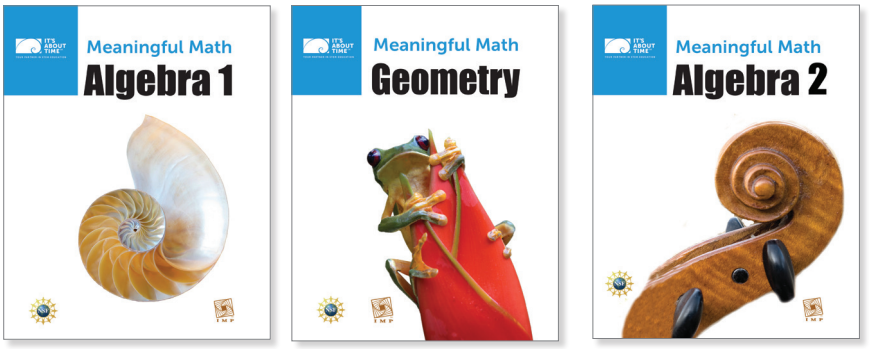
IT'S ABOUT TIME®

YOUR PARTNER IN STEM EDUCATION

Think Common Core...

Meaningful Math—

Algebra 1, Geometry, Algebra 2



Curriculum Map and Scope and Sequence

Think Meaningful Math

Active Learning

Problem-Based Learning

Technology Enhanced Learning

Total Support for Learning

Meaningful Math Overview

The pages that follow include a curriculum map that provides a conceptual overview of each unit in *Meaningful Math—Algebra 1*, *—Geometry*, and *—Algebra 2*, and a Scope and Sequence summarizing the standards addressed in each unit.

The Scope and Sequence lists the standards clusters taught in each unit, along with designation of PARCC's Content Emphasis—each cluster is designated as Major, Supporting, or Additional. PARCC suggests that Major content consume approximately 70% of curricular time. You'll see that "Major" over-arching clusters such as "Interpret the structure of expressions" and "Create equations that describe numbers or relationships" are taught spanning most of the units, while Supporting or Additional content are usually more limited in scope and are taught only in a single unit. Familiarize yourself with the Major emphases, and you'll see that these are addressed repeatedly throughout the course.

In addition to the Content Standards, the Standards for Mathematical Practice are broad, and are attended to on a daily basis in *Meaningful Math*.

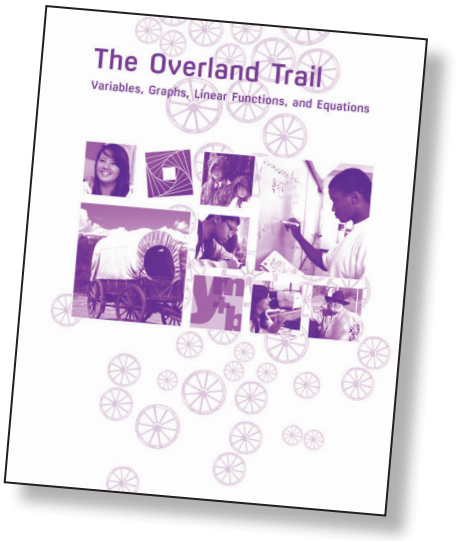
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

PARCC notes that while all of these standards should be attended to in all grades, Standards for Mathematical Practice 1 and 4 are particularly important in *Algebra 1*, Standards for Mathematical Practice 2, 3, 5, 6, and 7 are particularly important in *Geometry*, and Standards for Mathematical Practice 3, 6, 7, and 8 are particularly important in *Algebra 2*.

Meaningful Math supports the Standards for Mathematical Practice like no other curriculum, having been built from the ground up on principles of reasoning and constructing precise arguments; persevering in tackling big problems; and analyzing through recognition of structure, regularity, and pattern. Through working on big problems throughout the curriculum in a classroom environment that relies on group work, class discussion, and presentation, students inherently develop their problem-solving and analysis abilities, ability to model, reason, and argue and critique.

The Common Core Learning Standards, NYC Instructional Shifts, and other resources support an approach to learning that balances conceptual understanding, application, and procedural fluency. The foundation of *Meaningful Math* is applications and modeling, so in most units you'll see application and context in virtually every activity. This provides a rich basis on which to build understanding, which is carefully constructed through the arc of activities in each unit. Most procedural fluency is developed through repeated contextual application of skills that have been built, but every unit intersperses periodic focused procedural fluency development

Unit 1 – The Overland Trail



Mathematics

The focus of this unit is on linear functions. Students will use starting values and rate of change to characterize linear functions, build In-Out tables, draw graphs, and write equations to represent specific contexts. They will use tables, graphs, and symbols to solve linear equations and systems of linear equations. They will fit lines to real data and use graphs and symbols representing these lines to solve problems in the context of the unit. The main concepts and skills that students will encounter and practice during the course of this unit can be summarized by category.

Constraints and Decision Making

- Creating examples that fit a set of constraints
- Finding numbers that fit several conditions
- Using tables of information and lines of best fit to make predictions and estimates
- Working with mean and median

Algorithms, Variables, and Notation

- Strengthening understanding of the distributive property
- Developing numeric algorithms for problem situations
- Expressing algorithms in words and symbols
- Interpreting algebraic expressions in words using summary phrases
- Developing meaningful algebraic expressions

Basics of Graphing

- Reviewing the coordinate system
- Interpreting graphs intuitively and using graphs intuitively to represent situations
- Making graphs from tabular information
- Quantifying graphs with appropriate scales
- Using graphs to represent two-variable equations and data sets
- Using multiple representations—graphs, tables, and algebraic relationships to describe situations

