



# InspireData™ Standards Match

## CALIFORNIA



### Mathematics Content Standards

Meeting curriculum standards is a major focus in education today. This document highlights the correlation of **InspireData™** with the **California Mathematics Content Standards**.

The Inspired Standards Match is designed to demonstrate the many ways InspireData supports the standards and to give educators ideas for using this tool to meet learning goals.

#### **How to read the InspireData Standards Match:**

- ▶ **Yellow** highlight indicates a standard or objective that can be supported by the use of InspireData databases, database templates, user generated databases, lesson plans or program features.
- ▶ **Green** notes list details about how InspireData can be used to meet the standards, including examples of specific databases, lesson plans or features that support them.

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# Grade Four

By the end of grade four, students understand large numbers and addition, subtraction, multiplication, and division of whole numbers. They describe and compare simple fractions and decimals. They understand the properties of, and the relationships between, plane geometric figures. They collect, represent, and analyze data to answer questions.

## Number Sense

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### 1.0 Students understand the place value of whole numbers and decimals to two decimal places and how whole numbers and decimals relate to simple fractions. Students use the concepts of negative numbers:

- 1.1 Read and write whole numbers in the millions.
- 1.2 Order and compare whole numbers and decimals to two decimal places.
- 1.3 Round whole numbers through the millions to the nearest ten, hundred, thousand, ten thousand, or hundred thousand.
- 1.4 Decide when a rounded solution is called for and explain why such a solution may be appropriate.



1.5 Explain different interpretations of fractions, for example, parts of a whole, parts of a set, and division of whole numbers by whole numbers; explain equivalents of fractions (see Standard 4.0).

- 1.6 Write tenths and hundredths in decimal and fraction notations and know the fraction and decimal equivalents for halves and fourths (e.g.,  $\frac{1}{2} = 0.5$  or  $.50$ ;  $\frac{7}{4} = 1\frac{3}{4} = 1.75$ ).
- 1.7 Write the fraction represented by a drawing of parts of a figure; represent a given fraction by using drawings; and relate a fraction to a simple decimal on a number line.
- 1.8 Use concepts of negative numbers (e.g., on a number line, in counting, in temperature, in “owing”).
- 1.9 Identify on a number line the relative position of positive fractions, positive mixed numbers, and positive decimals to two decimal places.

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**2.0 Students extend their use and understanding of whole numbers to the addition and subtraction of simple decimals:**

- 2.1 Estimate and compute the sum or difference of whole numbers and positive decimals to two places.
- 2.2 Round two-place decimals to one decimal or the nearest whole number and judge the reasonableness of the rounded answer.

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**3.0 Students solve problems involving addition, subtraction, multiplication, and division of whole numbers and understand the relationships among the operations:**

- 3.1 Demonstrate an understanding of, and the ability to use, standard algorithms for the addition and subtraction of multidigit numbers.
- 3.2 Demonstrate an understanding of, and the ability to use, standard algorithms for multiplying a multidigit number by a two-digit number and for dividing a multidigit number by a one-digit number; use relationships between them to simplify computations and to check results.
- 3.3 Solve problems involving multiplication of multidigit numbers by two-digit numbers.
- 3.4 Solve problems involving division of multidigit numbers by one-digit numbers.

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**4.0 Students know how to factor small whole numbers:**

- 4.1 Understand that many whole numbers break down in different ways (e.g.,  $12 = 4 \times 3 = 2 \times 6 = 2 \times 2 \times 3$ ).
- 4.2 Know that numbers such as 2, 3, 5, 7, and 11 do not have any factors except 1 and themselves and that such numbers are called prime numbers.

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## Algebra and Functions

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**1.0 Students use and interpret variables, mathematical symbols, and properties to write and simplify expressions and sentences:**

- 1.1 Use letters, boxes, or other symbols to stand for any number in simple expressions or equations (e.g., demonstrate an understanding and the use of the concept of a variable).
- 1.2 Interpret and evaluate mathematical expressions that now use parentheses.
- 1.3 Use parentheses to indicate which operation to perform first when writing expressions containing more than two terms and different operations.

- 1.4 Use and interpret formulas (e.g., area = length  $\times$  width or  $A = lw$ ) to answer questions about quantities and their relationships.
  - 1.5 Understand that an equation such as  $y = 3x + 5$  is a prescription for determining a second number when a first number is given.
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## **2.0 Students know how to manipulate equations:**

- 2.1 Know and understand that equals added to equals are equal.
- 2.2 Know and understand that equals multiplied by equals are equal.

# **Measurement and Geometry**

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## **1.0 Students understand perimeter and area:**

- 1.1 Measure the area of rectangular shapes by using appropriate units, such as square centimeter ( $\text{cm}^2$ ), square meter ( $\text{m}^2$ ), square kilometer ( $\text{km}^2$ ), square inch ( $\text{in}^2$ ), square yard ( $\text{yd}^2$ ), or square mile ( $\text{mi}^2$ ).
  - 1.2 Recognize that rectangles that have the same area can have different perimeters.
  - 1.3 Understand that rectangles that have the same perimeter can have different areas.
  - 1.4 Understand and use formulas to solve problems involving perimeters and areas of rectangles and squares. Use those formulas to find the areas of more complex figures by dividing the figures into basic shapes.
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## **2.0 Students use two-dimensional coordinate grids to represent points and graph lines and simple figures:**

- 2.1 Draw the points corresponding to linear relationships on graph paper (e.g., draw 10 points on the graph of the equation  $y = 3x$  and connect them by using a straight line).
  - 2.2 Understand that the length of a horizontal line segment equals the difference of the  $x$ -coordinates.
  - 2.3 Understand that the length of a vertical line segment equals the difference of the  $y$ -coordinates.
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## **3.0 Students demonstrate an understanding of plane and solid geometric objects and use this knowledge to show relationships and solve problems:**

- 3.1 Identify lines that are parallel and perpendicular.
- 3.2 Identify the radius and diameter of a circle.

- 3.3 Identify congruent figures.
- 3.4 Identify figures that have bilateral and rotational symmetry.
- 3.5 Know the definitions of a right angle, an acute angle, and an obtuse angle. Understand that  $90^\circ$ ,  $180^\circ$ ,  $270^\circ$ , and  $360^\circ$  are associated, respectively, with  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and full turns.
- 3.6 Visualize, describe, and make models of geometric solids (e.g., prisms, pyramids) in terms of the number and shape of faces, edges, and vertices; interpret two-dimensional representations of three-dimensional objects; and draw patterns (of faces) for a solid that, when cut and folded, will make a model of the solid.
- 3.7 Know the definitions of different triangles (e.g., equilateral, isosceles, scalene) and identify their attributes.
- 3.8 Know the definition of different quadrilaterals (e.g., rhombus, square, rectangle, parallelogram, trapezoid).

## Statistics, Data Analysis, and Probability

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### 1.0 Students organize, represent, and interpret numerical and categorical data and clearly communicate their findings:

- 1.1 Formulate survey questions; systematically collect and represent data on a number line; and coordinate graphs, tables, and charts.
- 1.2 Identify the mode(s) for sets of categorical data and the mode(s), median, and any apparent outliers for numerical data sets.
- 1.3 Interpret one- and two-variable data graphs to answer questions about a situation.



