Mathematics

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College of Physical and Mathematical Sciences Advisement Center
N-179 ESC, (801) 422-6270

Admission to Degree Program

The degree program in the Department of Mathematics is open enrollment.

The Discipline

Mathematics is a means of dealing with order, pattern, and number as seen in the world around us. The abilities to compute, to think logically, and to take a reasoned approach to solving problems are highly valued in society and are characteristics of any educated person. Mathematics is not just a body of knowledge, but a process of analysis, reasoning, comparison, deduction, generalization, and problem solving.

A mathematician's stock in trade is the ability to solve problems and to explain the solutions to others. Having once determined what the right questions are, solving problems involves analyzing both concrete and abstract situations, relating them to mathematical ideas, and using mathematical techniques to work toward solutions. Explaining the solution involves pointing out what has been solved and why the solution is valid.

Career Opportunities

Majors in mathematics (BS) prepare for a wide variety of careers. Some enter graduate school or professional schools and prepare for careers in such fields as college teaching, consulting, research and development, law, medicine, and business administration. Others take positions in government agencies, industrial laboratories, information management firms, or business organizations. All of them spend much time communicating with colleagues about the problems they are solving as they continue to learn more mathematics and share mathematical ideas with others.

Graduation Requirements

To receive a BYU bachelor's degree a student must complete, in addition to all requirements for a specific major, the following university requirements:

- The university core, consisting of requirements in general and religious education (See the University Core section of this catalog for details. For a complete listing of courses that meet university core requirements, see the current class schedule.)
- A minimum of 30 credit hours in residence
- A minimum of 120 credit hours
- A cumulative GPA of at least 2.0

Undergraduate Programs and Degrees

BS	Mathematics
Minor	Mathematics

Students should see their college advisement center for help or information concerning the undergraduate programs.

Graduate Programs and Degrees

MS	Mathematics
PhD	Mathematics

For more information see the BYU 2007–2008 Graduate Catalog.

Advisement

Upon completion of five core courses (from Math 112, 113, 190, 214, 343), undergraduate majors are required to meet with an assigned faculty advisor. Students whose grade point average is less than a B in the first four core courses need to realize that advanced courses require much more depth of understanding and may be difficult for them.

Students who are considering graduate work in mathematics may receive advice from the graduate coordinator.

General Information

1. It is recommended that a student complete the following courses in high school:

   4 units of English
   1 unit of physics or chemistry.
   4 units of mathematics, including 2.5 units of algebra, 1 unit of geometry, and .5 unit of trigonometry. This qualifies a student to begin college mathematics with Math 112. If calculus is available in high school, a student planning to major in mathematics is strongly encouraged to take it; doing so requires completing one of the preceding algebra units before high school.

   Advanced Placement (AP) credit is available in mathematics as follows:

   A score of 3 on the calculus AB exam gives credit in Math 110 and 111; a score of 4 or 5 on the calculus AB exam gives credit in Math 110 and 112.
   A score of 3, 4, or 5 on the calculus BC exam gives credit in Math 112 and 113.
   An AP student without credit in Math 112 must begin with Math 112; an AP student without credit in Math 113 must begin with Math 112 or 113.
   AP students with credit in Math 113 are urged to begin with Math 113 anyway, unless they scored 5 on the calculus BC exam.
   AP students should direct Educational Testing Service (ETS) to report scores to BYU to have credit posted.

   Questions regarding placement should be directed to the Mathematics Department, 292 TMCB.

2. Majors are strongly urged to study Phscs 121 and 220 during their first two years.

BS Mathematics (53 hours*)

Major Requirements

1. Grades of C– or below will not be acceptable in major courses.
2. Complete the following core requirements:
   Math 112, 113, 190, 214, 315, 334, 343, 371.

   Note: Math 112, 113 should be honors sections.
3. Complete the following:
   Math 316, 332.
4. Complete the following:
   C S 142.
5. Complete one of the following:
   Stat 321, 441.
6. After consulting with a faculty advisor, complete four courses from one of the following areas of specialization (at least one 500-level course must be included):
   Applied mathematics: Math 347, 511, 521, 522, 534, 541, 542, 547, 570.
   Discrete math and geometry: Math 350, 355, 362, 387, 451, 532, 553, 554, 570.
   Numerical analysis: Math 347, 410, 411, 510, 511.
   Pure mathematics: Math 372, 387, 451, 532, 541, 542, 553. 554.

