidean transformational geometry, symmetry, geometric optimization (shortest path problems), theorem of the arithmetic and geometric means, isoperimetric problem, polyhedra, and 3- and... 2-dimensional crystallography.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV330](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 330 or MATV 330

Prerequisite(s): MATH 215.

Usually offered: Fall.

[MATH 355](#) -- Analysis of Ordinary Differential Equations (3 units)

Description: Linear and nonlinear equations; basic solution techniques; qualitative and numerical methods; systems of equations; computer studies; applications drawn from physical, biological and social sciences.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV355](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 355 or MATV 355

Prerequisite(s): MATH 215. Credit allowed for only one of these courses: MATH 355, MATH 254, or MATH 250B.

Usually offered: Fall, Spring.

[MATH 362](#) -- Introduction to Probability Theory (3 units)

Description: Sample spaces, random variables and their properties, with considerable emphasis on applications. Computer exercises and hands-on activities will be used in class to introduce the concepts.

Grading: [Regular grades](#) are awarded for this course: A B C D E. Available to qualified students for [Pass/Fail Option](#).

Equivalent to: [MATV362](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 362 or MATV 362

Prerequisite(s): MATH 129 or MATH 250A.

Usually offered: Fall, Spring.

[MATH 363](#) -- Introduction to Statistical Methods (3 units)

Description: In Introduction to Statistical Methods, we shall be using your background in biology and your previous knowledge of calculus and differential equations to consider the issues of collection, model derivation and analysis, interpretation, explanation, and presentation of data. Even though our examples derive mainly from the life sciences, statistics is applicable to a wide variety of academic disciplines, from the natural and social sciences to the humanities.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 250B; or MATH 223 and MATH 254. MATH 254 may be taken concurrently.

Usually offered: Fall, Spring.

[MATH 368](#) -- An Introduction to the Mathematics of Investing (3 units)

Description: [Taught Spring semester in even-numbered years] Practical investment topics (interest, inflation, annuities, student loans, mortgages, credit cards, bonds, stocks) are used to motivate mathematical ideas (existence theorems, uniqueness theorems, proof by induction, proof by contradiction, recurrence relations, arithmetic-geometric mean, Cauchy inequality).

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 129.

Usually offered: Spring.

MATH 380 -- Math Models In Biology (3 units)

Description: Introduction to mathematical techniques in the biological sciences. Applications

include biochemistry, physiology, and ecology.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 129 or consent of instructor.

Identical to: ECOL 380; ECOL is home department.

Usually offered: Fall.

MATH 393 -- Internship (1-10 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or government establishment.

Grading: [Alternative grades](#) are awarded for this course: S P F.

Usually offered: Fall, Spring, Summer.

MATH 396C -- Undergraduate Research Seminar (1 unit)

Description: Several different faculty members will present 2-4 lectures each on research topics/projects in which undergraduates can become involved. This course may not be used to fulfill degree requirements for the math major or minor.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E. Available to qualified students for [Pass/Fail Option](#).

Prerequisite(s): MATH 223 or MATH 215.

May be repeated: for credit 3 times (maximum 4 enrollments).

Usually offered: Spring.

MATH 399 -- Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 399H -- Honors Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring.

MATH 401A -- Symbolic Logic (3 units)

Description: Intermediate propositional logic and quantificational theory, natural deduction, axiom systems, elementary metatheorems, introduction to notions of modal logic, selected topics in philosophy of logic.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: PHIL 401A; PHIL is home department.

May be convened with: MATH 501A.

Usually offered: Fall.

MATH 401B -- Symbolic Logic (3 units)

Description: Advanced propositional logic and quantification theory; metatheorems on consistency, independence, and completeness; set theory, number theory, and modal theory;

recursive function theory and Goedel's incompleteness theorem.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: PHIL 401B; PHIL is home department.

May be convened with: MATH 501B.

Usually offered: Spring.

MATH 402 -- Mathematical Logic (3 units)

Description: [Taught Fall semester in odd-numbered years] Sentential calculus, predicate calculus; consistency, independence, completeness, and the decision problem. Designed to be of interest to majors in mathematics or philosophy.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV402](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 402 or MATV 402

Prerequisite(s): MATH 124 or MATH 125; experience with theoretical mathematical reasoning.

Credit allowed for only one of these courses: MATH 402 or MATH 401A.

Identical to: C SC 402, PHIL 402.

May be convened with: MATH 502.

Usually offered: Fall.

[MATH 403](#) -- Foundations of Mathematics (3 units)

Description: [Taught Spring semester in even-numbered years] Topics in set theory such as functions, relations, transfinite induction and recursion, cardinal and ordinal arithmetic; related topics such as axiomatic systems, the development of the real number system, recursive functions and philosophy of Mathematics.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 215.

Identical to: PHIL 403.

May be convened with: MATH 503.

Usually offered: Spring.

MATH 404 -- History of Mathematics (3 units)

Description: The development of mathematics from ancient times through the 17th century, with emphasis on problem solving. The study of selected topics from each field is extended to the 20th century.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 323.

May be convened with: MATH 504.

Usually offered: Fall.

[MATH 406A](#) -- Curriculum & Assessment in Secondary School Mathematics (4 units)

Description: Examination of secondary school mathematics curricula with emphasis on the development of math topics; study of assessment with emphasis on its alignment with instruction; and practicum experiences with emphasis on curriculum analysis and implementation of assessment measures.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 330, STCH 250, STCH 310; MATH 315 and MATH 362 must either be taken prior or concurrently with MATH 406A. This course is for Math Education majors only.

Usually offered: Spring.

MATH 406B -- Methods of Teaching Mathematics in Secondary Schools (4 units)

Description: Provides students with knowledge and experience to enable them to become effective secondary school mathematics teachers. Emphasis on modes of instruction, problem solving, use of technology, assessment, and national standards with special attention to the teaching of geometry, algebra, statistics, and discrete mathematics. Practicum experience focuses on effective teaching strategies and techniques used in secondary schools.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 406A, STCH 310. This course is for Math Education majors only.

Usually offered: Fall.

MATH 407 -- Synthesis of Mathematical Concepts (3 units)

Description: Math taught in secondary schools from an advanced perspective: Algebra, Geometry, and Discrete Math - with particular emphasis on modeling and investigating the deep mathematics behind "routine" problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 323 and MATH 315 or MATH 415A and MATH 330.

Usually offered: Fall.

MATH 408 -- Harmonic Analysis (3 units)

Description: [Taught Spring semester in even-numbered years]. Fast Fourier transforms, classical Fourier analysis, related group theory done concretely.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 215; MATH 322 or MATH 323.

May be convened with: MATH 508.

Usually offered: Spring.

MATH 410 -- Matrix Analysis (3 units)

Description: The role of matrices in systems of equations; vector spaces and linear transformations; determinants; eigenvectors and eigenvalues; and applications. This is a general introductory course in the theory of matrices.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 254 or MATH 355 or MATH 250B; knowledge of matrix operations (as contained in, for example, MATH 215 or SIE 270). Credit allowed for only one of the following: MATH 410, MATH 413.

