

# MATHEMATICS (MATH)

Mathematics is the language used to understand the universe, from atomic-level chemical reactions, to the motion of the planets around the sun, and everything in between. While many graduates continue on to masters- or doctoral-level studies it's no surprise that others use the critical thinking and reasoning skills learned at Western in a wide variety of fields including engineering, education, software programming, database management, research for business firms, and more. A degree in Mathematics can open the door to almost any career.

Western's Mathematics program provides several paths into these exciting professions. The standard major gives a sound foundation from which one can pursue advanced degrees or enter the business world with excellent quantitative skills. The secondary licensure emphasis is designed for people who want to teach in high schools or middle schools, where a shortage of well-qualified math teachers provides excellent job opportunities. The actuarial science emphasis trains students to analyze risk for the insurance and finance industries. Many actuarial science students are able to pass the first professional certification test before they graduate.

Regardless of one's major, the two mathematics minors will add quantitative skills critical to success and advancement in any profession. The standard minor provides a well-rounded set of problem solving skills and the ability to analyze complicated situations. The data analytics minor is designed to add the computational fluency which is driving nearly every profession now. This minor prepares students to analyze large data sets and extract valuable knowledge from data. These data are being produced in many fields and this minor allows students to work with professionals in other fields to derive appropriate solutions.

## Program Goals

- Students will develop mathematical thinking and communication skills.
- Students will develop relevant skills with technological tools.
- Students will experience a variety of interconnections both in and outside of the mathematical sciences
- Students will develop mathematical independence and will be well prepared for further study or employment in a related field.
- Advanced Level Mathematics Certificate (<https://catalog.western.edu/undergraduate/programs/mathematics/advanced-level-mathematics-certificate/>)
- Applied Statistics Certificate (<https://catalog.western.edu/undergraduate/programs/mathematics/applied-statistics-certificate/>)
- Data Analytics Minor (<https://catalog.western.edu/undergraduate/programs/mathematics/data-analytics-minor/>)
- Mathematical Risk Analysis Certificate (<https://catalog.western.edu/undergraduate/programs/mathematics/mathematical-risk-analysis-certificate/>)
- Mathematics Comprehensive Major: Actuarial Science Emphasis (<https://catalog.western.edu/undergraduate/programs/mathematics/mathematics-comprehensive-actuarial-science/>)
- Mathematics Comprehensive Major: Secondary Licensure Emphasis (<https://catalog.western.edu/undergraduate/programs/mathematics/mathematics-comprehensive-secondary-licensure/>)
- Mathematics Comprehensive Major: Secondary Licensure Emphasis (with a 3+2 Master of Arts in Education) (<https://>)

[catalog.western.edu/undergraduate/programs/mathematics/mathematics-comprehensive-secondary-licensure-3-2/](https://catalog.western.edu/undergraduate/programs/mathematics/mathematics-comprehensive-secondary-licensure-3-2/))

- Mathematics Major: Standard Program (<https://catalog.western.edu/undergraduate/programs/mathematics/mathematics-standard-program/>)
- Mathematics Minor (<https://catalog.western.edu/undergraduate/programs/mathematics/mathematics-minor/>)

## Capstone Course Requirement

The following course fulfills the capstone course requirement: MATH 495 Senior Seminar

## Mathematics Courses

### MATH 098. Beginning Algebra. (3 Credits)

An introduction to algebra with a review of basic arithmetic. Includes decimals, fractions, percentages, ratios, proportions, signed numbers, algebraic expressions, factoring, exponents and radicals, linear equations, and graphs. Credit does not count toward graduation. Graded Satisfactory/Unsatisfactory only.

### MATH 099. Intermediate Algebra. (3 Credits)

A review of the arithmetic of fractions and decimals, percentage problems, signed numbers, arithmetic, and topics of basic algebra, including simplifying algebraic expressions, solving and graphing linear equations, basic factoring, working with algebraic fractions, and solving rational and quadratic equations. This course is designed for students who need a review of the basic algebra skills necessary to complete the required mathematics course MATH 140. Credit does not count toward graduation. Graded Satisfactory/Unsatisfactory only. Prerequisite: ACT math score of 16 or above; SAT math score of 440 or above, MATH 098; ALEKS test score of 26 or higher; or Accuplacer Quantitative Reasoning, Algebra, and Statistics test score of 265 or above. Or instructor permission.