7. Complete an additional 3 hours from the following:
   Math 300, 347, 350, 355, 362, 372, 387, 410, 411, 451, 460R, 480, 495R, 510, 511, 513R, 521, 522, 532, 534, 541, 542, 543, 547, 553, 554, 561, 562, 570, 586, 587, ~~588~~.
   ~~Phscs 517~~.
8. Students who continue toward graduate work should complete Math 372, 532, 541, and 542.
9. Those planning for doctoral work should also complete Math 451, 553, and 554 and are advised to gain competence in one or two languages from French, German, and Russian.
10. Students are required to take the mathematics major field test the last semester before they graduate. The test is an ETS (Educational Testing Service) standardized assessment test of undergraduate mathematics. Go to ETS Major Field Tests (http://www.ets.org/hea/mft/index.html) for a test description and sample problems. A passing score is required. This test does not appear on the transcript or affect the GPA.
11. Students must participate in an exit interview before graduation.

Recommended Courses

Phscs 121, 220.

*Hours include courses that may fulfill university core requirements.

Minor Mathematics (20 hours*)

Minor Requirements

1. Grades of C– or below will not be accepted.
2. Complete the following courses:
   Math 112, 113, 343.
3. Complete one course from the following:
   Math 214, 302, 315, 316.
4. Complete 6 hours from the following:
   Math 300, 315, 316, 332, 334 (or 303), 347, 350, 355, 362, 371, 372, 387, or any 400- or 500-level mathematics course.

*Hours include courses that may fulfill university core requirements.

Mathematics (Math)

Undergraduate Courses

Note: For courses containing material preparatory to Math 97 (up through beginning algebra) please refer to Independent Study.

97. Intermediate Algebra. (0:2:1) F, W, Sp, Su Independent Study also. Prerequisite: high school algebra.
Elementary logic, real number system, equations and inequalities (linear, polynomial, rational, and radical expressions), graphing, function notation, inverse function, exponential functions, systems of equations, variations. Fee.

102. Quantitative Reasoning. (3:3:0) F, W, Sp, Su For students who do not need developmental algebra for subsequent courses.
Practicing and applying quantitative reasoning: personal finance, consumer statistics, etc.

110. College Algebra. (3:3:0) F, W, Sp, Su Independent Study also. Prerequisite: Math 97 or equivalent.
Functions, polynomials, theory of equations, exponential and logarithmic functions, matrices, determinants, systems of linear equations, permutations, combinations, binomial theorem.

111. Trigonometry. (2:2:0) F, W, Sp, Su Independent Study also. Prerequisite: Math 110 or equivalent.
Circular functions, triangle relationships, identities, inverse trig functions, trigonometric equations, vectors, complex numbers, DeMoivre's theorem.

112. Calculus 1. (4:5:0) F, W, Sp, Su Honors also. Prerequisite: Math 110 and 111 or equivalents.
Differential and integral calculus: limits; continuity; the derivative and applications; extrema; the definite integral; fundamental theorem of calculus; L'Hôpital's rule.

113. Calculus 2. (4:5:0) F, W, Sp, Su Honors also. Prerequisite: Math 112 or equivalent.
Techniques and applications of integration; sequences, series, convergence tests, power series; parametric equations; polar coordinates.

119. Introduction to Calculus. (4:4:1) For students in the College of Biology and Agriculture and the Marriott School of Management. Independent Study also. F, W, Sp, Su Prerequisite: Math 110 or equivalent.
Introduction to plane analytic geometry and calculus.

190. Fundamentals of Mathematics. (3:3:0) F, W, Su Prerequisite: Math 112 or concurrent enrollment with instructor's consent.
Achieving maturity in mathematical communication. Introduction to mathematical proof; methods of proof; analysis of proof; induction; logical reasoning.