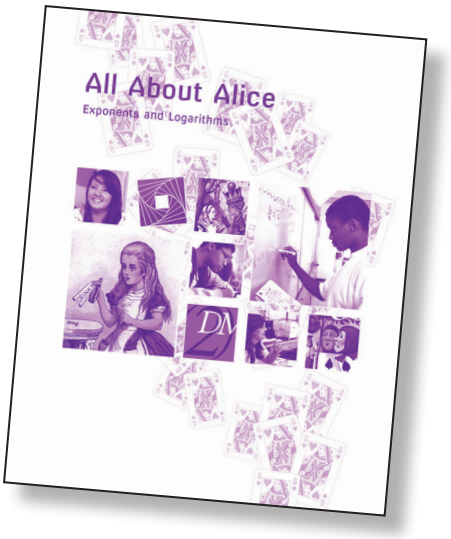
Linear Equations, Graphs, and Situations

- Finding and interpreting lines of best fit intuitively
- Seeing the role of constant rate in linear situations
- Using rates and starting values, or other data points, to create equations for straight lines
- Laying the groundwork for the concept of slope
- Using the point of intersection of two graphs to find values that satisfies two conditions
- Solving linear equations for one variable in terms of another
- Solving problems involving two linear conditions
- Solving linear equations in one variable

Graphs and Technology

- Making and interpreting graphs on a graphing calculator
- Using the zoom and trace features to get information from a graphing calculator

Unit 2 – All About Alice



Mathematics

Unlike most other *Meaningful Math* units, *All About Alice* has no central problem to solve. Instead, there is a general context to the unit, as in *The Overland Trail*. In particular, the Alice story provides a metaphor for understanding exponents. When Alice eats an ounce of cake, her height is multiplied by a particular whole-number amount; when she drinks an ounce of beverage, her height is multiplied by a particular fractional amount. Using this metaphor, students reason about exponential growth and decay. Students use several approaches to extend exponentiation beyond positive integers: a contextual situation, algebraic laws, graphs, and number patterns. They then apply principles of exponents to study logarithms and scientific notation.

The main concepts and skills students will encounter and practice during the course of this unit are summarized by category here.

Extending the Operation of Exponentiation

- Defining the operation for an exponent of zero
- Defining the operation for negative integer exponents
- Defining the operation for fractional exponents

Laws of Exponents

- Developing the additive law of exponents
- Developing the law of repeated exponentiation

Graphing

- Describing the graphs of exponential functions
- Comparing graphs of exponential functions for different bases
- Describing the graphs of logarithmic functions
- Comparing graphs of logarithmic functions for different bases

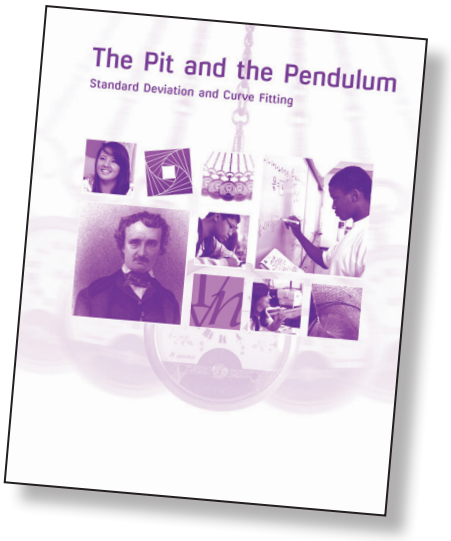
Logarithms

- Understanding the meaning of logarithms
- Making connections between exponential and logarithmic equations

Scientific Notation

- Converting numbers from ordinary notation to scientific notation, and vice versa
- Developing principles for doing computations using scientific notation
- Using the concept of order of magnitude in estimation

Unit 3 – The Pit and the Pendulum



Mathematics

This unit draws on and extends students' work in the first two units. It blends scientific experiments with the statistical concepts of normal distribution and standard deviation and the algebra of functions and graphs. The main concepts and skills that students will encounter and practice during the course of this unit are summarized below. References to graphing calculators should be understood to include other technology that might be available.

Experiments and Data

- Planning and performing controlled scientific experiments
- Working with the concept of period
- Recognizing and accommodating for the phenomenon of measurement variation
- Collecting and analyzing data
- Expressing experimental results and other data using frequency bar graphs

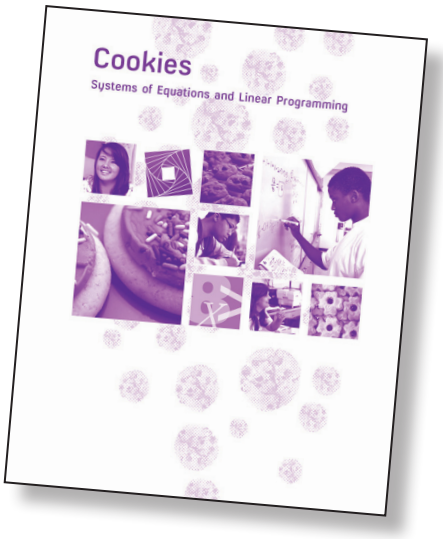
Statistics

- Recognizing the normal distribution as a model for certain kinds of data
- Making area estimates to understand the normal distribution
- Developing concepts of data spread, especially standard deviation
- Working with symmetry and concavity in connection with the normal distribution and standard deviation
- Applying standard deviation and the normal distribution in problem contexts
- Distinguishing between population standard deviation and sample standard deviation
- Calculating the mean and standard deviation of data sets, both by hand and with calculators
- Using standard deviation to decide whether a variation in experimental results is significant

Functions and Graphs

- Using function notation
- Using graphing calculators to explore the graphs of various functions
- Fitting a function to data using a graphing calculator
- Making predictions based on curve-fitting

Unit 4 – Cookies



Mathematics

The central mathematical focus of *Cookies* is the formulation and solution of problems of optimization, or linear programming problems. In problems of this type, a linear function is to be optimized and a set of linear conditions constraints the possible solutions. Linearity is an important feature of these two-variable problems, in two ways:

- The constraints are linear, so the feasible region is a polygon and its vertices can be found by solving pairs of linear equations.
- The expression to be maximized or minimized is linear, so the points that give this expression a particular value lie on a straight line, and investigating a series of values produces a family of parallel lines.

