Cambridge Public Schools
Algebra I Honors/College Prep Curriculum Map
2013 – 2014

The 2013-2014 school year will be the start of the district's full implementation to the new 2011 Massachusetts Mathematics Curriculum Framework for Grades 9 through 12.

In Algebra I, instructional time should focus on four critical areas:

(1) deepen and extend understanding of linear and exponential relationships;
(2) contrast linear and exponential relationships with each other and engage in methods for analyzing, solving, and using quadratic functions;
(3) extend the laws of exponents to square and cube roots; and
(4) apply linear models to data that exhibit a linear trend.

(1) By the end of eighth grade, students have learned to solve linear equations in one variable and have applied graphical and algebraic methods to analyze and solve systems of linear equations in two variables. In Algebra I, students analyze and explain the process of solving an equation and justify the process used in solving a system of equations. Students develop fluency writing, interpreting, and translating among various forms of linear equations and inequalities, and use them to solve problems. They master the solution of linear equations and apply related solution techniques and the laws of exponents to the creation and solution of simple exponential equations.

(2) In earlier grades, students define, evaluate, and compare functions, and use them to model relationships between quantities. In Algebra I, students learn function notation and develop the concepts of domain and range. They focus on linear, quadratic, and exponential functions, including sequences, and also explore absolute value, step, and piecewise-defined functions; they interpret functions given graphically, numerically, symbolically, and verbally; translate between representations; and understand the limitations of various representations. Students build on and extend their understanding of integer exponents to consider exponential functions. They compare and contrast linear and exponential functions, distinguishing between additive and multiplicative change. Students explore systems of equations and inequalities, and they find and interpret their solutions. They interpret arithmetic sequences as linear functions and geometric sequences as exponential functions.

(3) Students extend the laws of exponents to rational exponents involving square and cube roots and apply this new understanding of number; they strengthen their ability to see structure in and create quadratic and exponential expressions. They create and solve equations, inequalities, and systems of equations involving quadratic expressions. Students become facile with algebraic manipulation, including rearranging and collecting terms, and factoring, identifying, and canceling common factors in rational expressions. Students consider quadratic functions, comparing the key characteristics of quadratic functions to those of linear and exponential functions. They select from among these functions to model phenomena. Students learn to anticipate the graph of a quadratic function by interpreting various forms of quadratic expressions. In particular, they identify the real solutions of a quadratic equation as the zeros of a related quadratic function. Students expand their experience with functions to include more specialized functions—absolute value, step, and those that are piecewise-defined.

(4) Building upon their prior experiences with data, students explore a more formal means of assessing how a model fits data. Students use regression techniques to describe approximately linear relationships between quantities. They use graphical representations and knowledge of context to make judgments about the appropriateness of linear models. With linear models, they look at residuals to analyze the goodness of fit.

Standards for Mathematical Practice

The 2011 framework introduces Standards for Mathematical Practice. These standards complement the content standards so that students increasingly engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle, and high school years. These standards are the same at all grades from Pre-Kindergarten to 12th grade. These eight practices can be clustered into the following categories as shown in the chart below:

Habits of Mind of a Productive Mathematical Thinker: MP.1: Make sense of problems and persevere in solving them. MP.6: Attend to precision.	***Reasoning and Explaining*** MP.2: Reason abstractly and quantitatively. MP.3: Construct viable arguments and critique the reasoning of others
	Modeling and Using Tools MP.4: Model with mathematics. MP.5: Use appropriate tools strategically.
	Seeing Structure and Generalizing MP.7: Look for and make use of structure. MP.8: Look for and express regularity in repeated reasoning.

The Standards for Mathematical Practice in High School

The Pre-K – 12 Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. The following lists examples of what the practice standards look like in High School.

Standards	***Explanations and Examples***
Students are expected to: **1. Make sense of problems and persevere in solving them**.	High school students start to examine problems by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. By high school, students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. They check their answers to problems using different methods and continually ask themselves, “Does this make sense?” They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.

