

Mathematics

In the College of Sciences

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Faculty

Emeritus: Carlson, Deaton, Eisemann, Elwin, Garrison, Geveci, Grone, Hager, Hintzman, Hui, Lesley, Lutz, Marcus, McLeod, Nemirovsky, Nower, Pierce, Salamon, Saltz, Short, Smith, Sowder, J., Sowder, L., Thompson, Van de Wetering, Whitman
Chair: O'Sullivan
Professors: Blomgren, Carretero, Castillo, Dunster, Interlando, Lobato, Mahaffy, O'Sullivan, Palacios, Ponomarenko, Rasmussen, Shen, S., Verzi (IVC)
Associate Professors: Bowers, Kirschvink, Nickerson, Shen, B.
Assistant Professors: Curtis, Gilles, Luque, Reinholz, Zahner

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 science.
Teaching major in mathematics for the single subject teaching credential.
Minor in mathematics.
Certificate in communication systems (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.

Impacted Program

The mathematics major and emphases are impacted programs. To be admitted to the mathematics major or an emphasis, students must meet the following criteria:

- Complete preparation for the major. Refer to the individual program for specific impactation criteria;
- Complete a minimum of 60 transferable semester units;
- Have a minimum cumulative GPA of 2.0.

To complete the major, students must fulfill the degree requirements for the major described in the catalog in effect at the time they are accepted into the premajor at SDSU (assuming continuous enrollment).

Major Academic Plans (MAPs)

Visit <http://www.sdsu.edu/mymap> for the recommended courses needed to fulfill your major requirements. The MAPs website 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) (SIMS Code: 776301)

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 and statistics courses can apply to the degree.

A minor is not required with this major.

Impacted Program. Complete with a grade of C (2.0) or better: Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better.

Preparation for the Major. Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses must be completed with a grade of C (2.0) or better, and cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better. (24 units)

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 Placement Assessment with a score of 10 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 to include Mathematics 337, 521A, 524, 534A; at least one course selected from Mathematics 521B, 531, 534B, 537, 538, 542, 543, Statistics 551B; and 12 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 major department.

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 three emphases offered in this major: Applied Mathematics, Computational Science, and Science.

Emphasis in Applied Mathematics

(SIMS Code: 776313)

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.

A minor is not required with this major.

Impacted Program. Complete with a grade of C (2.0) or better: Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better.

Preparation for the Major. Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses must be completed with a grade of C (2.0) or better, and cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better. (24 units)

Graduation Writing Assessment Requirement. Passing the Writing Placement Assessment with a score of 10 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, 534A, 541; 524 or 543; 531 or 532 or 534B; Statistics 350A or 550 or 551A; and 15 units of electives in mathematics or an area to which mathematics may be applied (approved by the Applied Mathematics adviser) excluding Mathematics 302, 303, 311, 312, 313, 315, 342A, 342B, 413, 414, 509.

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

Auxiliary Area. A minimum of 10 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 10 unit requirement is minimal, and a minor in an approved field is highly recommended.

Emphasis in Computational Science

(SIMS Code: 776322)

A minor is not required with this major.

Impacted Program. Complete with a grade of C (2.0) or better: Mathematics 150, 151, 245, 252, 254, Computer Science 107, 108, and Statistics 250. These courses cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better.

Preparation for the Major. Mathematics 150, 151, 245, 252, 254, Computer Science 107, 108, and Statistics 250. These courses must be completed with a grade of C (2.0) or better, and cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be C+ (2.3) or better. (27 units)

Graduation Writing Assessment Requirement. Passing the Writing Placement Assessment with a score of 10 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, 521A, 524 or 543, 534A, 541; Computer Science 310; at least nine units selected from Computational Science 526, 536, Computer Science 503, 558, Mathematics 336, 525, 532, 537, 542, 543; three units of Mathematics 499 (Senior Project); and nine units of electives in computer science, mathematics, or statistics (approved by the Applied Mathematics adviser) excluding Mathematics 302, 303, 311, 312, 313, 315, 342A, 342B, 413, 414, 509.

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

Emphasis in Science

(SIMS Code: 776348)

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.

A minor is not required with this major.

Impacted Program. Complete with a grade of C (2.0) or better: Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better.

Preparation for the Major. Mathematics 150, 151, 245, 252, 254, Statistics 250, and either Mathematics 242 or Computer Science 107. These courses must be completed with a grade of C (2.0) or better, and cannot be taken for credit/no credit (Cr/NC). The cumulative GPA in Mathematics 245, 252, and 254 must be a C+ (2.3) or better. (24 units)

Graduation Writing Assessment Requirement. Passing the Writing Placement Assessment with a score of 10 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, 534A; 524 or 543; 532 or 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, 311, 312, 313, 315, 342A, 342B, 413, 414, 509.