214. Calculus of Several Variables. (3:3:0) F, W, Sp, Su Prerequisite: Math 113; 343 or concurrent enrollment.
Partial differentiation, the Jacobian matrix, and integral theorems of vector calculus.

300. (Math-MthEd) History and Philosophy of Mathematics. (3:3:0) F, W, Sp Prerequisite: Math 113.
Historical development of important mathematical ideas and philosophies; implications for the mathematical curriculum.

302. Mathematics for Engineering 1. (4:4:0) F, W Prerequisite: Math 113 and passing grade on required preparatory exam taken during first week of class. (Practice exams available on class Web site.)
Multivariable calculus, linear algebra, and numerical methods.

303. Mathematics for Engineering 2. (4:4:0) F, W Prerequisite: Math 302; or Math 214 and 343.
ODEs, Laplace transforms, Fourier series, PDEs, numerical methods.

315, 316. Theory of Analysis. (3:3:0 ea.) 315: F, W; 316: F, W Prerequisite: for 315: Math 113, 190, 343; for 316: Math 315.
Rigorous treatment of calculus of single and several variables. Topics include uniform continuity, metric spaces, Riemann integral, implicit function theorem, and integral theorems of vector calculus.

332. Introduction to Complex Analysis. (3:3:0) F, W Prerequisite: Math 214 or 316.
Complex algebra, analytic functions, integration in the complex plane, infinite series, theory of residues, conformal mapping.

334. Ordinary Differential Equations. (3:3:0) F, W, Sp, Su Prerequisite: Math 113, 343.
Methods and theory of ordinary differential equations.

343. Elementary Linear Algebra. (3:3:0) F, W, Sp, Su Prerequisite: Math 112 or 119.
Linear systems, matrices, vectors and vector spaces, linear transformations, determinants, inner product spaces, eigenvalues, and eigenvectors.

347. Introduction to Partial Differential Equations. (3:3:0) W, Su Prerequisite: Math 303 or 334.
Boundary value problems; transform methods; Fourier series; Bessel functions; Legendre polynomials.

350. Combinatorics. (3:3:0) Prerequisite: Math 343, 371.
Permutations, combinations, recurrence relations, applications.

355. Graph Theory. (3:3:0) Prerequisite: Math 343.
Maps, graphs and digraphs, coloring problems, applications.

362. (Math-MthEd) Survey of Geometry. (3:3:0) F, W, Sp
Prerequisite: Math 112, 190.
Logical and historical development of Euclidean and non-Euclidean geometry, transformations and symmetry; relationships among axiomatic systems; use of software and other geometric models; proofs and Van Hiele levels.

371, 372. Abstract Algebra. (3:3:0 ea.) 371: F, W, Sp; 372: W
Prerequisite: for 371: Math 190, 343; for 372: Math 371.
Groups, rings, fields, vector spaces, linear transformations, matrices, field extensions, etc.

387. Number Theory. (3:3:0) Prerequisite: Math 343, 371.
Foundations; congruences; quadratic reciprocity; unique factorization, prime distribution or Diophantine equations.

391R. Seminar in Mathematics. (1:1:0) F
Topics from classical problems of antiquity, combinatorial mathematics, graph theory, real functions, number theory, functional equations.

399R. Academic Internship. (1–9:9:0 ea.) On dem.
On-the-job experience.

410. Introduction to Numerical Methods. (3:3:0) F, W
Prerequisite: Math 214, 343.
Root finding, interpolation, curve fitting, numerical differentiation and integration, multiple integrals, direct solvers for linear systems, least squares, rational approximations, Fourier and other orthogonal methods.

411. Numerical Methods. (3:3:0) W Prerequisite: Math 334, 410.
Iterative solvers for linear systems, eigenvalue, eigenvector approximations, numerical solutions to nonlinear systems, numerical techniques for initial and boundary value problems, elementary solvers for PDEs.

451. Introduction to Topology. (3:3:0) F, W Prerequisite: Math 315.
Developing topological concepts, beginning from a linear setting. Developing proofs or counterexamples from axioms to a structured sequence of topological propositions using only notes provided.

