
Mathematics

In the College of Sciences

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Faculty

Emeritus: Bray, Carlson, Deaton, Eisemann, Elwin, Fountain, Garrison, Hager, Harvey, Hintzman, Ho, Holmes, Lesley, Lutz, Marcus, McLeod, Nower, Pierce, Riggs, Ross, Saltz, Short, Smith, Sowder, J., Sowder, L., Springer, Thompson, Van de Wetering, Villone, Whitman

Chair: Shen

Professors: Castillo, Dunster, Geveci, Grone, Hui, Mahaffy, Nemirovsky, Salamon, Shen

Associate Professors: Blomgren, Bowers, Carretero, Kirschvink, Lobato, O'Sullivan, Palacios, Rasmussen, Smarandache

Assistant Professors: Interlando, Nickerson, Ponomarenko

Lecturers: Brock, Cavanaugh, Rotar

Offered by the Department of Mathematics and Statistics

Master of Arts degree in mathematics.

Master of Science degree in applied mathematics.

Concentration in dynamical systems.

Concentration in mathematical theory of communication systems.

Master of Arts for teaching service with a concentration in mathematics.

Major in mathematics with the B.A. degree in liberal arts and sciences.

Major in mathematics with the B.S. degree in applied arts and sciences.

Emphasis in applied mathematics.

Emphasis in computational science.

Emphasis in mathematical finance.

Emphasis in science.

Teaching major in mathematics for the single subject teaching credential.

Minor in mathematics.

Certificate in communications systems (refer to the *Graduate Bulletin*).

Certificate in mathematics specialist (refer to the *Graduate Bulletin*).

Certificate in single subject mathematics.

The Majors

Mathematics is the language and instrument for the sciences and technology. It is concerned with a wide range of diverse problems from developing techniques to model real world applications and designing efficient methods for calculating their solutions, to creating new branches of mathematics and theories for as yet unsolved problems. Some students find mathematics stimulating because of its many and varied applications, while others are fascinated and attracted to it for the beauty of its intrinsic order, structure, and form.

Because of its broad scope, degrees in mathematics can prepare students for many different careers and the Department of Mathematics and Statistics offers a variety of such degrees and emphases to provide students with several blends and specialties according to their interests and goals.

Graduates with a mathematics major have many options for either careers in applications, for further study in graduate school, or for teaching. Mathematics majors are important because their training involves quantitative abilities and critical reasoning that many potential employers can utilize. With a minor in an area of applications, graduates are suited for further graduate study in many areas that heavily depend upon mathematical methods and techniques. Graduates with an interest in the more theoretical aspects of

mathematics are sought after in many diverse graduate programs from applied and pure mathematics to computer and computational sciences and statistics. Careers in teaching include positions in secondary schools, for which a teaching credential is additionally required, teaching in two year colleges, for which a master's degree is required, and teaching at the university level, which requires a doctorate degree and involves research and creation of new mathematics.

Major Academic Plans (MAPs)

Visit <http://www.sdsu.edu/mymap> for the recommended courses needed to fulfill your major requirements. The MAPs Web site was created to help students navigate the course requirements for their majors and to identify which General Education course will also fulfill a major preparation course requirement.

Mathematics Major

**With the B.A. Degree in Liberal Arts and Sciences
(Major Code: 17011)**

All candidates for a degree in liberal arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements." No more than 48 units in mathematics courses can apply to the degree.

A minor is not required with this major.

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Computer Science 107. (22 units)

Recommended: Physics 195, 195L, 196, 196L, 197, 197L.

Language Requirement. Competency (successfully completing the third college semester or fifth college quarter) is required in one foreign language to fulfill the graduation requirement. Refer to the section of this catalog on "Graduation Requirements."

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 27 upper division units, selected with approval of the departmental adviser before starting upper division work, including Mathematics 337, 521A, 524, 534A, and one two-semester sequence selected from: Mathematics 521A-521B; Mathematics 337 and 531; 337 and 537; 337 and 538; 534A-534B; 541 and 542; 541 and 543; Statistics 550 and 570; Statistics 551A and 551B; and nine units of electives.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Mathematics Major

**With the B.S. Degree in Applied Arts and Sciences
(Major Code: 17031)**

All candidates for a degree in applied arts and sciences must complete the graduation requirements listed in the section of this catalog on "Graduation Requirements."

