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# mathematics and statistics

bachelor of arts • subject matter program • minor • master of arts

## Program Description

In today's highly technological society, the study of Mathematics takes on an increasingly important role. The Sacramento State Mathematics Department designs its courses with the goal of providing students with the mathematical concepts appropriate to the student's field.

The program consists of sequences of courses that lead to a Bachelor of Arts with a major in Mathematics, a major in Mathematics with emphasis in Applied Mathematics and Statistics, a minor in Mathematics or Statistics; and a Master of Arts in Mathematics.

In cooperation with the Computer Science Department, a BA double major program in mathematics and computer science is offered.

## Special Features

- The study of mathematics at Sacramento State has several strong advantages. The flexibility of the major gives students enough freedom to mold their degree along their particular interest.
- An excellent computer facility gives mathematics students easy access to the campus computer resources.
- Currently there is a demand for majors in mathematics with training in Applied Mathematics and Statistics. Program graduates have had much success in finding employment in public and private sectors.
- Since there is presently a need for high school mathematics teachers, some majors pursue a secondary teaching career. Graduate students in Mathematics are finding opportunities for public and private employment in jobs requiring more advanced training in Mathematics and Statistics. Sacramento State Master's Degree graduates now teach at community colleges throughout the state. Upper division majors may check with the Mathematics Administrative Support Coordinator on the possibility of applying for paid positions as Student Assistants.
- Student Assistants work from 10-20 hours per week in math-related duties on campus.

**Note:** Students interested in majoring or minoring in Mathematics should contact the Department secretary for an advising appointment with a Mathematics Advisor.

## Career Possibilities

Mathematics • Teacher • Numerical Analyst • Engineering Analyst • Systems Analyst • Operations Analyst • Actuary • Casualty Rater • Technical Writer • Types of Statisticians: Survey/Polling, Biological/Agricultural, Business/Economics, Physical Sciences/Engineering

## Faculty

Elaine Alexander, Edward Bradley, Andras Domokos, Elizabeth Ebrahimzadeh, Kimberly Elce, Roland Esquerra, Robert Etter, Wallace Etterbeek, Scott Farrand, James Gehrmann, Charles Hagopian, Howard Hamilton, Tracy Hamilton, John Ingram, Robert Jaffa, Elaine Kasimatis, Earl Kymala, Roger Leezer, Bin Lu, Marcus Marsh, K. C. Ng, Janusz Prajs, Doraiswamy Ramachandran, Geetha Ramachandran, Thomas Schulte, Gary Shannon, Ed Shea, Lisa Taylor, David Zeigler, Kathy Zhong, Kecheng Zhou

## Contact Information

Doraiswamy Ramachandran, *Department Chair* • Sharon Jordan, *Administrative Support Coordinator* • Brighton Hall 141 • (916) 278-6534 • [www.csus.edu/math](http://www.csus.edu/math)

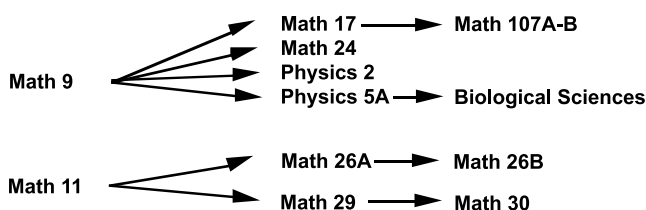
# Undergraduate Programs

Prerequisites must be completed with grade “C-” or better.  
Grade “C-” or better required in all courses applied to Mathematics major or to the Mathematics or Statistics minors.  
PHYS 011A and PHYS 011C are recommended for all Mathematics majors.

## Requirements • Placement – Mathematics Courses

Students who have not completed four years of high school mathematics consisting of:

- Beginning Algebra (one year)
- Geometry (one year)
- Intermediate Algebra-Trigonometry (one year)
- Analytic Geometry-Mathematical Analysis (one year) may need to complete part of this preparation at the University. The following diagram, which is based upon course prerequisites and major objectives, may be of assistance in selecting the necessary course work.



Satisfactory completion of the Entry Level Mathematics (ELM) requirement is a prerequisite to enrollment in any mathematics or statistics course in Group IIA (Quantitative Reasoning) of General Education. The mathematics and statistics courses listed in Group IIA are: MATH 001, MATH 017, MATH 024, MATH 026A, MATH 026B, MATH 029, MATH 030, MATH 031, MATH 035, STAT 001, and STAT 050.

Students Planning to take any of the following courses: MATH 009, MATH 011, MATH 017, MATH 024, MATH 026A, MATH 029, MATH 030, MATH 107A, or STAT 001 must pass a diagnostic test. A brochure describing the diagnostic tests and containing sample questions is available in the campus bookstore. The following table gives the course and appropriate diagnostic test.

Course	Diagnostic Test
Math 9, Math 11	Elementary Algebra
Math 17, Math 24 Math 26A, Math 29 Math 107A, Stat 1	Intermediate Algebra
Math 30	Precalculus

Those students who want to prepare for the ELM or the Elementary Algebra Diagnostic Test may purchase the Entry Level Mathematics workbook at the Hornet Bookstore (see the Learning Skills section of catalog). All students planning to take MATH 030, Calculus I, must take the pre-calculus diagnostic test prior to the semester of enrollment in MATH 030. Arrangements should be made with the Sacramento State Testing Center (916) 278-6296.