Usually offered: Fall, Spring.

MATH 413 -- Linear Algebra (3 units)

Description: Vector spaces, linear transformations and matrices, determinants, eigenvalues and diagonalization, bilinear forms, orthogonal and unitary transformations, Jordan canonical form.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV413](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 413 or MATV 413

Prerequisite(s): MATH 323. Credit allowed for only one of the following: MATH 413, MATH 410.

May be convened with: MATH 513.

Usually offered: Fall, Spring.

MATH 415A -- Introduction to Abstract Algebra (3 units)

Description: Introduction to groups, rings, and fields.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV415A](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 415A or MATV 415A

Prerequisite(s): MATH 323.

May be convened with: MATH 515A.

Usually offered: Fall.

[MATH 415B](#) -- Second Course in Abstract Algebra (3 units)

Description: A continuation of MATH 415A/515A. Topics may include finite groups, matrix groups, Galois theory, linear and multilinear algebra, finite fields and coding theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV415B](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 415B or MATV 415B

Prerequisite(s): MATH 415A.

May be convened with: MATH 515B.

Usually offered: Spring.

MATH 421 -- Complex Variables with Applications (3 units)

Description: Complex numbers, analytic functions, harmonic functions, elementary functions, complex integration, Cauchy's integral theorem, series representations for analytic functions, residue theory, conformal mapping, applications to steady-state temperature and oscillating systems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 254 or MATH 355 or MATH 250B. Credit allowed for only one of the following: MATH 421 or MATH 424.

May be convened with: MATH 521.

Usually offered: Fall.

[MATH 422](#) -- Advanced Applied Analysis (3 units)

Description: Review of multivariable calculus, series solutions of differential equations, Laplace transforms, Fourier series, introduction to partial differential equations.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 254 or MATH 355 or MATH 250B. Credit allowed for only one of the following: MATH 422 or MATH 322.

May be convened with: MATH 522.

Usually offered: Fall, Spring.

[MATH 424](#) -- Theory of Complex Variables (3 units)

Description: Complex numbers, complex-valued functions, analytic functions, elementary functions, series, residues and poles, mapping by elementary functions, conformal mapping, the Schwarz-Christoffel transformation, integral formulas of Poisson type.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 323 or consent of instructor. Credit allowed for only one of the following: MATH 424 or MATH421.

May be convened with: MATH 524.

Usually offered: Spring.

MATH 425A -- Real Analysis of One Variable (3 units)

Description: Continuity and differentiation of functions of one variable. Riemann integration, sequences and series of functions and uniform convergence.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 323.

May be convened with: MATH 525A.

Usually offered: Fall.

[MATH 425B](#) -- Real Analysis of Several Variables (3 units)

Description: Continuity and differentiation in higher dimensions, curves and surfaces; change of coordinates; theorems of Green, Gauss and Stokes; inverse and implicit function theorems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 425A.

May be convened with: MATH 525B.

Usually offered: Spring.

MATH 432 -- Topological Spaces (3 units)

Description: Set theory (countability/uncountability), topological spaces and continuous maps, metric spaces, connectedness and compactness, separability axioms and Hausdorff spaces, Tychonoff product theorem, introductory topics from algebraic topology (homotopy, fundamental group) or category theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 323.

May be convened with: MATH 532.

Usually offered: Spring.

MATH 443 -- Theory of Graphs and Networks (3 units)

Description: [Taught Fall semester in even-numbered years] Undirected and directed graphs, connectivity, circuits, trees, partitions, planarity, coloring problems, matrix methods, applications in diverse disciplines.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV443](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 443 or MATV 443

Prerequisite(s): MATH 323 or MATH 243 or C SC 245.

Identical to: C SC 443.

May be convened with: MATH 543.

Usually offered: Fall.

[MATH 445](#) -- Introduction to Cryptography (3 units)

Description: [Taught Spring semester in even-numbered years]. Introduction to cryptosystems and cryptanalysis. Basic number theory and finite fields. Basic complexity theory and probability. RSA and Diffie-Hellman protocols, factorization and discrete log attacks. Advanced encryption standard. Additional topics as times allows.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV445](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 445 or MATV 445

Prerequisite(s): MATH 215, ability to program in C or Java.

Usually offered: Spring.

MATH 446 -- Theory of Numbers (3 units)

Description: [Taught Spring semester in odd-numbered years]. Divisibility properties of primes, congruences, quadratic residues, number-theoretic functions, primality, factoring, applications to cryptography, introduction to algebraic numbers.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV446](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 446 or MATV 446

Prerequisite(s): MATH 215.

May be convened with: MATH 546.

Usually offered: Spring.

MATH 447 -- Combinatorial Mathematics (3 units)

Description: [Taught Spring semester in odd-numbered years]. Enumeration and construction of arrangements and designs; generating functions; principle of inclusion-exclusion; recurrence relations; a variety of applications.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 215 or MATH 243.

May be convened with: MATH 547.

Usually offered: Spring.

MATH 454 -- Ordinary Differential Equations and Stability Theory (3 units)

Description: General theory of initial value problems, linear systems and phase portraits, linearization of nonlinear systems, stability and bifurcation theory, an introduction to chaotic dynamics.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 254 or MATH 355 or MATH 250B.

Usually offered: Fall.

MATH 456 -- Applied Partial Differential Equations (3 units)

Description: Properties of partial differential equations and techniques for their solution: Fourier methods, Green's functions, numerical methods.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 322 or MATH 422.

May be convened with: MATH 556.

Usually offered: Spring.

MATH 461 -- Elements of Statistics (3 units)

Description: Probability spaces, random variables, standard distributions, point and interval estimation, tests of hypotheses; includes use of statistical software.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 223.

Usually offered: Spring.

MATH 464 -- Theory of Probability (3 units)

Description: Probability spaces, random variables, weak law of large numbers, central limit theorem, various discrete and continuous probability distributions.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 322 or MATH 323.

May be convened with: MATH 564.

Usually offered: Fall.

MATH 466 -- Theory of Statistics (3 units)

Description: Sampling theory. Point estimation. Limiting distributions. Testing Hypotheses. Confidence intervals. Large sample methods.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 464.

May be convened with: MATH 566.

Usually offered: Spring.

MATH 468 -- Applied Stochastic Processes (3 units)

Description: Applications of Gaussian and Markov processes and renewal theory; Wiener and Poisson processes, queues.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 464.

May be convened with: MATH 568.

Usually offered: Spring.

MATH 475A -- Mathematical Principles of Numerical Analysis (3 units)

Description: Analysis of errors in numerical computations, solution of linear algebraic systems of equations, matrix inversion, eigenvalues, roots of nonlinear equations, interpolation and approximation. The software package Matlab (or something similar) is used.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV475A](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 475A or MATV 475A

Prerequisite(s): MATH 254 or MATH 355 or MATH 250B, MATH 215.

