MATHEMATICS

THE FACULTY
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THE MAJOR
The Bachelor of Science degree in mathematics offers both breadth and depth in mathematical preparation appropriate for graduate studies or careers in a variety of fields. The requirements for the major in mathematics include both theoretical and applied courses. Students should plan with their advisors as they select elective courses appropriate to their educational interests and goals.

Students declaring a mathematics major are required to have a 2.3 cumulative GPA in the sophomore core mathematics sequences (MATH 201, or MATH 204, MATH 221, MATH 241). In order for students to maintain satisfactory progress toward graduation in four years, students should have successfully completed MATH 201, or MATH 204, MATH 221, and MATH 241 by the end of their sophomore year. In order for transfer students to graduate in two years after matriculation to the University of Redlands, they need to have completed the Calculus sequence (I, II, and III) and Linear Algebra prior to transferring to Redlands; additionally, a course in discrete mathematics or introduction to proofs is highly recommended.

Learning outcomes for this program may be found at http://www.redlands.edu/BS-MATH/learning-outcomes.

BACHELOR OF SCIENCE

CORE REQUIREMENTS: 5 courses/ 19-20 credits
-- MATH 122 Calculus II (4) (except for those mathematics majors who begin the calculus sequence with MATH 221)
-- MATH 201 Discrete Mathematical Structures (4) or MATH 204 Conjecture and Proof in Discrete Mathematics (3)
-- MATH 221 Calculus III (4)
-- MATH 241 Linear Algebra (4)
-- MATH 459 Senior Research Seminar (4)

MATHEMATICAL REASONING REQUIREMENTS: 2 courses/ 8 credits
At least two courses from, with at least one numbered 321 or above.
-- MATH 245 Number Theory/History of Mathematics (4)
-- MATH 251 College Geometry (4)
-- MATH 321 Real Analysis (4)
-- MATH 341 Abstract Algebra (4)

MATHEMATICAL APPLICATIONS REQUIREMENTS: 1 course/ 4 credits
At least one course from
–– MATH 311 Probability (4)
–– MATH 331 Numerical Analysis (4)
–– MATH 338 Partial Differential Equations (4)

ELECTIVES REQUIREMENTS: 4 courses/ 14-16 credits
Four additional courses from
–– MATH 201 Discrete Mathematical Structures (4) and above. At most two of MATH 208, MATH 231, or MATH 212 may count toward the major. If taken as part of a second major, one of MATH 208, MATH 231, or MATH 212 can be replaced with ECON 202, ECON 400, ECON 401; PHYS 331, PHYS 332, PHYS 341, PHYS 344; CHEM 331, CHEM 332; any CS course at the CS 111 level and above (except CS 301); PHIL 151 (4 credits).

UPPER DIVISION REQUIREMENTS: 3 courses/ 12 credits
Beyond the mathematical core requirements, a total of 3 courses taken in the major must be numbered above MATH 300, not including MATH 459.

RELATED FIELD REQUIREMENTS: 4 courses/ 16 credits
At least 16 credits in courses outside mathematics that involve quantitative or logical reasoning, or a minor or second major in any field. These courses must include CS 110, Introduction to Programming, or a course in a structured programming language, or the student must demonstrate proficiency in a structured programming language.

SINGLE-SUBJECT TEACHING CREDENTIAL
Students interested in obtaining the California Single-Subject Teaching Credential in mathematics should meet with advisors in the Mathematics Department and the School of Education. Most students complete the teacher preparation program, including student teaching, during a fifth year of study following graduation.

The following courses are recommended for students interested in obtaining the California Single-Subject Teaching Credential:
–– MATH 245 Number Theory/History of Mathematics (4)
–– MATH 251 College Geometry (4)
–– MATH 311 Probability (4)
–– MATH 312 Mathematical Statistics (4)
–– MATH 321 Real Analysis (4)
–– MATH 341 Abstract Algebra (4)

In addition, students seeking a Single-Subject Teaching Credential must satisfy the requirements for admission to the Basic Teaching Credential Program and, once admitted to this program, must satisfy the professional preparation requirements of the Single-Subject Credential Program. See the School of Education section of this Catalog for details.

The Department of Mathematics recommends that students seeking a California Single-Subject Teaching Credential in mathematics complete a minor in another academic area commonly taught in secondary schools.

THE MINOR

A minor in mathematics consists of 6 courses/ 23–24 credits
−− MATH 121 Calculus I (4)
−− MATH 122 Calculus II (4)
−− MATH 221 Calculus III (4)

At least one course from
−− MATH 201 Discrete Mathematical Structures (4)
−− MATH 204 Conjecture and Proof in Discrete Mathematics (3)
−− MATH 241 Linear Algebra (4)
−− MATH 300 level and above

Two additional courses from
−− MATH 201 and above, to include at most one of MATH 208, MATH 212, MATH 231.