## Requirements • Bachelor of Arts Degree

Units required for Major: 47-51  
Minimum total units required for the BA: 120  
**Courses in parentheses are prerequisites.**

- A. Lower Division Core Courses (20-21 units)**
- MATH 030 Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
  - MATH 031 Calculus II (MATH 030 or appropriate high school based AP credit)
  - MATH 032 Calculus III (MATH 031)
  - MATH 035 Introduction to Linear Algebra (MATH 030 or appropriate high school based AP credit)
  - MATH 045 Differential Equations for Science and Engineering (MATH 031)
- (2-3) Select one of the following:
- CSC 010 Introduction to Programming (Passing grade on the ELM)
  - CSC 015 Programming Concepts and Methodology I (CSC 010 or programming experience in a high-level programming language)
  - CSC 022 Visual Programming in BASIC
  - CSC 025 Introduction to C Programming
- B. Upper Division Core Courses (15 units)**
- MATH 108 Introduction to Formal Mathematics (MATH 031, MATH 035)
  - MATH 110A Modern Algebra (MATH 108)
  - MATH 110B Modern Algebra (MATH 110A)
  - MATH 130A Functions of a Real Variable (MATH 032, MATH 045, MATH 108)
  - MATH 130B Functions of a Real Variable (MATH 130A)
- C. Additional Requirements for Specialized Study (12-15 units)**
- Select one from the following three choices below:
- Pure Mathematics (12 units)**
- MATH 117 Linear Algebra (MATH 110A)
  - MATH 134 Functions of a Complex Variable and Applications (MATH 032)
  - Select 6 units of upper division Mathematics or Statistics relating to the students academic and professional objectives; consult advisor.
- Applied Mathematics and Statistics (12 units)**
- STAT 115A Introduction to Probability Theory (MATH 031)
  - STAT 115B Introduction to Mathematical Statistics (STAT 115A)

- (6) Select two of the following:
- MATH 104 Vector Analysis (MATH 032)
  - MATH 105A Advanced Mathematics for Science and Engineering I (MATH 032, MATH 045)
  - MATH 105B Advanced Mathematics for Science and Engineering II (MATH 105A)
  - MATH 117 Linear Algebra (MATH 110A)
  - MATH 134 Functions of a Complex Variable and Applications (MATH 032)
  - MATH 150 Introduction to Numerical Analysis (MATH 032 or MATH 045)
  - MATH 170 Linear Programming (MATH 031; MATH 035 or MATH 100)
  - STAT 155 Introduction to Techniques of Operations Research (MATH 031; STAT 050, STAT 103, or STAT 115A; MATH 031 may be taken concurrently)

**Teacher Preparation Program (15 units)**

- (3) MATH 102 Number Theory (MATH 031)
- (3) MATH 121 College Geometry (MATH 031; MATH 032 or MATH 035)
- (3) MATH 190 History of Mathematics (MATH 031 and upper division status in mathematics)
- (3) MATH 193 Capstone Course for the Teaching Credential Candidate (Successful completion of at least five of the following: MATH 102, MATH 110A, MATH 110B, MATH 121, MATH 130A, MATH 130B, or MATH 190; MATH 110A or MATH 130A may be taken concurrently)
- (3) STAT 001 Introduction to Statistics (MATH 009 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test)

**Notes:**

- Prerequisites must be completed with grade “C-” or better.
- Grade “C-” or better required in all courses applied to a Mathematics major, or the Mathematics or Statistics minors.
- PHYS 011A and PHYS 011C recommended for all Mathematics majors.

**Requirements • Subject Matter Program (pre-credential preparation)**

Students interested in a Secondary Teaching Credential should select Teacher Preparation Program in Section C in the BA requirements outlined above.

Teaching credential candidates must also complete the Professional Education Program in addition to other requirements for a teaching credential. Consult the Department credential advisor for details. You may also obtain information about the Professional Education Program from the Teacher Preparation and Credentials office, Eureka Hall 216, (916) 278-6403.

**Note:** Due to policy changes from the California Commission on Teacher Credentialing and the federal No Child Left Behind mandate, the Subject Matter program was under review at the time of this 2006-2008 catalog printing and is subject to revision. As a result it is important to consult a credential advisor for current details.

**Requirements • Integrated Mathematics Major / Single Subject Credential Program**

Students in the Integrated Mathematics Major/Single Subject Credential Program (also called the Blended Program in Mathematics) begin their pedagogical studies while they are completing the mathematics courses required for the Bachelor’s degree in Mathematics. The mathematics requirements include all of the courses required for the subject matter program in mathematics (see above), and MATH 198. Students who are interested in being admitted to the Blended Program in Mathematics must plan ahead, and must see their advisor as soon as possible.

Admission requirements for the Blended Program include a minimum overall GPA of 2.67, a grade of “C-” or better in MATH 108, passing the Writing Proficiency Exam (WPE), spending and documenting at least 45 hours observing classes, tutoring, or teaching in a variety of settings in grades 7-12, taking all three sections of the California Basic Education Skills Test (CBEST), and submitting an application packet to the Department of Mathematics and Statistics. A completed application packet includes:

- an application form;
- an essay outlining reasons for entering a career in teaching;
- two letters of recommendation;
- two sets of transcripts from each college or university attended, *other than Sacramento State*; and
- one complete Sacramento State transcript.