### 2.0 Students make predictions for simple probability situations:

- 2.1 Represent all possible outcomes for a simple probability situation in an organized way (e.g., tables, grids, tree diagrams).
- 2.2 Express outcomes of experimental probability situations verbally and numerically (e.g., 3 out of 4;  $\frac{3}{4}$ ).

## Mathematical Reasoning

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### 1.0 Students make decisions about how to approach problems:

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
  - 1.2 Determine when and how to break a problem into simpler parts.
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### 2.0 Students use strategies, skills, and concepts in finding solutions:

- 2.1 Use estimation to verify the reasonableness of calculated results.
  - 2.2 Apply strategies and results from simpler problems to more complex problems.
  - 2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
  - 2.4 Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.
  - 2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.
  - 2.6 Make precise calculations and check the validity of the results from the context of the problem.
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### 3.0 Students move beyond a particular problem by generalizing to other situations:

- 3.1 Evaluate the reasonableness of the solution in the context of the original situation.
- 3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
- 3.3 Develop generalizations of the results obtained and apply them in other circumstances.



## Grade Five

By the end of grade five, students increase their facility with the four basic arithmetic operations applied to fractions, decimals, and positive and negative numbers. They know and use common measuring units to determine length and area and know and use formulas to determine the volume of simple geometric figures. Students know the concept of angle measurement and use a protractor and compass to solve problems. They use grids, tables, graphs, and charts to record and analyze data.

### Number Sense


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- 1.0 Students compute with very large and very small numbers, positive integers, decimals, and fractions and understand the relationship between decimals, fractions, and percents. They understand the relative magnitudes of numbers:**
- 1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
  - 1.2 Interpret percents as a part of a hundred; find decimal and percent equivalents for common fractions and explain why they represent the same value; compute a given percent of a whole number.
  - 1.3 Understand and compute positive integer powers of nonnegative integers; compute examples as repeated multiplication.
  - 1.4 Determine the prime factors of all numbers through 50 and write the numbers as the product of their prime factors by using exponents to show multiples of a factor (e.g.,  $24 = 2 \times 2 \times 2 \times 3 = 2^3 \times 3$ ).
  - 1.5 Identify and represent on a number line decimals, fractions, mixed numbers, and positive and negative integers.

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- 2.0 Students perform calculations and solve problems involving addition, subtraction, and simple multiplication and division of fractions and decimals:**
- 2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
  - 2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
  - 2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
  - 2.4 Understand the concept of multiplication and division of fractions.
  - 2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.

## Algebra and Functions

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- 1.0 Students use variables in simple expressions, compute the value of the expression for specific values of the variable, and plot and interpret the results:**
- 1.1 Use information taken from a graph or equation to answer questions about a problem situation.
  - 1.2 Use a letter to represent an unknown number; write and evaluate simple algebraic expressions in one variable by substitution.
  - 1.3 Know and use the distributive property in equations and expressions with variables.
  - 1.4 Identify and graph ordered pairs in the four quadrants of the coordinate plane.
  -  1.5 Solve problems involving linear functions with integer values; write the equation; and graph the resulting ordered pairs of integers on a grid.

## Measurement and Geometry

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### 1.0 Students understand and compute the volumes and areas of simple objects:

- 1.1 Derive and use the formula for the area of a triangle and of a parallelogram by comparing it with the formula for the area of a rectangle (i.e., two of the same triangles make a parallelogram with twice the area; a parallelogram is compared with a rectangle of the same area by cutting and pasting a right triangle on the parallelogram).
- 1.2 Construct a cube and rectangular box from two-dimensional patterns and use these patterns to compute the surface area for these objects.
- 1.3 Understand the concept of volume and use the appropriate units in common measuring systems (i.e., cubic centimeter [ $\text{cm}^3$ ], cubic meter [ $\text{m}^3$ ], cubic inch [ $\text{in}^3$ ], cubic yard [ $\text{yd}^3$ ]) to compute the volume of rectangular solids.
- 1.4 Differentiate between, and use appropriate units of measures for, two- and three-dimensional objects (i.e., find the perimeter, area, volume).

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### 2.0 Students identify, describe, and classify the properties of, and the relationships between, plane and solid geometric figures:

- 2.1 Measure, identify, and draw angles, perpendicular and parallel lines, rectangles, and triangles by using appropriate tools (e.g., straightedge, ruler, compass, protractor, drawing software).
- 2.2 Know that the sum of the angles of any triangle is  $180^\circ$  and the sum of the angles of any quadrilateral is  $360^\circ$  and use this information to solve problems.
- 2.3 Visualize and draw two-dimensional views of three-dimensional objects made from rectangular solids.

## Statistics, Data Analysis, and Probability

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### 1.0 Students display, analyze, compare, and interpret different data sets, including data sets of different sizes:

-  1.1 Know the concepts of mean, median, and mode; compute and compare simple examples to show that they may differ.
-  1.2 Organize and display single-variable data in appropriate graphs and representations (e.g., histogram, circle graphs) and explain which types of graphs are appropriate for various data sets.



1.3 Use fractions and percentages to compare data sets of different sizes.



1.4 Identify ordered pairs of data from a graph and interpret the meaning of the data in terms of the situation depicted by the graph.

1.5 Know how to write ordered pairs correctly; for example,  $(x, y)$ .

## Mathematical Reasoning

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### 1.0 Students make decisions about how to approach problems:

1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.

1.2 Determine when and how to break a problem into simpler parts.

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### 2.0 Students use strategies, skills, and concepts in finding solutions:

2.1 Use estimation to verify the reasonableness of calculated results.

2.2 Apply strategies and results from simpler problems to more complex problems.

2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.

2.4 Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.

2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

2.6 Make precise calculations and check the validity of the results from the context of the problem.

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### 3.0 Students move beyond a particular problem by generalizing to other situations:

3.1 Evaluate the reasonableness of the solution in the context of the original situation.

3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.

3.3 Develop generalizations of the results obtained and apply them in other circumstances.



## Grade Six

By the end of grade six, students have mastered the four arithmetic operations with whole numbers, positive fractions, positive decimals, and positive and negative integers; they accurately compute and solve problems. They apply their knowledge to statistics and probability. Students understand the concepts of mean, median, and mode of data sets and how to calculate the range. They analyze data and sampling processes for possible bias and misleading conclusions; they use addition and multiplication of fractions routinely to calculate the probabilities for compound events. Students conceptually understand and work with ratios and proportions; they compute percentages (e.g., tax, tips, interest). Students know about  $\pi$  and the formulas for the circumference and area of a circle. They use letters for numbers in formulas involving geometric shapes and in ratios to represent an unknown part of an expression. They solve one-step linear equations.

### Number Sense

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- 1.0 Students compare and order positive and negative fractions, decimals, and mixed numbers. Students solve problems involving fractions, ratios, proportions, and percentages:**
- 1.1 Compare and order positive and negative fractions, decimals, and mixed numbers and place them on a number line.
  - 1.2 Interpret and use ratios in different contexts (e.g., batting averages, miles per hour) to show the relative sizes of two quantities, using appropriate notations ( $a/b$ ,  $a$  to  $b$ ,  $a:b$ ).
  - 1.3 Use proportions to solve problems (e.g., determine the value of  $N$  if  $4/7 = N/21$ , find the length of a side of a polygon similar to a known polygon). Use cross-multiplication as a method for solving such problems, understanding it as the multiplication of both sides of an equation by a multiplicative inverse.
  - 1.4 Calculate given percentages of quantities and solve problems involving discounts at sales, interest earned, and tips.

