

# Mathematics

IN THE COLLEGE OF SCIENCES

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## Faculty

**Emeritus:** Carlson, Deaton, Elwin, Garrison, Geveci, Grone, Hager, Hintzman, Hui, Lesley, Lutz, Marcus, McLeod, Nemirovsky, Noble, Nower, Pierce, Salamon, Saltz, Short, Smith, Sowder, J., Sowder, L., Thompson, Van de Wetering, Verzi (SDSU-IV), Whitman

**Chair:** O'Sullivan

**Professors:** Blomgren, Carretero, Castillo, Dunster, Interlando, Lobato, Mahaffy, O'Sullivan, Palacios, Ponomarenko, Rasmussen, Shen, S.

**Associate Professors:** Bowers, Curtis, Gilles, Kirschvink, Nickerson, Shen, B., Vaidya, Zahner

**Assistant Professors:** George, Hong, Luque, O'Neill, Pilgrim, Qin (SDSU-IV), Reinholz, Tang (SDSU-IV)

## 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 mathematics education.

Emphasis in science.

Teaching major in mathematics in preparation for the single subject teaching credential.

Emphasis in integrated teacher education program (ITEP-SS).

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 impact criteria;
- Complete a minimum of 60 transferable semester units;
- Have a minimum cumulative GPA of 2.0.
- For the mathematics major with an emphasis in integrated teacher education program (ITEP-SS) students must have a minimum cumulative GPA of 2.67.

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 60 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 one course selected from Computer Science 107, 200, Statistics 200. 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 one course selected from Computer Science 107, 200, Statistics 200. 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. (24-25 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 30 upper division units selected with approval of the departmental adviser before starting upper division work to include Mathematics 320, 330, 337, 340, 524; one course selected from Mathematics 520, 530, 531, 537, 538, 542, 543, Statistics 551B; and 12 units of electives. Students planning to take Mathematics 499 as an elective course must obtain approval from the program adviser.

**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 four emphases offered in this major: Applied Mathematics, Computational Science, Mathematics Education, 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 one course selected from Computer Science 107, 200, Statistics 200. 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 one course selected from Computer Science 107, 200, Statistics 200. 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. (24-25 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 320, 330, 337, 340; 524 or 543; 530 or 531 or 532; 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, 312, 313, 342A, 342B, 413, 414, 509. Students planning to take Mathematics 499 as an elective course must obtain approval from the program adviser.

**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 a 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 320, 330, 337, 340; 524 or 543; 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 – approved by the adviser); and nine units of electives in computer science, mathematics, or statistics (approved by the adviser) excluding Mathematics 302, 303, 312, 313, 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 Mathematics Education

(SIMS Code: 776335)

This emphasis allows students with a strong interest in mathematics and an interest in teaching in the secondary schools to be prepared for both graduate school in mathematics and admission into the Single Subject Teaching Credential program. This degree also prepares with options to teach at the community college level.

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, Teacher Education 211A, and one course selected from Computer Science 107, 200, Statistics 200. 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, Teacher Education 211A, and one course selected from Computer Science 107, 200, Statistics 200. 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. (25-26 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 37 upper division units in mathematics to include Mathematics 302, 303, 320, 330, 337, 340, 341, 414, 508 or 510, 524 or 543, 530 or 531 or 532, Statistics 350A or 550 or 551A; 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.

**Auxiliary Area.** A minimum of nine lower or upper division units of teaching-related electives are required from an area that will enhance understanding of teaching or applications of teaching mathematics. Elective courses include Physics 195, 195L, or Chemistry 200, 201. All programs must be approved by the adviser.

### 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 one course selected from Computer Science 107, 200, Statistics 200. 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 one course selected from Computer Science 107, 200, Statistics 200. 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. (24-25 units)

**Graduation Writing Assessment Requirement.** Passing the Writing Placement Assessment with a score of 10 or completing

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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 330, 337, 340; 524 or 543; at least six units selected from Mathematics 320, 525; 530 or 532; 531, 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, 413, 414, 509. Students planning to take Mathematics 499 as an elective course must obtain approval from the program adviser.

**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, 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, 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). (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 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 25 upper division units in mathematics to include Mathematics 302, 303, 320, 330, 341, 414, 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.