There are four emphases offered in this major: Applied Mathematics, Computational Science, Mathematical Finance, and Science.

Emphasis in Applied Mathematics

This emphasis is designed to train the student in those areas of mathematics which may be applied to formulate and solve problems in other disciplines. The program is designed to qualify the student for employment as an applied mathematician, but the graduate would also be well prepared for graduate study in pure or applied mathematics.

MATH

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Computer Science 107, Statistics 250. (25 units)

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 36 upper division units to include Mathematics 337, 521A, 524, 532, 534A, 534B, 541; Statistics 350A or 551A; and 12 units of electives in computer science, mathematics, or statistics (approved by the Applied Mathematics adviser) excluding Mathematics 302, 303, 312, 313, 342A, 342B, 414, 509, and Statistics 357.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Auxiliary Area. A minimum of 12 units (lower or upper division) from an area to which mathematics may be applied. A typical program might be Physics 195, 195L, 196, 196L, 197, 197L; or Chemistry 200, 201, and a course for which these are prerequisite; or Economics 101, 102, 320, 321. The intent is to train the student in an area in some depth. Some latitude may be allowed in the choice of department and mix of courses, but all programs must be approved by the Applied Mathematics adviser. The 12 unit requirement is minimal, and a minor in an approved field is highly recommended.

Emphasis in Computational Science

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Computer Science 107, 108, 205, Statistics 250. (31 units)

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 36 upper division units to include Mathematics 336, 337, 521A, 524, 534A, 541; at least nine units from Mathematics 525, 532, 537, 538, 542, 543, Computer Science 558, 575; three units of Mathematics 499 (Senior Project); and six units of electives from computer science, mathematics, or statistics (approved by the Applied Mathematics adviser) excluding Mathematics 302, 303, 312, 313, 342A, 342B, 414, 509, and Statistics 357.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Emphasis in Mathematical Finance

This emphasis is designed to train students for work in the field of financial mathematics, focusing on derivative instruments and risk management. The graduate would also be highly qualified for graduate study.

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Computer Science 107, Statistics 119 or 250, Accountancy 201, Economics 101, 102. (34 units) The student must complete these courses before being allowed to register for the upper division finance courses.

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 39 upper division units to include Mathematics 337, 524, 531, 544, 562, 580, 581, Statistics 550 or 551A, Statistics 551B or 570 or 575, Finance 323, 326 or Economics 490, Finance 327, 329 or 421.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Emphasis in Science

This purpose of this emphasis is to allow students with a strong interest in the mathematical aspects of a particular science to apply courses in that science to their major. This will provide a good background for employment or graduate work in applied mathematics or in that science.

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Computer Science 107, Statistics 250. (25 units) Some lower division courses will probably be prerequisite to science courses applied to the major.

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 36 upper division units to include Mathematics 337, 524, 534A, 534B; at least six units selected from Mathematics 521A, 525, 531, 532, 537; 12 units from a science to which mathematics may be applied (these should be from a single science and must be approved by the B.S. adviser); and six units of electives in computer science, mathematics, or statistics excluding Mathematics 302, 303, 312, 313, 342A, 342B, 414, 509, and Statistics 357.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Mathematics Major

In preparation for the Single Subject Teaching Credential With the B.A. Degree in Liberal Arts and Sciences (Major Code: 17011)

All candidates for a teaching credential must complete all requirements as outlined in this section of the catalog under Policy Studies or Teacher Education. For students completing the single subject teaching credential program, no more than 48 units in mathematics courses can apply to the degree.

This major may be used by students preparing to be high school teachers as an undergraduate major for the B.A. degree in liberal arts and sciences.

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Statistics 250. (22 units)

Recommended: Computer Science 107, Physics 195, 195L, 196, 196L, 197, 197L.

Language Requirement. Competency (successfully completing the third college semester or fifth college quarter) is required in one foreign language as part of the preparation for the major. Refer to the section of the catalog on "Graduation Requirements."