The linear programming problems that students encounter in this unit involve only two variables and a limited number of constraints. Their solutions are therefore easier to understand graphically, and the algebra needed to find their exact solutions is manageable.

The main concepts and skills that students will encounter and practice during the unit are summarized here.

Using Variables to Represent Problems

- Expressing and interpreting constraints using inequalities
- Expressing problem situations using systems of linear equations

Working with Variables, Equations, and Inequalities

- Finding equivalent equations and inequalities
- Solving linear equations for one variable in terms of another
- Developing and using a method for solving systems of two linear equations in two unknowns
- Recognizing inconsistent systems and dependent systems

Graphing

- Graphing linear inequalities and systems of linear inequalities
- Finding the equation of a straight line and the inequality for a half plane
- Using graphing calculators to draw feasible regions
- Relating the intersection point of graphed lines to the common solution of the related equations
- Using graphing calculators to estimate coordinates of points of intersection

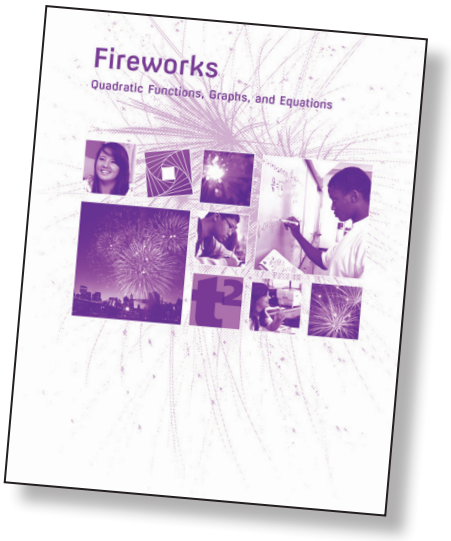
Reasoning Based on Graphs

- Recognizing that setting a linear expression equal to a series of constants produces a family of parallel lines
- Finding the maximum or minimum of a linear equation over a region
- Examining how the parameters in a problem affect the solution
- Developing methods of solving linear programming problems with two variables

Creating Word Problems

- Creating problems that can be solved using two equations in two unknowns
- Creating problems that can be solved by linear programming methods

Unit 5 – Fireworks



Mathematics

Fireworks focuses on the use of quadratic functions to represent a variety of real-world situations and on the development of algebraic skills for working with those functions. Experiences with graphs play an important role in understanding the behavior of quadratic functions.

The main concepts and skills students will encounter and practice during the unit are summarized here.

Mathematical Modeling

- Expressing real-world situations in terms of functions and equations
- Applying mathematical tools to models of real-world problems
- Interpreting mathematical results in terms of real-world situations

Graphs of Quadratic Functions

- Understanding the roles of the vertex and x-intercept in the graphs of quadratic functions
- Recognizing the significance of the sign of the x2 term in determining the orientation of the graph of a quadratic function
- Using graphs to understand and solve problems involving quadratic functions

Working with Algebraic Expressions

- Using an area model to understand multiplication of binomials, factoring of quadratic expressions, and completing the square of quadratic expressions
- Transforming quadratic expressions into vertex form
- Simplifying expressions involving parentheses
- Identifying certain quadratic expressions as perfect squares

Solving Quadratic Equations

- Interpreting quadratic equations in terms of graphs, and vice versa
- Estimating x-intercepts using a graph
- Finding roots of an equation using the vertex form of the corresponding function
- Using the zero product rule of multiplication to solve equations by factoring

CCSS Math Practice Standards

Because *Meaningful Math* was designed to guide and aid teachers into implementing the latest research and best teaching practices, all eight of the mathematical practices are deeply embedded in most of the activities in the curriculum. Students and teachers experience these practices on a daily basis.

CCSS Math Content Standards

Unit 1 – Variables, Graphs, Linear Functions, and Equations (Approximately 40 days)

[Major] (A-CED 1,2) Create equations that describe numbers or relationships
[Major] (A-REI 1) Understand solving equations as a process of reasoning and explain the reasoning
[Major] (A-REI 3) Solve equations in one variable
[Major] (A-REI 10,11) Represent and solve equations graphically
[Major] (F-IF 1,2,3) Understand the concept of a function and use function notation
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context
[Major] (A-SSE 1) Interpret the structure of expressions
[Supporting] (N-Q 1,2,3) Reason quantitatively and use units to solve problems
[Major] (S-ID 7) Interpret linear models
[Supporting] (S-ID 6) Summarize, represent, and interpret data on two categorical and quantitative variables

Unit 2 – Exponents and Logarithms (Approximately 25 days)

[Major] (A-SSE 1,2) Interpret the structure of expressions
[Supporting] (A-SSE 3) Write expressions in equivalent forms to solve problems
[Major] (A-CED 1,2,3,4) Create equations that describe numbers or relationships
[Supporting] (F-LE 1,2,3) Construct and compare linear, quadratic, and exponential models and solve problems
[Supporting] (F-LE 5) Interpret expressions for functions in terms of the situations they model
[Additional] (N-RN 3) Use properties of rational and irrational numbers

Unit 3 – Standard Deviation and Curve Fitting (Approximately 30 days)

[Major] (S-ID 7,8,9) Interpret linear models
[Supporting] (S-ID 5,6) Summarize, represent, and interpret data on two categorical and quantitative variables
[Additional] (S-ID 1,2,3,4) Summarize, represent, and interpret data on a single count or measurement variable
[Supporting] (F-BF 1) Build a function that models a relationship between two quantities
[Additional] (F-BF 3) Build new functions from existing functions
[Major] (F-IF 1,2) Understand the concept of a function and use function notation
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context
[Major] (A-CED 1,2,3,4) Create equations that describe numbers or relationships
[Supporting] (N-Q 1,2,3) Reason quantitatively and use units to solve problems