460R. Topics in Geometry. (3:3:0 ea.) On dem. Prerequisite: Math 343, 362; or equivalents.
Topics selected from the various aspects of synthetic, analytic, algebraic, and differential geometry.

480. Mathematical Models. (3:3:0) On dem. Prerequisite: Math 214, 334, 343, 410.
Construction, solution, and interpretation of discrete and continuous models applied to problems in the physical, natural, and social sciences.

495R. Readings in Mathematics. (1–2:0:3 ea.) F, W, Sp, Su
Prerequisite: instructor's consent.
Directed readings beyond the scope of usual undergraduate courses.

499R. Senior Thesis. (1–3:0:3 ea.) F, W, Sp, Su

500-Level Graduate Courses (available to advanced undergraduates)

510. Numerical Methods for Linear Algebra. (3:3:0) F
Prerequisite: Math 343, 410, or equivalents.
Numerical matrix algebra, orthogonalization and least squares methods, unsymmetric and symmetric eigenvalue problems, iterative methods, advanced solvers for partial differential equations.

511. Numerical Methods for Partial Differential Equations. (3:3:0) F Prerequisite: Math 303 or 347; 410; or equivalents.
Finite difference and finite volume methods for partial differential equations. Stability, consistency, and convergence theory.

513R. Advanced Topics in Applied Mathematics. (3:3:0 ea.) On dem. Prerequisite: instructor's consent.

521, 522. Methods of Applied Mathematics 1, 2. (3:3:0 ea.) On dem. Prerequisite: Math 334, 343; or equivalents.
Possible topics include: variational, integral, and partial differential equations; spectral and transform methods; nonlinear waves; Green's functions; scaling and asymptotic analysis; perturbation theory; continuum mechanics.

532. Complex Analysis. (3:3:0) Prerequisite: Math 332 or instructor's consent.
Introduction to theory of complex analysis at beginning graduate level. Topics: Cauchy integral equations, Riemann surfaces, Picard's theorem, etc.

534. Introduction to Dynamical Systems 1. (3:3:0) Prerequisite: Math 315, 334; or equivalents.
Discrete dynamical systems; iterations of maps on the line and the plane; bifurcation theory; chaos, Julia sets, and fractals. Computational experimentation.

541, 542. Real Analysis. (3:3:0 ea.) F, W Prerequisite: Math 315, 343; 214 or 316; or equivalents.
Rigorous treatment of differentiation and integration theory; Lebesque measure; Banach spaces.

543, 544. Advanced Probability 1, 2. (3:3:0 ea.) On dem. Prerequisite: Math 214 or equivalent. Recommended: Math 315, 316, Stat 441; or equivalents.
Probability theory and its applications. Topics include random variables, independence and conditioning, laws of large numbers, random walks, martingales, Markov chains, renewal processes, ergodic theorems, Brownian motion, and stochastic integration.

547, 548. Partial Differential Equations 1, 2. (3:3:0 ea.) On dem. Prerequisite: Math 214, 334; or equivalents. Recommended: Math 315, 316; or equivalents.
Topics include the method of characteristics, elliptic equations, potential theory, parabolic equations and systems, maximum principles, linear and nonlinear waves, Hamilton-Jacobi equations, Fourier transforms, Green's functions, distributions, and energy methods.

553. Foundations of Topology 1. (3:3:0) F, W Prerequisite: Math 451 or instructor's consent.
Naïve set theory, topological spaces, product spaces, subspaces, continuous functions, connectedness, compactness, countability, separation axioms, metrization, complete metric spaces, function spaces, and Baire spaces.

554. Foundations of Topology 2. (3:3:0) F, W Prerequisite: Math 553 or instructor's consent.
Fundamental group, retractions and fixed points, homotopy types, separation theorems, classification of surfaces, Seifert–van Kampen Theorem, classification of covering spaces, and applications to group theory.

561, 562. Introduction to Algebraic Geometry. (3:3:0) Prerequisite: Math 671 or concurrent enrollment.
Projective varieties, curves, surfaces, differential forms, and divisors.