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

Mathematics Major

In preparation for the Single Subject Teaching Credential With the B.A. Degree in Liberal Arts and Sciences (Major Code: 17011) (SIMS Code: 776303)

All candidates for a teaching credential must complete all requirements as outlined in this section of the catalog under Dual Language and English Learner Education or Teacher Education. For students completing the single subject teaching credential program, no more than 48 units in mathematics and statistics 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.

A minor is not required with this major.

Impacted Program. Complete with a grade of C (2.0) or better: Mathematics 150, 151, 241, 245, 252, 254, Statistics 250, and Teacher Education 211A. These courses cannot be taken for credit/no credit (Cr/NC).

Preparation for the Major. Mathematics 150, 151, 241, 245, 252, 254, Statistics 250, and Teacher Education 211A. These courses must be completed with a grade of C (2.0) or better, and cannot be taken for credit/no credit (Cr/NC). (23 units) Recommended: Mathematics 242 or 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 this catalog on "Graduation Requirements."

Graduation Writing Assessment Requirement. Passing the Writing Placement Assessment with a score of 10 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 adviser for the major.

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

Mathematics Minor

(Minor Code: 17011) (SIMS Code: 776301)

The minor in mathematics consists of a minimum of 20-21 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

(SIMS Code: 776357)

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, 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 Departmental Placement Examination

All students who expect to enroll in Computer Science 100, 107, Mathematics 105, 118, 120, 122, 124, 141, 150, 210, 211, Statistics 119, 250 must satisfy the Entry-Level Mathematics Examination requirement. For Mathematics 150, 311, and 312, students must also 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 *Courses and Curricula 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 105, 118, 120, 122, 124, 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, 124, or 141.

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

Prerequisite: 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]

Prerequisite: Satisfaction of the Entry-Level Mathematics requirement.

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

Prerequisite: Satisfaction of the Entry-Level Mathematics requirement.

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 124. Calculus for the Life Sciences (4) [GE]

Three lectures and three hours of laboratory.

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.**

Basic concepts of calculus with life science applications. Topics from differential and integral calculus and an introduction to elementary differential equations. Computer applications to biological problems. Not open to students with credit in Mathematics 121 and 122, or 150.

MATH 141. Precalculus (3) [GE]

Two lectures and two hours of activity.

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, 121, 124, or 150.

MATH 150. Calculus I (4) [GE]

Three lectures and two hours of activity.

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 better; 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]

Three lectures and two hours of activity.

Prerequisite: Mathematics 150 with a grade of C (2.0) or better.

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]

Prerequisite: 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 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 241. Mathematics Software Workshop (1)

Prerequisite: Mathematics 150.

Introduction to dynamic geometry software to include Geometer's Sketchpad and GeoGebra. Constructions in Euclidean geometry, exploration of symmetry and plane transformations, graphing of functions and algebraic equations.

MATH 242. Mathematical Programming (3)

Prerequisite: Credit or concurrent registration in Mathematics 151.

Introduction to mathematical programming. Modeling, problem solving, visualization.

MATH 245. Discrete Mathematics (3) [GE]

Prerequisite: Mathematics 124 or 150 with a grade of C (2.0) or better. Recommended: Mathematics 151.

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]

Prerequisite: Mathematics 151 with a grade of C (2.0) or better.

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

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

Prerequisite: Mathematics 151 with a grade of C (2.0) or better.

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)

Prerequisite: 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)

Prerequisite: Mathematics 141 or 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]

Prerequisite: Mathematics 141 or completion of the General Education requirement in Foundations of Learning IIA., Natural Sciences and Quantitative Reasoning for nonmajors.

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: Statistics and Probability (3)

Prerequisites: Mathematics 211 and satisfactory performance on Liberal Studies Mathematics Proficiency Assessment.

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. Topics in Elementary Mathematics: Algebra of Change (3)

Prerequisites: Mathematics 211 and satisfactory performance on Liberal Studies Mathematics Proficiency Assessment.

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, 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)

Prerequisite: Mathematics 254 with a grade of C (2.0) or better.

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)

Prerequisite: Mathematics 254 or 342A with a grade of C (2.0) or better.

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)

Prerequisite: 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.

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

Prerequisite: Mathematics 342A with a grade of C (2.0) or better.

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.

MATH 413. Mathematics for the Middle Grades (3)

Prerequisite: Mathematics 313.

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 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)

Prerequisite: Consent of instructor.
Individual study. Maximum credit six units.

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

MATH 509. Computers in Teaching Mathematics (3)

Two lectures and three hours of laboratory.

Prerequisite: Mathematics 252 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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)

Prerequisite: Mathematics 151 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

The foundations of Euclidean and hyperbolic geometries. Highly recommended for all prospective teachers of high school geometry.