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- 2.0 Students calculate and solve problems involving addition, subtraction, multiplication, and division:**
- 2.1 Solve problems involving addition, subtraction, multiplication, and division of positive fractions and explain why a particular operation was used for a given situation.
  - 2.2 Explain the meaning of multiplication and division of positive fractions and perform the calculations (e.g.,  $\frac{5}{8} \div \frac{15}{16} = \frac{5}{8} \times \frac{16}{15} = \frac{2}{3}$ ).
  - 2.3 Solve addition, subtraction, multiplication, and division problems, including those arising in concrete situations, that use positive and negative integers and combinations of these operations.
  - 2.4 Determine the least common multiple and the greatest common divisor of whole numbers; use them to solve problems with fractions (e.g., to find a common denominator to add two fractions or to find the reduced form for a fraction).

## Algebra and Functions

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- 1.0 Students write verbal expressions and sentences as algebraic expressions and equations; they evaluate algebraic expressions, solve simple linear equations, and graph and interpret their results:**
- 1.1 Write and solve one-step linear equations in one variable.
  - 1.2 Write and evaluate an algebraic expression for a given situation, using up to three variables.
  - 1.3 Apply algebraic order of operations and the commutative, associative, and distributive properties to evaluate expressions; and justify each step in the process.
  - 1.4 Solve problems manually by using the correct order of operations or by using a scientific calculator.



**2.0 Students analyze and use tables, graphs, and rules to solve problems involving rates and proportions:**

- 2.1 Convert one unit of measurement to another (e.g., from feet to miles, from centimeters to inches).
- 2.2 Demonstrate an understanding that *rate* is a measure of one quantity per unit value of another quantity.
- 2.3 Solve problems involving rates, average speed, distance, and time.

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**3.0 Students investigate geometric patterns and describe them algebraically:**

- 3.1 Use variables in expressions describing geometric quantities (e.g.,  $P = 2w + 2l$ ,  $A = \frac{1}{2}bh$ ,  $C = \pi d$ —the formulas for the perimeter of a rectangle, the area of a triangle, and the circumference of a circle, respectively).
- 3.2 Express in symbolic form simple relationships arising from geometry.

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**Measurement and Geometry**

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**1.0 Students deepen their understanding of the measurement of plane and solid shapes and use this understanding to solve problems:**

- 1.1 Understand the concept of a constant such as  $\pi$ ; know the formulas for the circumference and area of a circle.
- 1.2 Know common estimates of  $\pi$  (3.14;  $\frac{22}{7}$ ) and use these values to estimate and calculate the circumference and the area of circles; compare with actual measurements.
- 1.3 Know and use the formulas for the volume of triangular prisms and cylinders (area of base  $\times$  height); compare these formulas and explain the similarity between them and the formula for the volume of a rectangular solid.

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**2.0 Students identify and describe the properties of two-dimensional figures:**

- 2.1 Identify angles as vertical, adjacent, complementary, or supplementary and provide descriptions of these terms.
- 2.2 Use the properties of complementary and supplementary angles and the sum of the angles of a triangle to solve problems involving an unknown angle.
- 2.3 Draw quadrilaterals and triangles from given information about them (e.g., a quadrilateral having equal sides but no right angles, a right isosceles triangle).

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**Statistics, Data Analysis, and Probability**

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**1.0 Students compute and analyze statistical measurements for data sets:**

- 1.1 Compute the range, mean, median, and mode of data sets.
- 1.2 Understand how additional data added to data sets may affect these computations of measures of central tendency.
- 1.3 Understand how the inclusion or exclusion of outliers affects measures of central tendency.
- 1.4 Know why a specific measure of central tendency (mean, median, mode) provides the most useful information in a given context.



## 2.0 Students use data samples of a population and describe the characteristics and limitations of the samples:

- 2.1 Compare different samples of a population with the data from the entire population and identify a situation in which it makes sense to use a sample.
- 2.2 Identify different ways of selecting a sample (e.g., convenience sampling, responses to a survey, random sampling) and which method makes a sample more representative for a population.
- 2.3 Analyze data displays and explain why the way in which the question was asked might have influenced the results obtained and why the way in which the results were displayed might have influenced the conclusions reached.
- 2.4 Identify data that represent sampling errors and explain why the sample (and the display) might be biased.
- 2.5 Identify claims based on statistical data and, in simple cases, evaluate the validity of the claims.



## 3.0 Students determine theoretical and experimental probabilities and use these to make predictions about events:

- 3.1 Represent all possible outcomes for compound events in an organized way (e.g., tables, grids, tree diagrams) and express the theoretical probability of each outcome.
- 3.2 Use data to estimate the probability of future events (e.g., batting averages or number of accidents per mile driven).
- 3.3 Represent probabilities as ratios, proportions, decimals between 0 and 1, and percentages between 0 and 100 and verify that the probabilities computed are reasonable; know that if  $P$  is the probability of an event,  $1-P$  is the probability of an event not occurring.
- 3.4 Understand that the probability of either of two disjoint events occurring is the sum of the two individual probabilities and that the probability of one event following another, in independent trials, is the product of the two probabilities.
- 3.5 Understand the difference between independent and dependent events.

## Mathematical Reasoning

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### 1.0 Students make decisions about how to approach problems:

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.
  - 1.2 Formulate and justify mathematical conjectures based on a general description of the mathematical question or problem posed.
  - 1.3 Determine when and how to break a problem into simpler parts.
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### 2.0 Students use strategies, skills, and concepts in finding solutions:

- 2.1 Use estimation to verify the reasonableness of calculated results.
  - 2.2 Apply strategies and results from simpler problems to more complex problems.
  - 2.3 Estimate unknown quantities graphically and solve for them by using logical reasoning and arithmetic and algebraic techniques.
  - 2.4 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
  - 2.5 Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.
  - 2.6 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.
  - 2.7 Make precise calculations and check the validity of the results from the context of the problem.
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### 3.0 Students move beyond a particular problem by generalizing to other situations:

- 3.1 Evaluate the reasonableness of the solution in the context of the original situation.
- 3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
- 3.3 Develop generalizations of the results obtained and the strategies used and apply them in new problem situations.



# Grade Seven

By the end of grade seven, students are adept at manipulating numbers and equations and understand the general principles at work. Students understand and use factoring of numerators and denominators and properties of exponents. They know the Pythagorean theorem and solve problems in which they compute the length of an unknown side. Students know how to compute the surface area and volume of basic three-dimensional objects and understand how area and volume change with a change in scale. Students make conversions between different units of measurement. They know and use different representations of fractional numbers (fractions, decimals, and percents) and are proficient at changing from one to another. They increase their facility with ratio and proportion, compute percents of increase and decrease, and compute simple and compound interest. They graph linear functions and understand the idea of slope and its relation to ratio.

## Number Sense

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- 1.0 Students know the properties of, and compute with, rational numbers expressed in a variety of forms:**
- 1.1 Read, write, and compare rational numbers in scientific notation (positive and negative powers of 10) with approximate numbers using scientific notation.
  - 1.2 Add, subtract, multiply, and divide rational numbers (integers, fractions, and terminating decimals) and take positive rational numbers to whole-number powers.
  - 1.3 Convert fractions to decimals and percents and use these representations in estimations, computations, and applications.
  - 1.4 Differentiate between rational and irrational numbers.
  - 1.5 Know that every rational number is either a terminating or repeating decimal and be able to convert terminating decimals into reduced fractions.