Identical to: C SC 475A.

Usually offered: Fall.

MATH 475B -- Mathematical Principles of Numerical Analysis (3 units)

Description: Numerical integration, solution of systems of ordinary differential equations, initial value and boundary value problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Equivalent to: [MATV475B](#)

Mutually Exclusive: Credit allowed for only one of these courses: MATH 475B or MATV 475B

Prerequisite(s): MATH 475A.

Identical to: C SC 475B.

Usually offered: Spring.

MATH 479 -- Game Theory and Mathematical Programming (3 units)

Description: [Taught Spring semester in even-numbered years] Linear inequalities, games of strategy, minimax theorem, optimal strategies, duality theorems, simplex method, nonzero sum games, applications to economics and decision making, Nash theorems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 410 or MATH 413 or MATH 415A.

Identical to: C SC 479.

May be convened with: MATH 579.

Usually offered: Spring.

MATH 485 -- Mathematical Modeling (3 units)

Description: Development, analysis, and evaluation of mathematical models for physical, biological, social, and technical problems; both analytical and numerical solution techniques are required. This is a [Writing Emphasis Course](#).

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$21.

Prerequisite(s): Satisfaction of the [Mid-Career Writing Assessment \(MCWA\)](#).

May be convened with: MATH 585.

Usually offered: Spring.

MATH 488 -- Topics in Mathematical Physics (3 units)

Description: Advanced topics in field theories, mathematical theory of quantum mechanics, mathematical theory of statistical mechanics; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 215, MATH 223, MATH 254, Math 425B preferred, knowledge of Special Relativity is necessary.

May be repeated: for credit 4 times (maximum 5 enrollments).

May be convened with: MATH 588.

Usually offered: Fall, Spring.

MATH 493 -- Internship (1-10 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or government establishment.

Grading: [Alternative grades](#) are awarded for this course: S P F.

Usually offered: Fall, Spring, Summer.

MATH 495F -- Topics in Entrepreneurship for Scientists (1 unit)

Description: This course will present different topics in and aspects of entrepreneurship specifically for students in science and engineering. Students learn how to start tech-based businesses and manage aspects of those businesses including marketing, supply chain management, product development, human management, and financing. Undergraduates will do a marketing plan or a case study of a new technological innovation. The course exposes students to an extensive array of entrepreneurial leaders, who serve as guest speakers and mentors to the students. Students also attend industry events and learn how to network and prepare presentations, as well as other strategic professional development skills. The culmination of the class is an industry event designed to showcase students for job opportunities and potential seed capital. The class is for students in any area of science and engineering.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

Prerequisite(s): Some business knowledge is presumed, but not required. Proposal writing experience beneficial.

May be repeated: for credit 3 times (maximum 4 enrollments).

Identical to: PHYS 495F; PHYS is home department.

May be convened with: MATH 595F.

Usually offered: Spring.

MATH 496N -- Non-Linear Dynamics of Biological Systems (2-4 units)

Description: Non-linear dynamics of biological systems with applications in biochemistry, ecology, epidemiology, and molecular biology. Student/faculty presentations, opportunity for independent projects.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

Prerequisite(s): two semesters of calculus, consent of instructor.

May be repeated: for credit 4 times (maximum 5 enrollments).

Identical to: ECOL 496N; ECOL is home department.

Usually offered: Spring.

MATH 498 -- Senior Capstone (1-3 units)

Description: A culminating experience for majors involving a substantive project that demonstrates a synthesis of learning accumulated in the major, including broadly comprehensive knowledge of the discipline and its methodologies. Senior standing required.

Grading: Regular or alternative grades can be awarded for this course: A B C D E or S P C D E.

Usually offered: Fall, Spring.

MATH 498H -- Honors Thesis (3 units)

Description: An honors thesis is required of all the students graduating with honors. Students ordinarily sign up for this course as a two-semester sequence. The first semester the student performs research under the supervision of a faculty member; the second semester the student writes an honors thesis.

Grading: Regular grades are awarded for this course: A B C D E.

May be repeated: for a total of 9 units of credit.

Usually offered: Fall, Spring.

MATH 499 -- Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: Alternative grades are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 499H -- Honors Independent Study (1-5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading: Regular grades are awarded for this course: A B C D E.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 500A -- Research on the Learning of Mathematics for Teachers (3 units)

Description: Research on student learning of mathematics with a focus on implications for classroom practice; topics include number/operation, algebraic reasoning, geometry and measurement, mental computation and estimation, and data analysis and probability.

Grading: Regular grades are awarded for this course: A B C D E.

Usually offered: Summer.

MATH 501A -- Symbolic Logic (3 units)

Description: Intermediate propositional logic and quantificational theory, natural deduction, axiom systems, elementary metatheorems, introduction to notions of modal logic, selected topics in philosophy of logic. Graduate-level requirements include an in-depth research project on a central theme or topic of the course.

Grading: Regular grades are awarded for this course: A B C D E.

Identical to: PHIL 501A; PHIL is home department.

May be convened with: MATH 401A.

Usually offered: Fall.

MATH 501B -- Symbolic Logic (3 units)

Description: Advanced propositional logic and quantification theory; metatheorems on consistency, independence, and completeness; set theory, number theory, and modal theory; recursive function theory and Goedel's incompleteness theorem. Graduate-level requirements include an in-depth research project on a central theme or topic of the course.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: PHIL 501B; PHIL is home department.

May be convened with: MATH 401B.

Usually offered: Spring.

MATH 502 -- Mathematical Logic (3 units)

Description: [Taught Fall semester in odd-numbered years] Sentential calculus, predicate calculus; consistency, independence, completeness, and the decision problem. Designed to be of interest to majors in mathematics or philosophy. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: C SC 502, PHIL 502.

May be convened with: MATH 402.

Usually offered: Fall.

MATH 503 -- Foundations of Mathematics (3 units)

Description: [Taught Spring semester in even-numbered years] Topics in set theory such as functions, relations, transfinite induction and recursion, cardinal and ordinal arithmetic; related topics such as axiomatic systems, the development of the real number system, recursive functions and philosophy of Mathematics. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: PHIL 503.

May be convened with: MATH 403.

Usually offered: Spring.

MATH 504 -- History of Mathematics (3 units)

Description: The development of mathematics from ancient times through the 17th century, with emphasis on problem solving. The study of selected topics from each field is extended to the 20th century. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): not applicable to M.A., M.S., or Ph.D. degrees for math majors except for the M.A. teaching option.

May be convened with: MATH 404.

Usually offered: Fall.

MATH 505C -- Algebra for Elementary & Middle School Teachers (3-4 units)

Description: This course focuses on the transition from arithmetic to algebraic thinking, particularly in grades 5-8. The pedagogical approach emphasizes problem-solving, use of technology and hands-on materials, communication, and strategies to work with English Language Learners.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Spring.