ADVANCED PLACEMENT IN MATHEMATICS

CALCULUS AB OR BC.

Students who attain BC scores of four or AB scores or AB sub-scores of four or five automatically receive 4 credits for MATH 121. Students with a BC score of five receive 4 credits for MATH 121 and 4 credits for MATH 122. Statistics students who attain scores of four or five receive 4 credits for MATH 111.

DEPARTMENTAL HONORS

A departmental honors program is available for exceptionally able and motivated students. Admission to the program may come by departmental invitation or, should students initiate their own applications, by affirmative vote of the mathematics faculty. Honors students are required to take a minimum of 4 courses above MATH 300, not including MATH 459, and must maintain a cumulative GPA of 3.45 or higher in their mathematics courses and overall. Interested students should consult during their junior year with a mathematics faculty member for information about procedures and requirements.

COURSE DESCRIPTIONS (MATH)

Unless otherwise indicated, all courses in the department are offered for either a numerical grade or evaluation with the permission of the instructor. To meet a course prerequisite, a minimum grade of 1.7 must have been earned in the prerequisite course. Placement in mathematics courses is determined based on either SAT/ACT scores (for MATH 100 and MATH 101) or a placement exam (for MATH 118, MATH 119 or MATH 121) completed prior to the start of classes. Students with AP Calculus credit are placed into a mathematics class based on a faculty interview. Students who do not place into a University of Redlands mathematics course required for a general education (LAF or LAI as appropriate) or academic program requirement will be placed in a 1-credit preparatory mathematics laboratory course as follows:
−− MATH 001L prepares students for MATH 100 or MATH 101.
−− MATH 002L prepares students for the MATH 118–MATH 119 sequence.
Placement in a course with prerequisites does not constitute a course challenge to any of the prerequisite courses.

100 Mathematics for the Real World.
Fall (4), Spring (4).
Selections from both historical and current topics in mathematics are included in this general interest course. Topics may include the mathematics of voting and power, fair division and apportionment, population growth, finance, management science and art.

101 Finite Math.
Fall (4), Spring (4).
Introduction to modern ideas in finite mathematics. Topics may include probability, logic, combinatorics, functions, matrix algebra, linear programming, and graph theory. MATH 101 is not a prerequisite to calculus.
Prerequisite: MATH 001L or placement at MATH 100/101 level.

102 Explorations in Mathematics for Prospective Educators.
Spring (4).
Topics include structure of mathematical systems, elementary number theory, operations in the real number system, and elementary problem solving. Review of arithmetic, algebraic, and geometric topics to reinforce existing knowledge. Introduction to methods and tools currently recommended for use by K–8 educators. An 80-minute lab experience is required weekly. Not recommended for first-year students.
Prerequisite: MATH 101 and LBST 101.

107 Math of Origami.
May Term (3).
Introduction to mathematical analysis of paper folding. Topics include geometric analysis of designs, constructing and analyzing polygons and polyhedra, Euler’s formula for polyhedra, three and four colorability criteria, Hamilton cycles, and theorems about when an origami crease pattern will fold flat.
Prerequisite: completion of Mathematics Placement Exam at Math 100 or MATH 101 level or higher, or by permission.
Prerequisite: Mathematics placement at MATH 100 / 101 level or by permission.

111 Elementary Statistics with Applications.
Fall (4), Spring (4).
Descriptive and inferential statistics for students from diverse fields. Distribution, correlation, probability, hypothesis testing, use of tables, and examination of the misuse of statistics and relation of statistics to vital aspects of life. Computer packages used as tools throughout the course.

115 Mathematics Through Its History.
Fall (3), Spring (3), May Term (3).
Introduction to the history of mathematics, especially elementary mathematics. Topics include early uses of counting, number systems, arithmetic, fractions, geometry, algebra, probability, and infinite series in civilizations around the world.
Prerequisite: Mathematics placement at MATH 100 / 101 level or by permission.
Offered as needed.

118 Integrated Calculus I.
Fall (4), Spring (4).
For students whose programs require calculus but who, based on their background and placement examination scores, are not prepared for MATH 121. Topics from precalculus include properties of linear, rational, exponential, logarithmic, and trigonometric functions; and compositions, transformations, and inverses of these functions. Calculus topics include successive approximation and limits of functions; local linearity and differentiation; applications of differentiation to graphing and optimization; and the definite integral, antiderivatives, and differential equations.
Prerequisite: MATH 002L or Math Placement at MATH 118 level or by permission.