565. Differential Geometry. (3:3:0) Prerequisite: Math 214, 315; or equivalents. Recommended: Math 316 or equivalent.
Curves and surfaces, including the first and second fundamental forms, Gauss map, curvatures, geodesics, minimal surfaces, and the Gauss-Bonnet Theorem.

570. Matrix Analysis. (3:3:0) Prerequisite: Math 302 or 343; or equivalents.
Special classes of matrices, canonical forms, matrix and vector norms, localization of eigenvalues, matrix functions, applications.

587. Introduction to Analytic Number Theory. (3:3:0) F or W
Prerequisite: Math 332 or equivalent; instructor's consent.
Arithmetical functions; distribution of primes; Dirichlet characters; Dirichlet's theorem; Gauss sums; primitive roots; Dirichlet L-functions; Riemann zeta-function; prime number theorem; partitions.

586 ~~588~~. Introduction to Algebraic Number Theory. (3:3:0) F or W
Prerequisite: Math 372 or equivalent; instructor's consent.
Algebraic integers, different and discriminant; decomposition of primes; class group; Dirichlet unit theorem; Dedekind zeta-function; cyclotomic fields; valuations; completions.

Graduate Courses

For 600- and 700-level courses, see the BYU 2007–2008 Graduate Catalog.

Mathematics Faculty

Orson Pratt Professor
Cannon, James W. (1986) BA, PhD, U. of Utah, 1967, 1969.

Professors
Baker, Roger C. (1991) BSc, PhD, U. of London, England, 1968, 1971.
Barrett, Wayne W. (1981) BS, U. of Utah, 1968; MS, PhD, New York U., 1975, 1975.
Chahal, Jasbir S. (1981) MA, Punjab U., India, 1970; PhD, Johns Hopkins U., 1979.
Fearnley, Lawrence (1957) BS, U. of London, 1953; PhD, U. of Utah, 1959; PhD, U. of London, 1970.
Forcade, Rodney W. (1981) BS, MS, U. of Chicago, 1961, 1963; PhD, U. of Washington, 1971.
Humphries, Stephen P. (1987) BSc, MSc, PhD, U. of Wales, 1974, 1978, 1983.
Jarvis, Tyler (1996) BS, MS, Brigham Young U., 1989, 1990; MA, PhD, Princeton U., 1992, 1994.
Kuttler, Kenneth L. (1999) BS, MS, Brigham Young U., 1974, 1976; PhD, U. of Texas, Austin, 1981.
Lang, William E. (1989) BA, Carleton Coll., 1974; MS, Yale U., 1975; PhD, Harvard U., 1978.
Lu, Kening (1990) BS, MS, Sichuan U., China, 1982, 1985; PhD, Michigan State U., 1988.
Ouyang, Tiancheng (1992) MS, Naukai U., China, 1981; PhD, U. of Minnesota, 1989.
Smith, William V. (1985) BS, PhD, U. of Utah, 1973, 1978.
Wright, David G. (1983) BS, Brigham Young U., 1970; MA, PhD, U. of Wisconsin, Madison, 1972, 1973.

Associate Professors
Cardon, David A. (1998) BS, Brigham Young U., 1990; MS, PhD, Stanford U., 1993, 1996.
Chow, Shue-Sum (1998) BS, U. of Canterbury, New Zealand, 1979; PhD, Australian National U., Australia, 1983.
Conner, Gregory R. (1992) BA, Humboldt State U., 1987; MS, PhD, U. of Utah, 1989, 1992.
Dallon, John (1999) BA, MA, PhD, U. of Utah, 1989, 1991, 1996.
Dorff, Michael (2000) BA, Brigham Young U., 1986; MS, U. of New Hampshire, 1992; PhD, U. of Kentucky, 1997.
Glasgow, Scott (2000) BS, Brigham Young U., 1988; PhD, U. of Arizona, 1993.
Grant, Christopher P. (1993) BS, MS, Brigham Young U., 1986, 1988; PhD, U. of Utah, 1991.
Li, Xian-Jin (2001) BS, Hunan Normal U., China, 1982; MS, Academia Sinica, Beijing, China, 1985; PhD, Purdue U., 1993.
Swenson, Eric L. (1998) BS, PhD, Brigham Young U., 1987, 1993.
Tolman, L. Kirk (1965) BS, MS, Brigham Young U., 1960, 1961; PhD, U. of New Mexico, 1972.
Villamizar, Vianey (2000) BS, MS, Universidad Central de Venezuela, 1977, 1983; PhD, Rensselaer Polytechnic Inst., 1987.