- 1.6 Calculate the percentage of increases and decreases of a quantity.
- 1.7 Solve problems that involve discounts, markups, commissions, and profit and compute simple and compound interest.

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**2.0 Students use exponents, powers, and roots and use exponents in working with fractions:**

- 2.1 Understand negative whole-number exponents. Multiply and divide expressions involving exponents with a common base.
- 2.2 Add and subtract fractions by using factoring to find common denominators.
- 2.3 Multiply, divide, and simplify rational numbers by using exponent rules.
- 2.4 Use the inverse relationship between raising to a power and extracting the root of a perfect square integer; for an integer that is not square, determine without a calculator the two integers between which its square root lies and explain why.
- 2.5 Understand the meaning of the absolute value of a number; interpret the absolute value as the distance of the number from zero on a number line; and determine the absolute value of real numbers.

## Algebra and Functions

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**1.0 Students express quantitative relationships by using algebraic terminology, expressions, equations, inequalities, and graphs:**

- 1.1 Use variables and appropriate operations to write an expression, an equation, an inequality, or a system of equations or inequalities that represents a verbal description (e.g., three less than a number, half as large as area A).
- 1.2 Use the correct order of operations to evaluate algebraic expressions such as  $3(2x + 25)$
- 1.3 Simplify numerical expressions by applying properties of rational numbers (e.g., identity, inverse, distributive, associative, commutative) and justify the process used.
- 1.4 Use algebraic terminology (e.g., variable, equation, term, coefficient, inequality, expression, constant) correctly.



- 1.5 Represent quantitative relationships graphically and interpret the meaning of a specific part of a graph in the situation represented by the graph.

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**2.0 Students interpret and evaluate expressions involving integer powers and simple roots:**

- 2.1 Interpret positive whole-number powers as repeated multiplication and negative whole-number powers as repeated division or multiplication by the multiplicative inverse. Simplify and evaluate expressions that include exponents.
- 2.2 Multiply and divide monomials; extend the process of taking powers and extracting roots to monomials when the latter results in a monomial with an integer exponent.

**3.0 Students graph and interpret linear and some nonlinear functions:**

- 3.1 Graph functions of the form  $y = nx^2$  and  $y = nx^3$  and use in solving problems.
- 3.2 Plot the values from the volumes of three-dimensional shapes for various values of the edge lengths (e.g., cubes with varying edge lengths or a triangle prism with a fixed height and an equilateral triangle base of varying lengths).
- 3.3 Graph linear functions, noting that the vertical change (change in  $y$ -value) per unit of horizontal change (change in  $x$ -value) is always the same and know that the ratio (“rise over run”) is called the slope of a graph.
- 3.4 Plot the values of quantities whose ratios are always the same (e.g., cost to the number of an item, feet to inches, circumference to diameter of a circle). Fit a line to the plot and understand that the slope of the line equals the quantities.

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**4.0 Students solve simple linear equations and inequalities over the rational numbers:**

- 4.1 Solve two-step linear equations and inequalities in one variable over the rational numbers, interpret the solution or solutions in the context from which they arose, and verify the reasonableness of the results.
- 4.2 Solve multistep problems involving rate, average speed, distance, and time or a direct variation.

## Measurement and Geometry

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### **1.0 Students choose appropriate units of measure and use ratios to convert within and between measurement systems to solve problems:**

- 1.1 Compare weights, capacities, geometric measures, times, and temperatures within and between measurement systems (e.g., miles per hour and feet per second, cubic inches to cubic centimeters).
  - 1.2 Construct and read drawings and models made to scale.
  - 1.3 Use measures expressed as rates (e.g., speed, density) and measures expressed as products (e.g., person-days) to solve problems; check the units of the solutions; and use dimensional analysis to check the reasonableness of the answer.
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### **2.0 Students compute the perimeter, area, and volume of common geometric objects and use the results to find measures of less common objects. They know how perimeter, area, and volume are affected by changes of scale:**

- 2.1 Use formulas routinely for finding the perimeter and area of basic two-dimensional figures and the surface area and volume of basic three-dimensional figures, including rectangles, parallelograms, trapezoids, squares, triangles, circles, prisms, and cylinders.
  - 2.2 Estimate and compute the area of more complex or irregular two- and three-dimensional figures by breaking the figures down into more basic geometric objects.
  - 2.3 Compute the length of the perimeter, the surface area of the faces, and the volume of a three-dimensional object built from rectangular solids. Understand that when the lengths of all dimensions are multiplied by a scale factor, the surface area is multiplied by the square of the scale factor and the volume is multiplied by the cube of the scale factor.
  - 2.4 Relate the changes in measurement with a change of scale to the units used (e.g., square inches, cubic feet) and to conversions between units (1 square foot = 144 square inches or  $[1 \text{ ft}^2] = [144 \text{ in}^2]$ , 1 cubic inch is approximately 16.38 cubic centimeters or  $[1 \text{ in}^3] = [16.38 \text{ cm}^3]$ ).
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### **3.0 Students know the Pythagorean theorem and deepen their understanding of plane and solid geometric shapes by constructing figures that meet given conditions and by identifying attributes of figures:**

- 3.1 Identify and construct basic elements of geometric figures (e.g., altitudes, midpoints, diagonals, angle bisectors, and perpendicular bisectors; central angles, radii, diameters, and chords of circles) by using a compass and straightedge.

- 3.2 Understand and use coordinate graphs to plot simple figures, determine lengths and areas related to them, and determine their image under translations and reflections.
- 3.3 Know and understand the Pythagorean theorem and its converse and use it to find the length of the missing side of a right triangle and the lengths of other line segments and, in some situations, empirically verify the Pythagorean theorem by direct measurement.
- 3.4 Demonstrate an understanding of conditions that indicate two geometrical figures are congruent and what congruence means about the relationships between the sides and angles of the two figures.
- 3.5 Construct two-dimensional patterns for three-dimensional models, such as cylinders, prisms, and cones.
- 3.6 Identify elements of three-dimensional geometric objects (e.g., diagonals of rectangular solids) and describe how two or more objects are related in space (e.g., skew lines, the possible ways three planes might intersect).

## Statistics, Data Analysis, and Probability

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**1.0 Students collect, organize, and represent data sets that have one or more variables and identify relationships among variables within a data set by hand and through the use of an electronic spreadsheet software program:**

- 1.1 Know various forms of display for data sets, including a stem-and-leaf plot or box-and-whisker plot; use the forms to display a single set of data or to compare two sets of data.
- 1.2 Represent two numerical variables on a scatterplot and informally describe how the data points are distributed and any apparent relationship that exists between the two variables (e.g., between time spent on homework and grade level).
- 1.3 Understand the meaning of, and be able to compute, the minimum, the lower quartile, the median, the upper quartile, and the maximum of a data set.