The application packet may be submitted during the semester in which the requirements for admission are being completed, so the application may be submitted during the semester in which enrollment in MATH 108 occurs.

There are four courses which are prerequisites or corequisites to the Blended Program and students are encouraged to take these courses prior to formal admission:

- (2) HLSC 136 School Health Education
- (3) EDBM 170 Introduction to Bilingual Education
- (2) EDS 100A Education of Exceptional Children/ Youth
- (1) EDTE 331 Educational Technology Laboratory Single Subject

In addition, students in the Blended Program take all the courses required for the Subject Matter Program in Mathematics (see above), as well as MATH 198 and the following education classes:

- (3) EDTE 116 Psychology of Instruction
- (3) EDTE 371A Schools and Community A (Acceptance into the Sacramento State Single Subject Teaching Credential Program; Corequisite: EDTE 470A)
- (3) EDTE 371B Schools and Community B (EDTE 371A; Corequisite EDTE 470B)
- (3) EDTE 372 Anthropology of Education
- (2) EDTE 373A Assessment Center Laboratory I
- (2) EDTE 373B Assessment Center Laboratory II

- (3) EDTE 384 Instruction and Assessment of Academic Literacy
  - (3) EDTE 386 Secondary School Mathematics
  - (7) EDTE 470A Student Teaching I: Secondary Schools
  - (13) EDTE 470B Student Teaching II: Secondary Schools
- Formal admission to the Blended Program is required before enrollment in these education courses.

## Requirements • Double Major – Mathematics and Computer Science

Units required for Double Major: 77

**Courses in parentheses are prerequisites.**

### A. Lower Division Courses (27 units)

#### Mathematics/Statistics (18 units)

- (4) MATH 030 Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) MATH 031 Calculus II (MATH 030 or appropriate high school based AP credit)
- (4) MATH 032 Calculus III (MATH 031)
- (3) MATH 035 Introduction to Linear Algebra (MATH 030 or appropriate high school based AP credit)
- (3) MATH 045 Differential Equations for Science and Engineering (MATH 031)

#### Computer Science (9 units)

- (3) CSC 015 Programming Concepts and Methodology I (CSC 010 or programming experience in a high-level programming language)
- (3) CSC 020 Programming Concepts and Methodology II (CSC 015)
- (3) CSC 035 Introduction to Computer Architecture (CSC 015)

### B. Upper Division Courses (50 units)

#### Mathematics/Statistics (21 units)

- (3) MATH 108 Introduction to Formal Mathematics (MATH 031, MATH 035)
- (3) MATH 110A Modern Algebra (MATH 108)
- (3) MATH 130A Functions of a Real Variable (MATH 032, MATH 045, MATH 108) **OR**
- MATH 134 Functions of a Complex Variable and Applications (MATH 032)
- (3) STAT 115A Introduction to Probability Theory (MATH 031)
- (3) STAT 115B Introduction to Mathematical Statistics (STAT 115A)
- (6) Select two of the following:
  - MATH 150 Introduction to Numerical Analysis (MATH 032 or MATH 045)
  - MATH 170 Linear Programming (MATH 031; MATH 035 or MATH 100)
  - STAT 155 Introduction to Techniques of Operations Research (MATH 031; STAT 050, STAT 103, or STAT 115A; MATH 031 may be taken concurrently)

### Computer Science (29 units)

- (3) CSC 130 Data Structures and Algorithm Analysis (CSC 020, CSC 028; CSC 028 may be taken concurrently)
- (3) CSC 131 Computer Software Engineering (CSC 130; may be taken concurrently)
- (3) CSC 134 Database Management and File Organization (CSC 130)
- (3) CSC 136 Programming Languages (CSC 035, CSC 132)
- (4) CSC 137 Computer Organization (CSC 028, CSC 035, CSC 130)
- (3) CSC 139 Operating System Principles (CSC 060, CSC 137 or equivalents)
- (3) CSC 148\* Modeling and Experimental Design (MATH 031, STAT 050, and proficiency in at least one programming language)
- (2) CSC 190 Senior Project: Part I (senior status; classification as a Computer Science major [not Pre-Computer Science] or a Mathematics/Computer Science Double Major; CSC 130 and CSC 131 plus four additional upper division Computer Science courses which are part of the major, excluding CSC 192 through CSC 199; passing score on the WPE)
- (2) CSC 191 Senior Project: Part II (CSC 190)
- (3) Select one of the following:
  - CSC 132 Computing Theory (CSC 028, CSC 130; CSC 130 may be taken concurrently)]
  - CSC 133 Object-Oriented Computer Graphics Programming (CSC 130, CSC 131)
  - CSC 138 Computer Organization (CSC 028, CSC 035, CSC 130)

\* CSC 132 may be taken in lieu of CSC 148 with department approval.

## Requirements • Minor – Mathematics

Units required for the Minor: 20-21, all of which must be taken in Mathematics or Statistics. A minimum of 8 upper division units is required. At least 6 upper division units must be taken at Sacramento State.

Select one of the two following options.

### Option I (20-21 units)

- (4) MATH 030 Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) MATH 031 Calculus II (MATH 030 or appropriate high school based AP credit)
- (3-4) Select one of the following:
  - MATH 032 Calculus III (MATH 031)
  - MATH 035 Introduction to Linear Algebra (MATH 030 or appropriate high school based AP credit)
  - STAT 050 Introduction to Probability and Statistics (MATH 026A, MATH 030, or appropriate high school based AP credit)

- (9) Select 9 units of upper division Mathematics and/or Statistics courses selected with approval of a Mathematics advisor.