MATH 505D -- Data Analysis and Probability for K-8 Teachers (3-4 units)

Description: The course focuses on developing a deep understanding of key ideas of probability and data analysis in grades K-8. Students will collect, represent and analyze data to make predictions in real-world situations. Experimental and theoretical probability will be discussed.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Fall.

MATH 505E -- Number and Operations for K-8 Teachers (3-4 units)

Description: This course focuses on K-8 concepts about number systems (e.g., whole numbers, integers, rational numbers) and number operations (meanings and algorithms). The pedagogical approach emphasizes explorations, use of hands-on materials and communication of problem-solving strategies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Spring.

MATH 505F -- Geometry and Measurement for K-8 Teachers (3-4 units)

Description: The course focuses on developing a deep understanding of key ideas of geometry and measurement in grades K-8 (e.g., shape, transformations, different measurements). Students will construct models and use hands-on materials and technology to engage in geometric problem-solving.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Fall.

MATH 506A -- Research on the Learning of Mathematics (3 units)

Description: [Taught Fall semester in even numbered years]. Research on learning theories and student learning of mathematics, including number/operation, spatial reasoning, algebra, proof, calculus and advanced topics; theories including constructivism, social, situated and enactivist perspectives, models/modeling, critical theory

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Fall.

MATH 506B -- Research Methods in Math Education (3 units)

Description: [Taught Spring semester in odd-numbered years]. Evolution of mathematics education research methodology; examination of survey research, clinical interviews, teaching experiments, ethnographies, and standardized testing, etc; development of skills to review research and identify researchable questions in mathematics education.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Spring.

MATH 506C -- Research on the Teaching of Mathematics (3 units)

Description: Examination of approaches to the study of mathematics teaching including evaluation of the theories and perspectives of mathematics instruction, the factors influencing instructional practice, studies of teachers' mathematical knowledge and beliefs, and research on teacher development and change.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Spring.

MATH 507C -- Problem Solving for Secondary Mathematics Teachers (3 units)

Description: This course provides secondary teachers with the opportunity to explore open-ended problems in Mathematics. The teachers will be introduced to the algorithms, and the concepts that underlie the exploratory problems. They will write up their research and also present their findings to the class.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Bachelors Degree.

Usually offered: Fall.

MATH 507D -- Modern Algebra for Secondary Mathematics Teachers (3 units)

Description: This course introduces secondary teachers to the structure and the theory behind algebra. It includes an in-depth study of polynomials; their factors, roots, and coefficients.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Bachelors Degree.

Usually offered: Spring.

MATH 507E -- Principles of Calculus for Secondary School Teachers (3 units)

Description: This course investigates the concepts underlying calculus. The most fundamental of these limits of functions. Numerical, algebraic, and graphical properties of functions are analyzed.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Bachelors Degree.

Usually offered: Fall.

MATH 507F -- Probability and Statistics for Secondary Math Teachers (3 units)

Description: This course develops both statistical thinking that will help in analyzing data sets and drawing useful conclusions, and combinatorial principles that will help in understanding the concept of probability.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Bachelors Degree.

Usually offered: Spring.

MATH 508 -- Harmonic Analysis (3 units)

Description: [Taught Spring semester in even-numbered years]. Fast Fourier transforms, classical Fourier analysis, related group theory done concretely. Graduate-level requirements include writing a paper dealing with almost periodic functions and their fourier series and solve a set of problems dealing with this topic.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 408.

Usually offered: Spring.

MATH 509C -- Statistics for Research (3 units)

Description: Statistical concepts and methods applied to research in other scientific disciplines. Principles of estimation and hypothesis testing for standard one-and two-sample procedures. Correlation, linear regression. Contingency tables and analysis of variance.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 110 or 112.

Identical to: GENE 509C, PCOL 509C.

Usually offered: Fall, Spring.

MATH 511A -- Algebra (3 units)

Description: Structure of groups, rings, modules, algebras; Galois theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 415A and MATH 415B, or MATH 413 and MATH 415A.

Usually offered: Fall.

MATH 511B -- Algebra (3 units)

Description: Structure of groups, rings, modules, algebras; Galois theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 511A.

Usually offered: Spring.

MATH 513 -- Linear Algebra (3 units)

Description: Vector spaces, linear transformations and matrices, determinants, eigenvalues and diagonalization, bilinear forms, orthogonal and unitary transformations, Jordan canonical form. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 413.

Usually offered: Fall, Spring.

MATH 514A -- Algebraic Number Theory (3 units)

Description: [Taught Fall semester in odd-numbered years] Dedekind domains, complete fields, class groups and class numbers, Dirichlet unit theorem, algebraic function fields.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 511B.

Usually offered: Fall.

MATH 514B -- Algebraic Number Theory (3 units)

Description: [Taught Spring semester in even numbered years] Dedekind domains, complete fields, class groups and class numbers, Dirichlet unit theorem, algebraic function fields.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 514A.

Usually offered: Spring.

MATH 515A -- Introduction to Abstract Algebra (3 units)

Description: Introduction to groups, rings, and fields. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 415A.

Usually offered: Fall.

MATH 515B -- Second Course in Abstract Algebra (3 units)

Description: A continuation of MATH 415A/515A. Topics may include finite groups, matrix groups, Galois theory, linear and multilinear algebra, finite fields and coding theory. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Also see: [MATH515B](#)

May be convened with: MATH 415B.

Usually offered: Spring.

MATH 516 -- Commutative Algebra (3 units)

Description: Commutative algebra is the foundation stone of modern algebraic geometry and this course should be viewed as a preparatory course for the Algebraic Geometry course (Math 536A/B) which is offered in the fall of every even numbered year. The course is designed with this purpose in mind. We will begin with the notion of localization of rings, notions of free, projective, injective modules, flat modules and move on to discuss prime and primary ideals and the primary decomposition theorem. After this we will introduce depth and dimension and prove the dimension theorem and introduce and study properties of local rings in some detail. The course will lead up to the characterization of regular local rings. This theorem, roughly speaking, lays the groundwork for the algebra-geometric analogue of the notion of smoothness. If time permits we will study the notion of Cohen-Macaulay and Gorenstein rings and some of their characterizations.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 511A and MATH 511B.

Usually offered: Spring.

MATH 517A -- Group Theory (3 units)

Description: [Taught Fall semester in even numbered years] Selections from such topics as finite groups, abelian groups, characters and representations.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 511B.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall.

MATH 517B -- Group Theory (3 units)

Description: [Taught Spring semester in odd-numbered years] Selections from such topics as finite groups, abelian groups, characters and representations.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 517A.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Spring.

MATH 518 -- Topics in Algebra (3 units)

Description: Advanced topics in groups, rings, fields, algebras; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall, Spring.

MATH 519 -- Topics in Number Theory and Combinatorics (3 units)

Description: Advanced topics in algebraic number theory, analytic number theory, class fields, combinatorics; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall, Spring.