### MATH 102. College Algebra Skills. (1 Credit)

A review of the math skills necessary to succeed in MATH 140, College Algebra. Prerequisites: an assessment equivalent to ACT math score between 17-20; SAT Math score between 450-530; ALEKS test score of 35 or higher; or an Accuplacer Advanced Algebra and Functions test score of 235 or above; and a high school GPA of 2.75 or higher. Or instructor permission. Co-requisite MATH 140. Note: this course is intended for those qualified students wanting to complete the Supplemental Academic Instruction (SAI) program in Math.

### MATH 103. Statistical Thinking Skills. (1 Credit)

A review of the math skills necessary to succeed in MATH 113, Statistical Thinking. Prerequisites: an assessment equivalent to ACT math score between 16-20; SAT Math score between 440-530; ALEKS test score of 26 or higher; or an Accuplacer Quantitative Reasoning, Algebra, and Statistics test score of 230 or above; and a high school GPA of 2.75 or higher; or MATH 098; or instructor permission. Co-requisite MATH 113. Note: this course is intended for those qualified students wanting to complete the Supplemental Academic Instruction (SAI) program in Math.

### MATH 105. Mathematics for the Liberal Arts (GT-MA1). (3 Credits)

Topics may include practical applications such as personal finance and numbers in the media, along with aesthetic applications such as connections between mathematics and art or music. GT-MA1

**MATH 113. Statistical Thinking (GT-MA1). (3 Credits)**

A course introducing the ideas of statistical analysis. Topics include data visualization and summarization, parameter estimation, and hypothesis testing. This course emphasizes practical aspects of data analysis and makes extensive use of spreadsheets and real data. Prerequisite: ACT math score of 21 or above; SAT math score of 540 or above; MATH 099; ALEKS test score of 46 or higher; or Accuplacer Quantitative Reasoning, Algebra, and Statistics test score of 240 or above; or co-requisite MATH 103 (SAI); or instructor permission. GT-MA1

**MATH 140. College Algebra (GT-MA1). (3 Credits)**

An integration of the essential algebraic manipulations, solving equations and inequalities, polynomial functions, exponential and logarithmic functions, and techniques of graphing. Prerequisite: ACT math score of 21 or above; SAT math score of 540 or above; MATH 099; ALEKS test score of 46 or higher; or Accuplacer Elementary Advanced Algebra and Functions test score of 245 or above; or co-requisite MATH 102 (SAI); or instructor permission. GT-MA1

**MATH 141. Precalculus (GT-MA1). (4 Credits)**

This course explores the theory and applications of trigonometry, and includes an introduction to vector and matrix analysis. Topics may include the unit circle, triangle trigonometry, trigonometric functions, polar coordinates, complex numbers, vector geometry, and applied matrix techniques. Prerequisite: ACT math score of 23 or above; SAT math score of 560 or above; MATH 140 with a minimum grade of C-; ALEKS test score of 61 or higher; or Accuplacer Advanced Algebra and Functions test with a score of 280 or above; or instructor permission.. GT-MA1

**MATH 151. Calculus I (GT-MA1). (4 Credits)**

A study of differential calculus, including limits, continuous functions, Intermediate Value Theorem, tangents, linear approximation, inverse functions, implicit differentiation, extreme values and the Mean Value Theorem. This course also introduces Integral calculus including anti-derivatives, definite integrals, and the Fundamental Theorem of Calculus. Prerequisite: ACT math score of 27 or above; SAT math score of 630 or above; ALEKS test score of 76 or higher; or MATH 141 with a minimum grade of C-; or instructor permission. GT-MA1

**MATH 197. SPECIAL TOPICS. (1-6 Credits)****MATH 200. Discrete Mathematics. (3 Credits)**

A study of the discrete mathematics necessary for computer science. Topics include logic, set theory, Boolean algebra, functions and relations, graphs, propositional and predicate calculus, proofs, mathematical induction, recurrence relations, combinatorics and discrete probability. Computer science applications are emphasized. Prerequisites: CS 190 and MATH 151 with minimum grades of C-; or instructor permission.