Standards	*Explanations and Examples*
Students are expected to: **2. Reason abstractly and quantitatively.**	High school students seek to make sense of quantities and their relationships in problem situations. They abstract a given situation and represent it symbolically, manipulate the representing symbols, and pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Students use quantitative reasoning to create coherent representations of the problem at hand; consider the units involved; attend to the meaning of quantities, not just how to compute them; and know and flexibly use different properties of operations and objects.
Students are expected to: **3. Construct viable arguments and critique the reasoning of others.**	High school students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. High school students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. High school students learn to determine domains to which an argument applies, listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.
Students are expected to: **4. Model with mathematics.**	High school students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. High school students making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

Standards	***Explanations and Examples***
Students are expected to: **5. Use appropriate tools strategically.**	High school students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. High school students should be sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. They are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.
Students are expected to: **6. Attend to precision.**	High school students try to communicate precisely to others by using clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. By the time they reach high school they have learned to examine claims and make explicit use of definitions.
Students are expected to: **7. Look for and make use of structure.**	By high school, students look closely to discern a pattern or structure. In the expression $x^2 + 9x + 14$, older students can see the 14 as 2×7 and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 – 3(x – y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y. High school students use these patterns to create equivalent expressions, factor and solve equations, and compose functions, and transform figures.

Standards	***Explanations and Examples***
Students are expected to: **8. Look for and express regularity in repeated reasoning**.	High school students notice if calculations are repeated, and look both for general methods and for shortcuts. Noticing the regularity in the way terms cancel when expanding $(x – 1)(x + 1)$, $(x – 1)(x^2 + x + 1)$, and $(x – 1)(x^3 + x^2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, derive formulas or make generalizations, high school students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

Organization of the High School Content Standards in the 2011 framework

The high school content standards specify the mathematics that all students should study in order to be college and career ready. Additional mathematics that students should learn in order to take advanced courses, such as calculus, advanced statistics, or discrete mathematics, is indicated by a (+) symbol. All standards without a (+) symbol should be in the common mathematics curriculum for all college and career ready students. Standards with a (+) symbol may also appear in courses intended for all students.

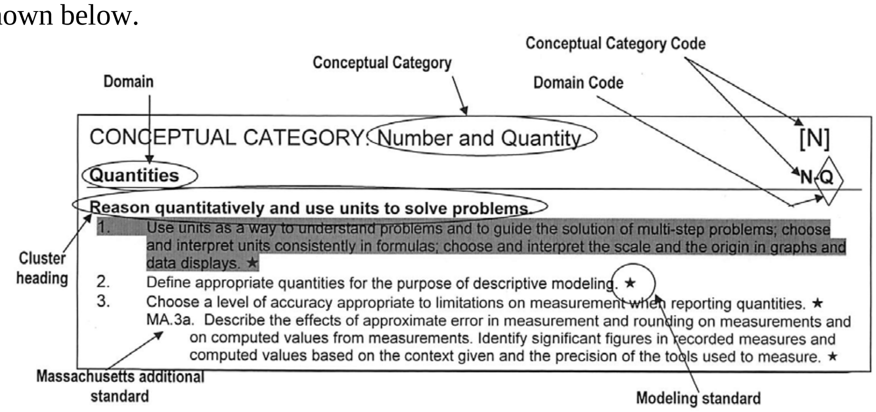
The high school standards are listed in **conceptual categories**:

- Number and Quantity (N)
- Algebra (A)
- Functions (F)
- Modeling (★)
- Geometry (G)
- Statistics and Probability (S)

Conceptual categories portray a coherent view of high school mathematics; a student's work with functions, for example, crosses a number of traditional course boundaries, potentially up through and including calculus. Similar to the grade level content standards, each conceptual category (except Modeling, see explanation following the illustration) is further subdivided into several domains, and each domain is subdivided into clusters.

Standards Identifiers/Coding

High school content standards are identified first by conceptual category, rather than by grade as for pre-kindergarten through grade 8 content standards. The code for each high school standard begins with the identifier for the conceptual category code (N, A, F, G, S), followed by the domain code, and the standard number, as shown below.



Unique Massachusetts Standards

Standards unique to Massachusetts are included in the appropriate domain and cluster and are initially coded by "MA." For example, the Massachusetts standard **MA.N.Q.3a** is identified with "MA" indicating a *Massachusetts* addition, "N" indicating it is from the *Number and Quantity* Conceptual Category, "Q" indicating the *Quantity* domain, and "3a" indicating that it is a further specification to the third standard in that domain.

The star symbol (★) following the standards in the illustration indicates those are also Modeling standards. Modeling is best interpreted not as a collection of isolated topics but in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol (★).