MATH 520A -- Complex Analysis (3 units)

Description: Analyticity, Cauchy's integral formula, residues, infinite products, conformal mapping, Dirichlet problem, Riemann mapping theorem.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 424.

Usually offered: Fall.

MATH 520B -- Complex Analysis (3 units)

Description: Rudiments of Riemann surfaces.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 520A or MATH 582.

Usually offered: Spring.

MATH 521 -- Complex Variables with Applications (3 units)

Description: Complex numbers, analytic functions, harmonic functions, elementary functions, complex integration, Cauchy's integral theorem, series representations for analytic functions, residue theory, conformal mapping, applications to steady-state temperature and oscillating systems. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 421.

Usually offered: Fall.

MATH 522 -- Advanced Applied Analysis (3 units)

Description: Review of multivariable calculus, series solutions of differential equations, Laplace transforms, Fourier series, introduction to partial differential equations. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 422.

Usually offered: Fall, Spring.

MATH 523A -- Real Analysis (3 units)

Description: Lebesgue measure and integration, differentiation, Radon-Nikodym theorem, L_p spaces, applications.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 425A.

Usually offered: Fall.

MATH 523B -- Real Analysis (3 units)

Description: Lebesgue measure and integration, differentiation, Radon-Nikodym theorem, L_p spaces, applications.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 523A.

Usually offered: Spring.

MATH 524 -- Theory of Complex Variables (3 units)

Description: Complex numbers, complex-valued functions, analytic functions, elementary functions, series, residues and poles, mapping by elementary functions, conformal mapping, the Schwarz-Christoffel transformation, integral formulas of Poisson type. Graduate-level requirements include more extensive problem sets or advanced project.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 424.

Usually offered: Spring.

MATH 525A -- Real Analysis of One Variable (3 units)

Description: Continuity and differentiation of functions of one variable. Riemann integration, sequences and series of functions and uniform convergence. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 425A.

Usually offered: Fall.

MATH 525B -- Real Analysis of Several Variables (3 units)

Description: Continuity and differentiation in higher dimensions, curves and surfaces; change of coordinates; theorems of Green, Gauss and Stokes; inverse and implicit function theorems. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 425B.

Usually offered: Spring.

MATH 527A -- Principles of Analysis (3 units)

Description: Metric spaces, basic properties of normed linear spaces, distributions, the Lebesgue integral and Lebesgue spaces, convergence theorems; applications chosen by the instructor.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 410, MATH 424, and a differential equations course.

Usually offered: Fall.

MATH 527B -- Principles of Analysis (3 units)

Description: Metric spaces, basic properties of normed linear spaces, distributions, the Lebesgue intergral and Lebesgue spaces, convergence theorems; applications chosen by the instructor.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 527A.

Usually offered: Spring.

MATH 528A -- Banach and Hilbert Spaces (3 units)

Description: Introduction to the theory of normed spaces, Banach spaces and Hilbert spaces, operators on Banach spaces, spectral theory of operators on Hilbert spaces, applications.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 527B or MATH 523A.

Usually offered: Fall.

MATH 528B -- Banach and Hilbert Spaces (3 units)

Description: Introduction to the theory of normed spaces, Banach spaces and Hilbert spaces, operators on Banach spaces, spectral theory of operators on Hilbert spaces, applications.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 528A.

Usually offered: Spring.

MATH 529 -- Topics in Modern Analysis (3 units)

Description: Advanced topics in measure and integration, complex analysis in one and several complex variables, probability, functional analysis, operator theory; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Fall, Spring.

MATH 531 -- Algebraic Topology (3 units)

Description: [Taught Fall semester in odd-numbered years] Poincare duality, fixed point theorems, characteristic classes, classification of principal bundles, homology of fiber bundles, higher homotopy groups, low dimensional manifolds.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 534B.

Usually offered: Fall.

MATH 532 -- Topological Spaces (3 units)

Description: Set theory (countability/uncountability), topological spaces and continuous maps, metric spaces, connectedness and compactness, separability axioms and Hausdorff spaces, Tychonoff product theorem, introductory topics from algebraic topology (homotopy, fundamental group) or category theory. Graduate-level requirements include additional assignments and/or projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 432.

Usually offered: Spring.

MATH 534A -- Topology-Geometry (3 units)

Description: Point set topology, the fundamental group, calculus on manifolds. Homology, de Rham cohomology, other topics. Examples will be emphasized.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 415A, MATH 425A.

Usually offered: Fall.

MATH 534B -- Topology-Geometry (3 units)

Description: Point set topology, the fundamental group, calculus on manifolds. Homology, de Rham cohomology, other topics. Examples will be emphasized.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 534A.

Usually offered: Spring.

MATH 535A -- The Mathematics of Computer Graphics (3 units)

Description: The mathematical aspects of computer graphics, including scan conversion methods, projective geometry and geometric transformations, the construction and rendering of curves and surfaces, and color models.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): C SC 352; MATH 215, MATH 322, or MATH 410.

Identical to: C SC 535A.

Usually offered: Fall.

MATH 536A -- Algebraic Geometry (3 units)

Description: [Taught Fall semester in even numbered years] Affine and projective varieties, morphisms and rational maps. Dimension, degree and smoothness. Basic coherent sheaf theory and Cech cohomology. Line bundles, Riemann-Roch theorem.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 520A, MATH 534A.

Usually offered: Fall.

MATH 536B -- Algebraic Geometry (3 units)

Description: [Taught Spring semester in odd-numbered years] Affine and projective varieties, morphisms and rational maps. Dimension, degree and smoothness. Basic coherent sheaf theory and Čech cohomology. Line bundles, Riemann-Roch theorem.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 536A.

Usually offered: Spring.

MATH 537A -- Global Differential Geometry (3 units)

Description: [Taught Fall semester in odd-numbered years] Surfaces in \mathbb{R}^3 , structure equations, curvature. Gauss-Bonnet theorem, parallel transport, geodesics, calculus of variations, Jacobi fields and conjugate points, topology and curvature; Riemannian geometry, connections, curvature tensor, Riemannian submanifolds and submersions, symmetric spaces, vector bundles. Morse theory, symplectic geometry.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 534A, MATH 534B.

Usually offered: Fall.

MATH 537B -- Global Differential Geometry (3 units)

Description: [Taught Spring semester in even-numbered years] Surfaces in \mathbb{R}^3 , structure equations, curvature. Gauss-Bonnet theorem, parallel transport, geodesics, calculus of variations, Jacobi fields and conjugate points, topology and curvature; Riemannian geometry, connections, curvature tensor, Riemannian submanifolds and submersions, symmetric spaces, vector bundles. Morse theory, symplectic geometry.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 537A.

Usually offered: Spring.

MATH 538 -- Topics in Geometry and Topology (3 units)

Description: Advanced topics in point set and algebraic topology, algebraic geometry, differential geometry; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall, Spring.