Unit 4 – Systems of Equations and Linear Programming (Approximately 40 days)

[Major] (A-SSE 1) Interpret the structure of expressions
[Major] (A-CED 1,2,3,4) Create equations that describe numbers or relationships
[Major] (A-REI 1) Understand solving equations as a process of reasoning and explain the reasoning
[Major] (A-REI 3) Solve equations and inequalities in one variable
[Additional] (A-REI 5,6) Solve systems of equations
[Major] (A-REI 10,11,12) Represent and solve equations and inequalities graphically
[Supporting] (N-Q 1,2,3) Reason quantitatively and use units to solve problems

Unit 5 – Quadratics Functions, Graphs, and Equations (Approximately 25 days)

[Supporting] (N-Q 1,2,3) Reason quantitatively and use units to solve problems
[Major] (A-SSE 1,2) Interpret the structure of expressions
(A-SSE 3) Write expressions in equivalent forms to solve problems
[Major] (A-APR 1) Perform arithmetic operations on polynomials
[Supporting] (A-APR 3) Understand the relationship between zeros and factors in polynomials
[Major] (A-CED 1,2,3,4) Create equations that describe numbers or relationships
[Major] (A-REI 1) Understand solving equations as a process of reasoning and explain the reasoning
[Major] (A-REI 4) Solve equations and inequalities in one variable
[Major] (A-REI 10,11) Represent and solve equations and inequalities graphically
[Major] (F-IF 1,2) Understand the concept of a function and use function notation
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context
[Supporting] (F-IF 7,8,9) Analyze functions using different representations

Unit 1 – Shadows

Mathematics

The concept of similarity is the central theme of this unit. Through this concept, students explore the following important ideas from geometry and algebra.

Similarity and Congruence

- Developing intuitive ideas about the meaning of "same shape" and learning the formal definitions of similar and congruent
- Discovering the special properties of triangles in connection with similarity, as well as other features of triangles as special polygons
- Understanding the role of similarity in defining the trigonometric functions of sine, cosine, and tangent

Proportional Reasoning and the Algebra of Proportions

- Understanding the meaning of proportionality in connection with similarity
- Developing equations of proportionality from situations involving similar figures
- Understanding the role of proportionality in nongeometric situations
- Developing techniques for solving equations involving fractional expressions

Polygons and Angles

- Developing angle sum formulas for triangles and other polygons
- Discovering the properties of angles formed by a transversal across parallel lines
- Discovering the triangle inequality and investigating its extension to polygons

Logical Reasoning and Proof

- Working with the concept of counterexample in understanding the criteria for similarity
- Proving conjectures about vertical angles and polygon angle sums
- Understanding the role of the parallel postulate in proofs

Right Triangles and Trigonometry

- Learning standard terminology for triangles, including hypotenuse, leg, opposite side, and adjacent side
- Learning the right triangle definitions of sine, cosine, and tangent
- Using sine, cosine, and tangent to solve real-world problems

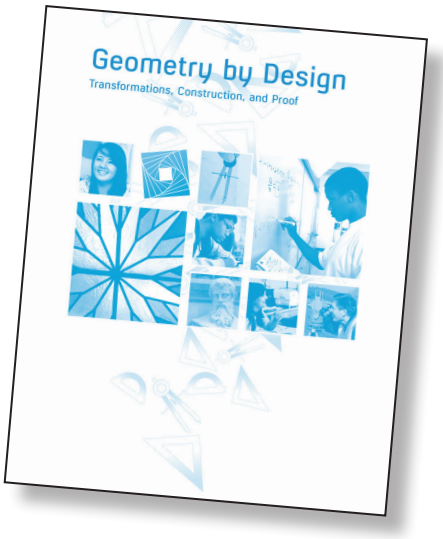
Experiments and Data Analysis

- Planning and carrying out controlled experiments
- Collecting and analyzing data
- Identifying key features in graphs of data

Mathematical Modeling

- Using a geometric diagram to represent a real-world situation
- Using scale drawings to solve problems
- Applying properties of similar triangles to real-world situations
- Exploring how models provide insight in a variety of situations

Unit 2 – Geometry By Design



Mathematics

The concepts of construction, proof, and transformation are central to this unit.

Students explore the following important ideas.

Transformations

- Transform figures using geometric descriptions of rigid motions
- Use the definition of congruence to decide if two figures are congruent in terms of rigid motions
- Show two triangles are congruent, in terms of rigid motions, if and only if corresponding pairs of angles and corresponding pairs of sides are congruent
- From the definition of congruence explain how the criteria for triangle congruence in terms of rigid motions

Prove Geometric Theorems

- Prove theorems about triangles
- Prove theorems about parallelograms

Experiment with Transformations in the Plane

- Based on undefined notions of point, line, distance along a line, and distance around a circular are, know precise definitions of geometric terms such as angle, circle, and perpendicular lines
- Represent transformations in the plane
- Describe the rotations and reflections of regular polygons that carry it onto itself
- Specify a sequence of transformations that will carry a given figure onto another
- Develop definitions of transformations in terms of angles, circles, perpendicular lines, parallel lines, and line segments

Apply Geometric Concepts in Modeling Situations

- Use geometric shapes to describe objects
- Use a geometric diagram to represent a real-world situation
- Apply geometric methods to solve design problems
- Use scale drawings to solve problems
- Apply properties of congruent triangles to real-world situations
- Explore how models provide insight in a variety of situations

Unit 3 – Do Bees Build It Best?

Mathematics

Concepts of measurement—especially area, surface area, and volume—are the mathematical focus of this unit. The main concepts and skills that students will encounter and practice during the unit are summarized by category here.