**Option II (20 units)**

- (4) MATH 030 Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) MATH 031 Calculus II (MATH 030 or appropriate high school based AP credit)
- (4) MATH 032 Calculus III (MATH 031)
- (4) MATH 105A Advanced Mathematics for Science and Engineering I (MATH 032, MATH 045)
- (4) MATH 105B Advanced Mathematics for Science and Engineering II (MATH 105A)

**Requirements • Minor – Statistics**

Units required for the Minor: 18, all of which must be taken in Mathematics or Statistics. A minimum of 6 upper division units is required. At least 6 upper division units must be taken at Sacramento State. Specific requirements are:

- (4) MATH 030 Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) MATH 031 Calculus II (MATH 030 or appropriate high school based AP credit)
- (4) MATH 032 Calculus III (MATH 031) **OR**
- STAT 050 Introduction to Probability and Statistics (MATH 026A, MATH 030, or appropriate high school based AP credit)
- (3) STAT 115A Introduction to Probability Theory (MATH 031)
- (3) STAT 115B Introduction to Mathematical Statistics (STAT 115A)

**Graduate Program**

The Department of Mathematics and Statistics offers a Master of Arts degree in Mathematics. The MA program is designed to provide qualified students with an opportunity to increase the breadth and depth of their mathematical knowledge and understanding. Beyond assuring that successful candidates are proficient in the basic areas of mathematics, the program is sufficiently flexible to permit graduates to pursue individual professional and mathematical interests ranging from teaching at the secondary or community college level to a career in the private sector, to preparation for graduate study beyond the master's degree. Graduate courses are usually offered in the late afternoon and early evening to accommodate students who work full-time.

**Admission Requirements**

Admission as a classified graduate student in Mathematics requires:

- an undergraduate major in Mathematics which includes one year each of Abstract Algebra and Advanced Calculus or an undergraduate major in a related field together with one year each of Modern Algebra and Advanced Calculus;
- a minimum 2.5 GPA; and
- a minimum 2.5 GPA in the last 60 units attempted and a 3.0 GPA in Mathematics course work.

Students who have deficiencies in admission requirements that can be removed by specified additional preparation may be admitted with conditionally classified graduate status. Any such deficiencies will be noted on a written response to the admission application. No credit will be given towards the MA for MATH 110A, MATH 110B, MATH 130A, or MATH 130B.

**Admission Procedures**

Applications are accepted as long as room for new students exists. However, students are strongly urged to apply by April 1 for the following fall or October 1 for the following spring in order to allow time for admission before Computer Access to Student Personal and Enrollment Records (CASPER). All prospective graduate students, including Sacramento State graduates, must file the following with the Office of Graduate Studies, River Front Center 206, (916) 278-6470:

- an online application for admission; and
- two sets of official transcripts from all colleges and universities attended, *other than Sacramento State*.

Approximately six weeks after receipt of all items listed, an admission decision will be mailed to the applicant.

**Advancement to Candidacy**

Each student must file an application for Advancement to Candidacy, indicating a proposed program of graduate study. This procedure should begin as soon as the classified graduate student has:

- removed any deficiencies in admission requirements;
- completed at least 18 units in the graduate program with a minimum 3.0 GPA, including at least 12 units at the 200 level; and

- passed the Writing Proficiency Examination (WPE) or secured approval for a WPE waiver.

Advancement to Candidacy forms are available in the Office of Graduate Studies. The student fills out the form after planning a degree program in consultation with a Mathematics advisor. The completed form is then returned to the Office of Graduate Studies for approval.

## Requirements • Master of Arts Degree

Units required for the MA: 30, including at least 24 units of approved 200-level courses

Minimum required GPA: 3.0.

### A. Required Courses (30 units)

- (3) MATH 210A \* Algebraic Structures (MATH 110B)
- (3) MATH 210B \* Algebraic Structures (MATH 210A)
- (3) MATH 230A \* Real Analysis (MATH 130B)
- (3) MATH 230B \* Real Analysis (MATH 230A)
- (12) Select twelve units from the following:
  - MATH 220A Topology (MATH 130B)
  - MATH 220B Topics in Topology (MATH 220A)
  - MATH 234A Complex Analysis (MATH 130B)
  - MATH 234B Topics in Complex Analysis (MATH 234A)
  - MATH 241A Methods of Applied Mathematics
  - MATH 241B Topics in Applied Mathematics (MATH 241A)
  - STAT 215A Introduction to Mathematical Statistics (STAT 115A, STAT 115B)
  - STAT 215B Topics in Introduction to Mathematical Statistics (STAT 215A)
- (6) Select one of the following with advisor approval:
  - MATH 296 Experimental Offerings in Mathematics
  - MATH 299 Special Problems
  - Electives in mathematics and related disciplines

\*Courses must be completed with grade "B-" or better.

### B. Culminating Requirement

Written Comprehensive Examination

**Note:** A foreign language is not required for the MA degree. However, students who plan further graduate study are encouraged to take course work in French, German, or Russian since proficiency in two of these languages is usually required in doctoral programs.

