

**PROGRAM FOR LICENSING ASSESSMENTS
FOR COLORADO EDUCATORS® (PLACE®)**

**TEST OBJECTIVES
FIELD 004: MATHEMATICS**

Subarea	Range of Objectives	Approximate Test Weighting
I. Foundations of Mathematics	001–004	19%
II. Functions and Relations	005–009	24%
III. Measurement and Geometry	010–013	19%
IV. Probability and Statistics	014–017	19%
V. Calculus and Discrete Mathematics	018–021	19%

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TEST OBJECTIVES FIELD 004: MATHEMATICS

FOUNDATIONS OF MATHEMATICS

Understand number relationships and problem-solving strategies.

Includes:

- using equivalent forms of a number (e.g., fraction, decimal, percent, scientific notation) to solve problems
- using ratios and proportions to solve problems
- analyzing and applying a variety of numerical problem-solving strategies (e.g., invented and standard algorithms, estimation, mental arithmetic)
- applying technology in problem-solving situations (e.g., graphing calculator)

Understand the structure and properties of the real and complex number systems and their subsystems.

Includes:

- analyzing similarities and differences among subsets of the real numbers (e.g., the rational numbers versus the real numbers)
- applying properties of the real numbers to arithmetic and algebraic operations
- solving problems involving multiple representations of the real numbers (e.g., roots, powers, infinite decimal expansions)
- using and performing operations on multiple representations of the complex numbers (e.g., algebraic, geometric, trigonometric, exponential)

Understand the principles of and connections among number theory and linear and abstract algebra.

Includes:

- applying concepts of prime numbers and divisibility (e.g., prime factorization, greatest common factor, least common multiple, modular arithmetic)
- analyzing and applying the properties and algebra of vectors and matrices to solve problems (e.g., applications to systems of equations, the geometry of matrix transformations, invertibility of matrices)
- identifying the basic properties of groups, rings, and fields

TEST OBJECTIVES FIELD 004: MATHEMATICS

Understand concepts of mathematical reasoning, communication, and the history of mathematics.

Includes:

- translating among algebraic, geometric, numeric, graphic, and written modes of representing mathematical ideas
- converting between standard English language and mathematical language (e.g., notation, symbols)
- demonstrating knowledge of the language of mathematical statements and proof (e.g., contrapositive, proof by contradiction)
- assessing the validity of a mathematical argument
- recognizing the development and use of mathematics throughout history and across cultures

FUNCTIONS AND RELATIONS

Understand the properties of functions.

Includes:

- evaluating functions (e.g., $f(2)$, $f(x + h)$)
- analyzing the properties of functions (e.g., domain, range, even/odd)
- determining the effects of transformations (e.g., $f(x + k)$, $kf(x)$) on the graphs of functions
- analyzing operations on functions (e.g., inverse, composition)
- connecting a variety of representations of functions (e.g., algebraic, geometric, graphic, tabular, numeric, verbal)

Understand linear functions.

Includes:

- analyzing the relationships among algebraic, geometric, graphic, tabular, and verbal representations of linear functions
- interpreting properties of linear equations in context (e.g., slope, intercepts)
- solving and analyzing systems of linear equations and inequalities using a variety of methods (e.g., analytical, graphical)
- applying linear equations and inequalities to model real-world phenomena and solve problems in other disciplines

TEST OBJECTIVES
FIELD 004: MATHEMATICS

Understand quadratic functions.

Includes:

- finding and analyzing real and complex roots of quadratic functions
- analyzing the relationships among algebraic, geometric, graphic, tabular, and verbal representations of quadratic functions
- solving and analyzing quadratic equations and systems of equations using a variety of methods (e.g., analytical, graphical)
- applying quadratic equations and inequalities to model real-world phenomena and solve problems in other disciplines

Understand polynomial, rational, absolute-value, and radical functions.

Includes:

- finding and analyzing the real and complex roots of polynomial functions
- analyzing the relationships among algebraic, geometric, graphic, tabular, and verbal representations of polynomial, rational, absolute-value, and radical functions
- solving and analyzing polynomial, rational, absolute-value, and radical equations using a variety of methods (e.g., analytical, graphical)
- applying polynomial, rational, absolute-value, and radical functions to model real-world phenomena and solve problems in other disciplines

Understand exponential, logarithmic, and trigonometric functions.