Area

- Understanding the role of units in measuring area
- Establishing standard units for area, especially those based on units of length
- Recognizing that a figure's perimeter alone does not determine its area
- Discovering formulas for the areas of rectangles, triangles, parallelograms, and trapezoids
- Establishing that a square has the greatest area of all rectangles with a fixed perimeter
- Developing a formula for the area of a regular polygon with a given perimeter in terms of the number of sides
- Discovering that for a fixed perimeter, the more sides a regular polygon has, the greater its area
- Discovering that the ratio of the areas of similar figures is equal to the square of the ratio of their corresponding linear dimensions

The Pythagorean Theorem

- Discovering the Pythagorean theorem by comparing the areas of the squares constructed on the sides of a right triangle
- Proving the Pythagorean theorem using an area argument
- Applying the Pythagorean theorem in a variety of situations

Surface Area and Volume

- Understanding the role of units in measuring surface area and volume
- Establishing standard units for surface area and volume, especially those based on a unit of length
- Recognizing that a solid figure's surface area alone does not determine its volume
- Developing principles relating the volume and surface area of a prism to the area and perimeter of its base
- Discovering that the ratio of the surface areas of similar solids is equal to the square of the ratio of their corresponding linear dimensions, and that the ratio of the volumes of similar solids is equal to the cube of the ratio of their corresponding linear dimensions

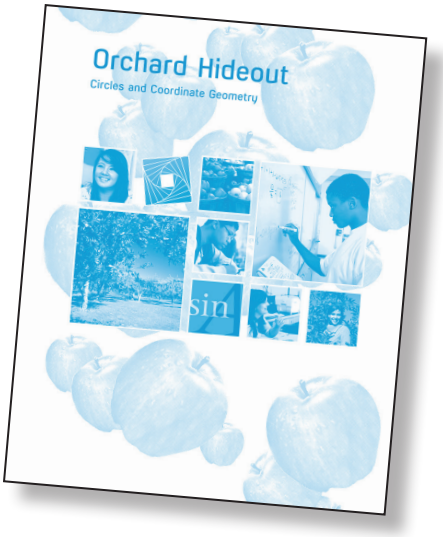
Trigonometry

- Reviewing right-triangle trigonometry
- Finding the ranges of the basic trigonometric functions (for acute angles)
- Using the terminology and notation of inverse trigonometric functions

Miscellaneous

- Reviewing similarity
- Reviewing the triangle inequality
- Reviewing the angle sum property for triangles
- Strengthening two- and three-dimensional spatial visualization skills
- Examining the concept of tessellation and discovering which regular polygons tessellate
- Developing some properties of square-root radicals
- Developing the general concept of an inverse function

Unit 4 – Orchard Hideout



Mathematics

The central unit problem concerns a couple who have planted an orchard of trees in careful rows and columns on a circular lot. The couple realize that, after a while, the trunks of their trees will become so thick that they will no longer be able to see out from the center of the orchard. In other words, the orchard will become a "hideout."

The main unit question is this:
How soon after the couple plant the orchard will the center of the lot become a true "orchard hideout"? Students' search for the answer to this question leads them to the study of several aspects of geometry.

Students use the Pythagorean theorem to measure distances within the orchard, leading to development of the distance formula. As a sidelight to their work with the distance formula, students construct the general equation of a circle.

Giving the initial size of the trees in terms of circumference and the growth rate in terms of cross-sectional area motivates development of the area and circumference formulas for a circle.

While solving the unit problem, students encounter a variety of tangents (both figuratively and literally). One result is a proof that a tangent to a circle is perpendicular to the radius at the point of tangency. They use the technique of completing the square to put certain quadratic equations into standard form to find the radius and center of the circles they represent. Other ideas arise through the unit's POWs. For example, students prove basic facts about perpendicular bisectors and angle bisectors, thereby establishing the existence of both circumscribed and inscribed circles for triangles.

The main concepts and skills students will encounter and practice during the unit are summarized below.

Coordinate Geometry

- Using the Cartesian coordinate system to organize a complex problem
- Developing and applying the distance formula
- Developing the standard form for the equation of a circle with a given center and radius
- Finding the distance from a point to a line in a coordinate setting
- Developing and applying the midpoint formula

Circles

- Using similarity to see that the circumference of a circle should be a constant times its radius, and that the area of a circle should be a constant times the square of its radius
- Finding formulas for the perimeter and area of regular polygons circumscribed about a circle
- Using circumscribed polygons to see that the "circumference coefficient" for the circle is twice the "area coefficient" for the circle
- Defining π and understanding why it appears in the formulas for both the circumference and the area of a circle
- Developing and applying formulas for the circumference and area of a circle

Synthetic Geometry

- Identifying and describing a set of points satisfying a geometric condition
- Discovering and proving that the set of points equidistant from two given points is the perpendicular bisector of the segment connecting the given points
- Defining the distance from a point to a line and proving that the perpendicular distance is the shortest
- Discovering and proving that any line through the midpoint of a segment is equidistant from the endpoints of the segment
- Discovering and proving that the set of points equidistant from two intersecting lines consists of the bisectors of the angles formed by the lines

Algebra

- Using the technique of completing the square to transform equations of circles into standard form
- Using algebra in a variety of proofs involving coordinates and angles

Logic

- Understanding and using the phrases "if-then" and "if and only if" in definitions and proofs
- Working with converses

Miscellaneous

- Using symmetry to help analyze a problem
- Learning about Pythagorean triples

Geometry Common Core Standards Alignment Scope and Sequence

CCSS Math Practice Standards

Because *Meaningful Math* was designed to guide and aid teachers into implementing the latest research and best teaching practices, all eight of the mathematical practices are deeply embedded in most of the activities in the curriculum. Students and teachers experience these practices on a daily basis.