Graduation Writing Assessment Requirement. Passing the Writing Proficiency Assessment with a score of 10 or above or completing one of the approved upper division writing courses (W) with a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

Major. A minimum of 24 upper division units in mathematics to include Mathematics 302, 303, 414, 521A, 534A, Statistics 550; an upper division course in geometry; and three units of electives in mathematics approved by the credential adviser.

Master Plan. A master plan of the courses taken to fulfill the major must be approved by the adviser and filed with the Office of Advising and Evaluations.

Mathematics Minor

The minor in mathematics consists of a minimum of 20-22 units in mathematics to include 12 upper division units, at least six of which have as prerequisite Mathematics 151; or Mathematics 252 and nine upper division units in mathematics, at least six of which have as prerequisite Mathematics 151. The courses selected will be subject to the approval of the minor adviser.

Courses in the minor may not be counted toward the major, but may be used to satisfy preparation for the major and general education requirements, if applicable. A minimum of six upper division units must be completed in residence at San Diego State University.

Single Subject Mathematics Certificate

The purpose of the Single Subject Mathematics Certificate program is to provide individuals appropriate mathematics coursework to establish their subject matter competency in accordance with California State requirements for high school mathematics teachers. Admission is open to individuals who are majoring or have majored in an area other than mathematics and who have the equivalent of two years of high school mathematics and satisfy the Entry-Level Mathematics Examination. In order to enroll in the program, individuals should contact the single subject mathematics credential adviser in the Department of Mathematics and Statistics.

The program consists of 46 units to include Mathematics 150, 151; and 241, 245, 252, 254, 302, 303, 414, 510 (or 511), 521A, 534A, Statistics 250, 550, and three units of upper division electives selected from mathematical or physical sciences.

Individuals must complete at least nine upper division units at San Diego State University and have a cumulative grade point average of 2.5 in the required courses to qualify for the certificate.

Mathematics Specialist Certificate Program

The Mathematics Specialist Certificate Program for Grades 4-6 is open only to credentialed teachers. The certificate program is described in the *Graduate Bulletin* in the Mathematics and Science Education section. Undergraduate mathematics courses for the certificate program are listed below.

Mathematics Departmental Placement Examination

All students who expect to enroll in Computer Science 106, 107, 108, Mathematics 118, 120, 121, 141, 150, 210, 211, 312, Statistics 119, 250 must satisfy the Entry-Level Mathematics Examination requirement and pass the required part of the Mathematics Departmental Placement Examination. For Mathematics 150, certain prerequisite courses taken at San Diego State University may be used to satisfy the Mathematics Departmental Placement Examination requirement.

COMPUTER SCIENCE (See this section of catalog under Computer Science)

STATISTICS (See this section of catalog under Statistics)

Courses (MATH)

Refer to *Curricula and Courses and University Policies* sections of this catalog for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

LOWER DIVISION COURSES

NOTE: Proof of completion of Entry-Level Mathematics requirement required for Mathematics 118, 120, 121, 122, 141, 150, 210, 211: Copy of ELM score or verification of exemption.

MATH 105. College Algebra (3) [GE]

Prerequisite: Satisfaction of the Entry-Level Mathematics requirement.

Real numbers, graphs, theory of functions, sinusoidal equations, and their applications to science. Excel and Maple programming. Not open to students with credit in Mathematics 121 or 141.

MATH 118. Topics in Mathematics (3) [GE]

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement.

Topics selected from algebra, analysis, geometry, logic, probability, or statistics, designed to give student insight into structure of mathematical theories and their applications.

MATH 120. Calculus for Business Analysis (3) [GE]

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement.

Matrix algebra. Calculus including differentiation and integration. Graphing and optimization. Exponential and logarithmic functions. Multivariable calculus.

MATH 121. Calculus for the Life Sciences I (3) [GE]

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement and IA examination, or Mathematics 105, or 141 with a grade of C (2.0) or better.

Basic concepts of differential calculus with life science applications. Not intended for physical science or engineering majors. Not open to students with credit in Mathematics 150.

MATH 122. Calculus for the Life Sciences II (3) [GE]

Two lectures and two hours of activity.

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement; qualification on the Mathematics Departmental Placement Examination; and Mathematics 121.