**MATH 213. Probability and Statistics (GT-MA1). (3 Credits)**

A course in the use of statistical techniques to draw knowledge from data. Topics include exploratory data analysis, descriptive statistics, t-procedures, ANOVA, chi squared procedures, regression, and non-parametric tests. Statistical software is used extensively to analyze real data sets. Prerequisite: ACT math score of 27 or above; or SAT math score of 630 or above; ALEKS test score of 76 or higher; or MATH 141 with a minimum grade of C-; or instructor permission.

**MATH 220. Introduction to Advanced Mathematics. (3 Credits)**

Students develop and use elementary logic and set theory to construct deductive proofs with relations, functions, and some algebraic structures. Topics include indexing, equivalence relation theory, and cardinality. Prerequisite: MATH 151 with a minimum grade of C-, or instructor permission.

**MATH 221. Foundations of Mathematics for Teaching I. (3 Credits)**

This course emphasizes the real number system and arithmetic operations. Explorations focus on mathematical structures and subsets of real numbers, via patterns, relationships, and properties. Content is presented using problem solving and exploration. Prerequisite: ACT math score of 21 or above; SAT math score of 540 or above; MATH 099; ALEKS test score of 46 or higher; or Accuplacer Advanced Algebra and Functions test score of 245 or above; or instructor permission.

**MATH 222. Foundations of Mathematics for Teaching II. (3 Credits)**

This course emphasizes proportional relationships, algebra, probability, and data analysis. Explorations focus on representing, analyzing, generalizing patterns and chances of future events. Content is presented using problem solving and exploration. Prerequisite: ACT math score of 21 or above; SAT math score of 540 or above; MATH 099; ALEKS test score of 46 or higher; or Accuplacer Advanced Algebra and Functions test score of 245 or above; or instructor permission. Co-requisite: MATH 140.

**MATH 232. Applied Calculus for the Managerial and Social Science. (3 Credits)**

An introduction to differential and integral calculus for students majoring in business, accounting or the social sciences. The calculus is presented using a variety of real-world business and economic applications, stressing marginality, elasticity, and accumulation. Prerequisite: ACT math score of 23 or above; SAT math score of 560 or above; MATH 140 with a minimum grade of "C-"; ALEKS test score of 61 or higher; or Accuplacer Advanced Algebra and Functions test with a score of 280 or above. Or instructor permission.

**MATH 251. Calculus II. (4 Credits)**

Topics include techniques of integration, area computations, improper integrals, infinite series and various convergence tests, power series, Taylor's Formula, polar coordinates, and parametric curves. Prerequisite: MATH 151 with a minimum grade of C-, or instructor permission.

**MATH 252. Calculus III. (4 Credits)**

Topics include calculus of functions of several variables, differentiation and elementary integration, vectors in the plane and space. Prerequisite: MATH 251 with a minimum grade of C-, or instructor permission.

**MATH 260. Applied Linear Algebra. (3 Credits)**

A course in the techniques and applications of linear algebra. The core topics include solving systems of linear equations, eigenvalues and eigenvectors, matrix decomposition, the pseudoinverse and least squares approximations, and the singular value decomposition. The theory is supplemented with extensive applications and computer programming. Prerequisite: MATH 141 or instructor permission.

**MATH 275. Scientific Programming, Modeling, and Simulation. (3 Credits)**

Designed to develop programming skills appropriate for scientific and industrial applications. Topics may include numerical solution of differential equations, singular value decomposition, and fourier analysis. Emphasis is placed on modeling, algorithm development and data visualization. Prerequisite: CS 190 and MATH 151 with a minimum grades of C-; or instructor permission.

**MATH 292. Independent Study. (1-6 Credits)****MATH 297. Special Topics. (1-6 Credits)****MATH 300. Introduction to Mathematical Modeling. (3 Credits)**

Introduction to and exploration of the mathematical modeling cycle with application to real-world problem-solving. Emphasis is placed on development, verification, interpretation, and communication of models. Includes connections to current real-world topics. Prerequisites: MATH 251 with minimum grades of C-; or instructor permission.