CCSS Math Content Standards

Unit 1 – Similarity, Right Triangles, and Trigonometry (Approximately 40 days)

[Major] (G-SRT 1,2 3) Understand similarity in terms of similarity transformations
[Major] (G-SRT 4,5) Prove theorems using similarity
[Major] (G-SRT 6,7,8) Define trigonometric ratios and solve problems involving right triangles
[Major] (G-CO 6,7,8) Understand congruence in terms of rigid motions
[Major] (G-CO 9,10) Prove geometric theorems
[Major] (G-MG 1) Apply geometric concepts in modeling situations

Unit 2 – Transformations, Construction, and Proof (Approximately 40 days)

[Major] (G-CO 6,7,8) Understand congruence in terms of rigid motions
[Major] (G-CO 10,11) Prove geometric theorems
[Supporting] (G-CO 1,2,3,4,5) Experiment with transformations in the plane
[Major] (G-MG 1,3) Apply geometric concepts in modeling situations

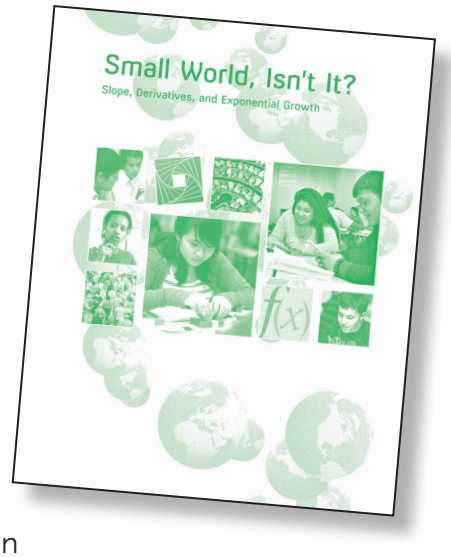
Unit 3 – Measurement, Trigonometry, and Modeling (Approximately 40 days)

[Major] (G-MG 1,2,3) Apply geometric concepts in modeling situations
[Major] (G-SRT 6,7,8) Define trigonometric ratios and solve problems involving right triangles
[Major] (G-GPE 7) Use coordinates to prove simple geometric theorems algebraically
[Additional] (G-GMD 1,3) Explain volume formulas and use them to solve problems
[Additional] (G-GMD 4) Visualize relationships between two-dimensional and three-dimensional objects
[Major] (G-CO 6,7,8) Understand congruence in terms of rigid motions
[Major] (G-CO 10,11) Prove geometric theorems

Unit 4 – Coordinate Geometry, Circles, and Proof (Approximately 40 days)

[Major] (G-GPE 4,5,6,7) Use coordinates to prove simple geometric theorems algebraically
[Additional] (G-GPE 1) Translate between the geometric description and the equation of a conic section
[Major] (G-MG 1,2,3) Apply geometric concepts in modeling situations
[Major] (G-SRT 6,7,8) Define trigonometric ratios and solve problems involving right triangles
[Supporting] (G-CO 12,13) Make geometric constructions
[Additional] (G-C 1,2,3) Understand and apply theorems about circles
[Additional] (G-C 5) Find arc lengths and areas of sectors of circles
[Additional] (G-GMD 1,3) Explain volume formulas and use them to solve problems
[Additional] (G-GMD 4) Visualize relationships between two-dimensional and three-dimensional objects

Unit 1 – Small World, Isn't It?



Mathematics

In this unit, students solve a problem involving population growth by fitting function to a set of data. In preparation for this, they consider the nature of various mathematical descriptions of growth, including linear and exponential functions, slope, and derivatives. Students also learn about common and natural logarithms.

The main concepts and skills that students will encounter and practice during this unit can be summarized by category.

Rate of Change

- Evaluating average rate of change in terms of the coordinates of points on a graph
- Understanding the relationship between the rate of change of a function and the appearance of its graph
- Realizing that in many contexts, the rate of growth or decline with respect to time in a population is proportional to the population

Slope and Linear Functions

- Developing an algebraic definition of slope
- Proving, using similarity, that a line has a constant slope
- Understanding the significance of a negative slope for a graph and an applied context
- Seeing that the slope of a line is equal to the coefficient of x in the $y = a + bx$ representation of the line
- Using slope to develop equations for lines

Derivatives

- Developing the concept of the derivative of a function at a point
- Seeing that the derivative of a function at a point is the slope of the tangent line at that point
- Finding numerical estimates for the derivatives of functions at specific points
- Working with the derivative of a function as a function in itself
- Realizing that for functions of the form $y = b^x$, the derivative at each point of the graph is proportional to the y-value at that point

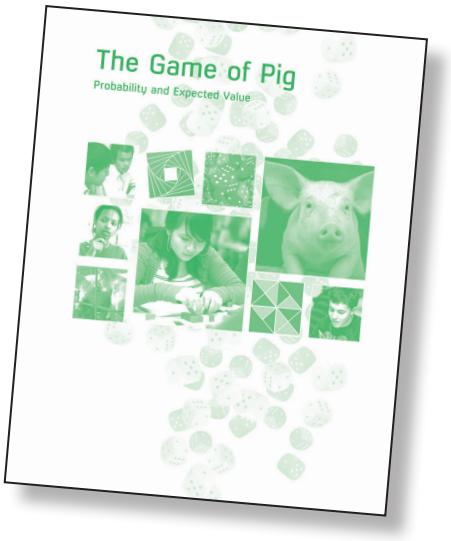
Exponential and Logarithmic Functions

- Using exponential functions to model real-life situations
- Strengthening understanding of logarithms
- Reviewing and applying the principles that $a^b \bullet a^c = a^{b+c}$ and $(a^b)^c = a^{bc}$
- Understanding and using the fact that $a^{\log_a b} = b$
- Discovering that any exponential function can be expressed using any positive number other than 1 as a base
- Learning the meaning of the terms *natural logarithm* and *common logarithm*
- Using an exponential function to fit a curve to numerical data

The Number and Compound Interest

- Estimating the value of b for which the function $y = b^x$ has a derivative at each point on its graph equal to the y-value at that point
- Developing and using a formula for compound interest
- Seeing that expressions of the form $(1 + 1/n)^n$ have a limiting value, called e, as n increases without bound
- Learning that the limiting value e is the same number as the special base for exponential functions
- Students work with other concepts in connection with the unit's *Problems of the Week*