## Mathematical Reasoning

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### 1.0 Students make decisions about how to approach problems:

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.
  - 1.2 Formulate and justify mathematical conjectures based on a general description of the mathematical question or problem posed.
  - 1.3 Determine when and how to break a problem into simpler parts.
- 

### 2.0 Students use strategies, skills, and concepts in finding solutions:

- 2.1 Use estimation to verify the reasonableness of calculated results.
  - 2.2 Apply strategies and results from simpler problems to more complex problems.
  - 2.3 Estimate unknown quantities graphically and solve for them by using logical reasoning and arithmetic and algebraic techniques.
  - 2.4 Make and test conjectures by using both inductive and deductive reasoning.
  - 2.5 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
  - 2.6 Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.
  - 2.7 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.
  - 2.8 Make precise calculations and check the validity of the results from the context of the problem.
- 

### 3.0 Students determine a solution is complete and move beyond a particular problem by generalizing to other situations:

- 3.1 Evaluate the reasonableness of the solution in the context of the original situation.
- 3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
- 3.3 Develop generalizations of the results obtained and the strategies used and apply them to new problem situations.



# Grades Eight Through Twelve

## Introduction

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The standards for grades eight through twelve are organized differently from those for kindergarten through grade seven. In this section strands are not used for organizational purposes as they are in the elementary grades because the mathematics studied in grades eight through twelve falls naturally under discipline headings: algebra, geometry, and so forth. Many schools teach this material in traditional courses; others teach it in an integrated fashion. To allow local educational agencies and teachers flexibility in teaching the material, the standards for grades eight through twelve do not mandate that a particular discipline be initiated and completed in a single grade. The core content of these subjects must be covered; students are expected to achieve the standards however these subjects are sequenced.

Standards are provided for algebra I, geometry, algebra II, trigonometry, mathematical analysis, linear algebra, probability and statistics, Advanced Placement probability and statistics, and calculus. Many of the more advanced subjects are not taught in every middle school or high school. Moreover, schools and districts have different ways of combining the subject matter in these various disciplines. For example, many schools combine some trigonometry, mathematical analysis, and linear algebra to form a precalculus course. Some districts prefer offering trigonometry content with algebra II.

Table 1, “Mathematics Disciplines, by Grade Level,” reflects typical grade-level groupings of these disciplines in both integrated and traditional curricula. The lightly shaded region reflects the minimum requirement for mastery by all students. The dark shaded region depicts content that is typically considered elective but that should also be mastered by students who complete the other disciplines in the lower grade levels and continue the study of mathematics.

**Table 1**  
**Mathematics Disciplines, by Grade Level**

<i>Discipline</i>	<i>Grades</i>				
	<i>Eight</i>	<i>Nine</i>	<i>Ten</i>	<i>Eleven</i>	<i>Twelve</i>
Algebra I					
Geometry					
Algebra II					
Probability and Statistics					
Trigonometry					
Linear Algebra					
Mathematical Analysis					
Advanced Placement Probability and Statistics					
Calculus					

Many other combinations of these advanced subjects into courses are possible. What is described in this section are standards for the academic content by discipline; this document does not endorse a particular choice of structure for courses or a particular method of teaching the mathematical content.

When students delve deeply into mathematics, they gain not only conceptual understanding of mathematical principles but also knowledge of, and experience with, pure reasoning. One of the most important goals of mathematics is to teach students logical reasoning. The logical reasoning inherent in the study of mathematics allows for applications to a broad range of situations in which answers to practical problems can be found with accuracy.

By grade eight, students' mathematical sensitivity should be sharpened. Students need to start perceiving logical subtleties and appreciate the need for sound mathematical arguments before making conclusions. As students progress in the

study of mathematics, they learn to distinguish between inductive and deductive reasoning; understand the meaning of logical implication; test general assertions; realize that one counterexample is enough to show that a general assertion is false; understand conceptually that although a general assertion is true in a few cases, it is not true in all cases; distinguish between something being proven and a mere plausibility argument; and identify logical errors in chains of reasoning.

Mathematical reasoning and conceptual understanding are not separate from content; they are intrinsic to the mathematical discipline students master at more advanced levels.

## Algebra I

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Symbolic reasoning and calculations with symbols are central in algebra. Through the study of algebra, a student develops an understanding of the symbolic language of mathematics and the sciences. In addition, algebraic skills and concepts are developed and used in a wide variety of problem-solving situations.

- 1.0 Students identify and use the arithmetic properties of subsets of integers and rational, irrational, and real numbers, including closure properties for the four basic arithmetic operations where applicable:
  - 1.1 Students use properties of numbers to demonstrate whether assertions are true or false.

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- 2.0 Students understand and use such operations as taking the opposite, finding the reciprocal, taking a root, and raising to a fractional power. They understand and use the rules of exponents.

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- 3.0 Students solve equations and inequalities involving absolute values.

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- 4.0 Students simplify expressions before solving linear equations and inequalities in one variable, such as  $3(2x-5) + 4(x-2) = 12$ .


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- 5.0 Students solve multistep problems, including word problems, involving linear equations and linear inequalities in one variable and provide justification for each step.

---

- 6.0 Students graph a linear equation and compute the  $x$ - and  $y$ -intercepts (e.g., graph  $2x + 6y = 4$ ). They are also able to sketch the region defined by linear inequality (e.g., they sketch the region defined by  $2x + 6y < 4$ ).

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-  7.0 Students verify that a point lies on a line, given an equation of the line. Students are able to derive linear equations by using the point-slope formula.

- 
- 8.0** Students understand the concepts of parallel lines and perpendicular lines and how those slopes are related. Students are able to find the equation of a line perpendicular to a given line that passes through a given point.
- 
- 9.0** Students solve a system of two linear equations in two variables algebraically and are able to interpret the answer graphically. Students are able to solve a system of two linear inequalities in two variables and to sketch the solution sets.
- 
- 10.0** Students add, subtract, multiply, and divide monomials and polynomials. Students solve multistep problems, including word problems, by using these techniques.
- 
- 11.0** Students apply basic factoring techniques to second- and simple third-degree polynomials. These techniques include finding a common factor for all terms in a polynomial, recognizing the difference of two squares, and recognizing perfect squares of binomials.
- 
- 12.0** Students simplify fractions with polynomials in the numerator and denominator by factoring both and reducing them to the lowest terms.
- 
- 13.0** Students add, subtract, multiply, and divide rational expressions and functions. Students solve both computationally and conceptually challenging problems by using these techniques.
- 
- 14.0** Students solve a quadratic equation by factoring or completing the square.
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- 15.0** Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.
- 
- 16.0** Students understand the concepts of a relation and a function, determine whether a given relation defines a function, and give pertinent information about given relations and functions.

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**17.0** Students determine the domain of independent variables and the range of dependent variables defined by a graph, a set of ordered pairs, or a symbolic expression.

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**18.0** Students determine whether a relation defined by a graph, a set of ordered pairs, or a symbolic expression is a function and justify the conclusion.

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**19.0** Students know the quadratic formula and are familiar with its proof by completing the square.

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**20.0** Students use the quadratic formula to find the roots of a second-degree polynomial and to solve quadratic equations.

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**21.0** Students graph quadratic functions and know that their roots are the  $x$ -intercepts.

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**22.0** Students use the quadratic formula or factoring techniques or both to determine whether the graph of a quadratic function will intersect the  $x$ -axis in zero, one, or two points.

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**23.0** Students apply quadratic equations to physical problems, such as the motion of an object under the force of gravity.

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**24.0** Students use and know simple aspects of a logical argument:

24.1 Students explain the difference between inductive and deductive reasoning and identify and provide examples of each.

24.2 Students identify the hypothesis and conclusion in logical deduction.

24.3 Students use counterexamples to show that an assertion is false and recognize that a single counterexample is sufficient to refute an assertion.