MATH 539 -- Algebraic Coding Theory (3 units)

Description: [Taught Spring semester in even-numbered years] Construction and properties of error correcting codes; encoding and decoding procedures and information rate for various codes.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 415A.

Identical to: ECE 539.

Usually offered: Spring.

MATH 541 -- Introduction to Mathematical Physics (3 units)

Description: Mathematical formulation and problems of statistical physics, quantum physics and field theory, relations between macroscopic and microscopic and between classical and

quantum descriptions of physical systems, analytical, probabilistic and geometric methods. Contents vary.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 523A, MATH 523B or MATH 527A, MATH 527B or consent of instructor.

May be repeated: for credit 2 times (maximum 3 enrollments).

Identical to: PHYS 541.

Usually offered: Fall.

MATH 543 -- Theory of Graphs and Networks (3 units)

Description: [Taught Fall semester in even-numbered years] Undirected and directed graphs, connectivity, circuits, trees, partitions, planarity, coloring problems, matrix methods, applications in diverse disciplines. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: C SC 543.

May be convened with: MATH 443.

Usually offered: Fall.

MATH 546 -- Theory of Numbers (3 units)

Description: [Taught Spring semester in odd-numbered years]. Divisibility properties of primes, congruences, quadratic residues, number-theoretic functions, primality, factoring, applications to cryptography, introduction to algebraic numbers. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 446.

Usually offered: Spring.

MATH 547 -- Combinatorial Mathematics (3 units)

Description: [Taught Spring semester in odd-numbered years]. Enumeration and construction of arrangements and designs; generating functions; principle of inclusion-exclusion; recurrence relations; a variety of applications. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 447.

Usually offered: Spring.

MATH 553A -- Partial Differential Equations (3 units)

Description: [Taught Fall semester in odd-numbered years] Theory and examples of linear equations; characteristics, well-posed problems, regularity, variational properties, asymptotics. Topics in nonlinear equations, such as shock waves, diffusion waves, and estimates in Sobolev spaces.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 523B or MATH 527B or MATH 583B.

Usually offered: Fall.

MATH 553B -- Partial Differential Equations (3 units)

Description: [Taught Spring semester in even-numbered years] Theory and examples of linear equations; characteristics, well-posed problems, regularity, variational properties, asymptotics. Topics in nonlinear equations, such as shock waves, diffusion waves, and estimates in Sobolev

spaces.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 553A.

Usually offered: Spring.

MATH 554 -- Ordinary Differential Equations (3 units)

Description: [Taught Fall semester in even-numbered years]. General theory of linear systems, Floquet theory. Local theory of nonlinear systems, stable manifold and Hartman-Grobman theorems. Poincaré-Bendixson theory, limit cycles, Poincaré maps. Bifurcation theory, including the Hopf theorem.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 413 or consent of instructor.

Usually offered: Fall.

[MATH 556](#) -- Applied Partial Differential Equations (3 units)

Description: Properties of partial differential equations and techniques for their solution: Fourier methods, Green's functions, numerical methods. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 456.

Usually offered: Spring.

MATH 557A -- Dynamical Systems and Chaos (3 units)

Description: Qualitative theory of dynamical systems, phase space analysis, bifurcation, period doubling, universal scaling, onset of chaos. Applications drawn from atmospheric physics, biology, ecology, fluid mechanics and optics.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 454 or (MATH 254 and MATH 422); and MATH 421 or MATH 424.

Usually offered: Fall.

[MATH 557B](#) -- Dynamical Systems and Chaos (3 units)

Description: Qualitative theory of dynamical systems, phase space analysis, bifurcation, period doubling, universal scaling, onset of chaos. Applications drawn from atmospheric physics, biology, ecology, fluid mechanics and optics.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 557A.

Usually offered: Spring.

MATH 559A -- Lie Groups and Lie Algebras (3 units)

Description: [Taught Fall semester in even-numbered years]. Correspondence between Lie groups and Lie algebras, structure and representation theory, applications to topology and geometry of homogeneous spaces, applications to harmonic analysis.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 511A, MATH 523A, MATH 534A, MATH 534B or consent of instructor.

Usually offered: Fall.

MATH 559B -- Lie Groups and Lie Algebras (3 units)

Description: [Taught Spring semester in odd-numbered years]. Correspondence between Lie groups and Lie algebras, structure and representation theory, applications to topology and geometry of homogeneous spaces, applications to harmonic analysis.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 559A.

Usually offered: Spring.

MATH 563 -- Probability Theory (3 units)

Description: Random variables, expectation and integration, Borel-Cantelli lemmas, independence, sums of independent random variables, strong law of large numbers, convergence in distribution, central limit theorem, infinitely divisible distributions

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 523B or MATH 527B or consent of instructor.

Identical to: STAT 563.

Usually offered: Fall.

MATH 564 -- Theory of Probability (3 units)

Description: Probability spaces, random variables, weak law of large numbers, central limit theorem, various discrete and continuous probability distributions. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Calculus through multivariable/vector calculus (at the level of MATH 125, MATH 129, MATH 223).

Identical to: STAT 564.

May be convened with: MATH 464.

Usually offered: Fall.

MATH 565A -- Stochastic Processes (3 units)

Description: [Taught Spring semester in odd-numbered years]. Stochastic Processes in continuous time: Levy processes, Martingales, Markov processes, introduction to stochastic integrals.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): strong probability background.

Usually offered: Spring.

MATH 565B -- Stochastic Processes (3 units)

Description: [Taught Fall semester in even-number years]. Stochastic processes in continuous time; Levy processes, martingales, Markov processes, introduction to stochastic integrals.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 565A.

Usually offered: Fall.

MATH 565C -- Stochastic Differential Equations (3 units)

Description: [Taught Spring semester in even-numbered years] Brownian motion, stochastic integrals, Ito formula, stochastic differential equations, diffusions, applications including: Partial differential equations, filtering, stochastic control

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 565B, MATH 468/568 or consent of instructor.

Usually offered: Spring.

MATH 566 -- Theory of Statistics (3 units)

Description: Sampling theory. Point estimation. Limiting distributions. Testing Hypotheses. Confidence intervals. Large sample methods. Graduate-level requirements include more

extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 564.

Identical to: STAT 566.

May be convened with: MATH 466.

Usually offered: Spring.

MATH 567A -- Theoretical Statistics (3 units)

Description: [Taught Spring semester in even-numbered years] Basic decision theory. Bayes' rules for estimation. Admissibility and completeness. The minimax theorem. Sufficiency. Exponential families of distributions. Complete sufficient statistics. Invariant decision problems. Location and scale parameters. Theory of nonparametric statistics. Hypothesis testing. Neyman-Pearson lemma. UMP and UMPU tests. Two-sided tests. Two-sample tests. Confidence sets. Multiple decision problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 466.

Identical to: STAT 596A.

Usually offered: Spring.