Includes:

- applying the laws of exponents and logarithms to solve problems
- recognizing the inverse relationship between exponential and logarithmic functions and converting between the two forms
- analyzing connections among right triangle trigonometry, the unit circle, and trigonometric functions
- analyzing the relationships among algebraic, geometric, graphic, tabular, and verbal representations of exponential, logarithmic, and trigonometric functions
- solving and analyzing exponential, logarithmic, and trigonometric equations using a variety of methods (e.g., analytical, graphical)
- applying exponential, logarithmic, and trigonometric functions to model real-world phenomena and solve problems in other disciplines

TEST OBJECTIVES
FIELD 004: MATHEMATICS

MEASUREMENT AND GEOMETRY

Understand concepts, systems, and units of measurement.

Includes:

- solving problems involving length, area, volume, capacity, time, temperature, angle, weight, and mass
- analyzing precision and error in measurement (e.g., percentage error, rounding error)
- converting within and between systems of measurement
- applying methods of indirect measurement (e.g., similarity, triangulation)

Understand trigonometry and Euclidean geometry in two and three dimensions.

Includes:

- using properties of points, lines, planes, and geometric figures to solve problems
- applying the Pythagorean theorem and right triangle trigonometry
- using similarity and congruence relationships
- analyzing connections between two- and three-dimensional figures (e.g., nets, projections, cross sections)

Understand connections between algebra and geometry.

Includes:

- representing figures in two- and three-dimensional coordinate systems
- analyzing translation, rotation, and reflection in the coordinate plane
- applying slope, distance, and midpoint formulas to investigate figures
- recognizing connections between algebra and geometry (e.g., conic sections, area representations of algebraic operations)

Understand the axiomatic structure of geometry.

Includes:

- identifying underlying principles of an axiomatic system
- recognizing and applying deductive and inductive reasoning
- making, testing, justifying, and proving conjectures and geometric constructions
- recognizing properties and examples of non-Euclidean geometries

TEST OBJECTIVES
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PROBABILITY AND STATISTICS

Understand the theory of probability.

Includes:

- determining empirical probabilities through analysis of data
- modeling and solving problems using principles (e.g., dependence, independence, conditionality) and techniques (e.g., tree diagrams, combinatorics, area models) of theoretical probability
- recognizing connections between theoretical and empirical probability
- applying binomial, uniform, and normal distributions to problem-solving situations

Understand descriptive statistics.

Includes:

- evaluating real-world situations to determine appropriate data-collection techniques
- constructing tables, charts, and graphs (e.g., box plots, histograms, scatter plots) to represent statistical data
- interpreting statistical data represented in tables, charts, and graphs (e.g., box plots, histograms, scatter plots)
- evaluating arguments and drawing conclusions based on a set of data

Understand methods of data analysis.

Includes:

- finding and interpreting percentiles, mean, median, mode, range, standard deviation, and variance
- recognizing the effects of data transformations on measures of central tendency and variability
- drawing conclusions about distributions of data based on statistical summaries
- applying technology (e.g., graphing calculator) to analyze a set of data
- using correlation to analyze the relationship between two sets of data

TEST OBJECTIVES
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Understand inferential statistics.

Includes:

- analyzing the effect of sampling techniques and sample size on the results of a statistical study (e.g., survey, experiment)
- interpreting confidence intervals
- formulating and testing hypotheses

CALCULUS AND DISCRETE MATHEMATICS

Understand limits, continuity, and average rates of change.

Includes:

- investigating the limits of functions, infinite sequences, and series
- analyzing the asymptotic behavior of functions
- interpreting continuity and discontinuity geometrically and analytically
- interpreting average rate of change as the slope of a secant line

Understand differentiation and its application to problem-solving situations.

Includes:

- recognizing the derivative of a function as the limit of the slope of a secant line (e.g., the difference quotient)
- interpreting the derivative in context and as an instantaneous rate of change
- using first and second derivatives to investigate the behavior of a function
- using differentiation to analyze and solve problems

Understand integration and its application to problem-solving situations.

Includes:

- using algebraic and geometric techniques to approximate the area under a curve
- interpreting the definite integral as the area under a curve
- applying the fundamental theorem of calculus to analyze connections between integration and differentiation
- using integration to model and solve real-world problems

TEST OBJECTIVES
FIELD 004: MATHEMATICS

Understand the fundamental principles of discrete mathematics.

Includes:

- using recursive formulas and difference equations
- modeling problems using graph theory
- solving problems involving permutations and combinations
- demonstrating an understanding of proof by mathematical induction
- analyzing sequences and series and using them to model and solve problems