Standards from the 2011 Math Curriculum Framework to be tested on the 2014 MCAS include:
For the Spring 2013 and Spring 2014 Grade 10 mathematics MCAS tests, **students will be assessed on content in the math standards from the 2011 framework that matches content in the grade 9-10 math standards from the 2000 framework**.

The degree to which standards match between the 2000 and 2011 frameworks can vary and is not always exact. As a result, the list of assessable standards for the Spring 2013 and Spring 2014 Grade 10 mathematics MCAS tests does not show a one-to-one correlation between the 2000 and 2011 standards, and contains some grade 5-8 standards from the 2011 framework.

Standards from the MA 2011 mathematics framework that are assessable on the mathematics MCAS tests
Only the content of these standards that matches content from the 2000 grade 9-10 standards will be assessed on the spring 2013 and spring 2014 grade 10 mathematics MCAS tests.

Number & Quantity	Algebra & Functions	Geometry	Statistics & Probability
N-RN.2 N-Q.3	A-SSE.2 A-APR.1 A-CED.1 A-CED.2 A-CED.3 A-REI.3 A-REI.4 A-REI.6 A-REI.12 F-IF.4 F-IF.8 F-BF.1 F-BF.2 F-LE.1 F-LE.2	G-CO.2 G-CO.3 G-CO.5 G-CO.6 G-CO.12 G-SRT.1 G-SRT.2 G-SRT.5 G-SRT.6 G-SRT.8 G-C.2 G-GPE.4 G-GPE.5 G-GPE.6 G-GPE.7 G-GMD.3	S-ID.1 S-ID.2 S-ID.3 S-ID.5 S-ID.6 S-ID.7
6.EE.2 7.NS.3 7.EE.3 8.NS.2 8.EE.1 8.EE.2	8.F.4	5.G.4 7.G.3 7.G.4 7.G.6 7.G.MA.7 8.G.2 8.G.5 8.G.8	6.SP.4 6.SP.5 7.SP.1

Information from the *PARCC Model Content Framework for Mathematics* (August 31, 2012)
Algebra I

The following are examples of *Key Advances* from Kindergarten through Grade 8

- Having already extended arithmetic from whole numbers to fractions (grades 4–6) and from fractions to rational numbers (grade 7), students in grade 8 encountered particular irrational numbers such as $\sqrt{5}$ or π. In Algebra I, students will begin to understand the real number *system*. For more on the extension of number systems, see page 58 of the Common Core State Standards document.
- Students in middle grades worked with measurement units, including units obtained by multiplying and dividing quantities. In Algebra I, students apply these skills in a more sophisticated fashion to solve problems in which reasoning about units adds insight (N-Q).
- Themes beginning in middle school algebra continue and deepen during high school. As early as grades 6 and 7, students began to use the properties of operations to generate equivalent expressions (6.EE.3, 7.EE.1). By grade 7, they began to recognize that rewriting expressions in different forms could be useful in problem solving (7.EE.2). In Algebra I, these aspects of algebra carry forward as students continue to use properties of operations to rewrite expressions, gaining fluency and engaging in what has been called "mindful manipulation."[1]
- Students in grade 8 extended their prior understanding of proportional relationships to begin working with functions, with an emphasis on linear functions. In Algebra I, students will master linear and quadratic functions. Students encounter other kinds of functions to ensure that general principles are perceived in generality, as well as to enrich the range of quantitative relationships considered in problems.
- Students in grade 8 connected their knowledge about proportional relationships, lines and linear equations (8.EE.5, 6). In Algebra I, students solidify their understanding of the analytic geometry of lines. They understand that in the Cartesian coordinate plane:
  - The graph of any linear equation in two variables is a line.
  - Any line is the graph of a linear equation in two variables.
- As students acquire mathematical tools from their study of algebra and functions, they apply these tools in statistical contexts (e.g., S-ID.6). In a modeling context, they might informally fit a quadratic function to a set of data, graphing the data and the model function on the same coordinate axes. They also draw on skills they first learned in middle school to apply basic statistics and simple probability in a modeling context. For example, they might estimate a measure of center or variation and use it as an input for a rough calculation.
- Algebra I techniques open a huge variety of word problems that can be solved that were previously inaccessible or very complex in grades K–8. This expands problem solving from grades K–8 dramatically.