Associate Teaching Professor
McKay, Steven (2002) BS, MS, Utah State U., 1983, 1985; PhD, Colorado State U., 1990.

Assistant Professors
Bakker, Lennard (2002) BS, MS, U. of Victoria, Canada, 1991, 1993; PhD, Queen's U., Canada, 1997.
Doud, Darrin M. (2001) BS, MS, Brigham Young U., 1992, 1993; MS, PhD, U. of Illinois, 1999, 1999.
Fisher, Todd (2007) BS, MS, Brigham Young U., 1998, 1999; PhD, Northwestern U., 2004.
Halverson, Denise M. (2001) BS, MS, Brigham Young U., 1989, 1994; PhD, U. of Tennessee, 1999.
Humpherys, Jeffrey (2005) BS, Utah State U., 1995; MA, PhD, Indiana U., 1997, 2002.

Emeriti
Chatterley, Louis J. (1962) BS, Brigham Young U., 1955; MS, U. of Utah, 1962; PhD, U. of Texas, Austin, 1972.
Clawson, Robert G. (1979) AA, Pasadena City Coll., 1960; BA, California State U., Los Angeles, 1963; MS, U. of South Dakota, 1971.
Crawley, Peter L. (1971) BS, PhD, California Inst. of Technology, 1957, 1961.
Fletcher, Harvey J., Jr. (1980) BS, Massachusetts Inst. of Technology, 1944; MS, California Inst. of Technology, 1948; PhD, U. of Utah, 1954.
Garbe, Douglas G. (1963) AS, Snow Coll., 1956; BS, Brigham Young U., 1962; MS, U. of Oregon, 1967; PhD, U. of Texas, Austin, 1973.
Garner, Lynn E. (1963) BS, Brigham Young U., 1962; MA, U. of Utah, 1964; PhD, U. of Oregon, 1968.
Gee, Burton C. (1960) BS, Brigham Young U., 1951; MS, EdD, Oregon State U., 1958, 1965.
Gill, Gurcharan S. (1960) BS, Brigham Young U., 1958; M.S, PhD, U. of Utah, 1960, 1965.
Haupt, Floyd E. (1954) BS, MS, U. of Arizona, 1947, 1948.
Hillam, Kenneth L. (1957) BS, MS, U. of Utah, 1949, 1956; PhD, U. of Colorado, 1962.
Jamison, Ronald D. (1963) BS, Brigham Young U., 1957; PhD, U. of Utah, 1965.
Larsen, Kenneth M. (1960) BA, U. of Utah, 1950; MA, Brigham Young U., 1956; PhD, U. of California, Los Angeles, 1964.
Moore, Hal G (1961) BS, MS, U. of Utah, 1952, 1957; PhD, U. of California, Santa Barbara, 1967.
Robinson, Donald W. (1956) BS, MA, U. of Utah, 1948, 1952; PhD, Case Inst. of Technology, 1956.
Skarda, R. Vencil (1965) BA, Pomona Coll., 1961; MS, PhD, California Inst. of Technology, 1964, 1965.
Snow, Donald Ray (1969) BA, BS, U. of Utah, 1959, 1959; MS, MS, PhD, Stanford U., 1960, 1962, 1965.
Wickes, Harry E. (1957) BS, MEd, Brigham Young U., 1950, 1954; MEd, Harvard U., 1962; EdD, Colorado State U., 1967.
Wight, Theodore A. (1963) BS, MS, EdD, U. of Utah, 1955, 1964, 1969.
Wynn, Jan Eugene (1966) BS, BS, U. of Idaho, 1962, 1962; MS, Utah State U., 1965; PhD, Colorado State U., 1972.