A continuation of Mathematics 121 with topics from integral calculus and an introduction to elementary differential equations. Not open to students with credit in Mathematics 150.

MATH 141. Precalculus (3) [GE]

Prerequisite: Satisfaction of the Entry-Level Mathematics requirement.

Real numbers, inequalities; polynomials; rational, trigonometric, exponential and logarithmic functions; conic sections. Not open to students with credit in Mathematics 105 or 121 or 150.

MATH 150. Calculus I (4) [GE]

Prerequisites: Knowledge of algebra, geometry, and trigonometry as demonstrated by either (1) satisfactory completion of Mathematics 141 with a grade of C (2.0) or above; or (2) satisfaction of the Entry-Level Mathematics requirement and qualification on the Mathematics Departmental Precalculus Proficiency Examination. Proof of completion of prerequisites required.

Algebraic and transcendental functions. Continuity and limits. The derivative and its applications. The integral and the fundamental theorem of calculus.

MATH 151. Calculus II (4) [GE]

Prerequisites: Mathematics 150 with minimum grade of C. Proof of completion of prerequisite required

Techniques and applications of integration. Improper integrals. Differential equations. Infinite series. Conic sections. Curves in parametric form, polar coordinates.

MATH 210. Number Systems in Elementary Mathematics (3) [GE]

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement.

Number sense, operation concepts, estimation, mental arithmetic, algorithms, problem solving, whole, rational, real numbers, ratio, and number theory. **This course or its equivalent is required for students working toward a multiple subject credential in elementary education.**

MATH

MATH 211. Geometry in Elementary Mathematics (3) [GE]

Prerequisites: Satisfaction of the Entry-Level Mathematics requirement and Mathematics 210.

Two and three dimensional shapes and interrelationships, congruence, similarity and proportional reasoning, measurement of length, angle size, area, volume, metric system, and problem solving.

MATH 215. Mathematics Placement Examination: Part LS Review (1) Cr/NC

Prerequisites: Score of 12 or lower on either section of Mathematics Placement Examination: Part LS.

Required review for students who have failed Mathematics Placement Examination: Part LS. Basic numbers (quantities, number systems, basic computations with integers and fractions), measurement and geometry (two- and three-dimensional objects, measurements, and measure systems).

MATH 241. Mathematics Software Workshop (1) (Selected sections offered as distance education)

Prerequisites: Mathematics 151.

Introduction to mathematical software environment such as MATLAB, MAPLE, MATHEMATICA or the Geometers Sketchpad. May be repeated for credit with different software. See Class Schedule for specific content. Maximum credit two units.

MATH 242. Mathematical Programming (3)

Prerequisite: Mathematics 122 or 151.

Rudiments of programming mathematical and scientific problems on various platforms which include: EXCEL, Matlab, and Maple.

MATH 245. Discrete Mathematics (3) [GE]

Prerequisites: Mathematics 121 or 150.

Logic, methods of proof, set theory, number theory, equivalence and order relations, counting (combinations and permutations), solving recurrence relations.

MATH 252. Calculus III (4) [GE]

Prerequisites: Mathematics 151 with minimum grade of C.

Functions of several variables. Vectors. Partial derivatives and multiple integrals. Line integrals and Green's Theorem.

MATH 254. Introduction to Linear Algebra (3) [GE]

Prerequisites: Mathematics 151.

Matrix algebra, Gaussian elimination, determinants, vector spaces, linear transformations, orthogonality, eigenvalues, and eigenvectors.

MATH 296. Experimental Topics (1-4)

Selected topics. May be repeated with new content. See Class Schedule for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree.

MATH 299. Special Study (1-3)

Prerequisites: Consent of instructor.

Individual study. Maximum credit six units.

UPPER DIVISION COURSES (Intended for Undergraduates)

NOTE: Proof of completion of prerequisites required for all upper division courses: Copy of transcript.

MATH 302. Transition to Higher Mathematics (3)

Prerequisites: Mathematics 150.

Selected topics in mathematics to emphasize proof writing and problem solving. Intended for those planning to teach secondary school mathematics.