Discussion of Mathematical Practices in Relation to Course Content
Two overarching practices relevant to Algebra I are:

- **Make sense of problems and persevere in solving them** (MP.1).
- **Model with mathematics** (MP.4).

Indeed, other mathematical practices in Algebra I might be seen as contributing specific elements of these two. The intent of the following set is not to decompose the above mathematical practices into component parts but rather to show how the mathematical practices work together.

- **Reason abstractly and quantitatively** (MP.2). This practice standard refers to one of the hallmarks of algebraic reasoning, the process of decontextualization and contextualization. Much of elementary algebra involves creating abstract algebraic models of problems (A-CED, F-BF) and then transforming the models via algebraic calculations (A-SSE, A-APR, F-IF) to reveal properties of the problems.

[1] See, for example, "Mindful Manipulation," in *Focus in High School Mathematics: Reasoning and Sense Making* (National Council of Teachers of Mathematics, 2009).

- **Use appropriate tools strategically** (MP.5). Spreadsheets, a function modeling language, graphing tools, and many other technologies can be used strategically to gain understanding of the ideas expressed by individual content standards and to model with mathematics.
- **Attend to precision** (MP.6). In algebra, the habit of using precise language is not only a mechanism for effective communication but also a tool for understanding and solving problems. Describing an idea precisely (A-CED, A-REI) helps students understand the idea in new ways.
- **Look for and make use of structure** (MP.7). For example, writing $49x^2 + 35x + 6$ as $(7x)^2 + 5(7x) + 6$, a practice many teachers refer to as "chunking," highlights the structural similarity between this expression and $z^2 + 5z + 6$, leading to a factorization of the original: $[(7x) + 3]\,[(7x) + 2]$ (A-SSE, A-APR).
- **Look for and express regularity in repeated reasoning** (MP.8). Creating equations or functions to model situations is harder for many students than working with the resulting expressions. An effective way to help students develop the skill of describing general relationships is to work through several specific examples and then express what they are doing with algebraic symbolism (A-CED). For example, when comparing two different text messaging plans, many students who can compute the cost for a given number of minutes have a hard time writing general formulas that express the cost of each plan for *any* number of minutes. Constructing these formulas can be facilitated by methodically calculating the cost for several different input values and then expressing the steps in the calculation, first in words and then in algebraic symbols. Once such expressions are obtained, students can find the break-even point for the two plans, graph the total cost against the number of messages sent, and make a complete analysis of the two plans.

Fluency Recommendations

A/G Algebra I students become fluent in solving characteristic problems involving the analytic geometry of lines, such as writing down the equation of a line given a point and a slope. Such fluency can support them in solving less routine mathematical problems involving linearity, as well as in modeling linear phenomena (including modeling using systems of linear inequalities in two variables).

A-APR.1 Fluency in adding, subtracting, and multiplying polynomials supports students throughout their work in algebra, as well as in their symbolic work with functions. Manipulation can be more mindful when it is fluent.

A-SSE.1b Fluency in transforming expressions and chunking (seeing parts of an expression as a single object) is essential in factoring, completing the square, and other mindful algebraic calculations.

Algebra 1 Overarching Standards
The following standards should be included in instruction and assessment throughout the Algebra 1 course:

Content Standards
- Standards with a triangle (▼) contain content that will be tested on the 2014 MCAS.
- Standards with a star (★) indicate Modeling standards, connected to Math Practice Standard 4.
- Standards with a blue open square □ represent Supporting Content from the PARCC Assessment.

<u>Quantities</u>
Reason quantitatively and use units to solve problems. □

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.★

Scope of standard:
- Working with quantities and the relationships between them provides grounding for work with expressions, equations, and functions. Consider problems where quantities are given in different units, which must be converted to make sense of the data set.

N-Q.2 Define appropriate quantities for the purpose of descriptive modeling.★

Scope of standard:
- For this unit, consider posing questions about best ways to measure quantities, for example, what types of measurements would you use to determine your income and expenses for one month? When are positive numbers appropriate and when are negative numbers more useful?
- This standard will be assessed on the PARCC Assessment in Algebra I by ensuring that some modeling tasks require the student to create a quantity of interest in the situation being described (i.e., a quantity of interest is not selected for the student by the task). For example, in a situation involving data, the student might autonomously decide that a measure of center is a key variable in a situation, and then choose to work with the mean.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.★▼

N-Q.MA.3.a Describe the effects of approximate error in measurement and rounding on measurements and on computed values from measurements. Identify significant figures in recorded measures and computed values based on the context given and the precision of the tools used to measure.*

Scope of standard:
- The margin of error and tolerance limit varies according to the measure, tool used, and context.