## Lower Division Courses

### Mathematics

**MATH 001. Mathematical Reasoning.** Recommended for students whose majors do not include a specific mathematics requirement. Objectives are to show some of the essence and quality of mathematics, and to enhance precision in the evaluation and expression of ideas, thereby developing a student's quantitative reasoning skills. Designed to give students an understanding of some of the vocabulary, methods, and reasoning of mathematics with a focus on ideas. **Prerequisite:** MATH 009 or three years of high school mathematics which includes two years of algebra and one year of geometry; and completion of ELM requirement. 3 units. (CAN MATH 002)

**MATH 009. Essentials of Algebra and Trigonometry.** Prepares students, especially in bioscience, economics and social science, for courses requiring basic algebra and trigonometry. Topics: measurement and scientific notation; review of basic algebra; factoring; laws of exponents; linear and quadratic equations; Cartesian coordinates and graphing; the trigonometric functions and their basic identities; solutions of right triangles; the laws of sines, cosines and tangents; solutions of general triangles; logarithms. **Note:** Applicable to workload credit for establishing full-time enrollment status, but not applicable to

the baccalaureate degree. **Prerequisite:** One year each of high school algebra and geometry; and a passing score on the Elementary Algebra Diagnostic Test. Graded Credit/No Credit. 3 units.

**MATH 011. College Algebra.** Prepares students for MATH 029 and other courses requiring college algebra. Topics: solution of polynomial equations; synthetic division; factoring; partial fractions; inequalities; determinants; mathematical induction and the binomial theorem. **Note:** Applicable to workload credit for establishing full-time enrollment status, but not applicable to the baccalaureate degree. **Prerequisite:** One year each of high school algebra and geometry; and a passing score on the Elementary Algebra Diagnostic Test. Graded Credit/No Credit. 4 units.

**MATH 017. An Introduction to Exploration, Conjecture, and Proof in Mathematics.** Prepares students for MATH 107A and MATH 107B. Students will explore mathematical patterns and relations, formulate conjectures, and prove their conjectures. Topics from number theory, probability and statistics, and geometry. **Prerequisite:** MATH 009 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test. 3 units.

**MATH 024. Modern Business Mathematics.** Mathematics for business world, including functions, math of finance, linear programming and rates of change. Applications to economics and business will be emphasized throughout. **Prerequisite:** MATH 009 or three years of high school math that includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test. 3 units.

**MATH 026A. Calculus I for the Social and Life Sciences.** Limits, differentiation with applications, integration and applications in the Social Sciences and Life Sciences. **Prerequisite:** MATH 011 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test. 3 units. (CAN MATH 030).

**MATH 026B. Calculus II for the Social and Life Sciences.** Continuation of MATH 026A, integration and applications to the Social Sciences and Life Sciences. Multi-variate analysis including partial differentiation and maximization subject to constraints; elementary differential equations; sequences and series. Calculus of the trigonometric functions as time allows. **Note:** Not open to students already having credit for MATH 031 or equivalent. **Prerequisite:** MATH 026A or appropriate high school based AP credit. 3 units. (CAN MATH 032)

**MATH 029. Pre-Calculus Mathematics.** Designed to prepare students for calculus. Topics: trigonometry, points and lines in the Cartesian plane; lines and planes in space; transformation of coordinates; the conics; graphs of algebraic relations; the elementary transcendental functions. **Prerequisite:** MATH 011 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and Intermediate Algebra Diagnostic Test. 4 units. (CAN MATH 016).

**MATH 029A. Pre-Calculus Mathematics A.** First semester of a two semester course that is designed to prepare students for calculus. Topics: functions and graphs, polynomial functions, rational functions and applications. Lecture two hours. **Prerequisite:** MATH 011 or three years of high school mathematics that includes two years of algebra and one year of geometry; completion of the Intermediate Algebra Diagnostic Test. **Corequisite:** MATH 029L. 2 units.

**MATH 029B. Pre-Calculus Mathematics B.** Second semester of a two semester course that is designed to prepare students for calculus. Topics: exponential and logarithmic functions, trigonometric functions, analytic geometry, and applications. Lecture two hours. **Prerequisite:** MATH 029A. **Corequisite:** MATH 029M. 2 units.

**MATH 029L. Lab for Pre-Calculus Math A.** Workshop designed to deepen the understanding of pre-calculus developed in MATH 029A. **Note:** May be taken for workload credit toward establishing full-time enrollment status, but is not applicable to the baccalaureate degree. Laboratory: 3 hours. **Corequisite:** MATH 029B. Graded Credit/No Credit. 1 unit.

**MATH 029M. Lab for Pre-Calculus Math B.** Workshop designed to deepen the understanding of pre-calculus developed in MATH 029B. **Note:** May be taken for workload credit toward establishing full-time enrollment status, but is not applicable to the baccalaureate degree. Laboratory: 3 hours. **Corequisite:** MATH 029B. Graded Credit/No Credit. 1 unit.

**MATH 030. Calculus I.** Functions and their graphs; limits; the derivative and some of its applications; trigonometric and hyperbolic functions and their inverses; the integral; the fundamental theorem; some applications of the integral. **Prerequisite:** MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test. 4 units. (CAN MATH 018)

**MATH 030L. Laboratory for First Semester Calculus.** Workshop designed to deepen the understanding of calculus developed in MATH 030. **Note:** May be taken for workload credit toward establishing full-time enrollment status, but is not applicable to the baccalaureate degree. Laboratory: 3 hours. **Corequisite:** Enrollment in a designated section of MATH 030. Graded Credit/No Credit. 1 unit.