MATH 303. History of Mathematics (3) [GE]

Prerequisites: Mathematics 141 or students using course to satisfy General Education must complete the General Education requirement in Foundations IIA., Natural Sciences and Quantitative Reasoning.

Major currents in the development of mathematics from ancient Egypt and Babylon to late nineteenth century Europe.

MATH 311. Statistics and Probability in Elementary Mathematics (2)

Prerequisites: Mathematics 211 and satisfactory performance on Mathematics Departmental Placement Examination, Part LS.

Topics from statistics and probability. Enrollment limited to liberal studies majors. Not open to students with credit in Mathematics 312.

MATH 312. Topics from Elementary Mathematics I (3)

Prerequisites: Mathematics 211 and satisfactory performance on Mathematics Departmental Placement Examination, Part LS.

Topics from statistics and probability. Enrollment limited to future teachers in grades K-8. Not open to students with credit in Mathematics 311.

MATH 313. Selected Topics in Elementary Mathematics (3)

Prerequisites: Mathematics 311 or 312.

Capstone course for prospective K-8 teachers. Advanced topics in mathematics selected from algebra, number systems, transformation geometry, and problem solving. Enrollment limited to future teachers in grades K-8.

MATH 315. Special Topics in Algebra, Geometry, and Problem Solving (2)

Prerequisites: Mathematics 210, 211, 311.

Capstone course for prospective elementary teachers to include algebra (describing change), geometry (rigid motions), and non-routine problem solving.

MATH 336. Introduction to Mathematical Modeling (3)

Prerequisites: Mathematics 254.

Models from the physical, natural, and social sciences including population models and arms race models. Emphasis on classes of models such as equilibrium models and compartment models.

MATH 337. Elementary Differential Equations (3)

Prerequisites: Mathematics 254 or 342A.

Integration of first-order differential equations, initial and boundary value problems for second-order equations, series solutions and transform methods, regular singularities.

MATH 342A. Methods of Applied Mathematics I (3)

Prerequisites: Mathematics 252.

Vector analysis, divergence and Stokes' theorem and related integral theorems. Matrix analysis, eigenvalues and eigenvectors, diagonalization. Introduction to ordinary differential equations. Computer software packages for matrix applications, solving, and graphing differential equations. Not open to students with credit in Physics 340A.

MATH 342B. Methods of Applied Mathematics II (3)

Prerequisites: Mathematics 342A with minimum grade of C.

Second order ordinary differential equations, power series methods, Bessel functions, Legendre polynomials. Linear partial differential equations, separation of variables, Fourier series, Sturm-Liouville theory, orthogonal expansions, Fourier Transforms. Use of computer software packages for symbolic algebra and solution of differential equations. Not open to students with credit in Physics 340B.

MATH 413. Mathematics for the Middle Grades (3)

Prerequisites: Senior standing and Mathematics 312.

Teacher-level look at mathematics taught in middle grades, to include proportional reasoning, rational and real numbers, probability, and algebra. Intended for those planning to teach mathematics in middle grades; cannot be used as part of the major or minor in mathematical sciences with exception of major for single subject teaching credential. Students in the SSTC major must receive instructor permission.

MATH 414. Mathematics Curriculum and Instruction (3)

Prerequisites: Senior standing and 12 upper division units in mathematics.

Historical development of mathematics and mathematics curriculum. Principles and procedures of mathematics instruction in secondary schools. For secondary and postsecondary teachers and teacher candidates. Course cannot be used as part of the major or minor in mathematical sciences with exception of major for the single subject teaching credential.

MATH 496. Experimental Topics (1-4)

Selected topics. May be repeated with new content. See Class Schedule for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree.

MATH 499. Special Study (1-3)

Prerequisites: Consent of instructor.

Individual study. Maximum credit six units.

UPPER DIVISION COURSES
(Also Acceptable for Advanced Degrees)

NOTE: Proof of completion of prerequisites required for all upper division courses: Copy of transcript.

MATH 509. Computers in Teaching Mathematics (3)

Two lectures and three hours of laboratory.
Prerequisites: Mathematics 252.
Solving mathematical tasks using an appropriate computer interface, and problem-based curricula. Intended for those interested in mathematics teaching.