Standards for Mathematical Practice

MP.1 Make sense of problems and persevere in solving them.
- Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary.

MP.4 Model with mathematics.
- Mathematically proficient students can apply the mathematics they know to solve problems arising in

everyday life, society, and the workplace.

Time Period 1: Interpreting Data

15 days (13 days + 2 days for testing/review)

Overview

This unit reviews the univariate data representations students studied previously, and then introduces statistical models for bivariate data. Data are gathered, displayed, summarized, examined, and interpreted to discover patterns and deviations from patterns. Centers (median and mean) are examined to analyze data. Which statistics to compare, which plots to use, and what the results of a comparison might mean, depend on the question to be investigated and the real-life actions to be taken. This unit goes beyond "what is the mean" to "how does the mean change if an outlier is eliminated in the calculation?" Teachers have the opportunity in this unit to understand their students' number sense as students work with data sets; therefore, teachers should consider using a variety of data set types (positive, negative, integer, and rational) in order to evaluate students' number sense. Technology (spreadsheets, graphing calculators, or statistical software) should be introduced as well for calculations, summaries, and comparisons of data sets.

Prior Knowledge: In the sixth grade, students have been introduced to dot plots, histograms, and box plots and have summarized data sets using measure of central tendency. In the seventh grade, students compared two populations using measures of central tendency.

Algebra Foundations: This unit is the first opportunity for students to model mathematics. Students will also use their data analysis skills in the statistical analysis unit later in the course as they continue to study data in terms of functions (linear, quadratic, and exponential).

Math Practice Standards: In this unit, students make sense of problems through data (**MP.1**). They create statistical models (**MP.4**) sometimes using different tools such as spreadsheets and graphing technology (**MP.5**).

Essential Concepts	Essential Questions
• Sets of data can be represented on number lines via dot plots, histograms, and box plots, in order to look at and compare the overall shape of the data, measures of center and spread. • Extreme data points (outliers) can affect the shape, measure of center, and spread of a given data set. • The measure of center or variability that best interprets a data set will depend upon the shape of the data distribution and context of data collection. • Two-way frequency tables can be used to interpret joint, marginal, and conditional relative frequencies of categorical data. • Two-way frequency tables can be used to identify possible associations and trends in the data.	• For a given data set, which measure of center or variability best describes the data and why? • How can extreme data point affect the shape, measures of center and spread of a data set? • What types of data would you want to display on a number line and why? • How does changing an element in a data set affect the center? • How do sets of data compare? • How are two-way frequency tables used to interpret joint, marginal, and conditional relative frequencies of categorical data? • How do you use a two-way frequency tables to identify associations or trends in a data set? • Why would you want to identify trends or associations in a data set?

Standards

- Standards with a triangle ▼ contain content that will be tested on the 2014 MCAS.
- Standards with a star ★ indicate Modeling standards, connected to Math Practice Standard 4.
- Standards with a blue open square ◻ represent Supporting Content from the PARCC Assessment.
- Standards with a yellow open circle ○ represent Additional Content from the PARCC Assessment.

Interpreting Categorical and Quantitative Data
Summarize, represent, and interpret data on a single count or measurement variable. ○

S-ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). ★▼

S-ID.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.★▼

S-ID.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).★▼

Interpreting Categorical and Quantitative Data
Summarize, represent, and interpret data on two categorical and quantitative variables ◻

S-ID.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.★▼

Scope of standard:

- Students may use spreadsheets, graphing calculators, and statistical software to create frequency tables and determine associations or trends in the data.
- On the PARCC Assessment, this standard will assessed with Math Practice Standards 1, 5, and 7.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Five Number Summaries	3 days	• Create box plot • Outliers • Skew • IQR	2-7
2	Formalizing Outliers	1 day	• What is an outlier (by definition)	needed
3	Compare/interpret	1 days	• Comparing box plots	needed
4	Measures of Center and Standard Deviation	2 days	• Resistant measure of spread • Technology based calculation • Dot plots/histograms • Interpret Standard Deviation/Mean	needed
5	Two-way Frequency Tables (including technology)	3 days	• Compare • Joint • Marginal • Conditional Relative	needed
6	Statistics Project/PBA	2 days	• Project	