**MATH 031. Calculus II.** MATH 030 continuation. Methods of integration; improper integrals; analytic geometry; infinite sequences and series. **Prerequisite:** MATH 030 or appropriate high school based AP credit. 4 units. (CAN MATH 020)

**MATH 031L. Laboratory for Second Semester Calculus.** Workshop designed to deepen the understanding of calculus developed in MATH 031. **Note:** May be taken for workload credit toward establishing full-time enrollment status, but is not applicable to the baccalaureate degree. Laboratory: 3 hours. **Corequisite:** Enrollment in a designated section of MATH 031. Graded Credit/No Credit. 1 unit.

**MATH 032. Calculus III.** Continuation of Calculus II. Algebra and calculus of vectors; functions of several variables; partial differentiation; multiple integration; vector analysis. **Prerequisite:** MATH 031. 4 units. (CAN MATH 022)

**MATH 035. Introduction to Linear Algebra.** Careful development of matrices, systems of equations, determinants, vector spaces, linear transformations, orthogonality, real and complex eigenvalues;  $\mathbb{R}^3$  viewed as a vector space with generalization to  $\mathbb{R}^n$ . **Prerequisite:** MATH 030 or appropriate high school based AP credit. 3 units. (CAN MATH 026)

**MATH 045. Differential Equations for Science and Engineering.** First order differential equations, second order differential equations with constant coefficients. Laplace transforms, small systems of linear differential equations, numerical methods, introduction to second order differential equations with variable coefficients. **Prerequisite:** MATH 031. 3 units. (CAN MATH 024)

**MATH 096. Experimental Offerings in Mathematics.** With demand from a sufficient number of qualified students, one of the staff will conduct a seminar on some topic in mathematics. 1-6 units.

**MATH 099. Special Problems.** Individual projects or directed reading. **Note:** Open only to students who appear competent to carry on individual work; admission requires the approval of the faculty member under whom individual work is to be conducted, and approval of the advisor and the Department Chair. 1-6 units.

## Statistics

**STAT 001. Introduction to Statistics.** Descriptive statistics, basic concepts of probability and sampling with the aim of introducing fundamental notions and techniques of statistical inference.

**Prerequisite:** MATH 009 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test. 3 units. (CAN STAT 002)

**STAT 050. Introduction to Probability and Statistics.** Sample spaces, combinatorics, and random variables. Density and distribution functions. Expectation, variance, and covariance. The binomial, uniform, poisson, negative binomial, hypergeometric, exponential, gamma, beta, and normal distributions. Sampling distributions, estimation, and hypothesis tests. Students are given periodic writing assignments which encourage them to think through concepts of the course. **Prerequisite:** MATH 026A, MATH 030, or appropriate high school based AP credit. 4 units.

**STAT 096. Experimental Offerings in Statistics.** When there is a demand from a sufficient number of qualified students, one of the staff will conduct a seminar on some topic in statistics. 1-6 units.

## Upper Division Courses

### Mathematics

**MATH 100. Applied Linear Algebra.** Linear algebra and its elementary applications. Topics: Matrix algebra; simultaneous linear equations; linear dependence and vector spaces; rank and inverses; determinants; numerical solution of simultaneous linear equations; linear transformations; eigenvalues and eigenvectors; unitary and similarity transformations; quadratic forms. **Note:** May not be taken for credit toward a mathematics major. **Prerequisite:** MATH 026B or MATH 031. 3 units.

**MATH 101. Mathematical Topics for Computer Science.** Formal logic including rules of inference and proof by derivation in propositional and predicate logic; logic of inductive and recursive proof and construction of recursive domains; and proofs of correctness procedures and general programming structures. **Prerequisite:** CSC 028, CSC 130. 3 units.

**MATH 102. Number Theory.** Theory of divisibility; some number theoretical functions; congruencies (linear and quadratic); some Diophantine equations. Simple continued fractions. **Prerequisite:** MATH 031. Spring only. 3 units.

**MATH 104. Vector Analysis.** Vector and scalar fields, integral theorems, orthogonal curvilinear coordinates, vector spaces and linear transformations, applications to physical fields and operators. **Prerequisite:** MATH 032. Spring only. 3 units.

**MATH 105A. Advanced Mathematics for Science and Engineering I.** Survey of second order linear differential equations, power series and Fourier series solutions, solution of partial differential equations by separation of variables. **Prerequisite:** MATH 032, MATH 045. 4 units.

**MATH 105B. Advanced Mathematics for Science and Engineering II.** Partial differential equations continued, complex function theory and its applications. **Prerequisite:** MATH 105A. 4 units.

**MATH 107A. Fundamental Mathematical Concepts.** First half of a one-year course in the structure of the real number system and its sub-systems and in the basic properties and concepts of geometry. Topics will include: definitions and properties of set theory and their use in the development of the natural and whole number systems, definitions and properties of the arithmetic relations and operations for the natural numbers, whole numbers, integers. **Note:** May not be taken for credit toward a mathematics major or minor. **Prerequisite:** MATH 017 and passing score on the Intermediate Algebra Diagnostic Test. 3 units.

**MATH 107B. Fundamental Mathematical Concepts.** Continuation of MATH 107A. Topics will include: rational numbers, real numbers, measurement, Euclidean Geometry. **Note:** May not be taken for credit toward a mathematics major or minor. **Prerequisite:** MATH 107A. 3 units.