- 
- 25.0** Students use properties of the number system to judge the validity of results, to justify each step of a procedure, and to prove or disprove statements:
- 25.1 Students use properties of numbers to construct simple, valid arguments (direct and indirect) for, or formulate counterexamples to, claimed assertions.
  - 25.2 Students judge the validity of an argument according to whether the properties of the real number system and the order of operations have been applied correctly at each step.
  - 25.3 Given a specific algebraic statement involving linear, quadratic, or absolute value expressions or equations or inequalities, students determine whether the statement is true sometimes, always, or never.

## Geometry

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The geometry skills and concepts developed in this discipline are useful to all students. Aside from learning these skills and concepts, students will develop their ability to construct formal, logical arguments and proofs in geometric settings and problems.

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- 1.0 Students demonstrate understanding by identifying and giving examples of undefined terms, axioms, theorems, and inductive and deductive reasoning.

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- 2.0 Students write geometric proofs, including proofs by contradiction.

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- 3.0 Students construct and judge the validity of a logical argument and give counterexamples to disprove a statement.

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- 4.0 Students prove basic theorems involving congruence and similarity.

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- 5.0 Students prove that triangles are congruent or similar, and they are able to use the concept of corresponding parts of congruent triangles.

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- 6.0 Students know and are able to use the triangle inequality theorem.

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- 7.0 Students prove and use theorems involving the properties of parallel lines cut by a transversal, the properties of quadrilaterals, and the properties of circles.

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- 8.0 Students know, derive, and solve problems involving the perimeter, circumference, area, volume, lateral area, and surface area of common geometric figures.

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- 9.0 Students compute the volumes and surface areas of prisms, pyramids, cylinders, cones, and spheres; and students commit to memory the formulas for prisms, pyramids, and cylinders.

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- 10.0 Students compute areas of polygons, including rectangles, scalene triangles, equilateral triangles, rhombi, parallelograms, and trapezoids.

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- 11.0 Students determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.

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- 12.0** Students find and use measures of sides and of interior and exterior angles of triangles and polygons to classify figures and solve problems.
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- 13.0** Students prove relationships between angles in polygons by using properties of complementary, supplementary, vertical, and exterior angles.
- 
- 14.0** Students prove the Pythagorean theorem.
- 
- 15.0** Students use the Pythagorean theorem to determine distance and find missing lengths of sides of right triangles.
- 
- 16.0** Students perform basic constructions with a straightedge and compass, such as angle bisectors, perpendicular bisectors, and the line parallel to a given line through a point off the line.
- 
- 17.0** Students prove theorems by using coordinate geometry, including the midpoint of a line segment, the distance formula, and various forms of equations of lines and circles.
- 
- 18.0** Students know the definitions of the basic trigonometric functions defined by the angles of a right triangle. They also know and are able to use elementary relationships between them. For example,  $\tan(x) = \sin(x)/\cos(x)$ ,  $(\sin(x))^2 + (\cos(x))^2 = 1$ .
- 
- 19.0** Students use trigonometric functions to solve for an unknown length of a side of a right triangle, given an angle and a length of a side.
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- 20.0** Students know and are able to use angle and side relationships in problems with special right triangles, such as  $30^\circ$ ,  $60^\circ$ , and  $90^\circ$  triangles and  $45^\circ$ ,  $45^\circ$ , and  $90^\circ$  triangles.
- 
- 21.0** Students prove and solve problems regarding relationships among chords, secants, tangents, inscribed angles, and inscribed and circumscribed polygons of circles.
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- 22.0** Students know the effect of rigid motions on figures in the coordinate plane and space, including rotations, translations, and reflections.

## Algebra II

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**This discipline complements and expands the mathematical content and concepts of algebra I and geometry. Students who master algebra II will gain experience with algebraic solutions of problems in various content areas, including the solution of systems of quadratic equations, logarithmic and exponential functions, the binomial theorem, and the complex number system.**

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**1.0** Students solve equations and inequalities involving absolute value.

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**2.0** Students solve systems of linear equations and inequalities (in two or three variables) by substitution, with graphs, or with matrices.

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**3.0** Students are adept at operations on polynomials, including long division.

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**4.0** Students factor polynomials representing the difference of squares, perfect square trinomials, and the sum and difference of two cubes.

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**5.0** Students demonstrate knowledge of how real and complex numbers are related both arithmetically and graphically. In particular, they can plot complex numbers as points in the plane.

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**6.0** Students add, subtract, multiply, and divide complex numbers.

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**7.0** Students add, subtract, multiply, divide, reduce, and evaluate rational expressions with monomial and polynomial denominators and simplify complicated rational expressions, including those with negative exponents in the denominator.

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**8.0** Students solve and graph quadratic equations by factoring, completing the square, or using the quadratic formula. Students apply these techniques in solving word problems. They also solve quadratic equations in the complex number system.

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**9.0** Students demonstrate and explain the effect that changing a coefficient has on the graph of quadratic functions; that is, students can determine how the graph of a parabola changes as  $a$ ,  $b$ , and  $c$  vary in the equation  $y = a(x-b)^2 + c$ .

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**10.0** Students graph quadratic functions and determine the maxima, minima, and zeros of the function.

---

**11.0** Students prove simple laws of logarithms.

11.1 Students understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

11.2 Students judge the validity of an argument according to whether the properties of real numbers, exponents, and logarithms have been applied correctly at each step.

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**12.0** Students know the laws of fractional exponents, understand exponential functions, and use these functions in problems involving exponential growth and decay.

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**13.0** Students use the definition of logarithms to translate between logarithms in any base.

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**14.0** Students understand and use the properties of logarithms to simplify logarithmic numeric expressions and to identify their approximate values.

---

**15.0** Students determine whether a specific algebraic statement involving rational expressions, radical expressions, or logarithmic or exponential functions is sometimes true, always true, or never true.

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**16.0** Students demonstrate and explain how the geometry of the graph of a conic section (e.g., asymptotes, foci, eccentricity) depends on the coefficients of the quadratic equation representing it.

- 
- 17.0 Given a quadratic equation of the form  $ax^2 + by^2 + cx + dy + e = 0$ , students can use the method for completing the square to put the equation into standard form and can recognize whether the graph of the equation is a circle, ellipse, parabola, or hyperbola. Students can then graph the equation.
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- 18.0 Students use fundamental counting principles to compute combinations and permutations.
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- 19.0 Students use combinations and permutations to compute probabilities.
- 
- 20.0 Students know the binomial theorem and use it to expand binomial expressions that are raised to positive integer powers.
- 
- 21.0 Students apply the method of mathematical induction to prove general statements about the positive integers.
- 
- 22.0 Students find the general term and the sums of arithmetic series and of both finite and infinite geometric series.
- 
- 23.0 Students derive the summation formulas for arithmetic series and for both finite and infinite geometric series.
- 
- 24.0 Students solve problems involving functional concepts, such as composition, defining the inverse function and performing arithmetic operations on functions.
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- 25.0 Students use properties from number systems to justify steps in combining and simplifying functions.

## Trigonometry

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Trigonometry uses the techniques that students have previously learned from the study of algebra and geometry. The trigonometric functions studied are defined geometrically rather than in terms of algebraic equations. Facility with these functions as well as the ability to prove basic identities regarding them is especially important for students intending to study calculus, more advanced mathematics, physics and other sciences, and engineering in college.