**MATH 313. Statistical Modeling and Simulation. (3 Credits)**

A study of statistical techniques used to model, simulate and understand complex data. The core topics include linear and nonlinear multivariate models, generalized additive models, tree-based models, and mixed effects models, as well as techniques for selection and regularization of models. Emphasis is placed on computational techniques appropriate to large data sets and data visualization. Prerequisites: MATH 213 or ECON 216; and MATH 260; and CS 190. Or instructor permission.

**MATH 314. Applied Probability I. (3 Credits)**

A study of the basic principles of probability theory and their applications. Topics include combinatorial analysis, conditional probabilities, discrete and continuous random variables, and measures of centrality and variance. Emphasis is placed on applications using probability distributions (including binomial, geometric, Poisson, uniform, exponential, and normal distributions) to assess and manage risk in the fields of finance, insurance, medicine, and quality control. Prerequisite: MATH 251 with a grade C- or better.

**MATH 317. Genome Analysis (with laboratory). (3 Credits)**

This course introduces students to the appropriate mathematical techniques to answer questions about information contained in genetic sequences. These techniques may include dynamic programming, motif similarity, Bayesian models, hidden Markov models, principal component analysis, and clustering. Students use standard genome query tools to annotate genomic DNA. MATH 317 and BIOL 317 cannot both be taken for credit. Prerequisite: MATH 213 and either MATH 151 or CS 190; or instructor permission.

**MATH 323. Foundations of Mathematics for Teaching III. (3 Credits)**

This course emphasizes development of spatial reasoning in geometry and measurement. Explorations focus on representations of one-, two-, and three-dimensional shapes, their properties, measurements, constructions, and transformations. Content is presented using problem solving and exploration. Prerequisite: ACT math score of 21 or above; SAT math score of 540 or above; MATH 099; ALEKS test score of 46 or higher; or Accuplacer Advanced Algebra and Functions test score of 245 or above; or instructor permission.

**MATH 330. Topics in Geometry. (3 Credits)**

An introduction to modern geometries. Topics include synthetic, analytic, vector, and transformational approaches to geometry. Classification of geometries, axiomatics, and the application of geometry may also be included. Co-requisite: MATH 200 or MATH 220; or instructor permission.

**MATH 354. Differential Equations. (3 Credits)**

A study of the theory and methods for solving ordinary differential equations. Only one of the following courses, MATH 358 or MATH 354, may be taken for credit. Prerequisite: MATH 251 with a minimum grade of C-; or instructor permission.

**MATH 358. Introduction to Differential Equations and Linear Algebra. (4 Credits)**

An introduction to ordinary differential equations, systems of linear equations, matrices, determinants, vector spaces, linear transformations, and systems of linear differential equations. Only one of the following courses, MATH 358 or MATH 354, may be taken for credit. Prerequisite: MATH 251 with a minimum grade of C-, or instructor permission.

**MATH 360. Linear Algebra. (3 Credits)**

A study of systems of linear equations, matrix operations, vector spaces, properties of determinants, eigenvalues, eigenvectors, orthogonality and least-squares. Emphasis is placed on theoretical aspects and general vector space properties with proof. Prerequisite: MATH 200 or MATH 220 with a minimum grade of C-, and MATH 260 with a minimum grade of C-; or instructor permission.

**MATH 367. Current Trends in Mathematics Education. (3 Credits)**

An introduction to key topics in mathematics teaching and learning at the secondary level. Pedagogical topics will include analysis of content standards, assessment, and methods. Content knowledge topics will emphasize secondary mathematics concepts from an advanced perspective. Prerequisite: ACT math score of 27 or above; or SAT math score of 630 or above; ALEKS test score of 76 or higher; or MATH 141 with a minimum grade of C-; or instructor permission.

**MATH 370. History of Mathematics. (3 Credits)**

Acquaints the student with the historical development of mathematics. Includes an introduction to the proper methods and accepted formats of written, graphical, and oral communication in mathematics. Prerequisites: MATH 200 or MATH 220 with minimum grades of C-, and MATH 251 with minimum grades of C-; or instructor permission.