MATH 510. Introduction to the Foundations of Geometry (3)

Prerequisites: Mathematics 122 or 151.
The foundations of Euclidean and hyperbolic geometries. Highly recommended for all prospective teachers of high school geometry.

MATH 511. Projective Geometry (3)

Prerequisites: Mathematics 254.
Geometry emphasizing relationships between points, lines, and conics. Euclidean geometry and some non-Euclidean geometries as special cases of projective geometry.

MATH 521A. Abstract Algebra (3)

Prerequisites: Mathematics 245 and 254.
Abstract algebra, including elementary number theory, groups, and rings.

MATH 521B. Abstract Algebra (3)

Prerequisites: Mathematics 521A.
Continuation of Mathematics 521A. Rings, ideals, quotient rings, unique factorization, noncommutative rings, fields, quotient fields, and algebraic extensions.

MATH 522. Number Theory (3)

Prerequisite: Mathematics 245.
Theory of numbers to include congruences, Diophantine equations, and a study of prime numbers; cryptography.

MATH 523. Mathematical Logic (3)

Prerequisites: Mathematics 245.
Propositional logic and predicate calculus. Rules of proof and models. Completeness and the undecidability of arithmetic. Not open to students with credit in Philosophy 521.

MATH 524. Linear Algebra (3)

Prerequisites: Mathematics 245 and 254; or 342A.
Vector spaces, linear transformations, orthogonality, eigenvalues and eigenvectors, normal forms for complex matrices, positive definite matrices and congruence.

MATH 525. Algebraic Coding Theory (3)

Prerequisites: Mathematics 254.
Linear codes, perfect and related codes, cyclic linear codes, BCH codes, burst error-correcting codes.

MATH 528. Information Theory and Data Compression (3)

Prerequisites: Mathematics 245 and 254.
Fundamental of discrete probability and information theory: joint and conditional distributions, Bayes' theorem, entropy, channel capacity. Noiseless coding theorem and data compression algorithms: Huffman codes, arithmetic coding, Ziv-Lempel codes. Information theory in error correction coding and cryptography.

MATH 531. Partial Differential Equations (3)

Prerequisites: Mathematics 252 and 337.
Boundary value problems for heat and wave equations: eigenfunction expansions, Sturm-Liouville theory and Fourier series. D'Alembert's solution to wave equation; characteristics. Laplace's equation, maximum principles, Bessel functions.

MATH 532. Functions of a Complex Variable (3)

Prerequisites: Mathematics 252.
Analytic functions, Cauchy-Riemann equations, theorem of Cauchy, Laurent series, calculus of residues, and applications.

MATH 533. Vector Calculus (3)

Prerequisites: Mathematics 254 or 342A.
Scalar and vector fields; gradient, divergence, curl, line and surface integrals: Green's, Stokes' and divergence theorems. Green's identities. Applications to potential theory or fluid mechanics or electromagnetism.

MATH 534A. Advanced Calculus I (3)

Prerequisites: Mathematics 245 and 254; or 342A.
Completeness of the real numbers and its consequences, sequences of real numbers, continuity, differentiability and integrability of functions of one real variable.

MATH 534B. Advanced Calculus II (3)

Prerequisites: Mathematics 534A.
Series and sequences of functions and their applications, functions of several variables and their continuity, differentiability and integrability properties.

MATH 537. Ordinary Differential Equations (3)

Prerequisites: Mathematics 337.
Theory of ordinary differential equations: existence and uniqueness, dependence on initial conditions and parameters, linear systems, stability and asymptotic behavior, plane autonomous systems, series solutions at regular singular points.

MATH 538. Discrete Dynamical Systems and Chaos (3)

Prerequisites: Minimum grade of C in Mathematics 151; Mathematics 254 or 342A, 342B.
One- and two-dimensional iterated maps, equilibria and their stability, sensitive dependence on initial conditions, Lyapunov exponents, horseshoe maps, period doubling, chaotic attractors, Poincare maps, stable/unstable manifolds, bifurcations. Applications in biology, chemistry, physics, engineering, and other sciences.

MATH 541. Introduction to Numerical Analysis and Computing (3)

Prerequisites: Mathematics 254 or 342A; and Computer Science 106 or 107 or 205.
Solution of equations of one variable, direct methods in numerical linear algebra, least squares approximation, interpolation and uniform approximation, quadrature.