**MATH 108. Introduction to Formal Mathematics.** Logic of mathematical proof, set theory, relations, functions. Examples and applications from set cardinality, algebra, and analysis. **Prerequisite:** MATH 031, MATH 035. 3 units.

**MATH 110A. Modern Algebra.** First half of a one-year introductory course in algebraic concepts. Topics include: groups, subgroups, properties of groups, permutation groups, factor groups, homomorphism theorems. **Prerequisite:** MATH 108. 3 units.

**MATH 110B. Modern Algebra.** Continuation of MATH 110A. **Note:** Topics include: rings and fields. Applications may be selected from lattice, machine, and coding theories. **Prerequisite:** MATH 110A. 3 units.

**MATH 117. Linear Algebra.** Abstract linear spaces and linear transformations; invariant subspaces; canonical forms. **Prerequisite:** MATH 110A. Fall only. 3 units.

**MATH 121. College Geometry.** Study of the axioms and theorems of Euclidean geometry. A comparison of several geometry axiom systems and their theorems, including those of some non-Euclidean and finite geometries. **Prerequisite:** MATH 031; MATH 032 or MATH 035. Fall only. 3 units.

**MATH 130A. Functions of a Real Variable.** First half of a one-year upper division course in functions of a real variable. The first semester will consist of a rigorous development of the theory of real-valued sequences and continuity and differentiation for functions of one real variable. **Prerequisite:** MATH 032, MATH 045, MATH 108. 3 units.

**MATH 130B. Functions of a Real Variable.** Continuation of MATH 130A. This semester will be devoted to a rigorous development of the theory of Riemann integration, infinite series, and sequences and series of functions. **Prerequisite:** MATH 130A. 3 units.

**MATH 134. Functions of a Complex Variable and Applications.** Complex plane; analytic functions; integration and Cauchy's Theorem; sequences and series; residue calculus; applications to potential theory; Fourier and Laplace transforms. **Prerequisite:** MATH 032. 3 units.

**MATH 150. Introduction to Numerical Analysis.** Finite differences and applications; interpolations, inverse interpolations; numerical differentiation and integration; inversion of matrices; numerical methods of solution of linear equations; algebraic and transcendental equations; numerical methods of solving ordinary and partial differential equations. **Prerequisite:** MATH 032 or MATH 045; some computer programming experience is desirable. 3 units.

**MATH 161. Mathematical Logic.** Advanced study of logic with special application to mathematics. **Prerequisite:** MATH 108. Fall only. 3 units.

**MATH 162. Set Theory.** Axiomatic study of set theory. Topics usually considered include: relations and functions; set theoretical equivalence; finite and infinite sets; cardinal arithmetic; ordinal numbers and transfinite induction; variants of the Axiom of Choice. **Prerequisite:** MATH 108. Spring only. 3 units.

**MATH 170. Linear Programming.** Theory of linear programming, duality, simplex method, integer programming, applications. **Prerequisite:** MATH 031; MATH 035 or MATH 100. Fall only. 3 units.

**MATH 190. History of Mathematics.** Study of the development of mathematical ideas and techniques and their impact on the general course of the history of western civilization. **Prerequisite:** MATH 031 and upper division status in mathematics. Fall only. 3 units.

**MATH 193. Capstone Course for the Teaching Credential Candidate.** Reviews the major themes presented in the upper division program in Mathematics, and relates the themes to junior high school and high school curriculum. Required for all subject matter students. **Note:** Not accepted for credit for non-Teaching Credential students. **Prerequisite:** Successful completion of at least five of the following: MATH 102, MATH 110A, MATH 110B, MATH 121, MATH 130A, MATH 130B or MATH 190; MATH 110A or MATH 130A may be taken concurrently. Spring only. 3 units.

**MATH 196. Experimental Offerings in Mathematics.** Given demand from a sufficient number of qualified students, one of the staff will conduct a seminar on some topic in mathematics. 1-6 units.

**MATH 198. Seminar for Mathematics Tutors.** Supports CSUS students who are working in tutorial and related roles in mathematics programs on campus. Focus on questioning as a fundamental strategy for teaching mathematics, on classroom observation, and on communication among mathematics instructors in support of effective teaching and learning. **Note:** May be repeated up to two times for credit. **Prerequisite:** Students must be working as tutors in a campus-based program. Graded Credit/No Credit. 2 units.

**MATH 199. Special Problems.** Individual projects or directed reading. Open only to those students who appear competent to carry on individual work. Admission to this course requires the approval of the faculty member under whom the individual work is to be conducted, in addition to the approval of the advisor and the Department Chair. 1-6 units.

### Statistics

**STAT 103. Intermediate Statistics.** Review of hypothesis testing—one sample. Hypothesis testing—two sample, variance. Regression and correlation. Analysis of variance including two-way. Analysis of categorical data. Non-parametric tests, goodness of fit, and tests for randomness. **Note:** Not applicable for credit to the mathematics major. **Prerequisite:** STAT 001 or STAT 050. 3 units.

**STAT 115A. Introduction to Probability Theory.** Probability axioms, discrete and continuous random variables, functions of random variables, joint densities, expectation, moment generating functions. Chebyshev's inequality, transformations, weak law of large numbers, central limit theorem. **Prerequisite:** MATH 031; STAT 001 or STAT 050 recommended. 3 units.