MATH 521A. Abstract Algebra (3)

Prerequisites: Mathematics 245 and 254 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

Elementary number theory and rings to include ideals, polynomial rings, quotient rings, ring homomorphisms and isomorphisms. Introduction to basic aspects of group theory.

MATH 521B. Abstract Algebra (3)

Prerequisite: Mathematics 521A with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

Continuation of Mathematics 521A. Group theory to include finite Abelian groups, group homomorphisms and isomorphisms, normal subgroups, quotient groups, and Sylow theorems. Selected advanced topics to include field extensions or integral domains.

MATH 522. Number Theory (3)

Prerequisite: Mathematics 245 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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

MATH 523. Mathematical Logic (3)

Prerequisite: Mathematics 245 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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 either 254 or 342A with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

Vector spaces, linear transformations, orthogonality, eigenvalues and eigenvectors, normal forms for complex matrices, positive definite matrices and congruence.

MATH 525. Algebraic Coding Theory (3)

Prerequisite: Mathematics 254 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

Linear codes, perfect and related codes, cyclic linear codes, BCH codes, burst error-correcting codes.

MATH 531. Partial Differential Equations (3)

Prerequisites: Mathematics 252 and 337 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

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)

Prerequisite: Mathematics 252 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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

MATH 533. Vector Calculus (3)

Prerequisite: Mathematics 254 or 342A with a grade of C (2.0) or better. **Proof of completion of prerequisite required:** Copy of transcript.

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 either 254 or 342A with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

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)

Prerequisite: Mathematics 534A with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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)

Prerequisite: Mathematics 337 with a grade of C (2.0) or better.

Proof of completion of prerequisite required: Copy of transcript.

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: Mathematics 151 and either 254 or 342B with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

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 either Mathematics 242 or Aerospace Engineering 280 or Computer Science 107 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

Solution of equations of one variable, polynomial interpolation and approximation, numerical differentiation and quadrature, linear least squares approximation, the fast Fourier transformation.

MATH 542. Introduction to Computational Ordinary Differential Equations (3)

Prerequisites: Mathematics 337 and 541 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

Initial and boundary value problems for ordinary differential equations. Runge-Kutta, linear multi-step, predictor-corrector, adaptive, hybrid, shooting, and general linear methods. System, stiffness, and non-linear problems. Iterative methods.

MATH 543. Numerical Matrix Analysis (3)

Prerequisite: Mathematics 541 with a grade of C (2.0) or better.
Proof of completion of prerequisite required: Copy of transcript.

Singular value decomposition. Projections, QR-factorization, orthogonalization, conditioning and stability, Gaussian Elimination, LU-Factorization, pivoting strategies, Cholesky Factorization. Iterative methods for diagonalization and eigensystem computation. Tridiagonal, Hessenberg, and Household matrices. The QR algorithm.

MATH 562. Mathematical Methods of Operations Research (3)

Prerequisites: Mathematics 252 and 254 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

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)

Prerequisite: Mathematics 245 with a grade of C (2.0) or better.
Proof of completion of prerequisite required: Copy of transcript.

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

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

Prerequisite: 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.

Mathematics Education

Courses (MTHED AND MATH)

Refer to *Courses and Curricula* 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 IN MATHEMATICS EDUCATION
 (Intended for Undergraduates)
 (MTHED)**

NOTE: Proof of completion of Entry-Level Mathematics requirement required for Mathematics 105, 118, 120, 122, 124, 141, 150, 210, 211: Copy of ELM score or verification of exemption.

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

Prerequisite: 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.

**UPPER DIVISION COURSES IN MATHEMATICS
 (Also Acceptable for Advanced Degrees)
 (MATH)**

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.

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.

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.

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.

MATH 506A. Algebra in the Middle Grades I (3)

Prerequisites: Teaching credential and consent of instructor.
 Mathematical foundations that underlie concepts and procedures emphasized in algebra I and algebra II as taught at middle and high school level, to include focus on real number system, ratios, proportional reasoning, equality, number theory, and proof.

MATH 506B. Algebra in the Middle Grades II (3)

Prerequisites: Mathematics 506A, practicing teachers with valid teaching credential, and consent of instructor.
 Mathematical foundations that underlie concepts and procedures emphasized in algebra I and algebra II as taught at middle and high school level, to include focus on functions in context of relations, patterns, and graphing.

MATH 507A. Functions and Study of Change I (2)

Prerequisites: Mathematics 506B, practicing teachers with valid teaching credential, and consent of instructor.
 Mathematical ideas surrounding linear functions and change to include proportionality, slope, and graphing. Arithmetic and geometric sequences.

MATH 507B. Functions and Study of Change II (3)

Prerequisites: Mathematics 507A, practicing teachers with valid teaching credential, and consent of instructor.
 Mathematical ideas surrounding nonlinear functions and variable rates of change to include quadratic and exponential situations.

**GRADUATE COURSES
 Refer to the Graduate Bulletin.**