### Emphasis in Integrated Teacher Education Program (ITEP-SS)

(SIMS Code: 776306)

This emphasis combines the degree and credential into a 129 unit, four year integrated teacher education program. The program is designed to qualify the student for a mathematics degree and a preliminary single subject teaching credential in 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; Teacher Education 170 [or Child and Family Development 170], 211A, 280. These courses must be completed with a grade of C (2.0) or better and cannot be taken for credit/no credit (Cr/NC).

**Preparation for the Major.** Mathematics 150, 151, 245, 252, 254, Statistics 250, Teacher Education 170 [or Child and Family Development 170], 211A, 280. (26 units) These courses must be completed with a grade of C (2.0) or better and cannot be taken for credit/no credit (Cr/NC).

**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 8 or above before taking Teacher Education 405W\* and earn a grade of C (2.0) or better. See "Graduation Requirements" section for a complete listing of requirements.

**Major.** A minimum of 28 upper division units in mathematics to include Mathematics 302, 303, 320, 330, 341, 414, 510; Statistics 550; Teacher Education 405W\*; and three units of electives in mathematics approved by the adviser for the major.

**Additional Requirements for Subject Matter Preparation Certification.** Certification of subject matter competency by the Department of Mathematics and Statistics requires completion of all preparation for the major and major courses with the required grades. (At most one grade of C- or lower among the courses listed under the major is permitted. If a course is repeated, the highest grade will count.) Certification must be achieved before student teaching.

**ITEP Admission Requirements.** Students apply for admission to the mathematics major with an emphasis in integrated teacher education program (ITEP-SS) during the spring semester of their sophomore year. Students who qualify for admission the summer prior to their junior year must have a GPA of 2.67 or better, passing scores on the CBEST, a documented field experience, and complete program application.

**Credential Requirements (32 units).** Education 484, 970 (1 unit); Special Education 450; Teacher Education 303 (3 units), 903 (1 unit), 914A (3 units), 924A (3 units), 933, 954 (3 units), 963 (9 units).

\*Required of all single subject ITEP majors regardless of Writing Proficiency Assessment score.

### 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 SDSU Mathematics/Quantitative Reasoning Assessment requirement. 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 245, 252, 254, 302, 303, 320, 330, 341, 414, 510, 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 Placement Assessment

All students who expect to enroll in Computer Science 100, 107, Mathematics 118, 120, 124, 140, 141, 150, 210, 211, Statistics 119, 250 must satisfy the SDSU Mathematics/Quantitative Reasoning Assessment requirement. For Mathematics 124, 141, and 150, students must also pass the Mathematics Placement Assessment. For Mathematics 150, certain prerequisite courses taken at San

Diego State University may be used to satisfy the Mathematics Placement Assessment requirement. For Mathematics 312 and 313, students must pass the Liberal Studies Mathematics Proficiency Assessment.

## 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

#### **MATH 110. Mathematics for Life (3) [GE]**

Mathematical problem solving pertinent to daily life. Exponential and logarithmic functions; conversion, estimation, and measurements; personal finance; probability and statistics.

#### **MATH 110X. Mathematics for Life Support (1) Cr/NC**

Three hours of activity.

Prerequisite: Concurrent registration in Mathematics 110. Required for students who have not satisfied the SDSU Mathematics/Quantitative Reasoning Assessment requirement.

Required support course for Mathematics 110. Credit in this course satisfies the SDSU Mathematics/Quantitative Reasoning Assessment requirement.

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

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]**

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

Three lectures and three hours of laboratory.

Prerequisite: 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) qualification on the Mathematics Placement Assessment. **Proof of completion of prerequisite 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 150.

#### **MATH 140. College Algebra (3) [GE]**

Solution of equations and inequalities, systems of equations, graphs and attributes of functions (transformations, end behavior, domain, range), polynomial and exponential functions. Not open to students with credit in Mathematics 120, 124, 141, or 150. (Formerly numbered Mathematics 105.)

#### **MATH 140X. College Algebra Support (1) Cr/NC**

Three hours of activity.

Prerequisite: Concurrent registration in Mathematics 140. Required for students who have not satisfied the SDSU Mathematics/Quantitative Reasoning Assessment requirement.

Required support course for Mathematics 140. Credit in this course satisfies the SDSU Mathematics/Quantitative Reasoning Assessment requirement. (Formerly numbered Mathematics 105X.)

#### **MATH 141. Precalculus (3) [GE]**

Two lectures and two hours of activity.