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- 1.0 Students understand the notion of angle and how to measure it, in both degrees and radians. They can convert between degrees and radians.
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- 2.0 Students know the definition of sine and cosine as  $y$ - and  $x$ -coordinates of points on the unit circle and are familiar with the graphs of the sine and cosine functions.
- 
- 3.0 Students know the identity  $\cos^2(x) + \sin^2(x) = 1$ :
- 3.1 Students prove that this identity is equivalent to the Pythagorean theorem (i.e., students can prove this identity by using the Pythagorean theorem and, conversely, they can prove the Pythagorean theorem as a consequence of this identity).
- 3.2 Students prove other trigonometric identities and simplify others by using the identity  $\cos^2(x) + \sin^2(x) = 1$ . For example, students use this identity to prove that  $\sec^2(x) = \tan^2(x) + 1$ .
- 
- 4.0 Students graph functions of the form  $f(t) = A \sin(Bt + C)$  or  $f(t) = A \cos(Bt + C)$  and interpret  $A$ ,  $B$ , and  $C$  in terms of amplitude, frequency, period, and phase shift.
- 
- 5.0 Students know the definitions of the tangent and cotangent functions and can graph them.
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- 6.0 Students know the definitions of the secant and cosecant functions and can graph them.
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- 7.0 Students know that the tangent of the angle that a line makes with the  $x$ -axis is equal to the slope of the line.
- 
- 8.0 Students know the definitions of the inverse trigonometric functions and can graph the functions.

- 
- 9.0** Students compute, by hand, the values of the trigonometric functions and the inverse trigonometric functions at various standard points.
- 
- 10.0** Students demonstrate an understanding of the addition formulas for sines and cosines and their proofs and can use those formulas to prove and/or simplify other trigonometric identities.
- 
- 11.0** Students demonstrate an understanding of half-angle and double-angle formulas for sines and cosines and can use those formulas to prove and/or simplify other trigonometric identities.
- 
- 12.0** Students use trigonometry to determine unknown sides or angles in right triangles.
- 
- 13.0** Students know the law of sines and the law of cosines and apply those laws to solve problems.
- 
- 14.0** Students determine the area of a triangle, given one angle and the two adjacent sides.
- 
- 15.0** Students are familiar with polar coordinates. In particular, they can determine polar coordinates of a point given in rectangular coordinates and vice versa.
- 
- 16.0** Students represent equations given in rectangular coordinates in terms of polar coordinates.
- 
- 17.0** Students are familiar with complex numbers. They can represent a complex number in polar form and know how to multiply complex numbers in their polar form.
- 
- 18.0** Students know DeMoivre's theorem and can give  $n$ th roots of a complex number given in polar form.
- 
- 19.0** Students are adept at using trigonometry in a variety of applications and word problems.

## Mathematical Analysis

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This discipline combines many of the trigonometric, geometric, and algebraic techniques needed to prepare students for the study of calculus and strengthens their conceptual understanding of problems and mathematical reasoning in solving problems. These standards take a functional point of view toward those topics. The most significant new concept is that of limits. Mathematical analysis is often combined with a course in trigonometry or perhaps with one in linear algebra to make a year-long precalculus course.

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- 1.0 Students are familiar with, and can apply, polar coordinates and vectors in the plane. In particular, they can translate between polar and rectangular coordinates and can interpret polar coordinates and vectors graphically.

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- 2.0 Students are adept at the arithmetic of complex numbers. They can use the trigonometric form of complex numbers and understand that a function of a complex variable can be viewed as a function of two real variables. They know the proof of DeMoivre's theorem.

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- 3.0 Students can give proofs of various formulas by using the technique of mathematical induction.

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- 4.0 Students know the statement of, and can apply, the fundamental theorem of algebra.

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- 5.0 Students are familiar with conic sections, both analytically and geometrically:
  - 5.1 Students can take a quadratic equation in two variables; put it in standard form by completing the square and using rotations and translations, if necessary; determine what type of conic section the equation represents; and determine its geometric components (foci, asymptotes, and so forth).
  - 5.2 Students can take a geometric description of a conic section—for example, the locus of points whose sum of its distances from  $(1, 0)$  and  $(-1, 0)$  is 6—and derive a quadratic equation representing it.

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- 6.0 Students find the roots and poles of a rational function and can graph the function and locate its asymptotes.

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7.0 Students demonstrate an understanding of functions and equations defined parametrically and can graph them.

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8.0 Students are familiar with the notion of the limit of a sequence and the limit of a function as the independent variable approaches a number or infinity. They determine whether certain sequences converge or diverge.

## Linear Algebra

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The general goal in this discipline is for students to learn the techniques of matrix manipulation so that they can solve systems of linear equations in any number of variables. Linear algebra is most often combined with another subject, such as trigonometry, mathematical analysis, or precalculus.

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- 1.0 Students solve linear equations in any number of variables by using Gauss-Jordan elimination.

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- 2.0 Students interpret linear systems as coefficient matrices and the Gauss-Jordan method as row operations on the coefficient matrix.

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- 3.0 Students reduce rectangular matrices to row echelon form.

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- 4.0 Students perform addition on matrices and vectors.

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- 5.0 Students perform matrix multiplication and multiply vectors by matrices and by scalars.

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- 6.0 Students demonstrate an understanding that linear systems are inconsistent (have no solutions), have exactly one solution, or have infinitely many solutions.

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- 7.0 Students demonstrate an understanding of the geometric interpretation of vectors and vector addition (by means of parallelograms) in the plane and in three-dimensional space.

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- 8.0 Students interpret geometrically the solution sets of systems of equations. For example, the solution set of a single linear equation in two variables is interpreted as a line in the plane, and the solution set of a two-by-two system is interpreted as the intersection of a pair of lines in the plane.

- 
- 9.0** Students demonstrate an understanding of the notion of the inverse to a square matrix and apply that concept to solve systems of linear equations.
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- 10.0** Students compute the determinants of  $2 \times 2$  and  $3 \times 3$  matrices and are familiar with their geometric interpretations as the area and volume of the parallelepipeds spanned by the images under the matrices of the standard basis vectors in two-dimensional and three-dimensional spaces.
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- 11.0** Students know that a square matrix is invertible if, and only if, its determinant is nonzero. They can compute the inverse to  $2 \times 2$  and  $3 \times 3$  matrices using row reduction methods or Cramer's rule.
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- 12.0** Students compute the scalar (dot) product of two vectors in  $n$ -dimensional space and know that perpendicular vectors have zero dot product.

## Probability and Statistics

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This discipline is an introduction to the study of probability, interpretation of data, and fundamental statistical problem solving. Mastery of this academic content will provide students with a solid foundation in probability and facility in processing statistical information.

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1.0 Students know the definition of the notion of *independent events* and can use the rules for addition, multiplication, and complementation to solve for probabilities of particular events in finite sample spaces.

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2.0 Students know the definition of *conditional probability* and use it to solve for probabilities in finite sample spaces.


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3.0 Students demonstrate an understanding of the notion of *discrete random variables* by using them to solve for the probabilities of outcomes, such as the probability of the occurrence of five heads in 14 coin tosses.


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4.0 Students are familiar with the standard distributions (normal, binomial, and exponential) and can use them to solve for events in problems in which the distribution belongs to those families.

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 5.0 Students determine the mean and the standard deviation of a normally distributed random variable.


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 6.0 Students know the definitions of the *mean*, *median*, and *mode* of a distribution of data and can compute each in particular situations.