MATH 567B -- Theoretical Statistics (3 units)

Description: [Taught Fall semester in even-numbered years] Basic decision theory. Bayes' rules for estimation. Admissibility and completeness. The minimax theorem. Sufficiency. Exponential families of distributions. Complete sufficient statistics. Invariant decision problems. Location and scale parameters. Theory of nonparametric statistics. Hypothesis testing. Neyman-Pearson lemma. UMP and UMPU tests. Two-sided tests. Two-sample tests. Confidence sets. Multiple decision problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 567A.

Identical to: STAT 567B.

Usually offered: Fall.

MATH 568 -- Applied Stochastic Processes (3 units)

Description: Applications of Gaussian and Markov processes and renewal theory; Wiener and Poisson processes, queues. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be convened with: MATH 468.

Usually offered: Spring.

MATH 571A -- Advanced Statistical Regression Analysis (3 units)

Description: Regression analysis including simple linear regression and multiple linear regression. Matrix formulation and analysis of variance for regression models. Residual analysis, transformations, regression diagnostics, multicollinearity, variable selection techniques, and response surfaces. Students will be expected to utilize standard statistical software packages for computational purposes.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 410 or MATH 413, or equivalent; and MATH 461 or MATH 466, or equivalent. Graduate standing.

Identical to: STAT 571A.

Usually offered: Fall.

MATH 571B -- Design of Experiments (3 units)

Description: Principles of designing experiments. Randomization, block designs, factorial experiments, response surface designs, repeated measures, analysis of contrasts, multiple comparisons, analysis of variance and covariance, variance components analysis.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 223 or equivalent, MATH 571A.

Identical to: STAT 571B.

Usually offered: Spring.

MATH 573 -- Theory of Computation (3 units)

Description: Chomsky hierarchy, undecidability; general recursive functions; recursion theory; computational complexity theory, NP-complete and provably intractable problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$50.

Prerequisite(s): C SC 473.

Identical to: C SC 573; C SC is home department.

Usually offered: Spring.

MATH 574E -- Environmental Statistics (3 units)

Description: Statistical methods for environmental and ecological sciences, including nonlinear regression, generalized linear models, temporal analyses, spatial analyses/kriging, quantitative risk assessment.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 571B, or PSYC 507C, or equivalent.

Identical to: STAT 574E; STAT is home department.

Usually offered: Fall, Spring.

MATH 574G -- Introduction to Geostatistics (3 units)

Description: [Taught Spring semester in odd-numbered years] Exploratory spatial data analysis, random function models for spatial data, estimation and modeling of variograms and covariances, ordinary and universal kriging estimators and equations, regularization of variograms, estimation of spatial averages, non-linear estimators, includes use of geostatistical software. Application of hydrology, soil science, ecology, geography and related fields.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$50.

Prerequisite(s): linear algebra, basic course in probability and statistics, familiarity with DOS/Windows, UNIX.

Identical to: GEOG 574G; GEOG is home department.

Usually offered: Spring.

MATH 574T -- Time Series Analysis (3 units)

Description: Methods for analysis of time series data. Time domain techniques. ARIMA models. Estimation of process mean and autocovariance. Model fitting. Forecasting methods. Missing data. Students will be expected to utilize standard statistical software packages for computational purposes.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: STAT 574T.

Usually offered: Fall, Spring.

MATH 575A -- Numerical Analysis (3 units)

Description: Error analysis, solution of linear systems and nonlinear equations, eigenvalue interpolation and approximation, numerical integration, initial and boundary value problems for ordinary differential equations, optimization.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 475B or MATH 456.

Identical to: C SC 575A.

Usually offered: Fall.

MATH 575B -- Numerical Analysis (3 units)

Description: Error analysis, solution of linear systems and nonlinear equations, eigenvalue interpolation and approximation, numerical integration, initial and boundary value problems for ordinary differential equations, optimization.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 575A.

Identical to: C SC 575B.

Usually offered: Spring.

MATH 576A -- Numerical Analysis PDE (3 units)

Description: [Taught Fall semester in even numbered years] Finite difference, finite element, and spectral discretization methods; semidiscrete, matrix, and Fourier analysis.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 413, MATH 456, MATH 575B.

Usually offered: Fall.

MATH 576B -- Numerical Analysis PDE (3 units)

Description: [Taught Spring semester in odd-numbered years] Well-posedness, numerical boundary conditions, nonlinear instability, time-split algorithms, special methods for stiff and singular problems.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 576A.

Usually offered: Spring.

MATH 577 -- Topics in Applied Mathematics (3 units)

Description: Advanced topics in asymptotics, numerical analysis, approximation theory, mathematical theory of mechanics, dynamical systems, differential equations and inequalities, mathematical theory of statistics; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: ATMO 577.

Usually offered: Fall, Spring.

MATH 579 -- Game Theory and Mathematical Programming (3 units)

Description: [Taught Spring semester in even-numbered years] Linear inequalities, games of strategy, minimax theorem, optimal strategies, duality theorems, simplex method, nonzero sum games, applications to economics and decision making, Nash theorems. Graduate-level requirements include more extensive problem sets or advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Identical to: C SC 579.

May be convened with: MATH 479.

Usually offered: Spring.

MATH 582 -- Applied Complex Analysis (3 units)

Description: [Taught Spring semester in odd numbered years] Representations of special functions, asymptotic methods for integrals and linear differential equations in the complex domain, applications of conformal mapping, Wiener-Hopf techniques.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 424.

Usually offered: Spring.

MATH 583A -- Principles and Methods of Applied Mathematics (3 units)

Description: Boundary value problems; Green's functions, distributions, Fourier transforms, the classical partial differential equations (Laplace, heat, wave) of mathematical physics. Linear operators, spectral theory, integral equations, Fredholm theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 421 or MATH 424 or MATH 520A.

Usually offered: Fall.

MATH 583B -- Principles and Methods of Applied Mathematics (3 units)

Description: Boundary value problems; Green's functions, distributions, Fourier transforms, the classical partial differential equations (Laplace, heat, wave) of mathematical physics. Linear operators, spectral theory, integral equations, Fredholm theory.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 583A.

Usually offered: Spring.

MATH 585 -- Mathematical Modeling (3 units)

Description: Development, analysis, and evaluation of mathematical models for physical, biological, social, and technical problems; both analytical and numerical solution techniques are required. Graduate-level requirements include more advanced projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Special course fee required: \$21.

May be convened with: MATH 485.

Usually offered: Spring.

MATH 586 -- Case Studies in Applied Mathematics (1-3 units)

Description: In-depth treatment of several contemporary problems or problem areas from a variety of fields, but all involving mathematical modeling and analysis; content varies.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: for a total of 6 units of credit.

Usually offered: Fall, Spring.

MATH 587 -- Perturbation Methods in Applied Mathematics (3 units)

Description: [Taught Fall semester in odd-numbered years] Regular and singular perturbations, boundary layer theory, multiscale and averaging methods for nonlinear waves and oscillators.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): MATH 422; MATH 421 or MATH 454.