MATH 542. Introduction to Numerical Solutions of Differential Equations (3)

Prerequisites: Mathematics 337 and 541.
Initial and boundary value problems for ordinary differential equations. Partial differential equations. Iterative methods, finite difference methods, and the method of lines.

MATH 543. Numerical Matrix Analysis (3)

Prerequisites: Mathematics 541.
Gaussian elimination, LU factorizations and pivoting strategies. Direct and iterative methods for linear systems. Iterative methods for diagonalization and eigensystem computation. Tridiagonal, Hessenberg, and Householder matrices. The QR algorithm.

MATH 544. Computational Finance (3)

Prerequisites: Statistics 550 or 551A.
Risk evaluation. Numerical procedures for evaluating financial derivatives. Monte Carlo simulation techniques.

MATH 561. Applied Graph Theory (3)

Prerequisites: Mathematics 245 or 254.
Undirected and directed graphs, trees, Hamiltonian circuits, classical problems of graph theory including applications to linear systems.

MATH 562. Mathematical Methods of Operations Research (3)

Prerequisites: Mathematics 252 and 254.
Theory and applications concerned with optimization of linear and non-linear functions of several variables subject to constraints, including simplex algorithms, duality, applications to game theory, and descent algorithms.

MATH 579. Combinatorics (3)

Prerequisites: Mathematics 245.
Permutations, combinations, generating functions, recurrence relations, inclusion-exclusion counting. Polya's theory of counting, other topics and applications.

MATH

MATH 580. Risk Management: Stocks and Derivative Securities (3)

Prerequisites: Statistics 550 or 551A.
Theory of derivative securities with focus on evolution of stock prices and pricing of options.

MATH 581. Risk Management: Portfolio Selection and Other Features of Finance Markets (3)

Prerequisites: Statistics 550 or 551A.
Derivatives and term structures, method of principal components, theory of portfolio optimization, some numerical methods.

MATH 596. Advanced Topics in Mathematics (1-4)

Prerequisites: Consent of instructor.
Selected topics in classical and modern mathematical sciences. May be repeated with the approval of the instructor. See Class Schedule for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Maximum credit of six units of 596 applicable to a bachelor's degree. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

Courses (MATHED)

Refer to *Curricula and Courses and University Policies* sections of this catalog for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

LOWER DIVISION COURSE (Intended for Undergraduates)

NOTE: Proof of completion of Entry-Level Mathematics requirement required for Mathematics 118, 120, 121, 122, 141, 150, 210, 211: Copy of ELM score or verification of exemption.

MTHED 212. Children's Mathematical Thinking (1-1.5)

Prerequisites: Credit or concurrent registration in Mathematics 210.

Children's mathematical thinking and in-depth analyses of children's understanding of operations (addition, subtraction, multiplication, and division) and place value. Students will observe individual children solving mathematics problems. Real, compact disc, and/or web-based experience included.

Courses (MATH) (MTHED)

Refer to *Curricula and Courses and University Policies* sections of this catalog for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

UPPER DIVISION COURSE (MATH) (Intended for Undergraduates)

NOTE: Proof of completion of prerequisites required for all upper division courses: Copy of transcript

MATH 487. Algebra in the Middle Grades (3)

One lecture and four hours of activity.
Prerequisites: Teaching credential and consent of instructor.
Algebra as a powerful tool for analyzing, describing, and symbolizing physical relationships. Role of functions in algebra and in other areas of mathematics.

UPPER DIVISION COURSES (MATH) (Also Acceptable for Advanced Degrees)

NOTE: Proof of completion of prerequisites required for all upper division courses: Copy of transcript.

MATH 501A. Reasoning: Place Value and Arithmetic Operations (1)

Prerequisites: Teaching credential and consent of instructor.
Place value and its role in development and understanding of arithmetic operations, to include numeration systems, student methods, standard algorithms, and mental computation. (Formerly numbered Mathematics 281A.)