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7.0 Students compute the variance and the standard deviation of a distribution of data.

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 8.0 Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.

## Advanced Placement Probability and Statistics

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This discipline is a technical and in-depth extension of probability and statistics. In particular, mastery of academic content for advanced placement gives students the background to succeed in the Advanced Placement examination in the subject.

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- 1.0 Students solve probability problems with finite sample spaces by using the rules for addition, multiplication, and complementation for probability distributions and understand the simplifications that arise with independent events.

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- 2.0 Students know the definition of *conditional probability* and use it to solve for probabilities in finite sample spaces.

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- 3.0 Students demonstrate an understanding of the notion of *discrete random variables* by using this concept to solve for the probabilities of outcomes, such as the probability of the occurrence of five or fewer heads in 14 coin tosses.


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- 4.0 Students understand the notion of a *continuous random variable* and can interpret the probability of an outcome as the area of a region under the graph of the probability density function associated with the random variable.

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- 5.0 Students know the definition of the *mean of a discrete random variable* and can determine the mean for a particular discrete random variable.

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-  6.0 Students know the definition of the *variance of a discrete random variable* and can determine the variance for a particular discrete random variable.

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- 7.0 Students demonstrate an understanding of the standard distributions (normal, binomial, and exponential) and can use the distributions to solve for events in problems in which the distribution belongs to those families.

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- 8.0 Students determine the mean and the standard deviation of a normally distributed random variable.

---

9.0 Students know the central limit theorem and can use it to obtain approximations for probabilities in problems of finite sample spaces in which the probabilities are distributed binomially.

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10.0 Students know the definitions of the *mean*, *median*, and *mode of distribution of data* and can compute each of them in particular situations.

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11.0 Students compute the variance and the standard deviation of a distribution of data.

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12.0 Students find the line of best fit to a given distribution of data by using least squares regression.

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13.0 Students know what the *correlation coefficient of two variables* means and are familiar with the coefficient's properties.

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14.0 Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line graphs and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.

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15.0 Students are familiar with the notions of a statistic of a distribution of values, of the sampling distribution of a statistic, and of the variability of a statistic.

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16.0 Students know basic facts concerning the relation between the mean and the standard deviation of a sampling distribution and the mean and the standard deviation of the population distribution.

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17.0 Students determine confidence intervals for a simple random sample from a normal distribution of data and determine the sample size required for a desired margin of error.

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18.0 Students determine the *P*-value for a statistic for a simple random sample from a normal distribution.

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19.0 Students are familiar with the *chi*-square distribution and *chi*-square test and understand their uses.

## Calculus

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When taught in high school, calculus should be presented with the same level of depth and rigor as are entry-level college and university calculus courses. These standards outline a complete college curriculum in one variable calculus. Many high school programs may have insufficient time to cover all of the following content in a typical academic year. For example, some districts may treat differential equations lightly and spend substantial time on infinite sequences and series. Others may do the opposite. Consideration of the College Board syllabi for the Calculus AB and Calculus BC sections of the Advanced Placement Examination in Mathematics may be helpful in making curricular decisions. Calculus is a widely applied area of mathematics and involves a beautiful intrinsic theory. Students mastering this content will be exposed to both aspects of the subject.

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- 1.0 Students demonstrate knowledge of both the formal definition and the graphical interpretation of limit of values of functions. This knowledge includes one-sided limits, infinite limits, and limits at infinity. Students know the definition of convergence and divergence of a function as the domain variable approaches either a number or infinity:
  - 1.1 Students prove and use theorems evaluating the limits of sums, products, quotients, and composition of functions.
  - 1.2 Students use graphical calculators to verify and estimate limits.
  - 1.3 Students prove and use special limits, such as the limits of  $(\sin(x))/x$  and  $(1-\cos(x))/x$  as  $x$  tends to 0.
- 2.0 Students demonstrate knowledge of both the formal definition and the graphical interpretation of continuity of a function.
- 3.0 Students demonstrate an understanding and the application of the intermediate value theorem and the extreme value theorem.
- 4.0 Students demonstrate an understanding of the formal definition of the derivative of a function at a point and the notion of differentiability:
  - 4.1 Students demonstrate an understanding of the derivative of a function as the slope of the tangent line to the graph of the function.

- 4.2 Students demonstrate an understanding of the interpretation of the derivative as an instantaneous rate of change. Students can use derivatives to solve a variety of problems from physics, chemistry, economics, and so forth that involve the rate of change of a function.
- 4.3 Students understand the relation between differentiability and continuity.
- 4.4 Students derive derivative formulas and use them to find the derivatives of algebraic, trigonometric, inverse trigonometric, exponential, and logarithmic functions.
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- 5.0 Students know the chain rule and its proof and applications to the calculation of the derivative of a variety of composite functions.
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- 6.0 Students find the derivatives of parametrically defined functions and use implicit differentiation in a wide variety of problems in physics, chemistry, economics, and so forth.
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- 7.0 Students compute derivatives of higher orders.
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- 8.0 Students know and can apply Rolle's theorem, the mean value theorem, and L'Hôpital's rule.
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- 9.0 Students use differentiation to sketch, by hand, graphs of functions. They can identify maxima, minima, inflection points, and intervals in which the function is increasing and decreasing.
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- 10.0 Students know Newton's method for approximating the zeros of a function.
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- 11.0 Students use differentiation to solve optimization (maximum-minimum problems) in a variety of pure and applied contexts.
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- 12.0 Students use differentiation to solve related rate problems in a variety of pure and applied contexts.
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- 13.0 Students know the definition of the definite integral by using Riemann sums. They use this definition to approximate integrals.

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- 14.0** Students apply the definition of the integral to model problems in physics, economics, and so forth, obtaining results in terms of integrals.
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- 15.0** Students demonstrate knowledge and proof of the fundamental theorem of calculus and use it to interpret integrals as antiderivatives.
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- 16.0** Students use definite integrals in problems involving area, velocity, acceleration, volume of a solid, area of a surface of revolution, length of a curve, and work.
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- 17.0** Students compute, by hand, the integrals of a wide variety of functions by using techniques of integration, such as substitution, integration by parts, and trigonometric substitution. They can also combine these techniques when appropriate.
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- 18.0** Students know the definitions and properties of inverse trigonometric functions and the expression of these functions as indefinite integrals.
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- 19.0** Students compute, by hand, the integrals of rational functions by combining the techniques in standard 17.0 with the algebraic techniques of partial fractions and completing the square.
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- 20.0** Students compute the integrals of trigonometric functions by using the techniques noted above.
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- 21.0** Students understand the algorithms involved in Simpson's rule and Newton's method. They use calculators or computers or both to approximate integrals numerically.
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- 22.0** Students understand improper integrals as limits of definite integrals.
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- 23.0** Students demonstrate an understanding of the definitions of convergence and divergence of sequences and series of real numbers. By using such tests as the comparison test, ratio test, and alternate series test, they can determine whether a series converges.

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- 24.0** Students understand and can compute the radius (interval) of the convergence of power series.
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- 25.0** Students differentiate and integrate the terms of a power series in order to form new series from known ones.
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- 26.0** Students calculate Taylor polynomials and Taylor series of basic functions, including the remainder term.
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- 27.0** Students know the techniques of solution of selected elementary differential equations and their applications to a wide variety of situations, including growth-and-decay problems.