**MATH 375. Numerical Methods. (3 Credits)**

A study of techniques of computation for power-series calculation of functions; roots of equations; nonlinear simultaneous equations; matrices, determinants, and linear simultaneous equations; numerical integration; and differential equations. Prerequisites: CS 190 and MATH 251 with minimum grades of C-; or instructor permission.

**MATH 380. Introduction to Cryptography. (3 Credits)**

A presentation of the mathematical background to modern cryptography. Topics include symmetric and asymmetric cryptography, block ciphers, hashing, digital signatures, RSA and discrete-logarithm-based systems, and error correction. The course emphasizes rigorous mathematical formulations as well as programming algorithms. Prerequisite: MATH 151 or CS 191 with minimum grade of C-; or instructor permission.

**MATH 390. Introduction to Peer Tutoring in Mathematics. (1 Credit)**

Strategies for tutoring mathematics at the college level, with a focus on presenting mathematical concepts and procedures, reducing anxiety, and improving study skills. May be repeated for up to four credits. Graded Satisfactory/Unsatisfactory only. Prerequisite: MATH 151 with a minimum grade of B- and instructor permission.

**MATH 391. Seminar in Mathematics. (1 Credit)**

A selected topic from areas of mathematics not usually included in the regular curriculum. Student involvement through presentations is emphasized. May be taken under different topics for a total of two credits.

**MATH 392. Independent Study in Mathematics. (1-4 Credits)****MATH 397. Special Topics. (1-6 Credits)****MATH 414. Applied Probability II. (3 Credits)**

A study of mathematical concepts useful in risk management, including multivariate probability and interest theory. Topics include the Central Limit Theorem, joint distributions, combinations of distributions, conditional and marginal probabilities, time value of money, annuities, and loans. Emphasis is placed on solving problems from the actuarial field, including applications to insurance and business. Prerequisite: MATH 314 with a minimum grade of C-.

**MATH 451. Analysis I. (3 Credits)**

An introduction to the theory of calculus. Topics include the usual topology of the reals, sequences, limits, continuity, differentiation, and Riemann integration. Prerequisites: MATH 220 and MATH 251 with minimum grades of C-; or instructor permission.

**MATH 456. Introduction to Complex Analysis. (3 Credits)**

An introduction to the theory and applications of complex variables. Topics include analytic and elementary functions, integrals, series, residues, and conformal mapping. Prerequisites: MATH 200 or MATH 220 with minimum grades of C-, and MATH 252 with minimum grades of C-; or instructor permission.

**MATH 471. Abstract Algebra I. (3 Credits)**

An introduction to the theory of groups and rings. The fundamental group properties and concepts including cyclic groups, subgroups, direct products, symmetric groups, cosets, normal subgroups, and the group homomorphism theorems are discussed. Prerequisite: MATH 200 or MATH 220 with a minimum grade of C-, and at least three upper-division mathematics credits; or instructor permission.

**MATH 490. Workshop. (2 Credits)**

A study of a variety of mathematical topics generally dictated by student interest. The course may be taken for credit three times if the content of the workshop differs.

**MATH 492. Independent Study. (1-4 Credits)**

**MATH 495. Senior Seminar. (2 Credits)**

A capstone course for all mathematics majors. Each student selects an area of interest, researches the selected area, generates a reference list and research paper, and presents the paper to a seminar of faculty and students. Prerequisites: MATH 260 and either MATH 451 or MATH 471; or instructor permission.

**MATH 496. Senior Seminar Professional Experience. (1 Credit)**

Provides students an opportunity to prepare their Senior Seminar research for the mathematics community outside of Western. Graded Satisfactory/Unsatisfactory only. Prerequisite: Instructor permission. Co-requisite: MATH 495.

**MATH 497. Special Topics. (1-6 Credits)**

**MATH 499. Internship in Mathematics. (1-12 Credits)**

Students participate in supervised field experience with a cooperating firm in the mathematics field. The sponsoring faculty member provides evaluations after the field experience is complete. A formal paper is required of the student. Specific department requirements must be met to participate in this course. Prerequisite: 18 credits of Mathematics course work, including nine upper-division credits. or instructor permission.