119 Integrated Calculus II.
Fall (4), Spring (4).
For students whose programs require calculus but who, based on their background and placement examination scores, are not prepared for MATH 121. Topics from precalculus include properties of linear, rational, exponential, logarithmic, and trigonometric functions; and compositions, transformations, and inverses of these functions. Calculus topics include successive approximation and limits of functions; local linearity and differentiation; applications of differentiation to graphing and optimization; and the definite integral, antiderivatives, and differential equations.
Prerequisite: MATH 118 or by permission.

120 Brief Calculus
Spring (4).
Intended for business, environmental science, or other related fields. The following topics are presented with applications in the business world and applied science: functions, graphs, limits, exponential and logarithmic functions, differentiation, integration, and relevant applications of integration and optimization. This course is NOT a prerequisite for MATH 122.
Prerequisite: Placement test or by credit in MATH 002L.
Offered every year.
Numeric grading only.

121 Calculus I.
Fall (4), Spring (4).
Functions and their graphs; successive approximation and limits; local linearity and differentiation; applications of differentiation to graphing and optimization; and the definite integral, antiderivatives, and differential equations.
Prerequisite: Mathematics Placement at MATH 121 Level or by Permission.

122 Calculus II.
Fall (4), Spring (4).
Riemann sums and the definite integral; techniques of integration and application of integrals; introduction to differential equation; sequences and series.
Prerequisite: MATH 121 or MATH 119 or by permission.

150 Techniques in Problem Solving.
Fall (1).
Practice in the mathematical area of problem solving in preparation for the Putnam Examination. Material and problems chosen from prior Putnam Exams, Mathematics Olympiads, and other sources; and from across mathematics, including basic strategies, combinatorics, geometry, induction, series, number theory, algebra, and calculus.
Credit/no credit grade option.
Prerequisite: permission of the instructor.

160 Introductory Topics in Mathematics.
Fall (4), Spring (4), May Term (3).
Introductory topics of current interest in mathematics not otherwise covered in the curriculum.
Prerequisite: completion of Mathematics Placement Exam at MATH 100 or MATH 101 level.
Offered as needed.
Prerequisites: Mathematics Placement at MATH 100/101 level.

201 Discrete Mathematical Structures.
Fall (4).
Study of discrete mathematical topics important in both mathematics and computer science, including combinatorial techniques, sets and relations, algorithms, and graph theory.
Prerequisite: MATH 221 – Must be completed prior to taking this course.
Offered as needed.

204 Conjecture and Proof in Discrete Mathematics.
May Term (3).
Introduction to the nature and structure of mathematics. Through active study and exploration of a selected area of discrete mathematics, students develop problem-solving skills, as well as skills in proving mathematical theorems. A different topic is selected each year based on student and faculty interest. May be repeated for up to 6 degree credits with departmental permission.
Prerequisite: MATH 221.

208 Game Theory.
May Term (3).
Games are used to model competition in economics, politics, and conflict. The mathematical techniques used to analyze these games are explored. Topics include zero-sum and nonzero-sum games, Nash equilibria, pure and mixed strategies, and cooperative games. Combinatorial games are also considered.
Offered in alternate years with ECON 202.

212 Mathematical Consulting.
Fall (2–4), Spring (2–4).
Application of mathematical techniques to real-world problems. Groups of students act as consultants on problems solicited from university departments, local businesses, and/or charitable organizations. Additional material may be included as needed. May be repeated for degree credit, but 4 credits maximum may be applied toward the math major or minor.
Evaluation grade only.
Prerequisite: CDIS 208 or MATH 111 or POLI 202 or PSYC 250, or by permission.
Offered as needed.

221 Calculus III.
Fall (4), Spring (4).
Topics in multivariable calculus related to differentiation and integration. Sequences, series, and Taylor approximations.
Prerequisite: MATH 122 or by permission.

222 Calculus IV, Vector Calculus.
May Term (3).
Investigation of vector calculus with an emphasis on applications in physics. Parametrized curves and surfaces; vector fields; line integrals and Green's Theorem; flux integrals; divergence and curl; the Divergence Theorem and Stokes's Theorem.
Prerequisite: MATH 221.
Offered as needed.

231 Introduction to Modeling.
Fall (4), Spring (4).
Investigation of the process of modeling. Special emphasis placed on how to build, test, and refine models; how to analyze assumptions and results; and defining model limitations. Deterministic and stochastic models, rate equations and population dynamics, and statistical analysis. Final project tied to outside interests.
Prerequisite: MATH 119 or MATH 121 or MATH 122 or MATH 221 or by permission.
Cross-listed with EVST.