MATH 501B. Reasoning: Rational Numbers and Real Number Systems (1)

Prerequisites: Teaching credential and consent of instructor.
Rational numbers and structure of real number system, to include meanings and models for fractions with attention to operations on rational numbers. (Formerly numbered Mathematics 281A.)

MATH 502A. Reasoning: Geometric Shapes (1)

Prerequisites: Teaching credential and consent of instructor.
Geometry to include classification and representation of polyhedra, hierarchical relationships among quadrilaterals, symmetry and transformations in the plane. (Formerly numbered Mathematics 281B.)

MATH 502B. Reasoning: Measurement (1)

Prerequisites: Teaching credential and consent of instructor.
Key ideas of measurement, development of area formulas for two-dimensional figures, size changes, and similarity. (Formerly numbered Mathematics 281B.)

MATH 503A. Reasoning: Foundations of Quantitative Thinking (1)

Prerequisites: Teaching credential and consent of instructor.
Reasoning about quantities and their measurement and relationships among these quantities, to include representations of these relationships. Understand situations that call for additive or multiplicative reasoning; important role of these ideas in development of quantitative reasoning skills in primary grades. (Formerly numbered Mathematics 381.)

MATH 503B. Reasoning: Foundations of Algebraic Thinking (1)

Prerequisites: Teaching credential and consent of instructor.
Pattern searching, equivalence, making and justifying conjectures. Preparation for teaching California required K-12 algebraic reasoning strand. (Formerly numbered Mathematics 382.)

MATH 504A. Reasoning: Quantities and Mathematical Relationships (1)

Prerequisites: Teaching credential and consent of instructor.
Reasoning about measurable characteristics in problem context, and relationships among these measurements. Additive, multiplicative reasoning, and proportional reasoning in middle grades. (Formerly numbered Mathematics 383.)

MATH 504B. Reasoning: Algebra and Nature of Change (1)

Prerequisites: Teaching credential and consent of instructor.
Pattern searching, generalizing, graphing to represent quantitative relationships, and role of these topics in preparing elementary and middle school students for algebra. (Formerly numbered Mathematics 384.)

MATH 505A. Reasoning: Probability (1)

Prerequisites: Teaching credential and consent of instructor.
Probabilistic situations, theoretical probabilities, and expected values. (Formerly numbered Mathematics 386.)

MATH 505B. Reasoning: Statistics (1)

Prerequisites: Teaching credential and consent of instructor.
Gathering, representing, and interpreting data sets, measures of central tendency, and characteristics of normal distributions. (Formerly numbered Mathematics 385.)

UPPER DIVISION COURSES (MTHED) (Also Acceptable for Advanced Degrees)

MTHED 502. Technology in Teaching and Learning Mathematics: Grades K-8 (3)

Prerequisites: Classified graduate standing; consent of instructor for undergraduates.

Research in use of technology in learning and teaching mathematics in grades K-8. Major focus devoted to use of applications. Other uses for technology addressed include simulations, communication, and calculational speed.

MTHED 571. Children's Mathematics Understanding in Primary Grades (Part I) (1-3)

Prerequisites: Admission to mathematics specialist certificate program.

Ongoing assessment and instructional decision-making for increasing children's achievement and understanding of number, operations, and algebra in the primary grades. Maximum credit three units.

MTHED 572. Children's Mathematics Understanding in Primary Grades (Part II) (1-3)

Prerequisites: Admission to mathematics specialist certificate program.

Ongoing assessment and instructional decision-making for increasing children's achievement and understanding of rational numbers, geometry, and measurement in the primary grades. Maximum credit three units.

MTHED 573. Children's Mathematics Understanding in Upper Elementary Grades (Part I) (1-3)

Prerequisites: Admission to mathematics specialist certificate program.

Ongoing assessment and instructional decision-making for increasing children's achievement and understanding of number, operations, and algebra in the upper elementary grades. Maximum credit three units.

MTHED 574. Children's Mathematics Understanding in Upper Elementary Grades (Part II) (1-3)

Prerequisites: Admission to mathematics specialist certificate program.

Ongoing assessment and instructional decision-making for increasing children's achievement and understanding of rational numbers, geometry and measurement in the upper elementary grades. Maximum credit three units.

GRADUATE COURSES
Refer to the *Graduate Bulletin*.