Usually offered: Fall.

MATH 588 -- Topics in Mathematical Physics (3 units)

Description: Advanced topics in field theories, mathematical theory of quantum mechanics,

mathematical theory of statistical mechanics; content varies. Graduate-level requirements include additional assignments and/or projects.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

May be convened with: MATH 488.

Usually offered: Fall, Spring.

MATH 589 -- Software Tools for Computational Science and Engineering (3 units)

Description: Techniques and tools useful at the interface between mathematical and technical computing on the one hand, and the Internet on the other. Topics include scripting languages such as Perl and Tcl/Tk, graphics file formats, the mathematics of raster and vector graphics, and standard libraries and applications for numerical and symbolic computing. Also, the fundamentals of computer networking from a user's point of view.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): C SC 352 and ability to program in at least one modern high-level language.

Identical to: C SC 589.

Usually offered: Spring.

MATH 593 -- Internship (1-3 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring.

MATH 595A -- Math Instruction (1 unit)

Description: The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for credit 11 times (maximum 12 enrollments).

Usually offered: Fall, Spring.

MATH 595B -- Research in Mathematics (1 unit)

Description: The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall, Spring.

MATH 595C -- Research in Applied Mathematics (1 unit)

Description: The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for credit 4 times (maximum 5 enrollments).

Usually offered: Fall, Spring.

MATH 595D -- Research in Mathematics Education (1-3 units)

Description: Readings and discussion of research in Mathematics education, usually in small group setting. Course includes presentations by different persons. Research projects may or may not be required of course registrants. Emphasis on exchange of scholarly information.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for a total of 6 units of credit.

Usually offered: Fall, Spring.

MATH 595F -- Topics in Entrepreneurship for Scientists (1 unit)

Description: This course will present different topics in and aspects of entrepreneurship specifically for students in science and engineering. Students learn how to start tech-based businesses and manage aspects of those businesses including marketing, supply chain management, product development, human management, and financing. Undergraduates will do a marketing plan or a case study of a new technological innovation. The course exposes students to an extensive array of entrepreneurial leaders, who serve as guest speakers and mentors to the students. Students also attend industry events and learn how to network and prepare presentations, as well as other strategic professional development skills. The culmination of the class is an industry event designed to showcase students for job opportunities and potential seed capital. The class is for students in any area of science and engineering. Graduate-level requirements include the development of an early stage business plan around a new technological innovation. Students present their projects to business leaders and investors at a competitive event.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

Prerequisite(s): Some business knowledge is presumed, but not required. Students encouraged to take B AD 510 or an equivalent course. Proposal writing experience beneficial.

May be repeated: for credit 3 times (maximum 4 enrollments).

Identical to: PHYS 595F; PHYS is home department.

May be convened with: MATH 495F.

Usually offered: Spring.

MATH 596A -- Topics in Mathematics (1-3 units)

Description: The development and exchange of scholarly information, usually in a small group setting. The scope of work shall consist of research by course registrants, with the exchange of the results of such research through discussion, reports, and/or papers.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for a total of 12 units of credit.

Usually offered: Fall, Spring.

MATH 596B -- Mathematics Mentoring Methods (1 unit)

Description: This course is designed to focus on adult learning theories in order that the participants can then assist other teachers to examine their own teaching practices so that lessons are designed and delivered to maximize student engagement and improve student achievement.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D

E.

Prerequisite(s): Bachelors in Elementary Education or Secondary certified in Mathematics.

Usually offered: Summer.

MATH 596C -- Mathematics Instruction for English Language Learners (3 units)

Description: This course focuses on mathematics education and English Language Learners (e.g., sheltered mathematics teaching strategies, assessment). It addresses content and pedagogy around topics such as proportional reasoning, algebraic thinking, patterns and functions, and measurement.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Usually offered: Spring.

MATH 596F -- Topics in Math for Elementary and Middle School Teachers (3 units)

Description: This course will focus on connections across key areas in K-8 mathematics (e.g., algebra, geometry, numbers and operations, data analysis and probability). The pedagogical approach will emphasize problem solving, use of technology, communication and hands-on materials.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

May be repeated: for credit 5 times (maximum 6 enrollments).

Usually offered: Fall.

MATH 596G -- Research Tutorial Group (1-3 units)

Description: Introduction to research interests of the faculty. Required in Spring of first year in Ph.D. program in Mathematics and in the following Fall. Content varies.

Grading: [Regular or alternative grades](#) can be awarded for this course: A B C D E or S P C D E.

Prerequisite(s): Ph.D student in Mathematics.

May be repeated: for credit 1 time (maximum 2 enrollments).

Usually offered: Fall, Spring.

MATH 597T -- Professional Development Workshop in Teaching Mathematics (1 unit)

Description: Introduction to the theory and practice of teaching lower-division college mathematics courses. This course is required of and intended only for Math and Applied Math graduate student GATs who are teaching in the Math Department for the first time.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): Math/Applied Math GAT - first year teaching in the Math Department.

Usually offered: Fall.

MATH 599 -- Independent Study (1-6 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 636 -- Information Theory (3 units)

Description: [Taught alternate years 2000-2001] Definition of a measure of information and

study of its properties; introduction to channel capacity and error-free communications over noisy channels; rate distortion theory; error detecting and correcting codes.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): ECE 503.

Identical to: ECE 636; ECE is home department.

Usually offered: Spring.

MATH 697B -- Applied Mathematics Laboratory (3 units)

Description: The practical application of theoretical learning within a group setting and involving an exchange of ideas and practical methods, skills, and principles.

Grading: [Regular grades](#) are awarded for this course: A B C D E.

Prerequisite(s): applied math core or equivalent.

Identical to: PHYS 697B, MSE 697B.

Usually offered: Spring, Summer.

MATH 699 -- Independent Study (1-6 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading: [Alternative grades](#) are awarded for this course: S P F.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring.

MATH 900 -- Research (2-8 units)

Description: Individual research, not related to thesis or dissertation preparation, by graduate students.

Grading: [Alternative grades](#) are awarded for this course: S P C D E K.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 910 -- Thesis (1-6 units)

Description: Research for the master's thesis (whether library research, laboratory or field observation or research, artistic creation, or thesis writing). Maximum total credit permitted varies with the major department.

Grading: [Alternative grades](#) are awarded for this course: S P E K.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 920 -- Dissertation (1-9 units)

Description: Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing).

Grading: [Alternative grades](#) are awarded for this course: S P E K.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.

MATH 930 -- Supplementary Registration (1-9 units)

Description: For students who have completed all course requirements for their advanced degree programs. May be used concurrently with other enrollments to bring to total number of units to the required minimum.

Grading: Grade of K is awarded for this course except for the final term.

May be repeated: an unlimited number of times, consult your department for details and possible restrictions.

Usually offered: Fall, Spring, Summer.