Unit 2 – The Game of Pig



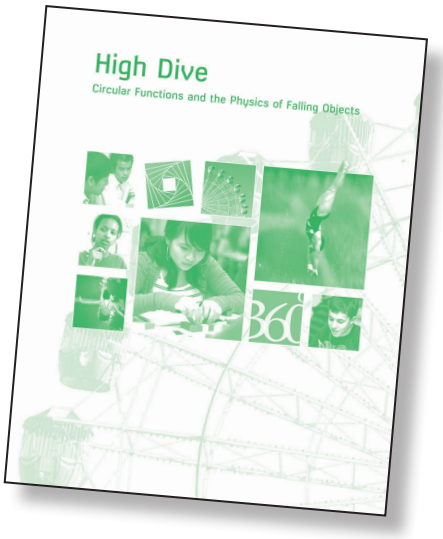
Mathematics

This unit is built around a central problem: developing optimal strategies for winning a dice game called Pig. The mathematics in this unit centers on key ideas of probability and strategic thinking.

The main concepts and skills that students will encounter and practice during this unit are summarized below.

- Understand and evaluate random processes underlying statistical experiments.
- Learning what constitutes a "complete strategy" for a game and developing and analyzing strategies
- Calculating probabilities as fractions, decimals, and percents by emphasizing equally likely outcomes and by constructing mathematical models, including area models and tree diagrams
- Use probability to evaluate outcomes of decisions
- Determining whether events are independent
- Understand independence and conditional probability and use them to interpret data.
- Using the idea of "in the long run" to develop the concept of expected value and calculating and interpreting expected values
- Solving problems involving conditional probability
- Use the rules of probability to compute probabilities of compound events
- Making and interpreting frequency bar graphs
- Using simulations to estimate probabilities and compare strategies
- Comparing the theoretical analysis of a situation with experimental results
- Examining how the number of trials in a simulation affects the results

Unit 3 – High Dive



Mathematics

In this unit, students study trigonometry in the context of a unit problem that involves a circus act in which a diver is dropped from a turning Ferris wheel into a tub of water carried by a moving cart. The basic problem is to determine when his fall should begin in order for the diver to land in the water. Topics covered include the extension of the trigonometric functions and the physics of objects falling from rest. The unit covers the physics of motion with both horizontal and vertical initial components, which students learn to express as vectors. This leads to a study of quadratic equations and the need to express a solution in terms of the coefficients. That work culminates in the development of the quadratic formula and an introduction of complex numbers.

The main concepts and skills that students will encounter and practice during This unit can be summarized by category.

Trigonometry

- Extending the trigonometric functions to all angles
- Reinforcing the importance of similarity in the definitions of the trigonometric functions
- Graphing the trigonometric functions and variations on those functions
- Defining the inverse trigonometric functions and principal values
- Discovering and explaining the Pythagorean identity $\sin^2 \theta + \cos^2 \theta = 1$, and other trigonometric identities
- Defining polar coordinates and finding rectangular coordinates from polar coordinates and vice versa
- Applying the principle that the tangent to a circle is perpendicular to the radius at the point of tangency

Physics

- Developing quadratic expressions for the height of free-falling objects, based on the principle of constant acceleration
- Recognizing that a person falling from a moving object will follow a different path than someone falling from a stationary object
- Expressing velocity in terms of vertical and horizontal components
- Representing the motion of falling objects when the vertical and horizontal components of the initial velocity are both nonzero

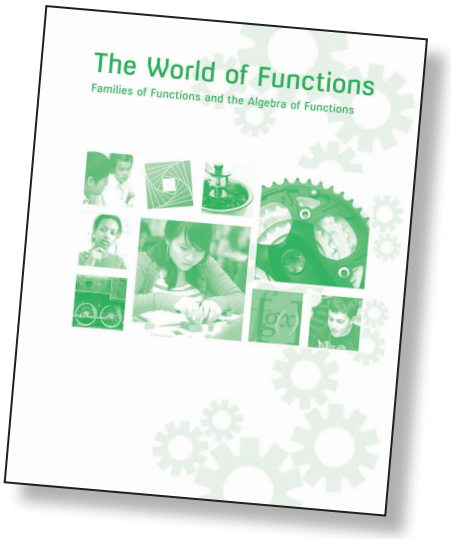
Quadratic Equations

- Developing simple quadratic equations to describe the behavior of falling objects
- Recognizing the importance of quadratic equations in the analysis of falling objects
- Developing the quadratic formula
- Using the quadratic formula to solve quadratic equations
- Finding a general solution for the falling time of objects with an initial vertical velocity

Complex Numbers

- Seeing the need to extend the number system to solve certain quadratic equations
- Establishing basic ideas about complex number arithmetic
- Representing complex numbers in the plane and seeing addition of complex numbers as a vector sum

Unit 4 – The World of Functions



Mathematics

In this unit, students explore many concepts related to functions, including combining functions, composing functions, and transforming functions. Students develop a wide range of ideas about functions. The main concepts and skills that students encounter and practice during the unit are summarized by category.