**STAT 115B. Introduction to Mathematical Statistics.** Point Estimation, interval estimation, hypothesis testing, the multivariate normal distribution, non-parametric tests. **Prerequisite:** STAT 115A. 3 units.

**STAT 155. Introduction to Techniques of Operations Research.** Formulation and analysis of mathematical models with emphasis on real systems applications. Introduction to Queueing theory and Markov Processes for application. **Prerequisite:** MATH 031; STAT 050, STAT 103, or STAT 115A; MATH 031 may be taken concurrently. Spring only. 3 units.

**STAT 196. Experimental Offerings in Statistics.** When a sufficient number of qualified students applies, one of the staff will conduct a seminar in probability and/or statistics. 1-6 units.

**STAT 199. Special Problems.** Individual projects or directed reading. Open only to students who appear competent to carry on individual work. Admission to this course requires approval of the instructor in addition to the approval of the advisor and the Department Chair. 1-6 units.



## Graduate Courses

### Mathematics

**MATH 210A. Algebraic Structures.** General algebraic systems and concepts; groups. **Prerequisite:** MATH 110B. Fall only, alternate years. 3 units.

**MATH 210B. Algebraic Structures.** Fields; vector spaces; Galois theory. **Prerequisite:** MATH 210A. Spring only, alternate years. 3 units.

**MATH 220A. Topology.** Point set topology, continuity, compactness, connectedness. **Prerequisite:** MATH 130B. Fall only, alternate years. 3 units.

**MATH 220B. Topics in Topology.** Continuation of MATH 220A with topics selected from: General topology/Foundations, Geometric Topology, Continuum Theory, Homology Theory, Homotopy Theory, Topological Dynamics. **Note:** May be taken twice with approval of the graduate coordinator. **Prerequisite:** MATH 220A. Spring only, alternate years. 3 units.

**MATH 230A. Real Analysis.** Metric topology; the theory of the derivative; measure theory. **Prerequisite:** MATH 130B. Fall only, alternate years. 3 units.

**MATH 230B. Real Analysis.** Continuation of MATH 230A, with topics selected from: Theory of the integral, including Riemann, Riemann Stieltjes, and Lebesgue integrals. **Note:** May be taken twice with approval of the graduate coordinator. **Prerequisite:** MATH 230A. Spring only, alternate years. 3 units.

**MATH 234A. Complex Analysis.** Complex numbers, complex functions, analytic functions, complex integration, harmonic functions. **Prerequisite:** MATH 130B; MATH 105B or MATH 134 is recommended. Fall only, alternate years. 3 units.

**MATH 234B. Topics in Complex Analysis.** Continuation of MATH 234A with topics selected from: Partial Fractions and Infinite Products, Entire Functions, Riemann Zeta Function, Normal Families, Riemann Mapping Theorem, Conformal Mapping of Polygons, Dirichlet Problem, Analytic Continuation. **Note:** May be taken twice with approval of the graduate coordinator. **Prerequisite:** MATH 234A. Spring only, alternate years. 3 units.

**MATH 241A. Methods of Applied Mathematics.** Topics from: Hilbert Space Theory, Operators on Hilbert Space, Generalized Functions with Applications to Sturm-Liouville Theory and Partial Differential Equations. **Note:** May be repeated for credit provided topic is not repeated. **Prerequisite:** MATH 134 recommended. Fall only, alternate years. 3 units.

**MATH 241B. Topics in Applied Mathematics.** Continuation of MATH 241A with topics: Calculus of Variations, Functional Analysis, Dynamical Systems, Integral Equations, Sobolev Spaces, Fourier Analysis, Potential Theory, and Optimal Control Theory. **Note:** May be taken twice with approval of the graduate coordinator. **Prerequisite:** MATH 241A. Spring only, alternate years. 3 units.

**MATH 296. Experimental Offerings in Mathematics.** With demand from a sufficient number of qualified students, one of the staff will conduct a seminar on some topics in mathematics. 1-6 units.

**MATH 299. Special Problems.** Any properly qualified student who wishes to pursue a problem may do so if the proposed subject is acceptable to the supervising instructor and to the student's advisor. 1-6 units.

**MATH 500. Culminating Experience.** Directed reading programs for master's candidates preparing for written comprehensive examinations. **Prerequisite:** Advanced to candidacy and permission of the graduate coordinator. Graded Credit/No Credit. 1-3 units.

### Statistics

**STAT 215A. Introduction to Mathematical Statistics.** Probability measure, conditional probability and independence, random variables, characteristic and moment-generating functions, modes of convergence. **Prerequisite:** STAT 115A, STAT 115B; MATH 134 is recommended. Fall only, alternate years. 3 units.

**STAT 215B. Topics in Introduction to Mathematical Statistics.** Continuation of STAT 215A with topics selected from: Statistical Inference, Estimation Theory, Testing Hypotheses, Linear Models, Nonparametric Methods, Multivariate Analysis, Computer intensive methods in Statistics and Sampling Theory. **Note:** May be taken twice with approval of Graduate Coordinator. **Prerequisite:** STAT 215A. Spring only, alternate years. 3 units.

**STAT 296. Experimental Offerings in Statistics.** When a sufficient number of qualified students applies, one of the staff will conduct a seminar on advanced topics in statistics. 1-6 units.

**STAT 299. Special Problems.** Any properly qualified student who wishes to pursue a problem may do so if the proposed subject is acceptable to the department committee, the supervising instructor and the student's advisor. 1-6 units.