235 Differential Equations.
Spring (4).
Differential equations theory and applications. First-order linear and nonlinear differential equations with analytic and numerical techniques. Higher-order linear differential equations and complex algebra. Phase trajectory and stability analysis. Systems of linear differential equations with constant coefficients. Matrix methods, Gauss-Jordan, and iterative techniques.
Prerequisite: MATH 221.

241 Linear Algebra.
Spring (4).
Study of vector spaces. Topics include systems of linear equations, matrices, the geometry of vectors, vector spaces, linear transformations, eigenvalues and eigenvectors, determinants, and selected applications.
Prerequisite: MATH 221.

245 Number Theory/History of Mathematics.
Spring (4).
Study in two related areas: number theory and history of mathematics. Number theory topics include primes, Diophantine equations, congruences, number theoretic functions, modern applications, and unsolved problems of number theory. Readings include primary and secondary historical sources.
Prerequisite: MATH 241 and MATH 201 or MATH 204.
Offered in alternate years.

251 College Geometry.
Fall (4).
A modern approach to classical geometries such as Euclidean, non-Euclidean, and projective. Sets, logic and synthetic and analytic proof techniques in geometry are studied.
Prerequisite: MATH 241 and MATH 201 or 204.
Offered in alternate years.

260 Topics in Mathematics.
360 Topics in Mathematics.
460 Topics in Mathematics.
Fall (4), Spring (4), May Term (3).
A group of students pursue topics in mathematics not otherwise covered in the curriculum. Prerequisite: by permission. May be repeated for degree credit, but maximum of 8 credits allowed for the degree from MATH 260, MATH 360, and MATH 460.
Offered as needed.

311 Probability.
Fall (4).
Introduction to the theory of probability with applications in management science and the physical and social sciences. Topics include combinatorial probability, densities, mathematical expectation, moment-generating functions, and the central limit theorem.
Prerequisite: MATH 221.

312 Mathematical Statistics.
Spring (4).
Principles of statistical decision theory. Estimation and hypothesis testing, regression, and parametric and non-parametric tests. Mathematical theory and applications of above.
Prerequisite: MATH 311 or by permission.
Offered in alternate years.

321 Real Analysis.
Fall (4).
Rigorous approach to the concepts underlying the calculus, building on the fundamental idea of the limit within the real number system. Topics include metric spaces, continuity, the derivative, the Riemann integral, and series of constants and functions.
Prerequisites: MATH 201 or MATH 204, MATH 221, and MATH 241, and junior standing or by permission.

325 Complex Analysis.
Spring (4).
Analytic functions and their properties, including contour integrals, residues, transforms, and conformal mappings.
Prerequisite: MATH 321.
Offered in alternate years.

331 Numerical Analysis.
Fall (4), Spring (4).
The theory and application of numerical methods for solving mathematical problems. Topics include numerical methods for solving algebraic equations and ordinary differential equations, interpolation and approximation, and numerical integration.
Prerequisite: MATH 235 or MATH 241.
Offered in alternate years.

335 Advanced Modeling Techniques.
Spring (4).
Techniques for mathematical modeling of continuous, discrete, and stochastic systems are presented. Topics include purpose and validation, continuous systems, random numbers and variables, and discrete systems.
Prerequisite: MATH 235.
Recommended: MATH 311.
Offered as needed.

338 Partial Differential Equations.
Fall (4).
Partial Differential Equations theory and applications. We will explore solution methods for parabolic, hyperbolic, and elliptic equations. Topics include separation of variables, transforming nonhomogeneous equations, Eigenfunction expansions, Integral Sine and Cosine transformations, Fourier and Laplace Transforms, the Method of Characteristics, and an introduction to Green's Functions.
Prerequisite: MATH 235.
Offered in alternate years.

341 Abstract Algebra.
Fall (4).
Study of significant algebraic structures and their properties, with particular attention given to groups, rings, and fields.
Prerequisites: MATH 201 or MATH 204, and MATH 241 and junior standing or by permission.

355 Point Set Topology.
Spring (4).
Metric spaces, topological spaces, continuous mappings and homeomorphisms, connectedness, and compactness.
Prerequisite: MATH 321.
Offered every third year.

359 Capstone Proposal Seminar.
Spring (1).
Preliminary background and research will be conducted to lay the groundwork for the senior capstone project in mathematics. A final proposal will be submitted outlining the project to be completed during senior year.

459 Senior Research Seminar.
Spring (4).
Selected topics are assigned for individual students to research and present to mathematics majors and faculty. A paper is submitted prior to presentation of the topic.
Prerequisite: Senior standing and successful completion of a minimum of seven mathematics courses at the 200 level or higher. At least one of MATH 321 or MATH 341 is strongly recommended.