General Notions Regarding Functions

- Recognizing four ways of representing a function—tabular, graphical, algebraic, and situational—and moving from one representation to another
- Formally defining functions as sets of ordered pairs
- Reviewing some basic families of functions

Properties of Specific Families of Functions

- Finding, describing, and proving patterns in the tables of linear, quadratic, cubic, and exponential functions based on the algebraic form of the functions
- Seeing the sets of linear and exponential functions as two-parameter families and comparing the two types of growth
- Applying the concepts of direct and inverse proportionality and constants of proportionality
- Using absolute value functions and step functions to model problem situations
- Using rational functions to model problem situations

End Behavior and Asymptotes of Functions

- Finding vertical and horizontal asymptotes for specific functions and finding functions with given asymptotes
- Relating asymptotic behavior to situations
- Characterizing end behavior of functions and finding the behavior of particular functions

Fitting Functions to Data

- Finding the specific function in a given family to fit a given situation or set of data
- Developing a measure of "quality of fit" of a function to a set of data
- Applying the least-squares criterion for quality of fit
- Using a calculator's regression feature to find a function that fits a given set of data

Combining and Modifying Functions

- Arithmetic operations on functions
- Describing situations using arithmetic combinations of functions
- Relating arithmetic operations on functions to graphs
- Formally defining arithmetic operations on functions
- Composition of Functions
- Developing the concept of composition of functions based on situations
- Defining composition notation
- Establishing that composition is not commutative
- Composing and decomposing functions
- Inverse functions
- Formally defining the concept of inverse function
- Finding a general algebraic equation for the inverse of a linear function
- Relating the concept of inverse function to graphs, tables, and situations
- Seeing that the graph of an inverse function is a reflection of the graph of the original function
- Transformations of functions
- Finding the graphs and tables of transformations of functions
- Using functional notation and understanding its use in characterizing the transformations of functions

Unit 5 – Is There Really a Difference?

Mathematics

The major focus of this unit is on determining whether a difference that shows up between samples from two populations implies, in a statistical sense, that there is a difference in the populations from which the samples come. Put another way, students use statistical techniques to determine the likelihood that an apparent difference may in actuality be nothing more than a normal fluctuation in sampling.

Setting Up Statistical Investigations

- Distinguishing between data snooping and hypothesis testing
- Describing the characteristics of a good sample
- Making null hypotheses
- Using proportional reasoning to analyze the consequences of a null hypothesis
- Designing and conducting statistical experiments
- Understanding and evaluating random processes underlying statistical experiments.

Interpreting Data

- Summarize, represent, and interpret data on a single count or measurement variable.
- Making hypotheses about larger populations by analyzing sample data
- Constructing and drawing inferences from charts, tables, and graphs, including frequency bar graphs and double-bar graphs
- Determining whether to accept or reject a null hypothesis
- Understanding the consequences of rejecting a null hypothesis
- Interpreting statistical experiments and communicating the outcomes
- Make inferences and justify conclusions from sample surveys, experiments and observational studies.

Related Concepts

- Understand independence and conditional probability and use them to interpret data.
- Using simulations to develop intuition and to obtain data about sampling fluctuation
- Developing intuition about when differences in samples indicate that the larger populations are likely to be different

CCSS Math Practice Standards

Because *Meaningful Math* was designed to guide and aid teachers into implementing the latest research and best teaching practices, all eight of the mathematical practices are deeply embedded in most of the activities in the curriculum. Students and teachers experience these practices on a daily basis.

CCSS Math Content Standards

Unit 1 – Slope, Rate of Change, and Exponential Growth (Approximately 35 days)

[Major] (A-SSE 1) Interpret the structure of expressions.
[Major] (A-SSE 4) Write expressions in equivalent forms to solve problems.
[Supporting] (A-CED 1, 2, 3, 4) Create equations that describe numbers or relationships.
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context.
[Supporting] (F-IF 7,8,9) Analyze functions using different representations.
[Additional] (F-BF 3) Build new functions from existing functions.
[Supporting] (F-LE 4) Construct and compare linear, quadratic, and exponential models and solve problems.

Unit 2 – Chance and Probability (Approximately 20 days)

[Supporting] (S-IC 2) Understand and evaluate random processes underlying statistical experiments.
[Additional] (S-CP 1,2,3) Understand independence and conditional probability and use them to interpret data.
[Additional] (S-CP 6,7) Use the rules of probability to compute probabilities of compound events in a uniform probability model

Unit 3 – Circular Functions and the Physics of Falling Objects (Approximately 40 days)

[Additional] (N-CN 1,2) Perform arithmetic operations with complex numbers.
[Additional] (N-CN 7,8,9) Use complex numbers in polynomial identities and equations.
[Major] (A-SSE 1) Interpret the structure of expressions.
[Supporting] (A-CED 1, 2, 3, 4) Create equations that describe numbers or relationships.
[Major] (A-REI 11) Represent and solve equations and inequalities graphically.
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context.
[Supporting] (F-IF 7,8,9) Analyze functions using different representations.
[Additional] (F-BF 3) Build new functions from existing functions.
[Additional] (F-TF 1, 2) Extend the domain of trigonometric functions using the unit circle.
[Additional] (F-TF 5) Model periodic phenomena with trigonometric functions.
[Additional] (F-TF 8) Prove and apply trigonometric identities.

Unit 4 – Families of Functions and the Algebra of Functions (Approximately 30 days)

[Major] (A-SSE 1,2) Interpret the structure of expressions.
[Major] (A-APR 2,3) Understand the relationship between zeros and factors of polynomials.
[Additional] (A-APR 4,5) Use polynomial identities to solve problems.
[Supporting] (A-APR 6,7) Rewrite rational expressions.
[Supporting] (A-CED 1, 2, 3, 4) Create equations that describe numbers or relationships.
[Major] (A-REI 2) Understand solving equations as a process of reasoning and explain the reasoning.
[Major] (F-IF 4,5,6) Interpret functions that arise in applications in terms of the context.
[Supporting] (F-IF 7,8,9) Analyze functions using different representations.
[Major] (F-BF 1) Build a function that models a relationship between two quantities.
[Additional] (F-BF 3,4) Build new functions from existing functions.
[Additional] (G-GPE 3) Translate between the geometric description and the equation for a conic section.

Unit 5 – Statistics and Inference (Approximately 20 days)

[Additional] (S-ID 4) Summarize, represent, and interpret data on a single count or measurement variable.
[Supporting] (S-IC 1,2) Understand and evaluate random processes underlying statistical experiments.
[Major] (S-IC 3,4,5,6) Make inferences and justify conclusions from sample surveys, experiments and observational studies.
[Additional] (S-CP 4,5) Understand independence and conditional probability and use them to interpret data.

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