Prerequisite: Knowledge of algebra as demonstrated by (1) satisfactory completion of Mathematics 140 with a grade of C (2.0) or better; or (2) qualification on the Mathematics Placement Assessment. **Proof of completion of prerequisite required.**

Rational, trigonometric, exponential and logarithmic functions; conic sections; parametric equations. Not open to students with credit in Mathematics 120, 124, or 150.

#### **MATH 141A. Precalculus ALEKS Laboratory (1)**

Three hours of laboratory.

Prerequisite: Concurrent registration in Mathematics 141.

ALEKS-based laboratory to assist students in achieving success in precalculus.

#### **MATH 150. Calculus I (4) [GE]**

Three lectures and two hours of activity.

Prerequisite: 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) qualification on the Mathematics Placement Assessment. **Proof of completion of prerequisite required.**

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

#### **MATH 150A. Calculus I ALEKS Laboratory (1)**

Three hours of laboratory.

Prerequisite: Concurrent registration in Mathematics 150.

ALEKS-based laboratory to assist students in achieving success in Calculus I.

#### **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]**

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 210X. Number Systems in Elementary Mathematics Support (1) Cr/NC**

Three hours of activity.

Prerequisite: Concurrent registration in Mathematics 210. Required for students who have not satisfied the SDSU Mathematics/Quantitative Reasoning Assessment requirement.

Required support course for Mathematics 210. Credit in this course satisfies the SDSU Mathematics/Quantitative Reasoning Assessment requirement.

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

Prerequisite: 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 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.

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### 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 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.

#### **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 320. 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. (Formerly numbered Mathematics 521A.)

#### **MATH 330. 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 implications, sequences of real numbers, and continuity and differentiability of functions of one real variable. (Formerly numbered Mathematics 534A.)

#### **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 340. Programming in Mathematics (3)**

Prerequisites: Mathematics 151 and 245 with a grade of C (2.0) or better in each course. **Proof of completion of prerequisites required:** Copy of transcript.

Introduction to programming in mathematics. Modeling, problem solving, visualization. Not open to students with credit in Mathematics 242.

#### **MATH 341. Mathematics Software Workshop (1)**

Two hours of activity.

Prerequisite: Mathematics 150.

Lesson plan design using teacher-based technologies. (Formerly numbered Mathematics 241.)

#### **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)**

Prerequisites: Consent of instructor and at least one 300-level mathematics course with a grade of C (2.0) or better.

Individual study. Maximum credit six units. No more than three units may be applied to the major.

### UPPER DIVISION COURSES

(Also Acceptable for Advanced Degrees)

#### **MATH 508. Dynamical Systems and Modeling (3)**

Prerequisite: Mathematics 254 or graduate standing.

Differential equations using analytical, graphical, and numerical representations.

#### **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 520. Algebraic Structures (3)**

Prerequisite: Mathematics 320 with a grade of C (2.0) or better or graduate standing. **Proof of completion of prerequisite required:** Copy of transcript.

Continuation of Mathematics 320. 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. (Formerly numbered Mathematics 521B.)

**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 530. Advanced Calculus II (3)**

Prerequisite: Mathematics 330 with a grade of C (2.0) or better or graduate standing. **Proof of completion of prerequisite required:** Copy of transcript.

Formal definitions and analysis within the framework of single variable functions. Advanced concepts in analysis. (Formerly numbered Mathematics 534B.)

**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 537. Ordinary Differential Equations (3)**

Prerequisite: Graduate standing or Mathematics 330 or 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)**

Prerequisite: Mathematics 330, 337, 340, or 342B with a grade of C (2.0) or better. **Proof of completion of prerequisite 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, Poincaré maps, stable/unstable manifolds, bifurcations. Applications in biology, chemistry, physics, engineering, and other sciences.

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

Prerequisites: Mathematics 340; and either Mathematics 337, 342A, or Aerospace Engineering 280 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)**

Prerequisites: Mathematics 340; and either Mathematics 254, 342A, or Aerospace Engineering 280 with a grade of C (2.0) or better. **Proof of completion of prerequisites 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. Tri-diagonal, 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 595. Mathematical Biology and Biomedicine (3)**

Prerequisites: Mathematics 254 and 337, or 342A, or Aerospace Engineering 280.

Mathematical and computational modeling techniques to include difference and differential equations; probabilistic and statistical models.

**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****Course (MTHED)**

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 (MTHED)**

(Intended for Undergraduates)

**MTHED 212. Children's Mathematical Thinking (1-2)**

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.

**GRADUATE COURSES**

Refer to the *Graduate Bulletin*.