	TOTAL	**13 days**	**+ 2 days for review/test**	**15 days**
	HONORS PACING	**4 days**	**+ 2 for review/test**	**6 days**

Time Period 2: Representing Relationships Mathematically: Introduction to Functions
18 days (16 days + 2 days for testing and review)

Overview

In this unit, students solidify their previous work with functional relationships as they begin to formalize the concept of a mathematical function. This unit provides an opportunity for students to reinforce their understanding of the various representations of functional relationships – words, numbers, graphs, and algebraic expressions. Students review the distinction between independent and dependent variables in a functional relationship. The standards for this unit will be revisited throughout Algebra 1 as students encounter new function families. Students will also investigate sequences as functions.

- To make the strongest connection between students' previous work, the focus for the Algebra standards should be on linear functions.
- The function families – linear, quadratic, and exponential – are all further investigated in the year. This unit is an introduction and builds on prior knowledge.
- In Algebra 1, tasks are limited to linear functions, quadratic functions, square root functions, cube root functions, piecewise-defined functions (including step functions and absolute value functions), and exponential functions with domains in the integers.
- Many of the standards are modeling standards; attention should be drawn to scale, units, and the reasonableness of answers.
- Geometric sequences could be included to foreshadow work with exponential functions later in the course.

Prior Knowledge: One of the critical areas of 8th grade is "grasping the concept of a function and using functions to describe quantitative relationships." Students have worked with functions and the definition of a function although vocabulary *domain* and *range* are new.

Algebra Foundations: The definition of a function and function notation will be used throughout this course and students' future mathematical courses. The various representations (table, graph, equation) are also foundational tools for the future.

Math Practice Standards: In this unit, students can build proficiency with **MP.4** as they create mathematical models of contextual situations while attending to limitations on those models. In order to create models and interpret the results, students must attend to **MP.2.** As students create graphs of functions relationships, they must pay careful attention to quantities and scale, and so should be demonstrating **MP.6.**

Essential Concepts	**Essential Questions**
• Expressions consist of terms (parts being added or subtracted.) • Terms can be either a constant, a variable with a coefficient, or a coefficient times a variable raised to a power. • Real-world problems with changing quantities can be represented by expressions with variables. • Multiple representations (graph, table, expression, equation, input-output table) can be used to represent mathematical relationships. • Create well-designed graphs using appropriate scale to present meaningful information. • Graphs should be set up with the appropriate scales and units for the given context. • A function is a rule that assigns each input to exactly on output. • In a function, $f(x)$ denotes that f is a function of x. • The set of all inputs (x) for a function is called the domain; the set of all outputs ($f(x)$) is called the range. • The domain and range of functions can be expressed as a set of numbers using set notation, an inequality, or as a graphed solution. • The graph of a function f is the graph of the equation $y = f(x)$. • Algebraic functions, written in function notation, can be used to evaluate functions for a given input. • For a function $f(x)$, $f(a)$ represents the value of the function when $x = a$. • The vertical line test can be use to determine if a graph is a function. • Sequences are functions that have a discrete domain, which is a subset of the integers. • A recursive sequence is a sequence in which each term is built upon the previous term. • A recursive formula for a sequence describes how to determine the next term from the pervious terms. • An explicit formula for a sequence describes how to determine any term in the sequence.	• How do you translate real-world situations into mathematical equations? • How can you determine which scale and unit to use when creating a graph to represent a set of data? • What makes a relation a function? • How can we represent functions in multiple ways? • Given a table or graph, how do you determine if it represents a function? • How could you use function notation to represent a specific output of a function? • How can the Fibonacci sequence be used to explain a recursive pattern? • How can you describe a sequence as a function? • How do we recognize, extend, and write formulas for arithmetic and geometric sequences? • How could you translate a recursive formula for a sequence into an explicit formula? Vice versa?

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- Standards with a blue open square □ represent Supporting Content from the PARCC Assessment.

Seeing Structure in Expressions
Interpret the structure in expressions. ■

A-SSE.1 Interpret expressions that represent a quantity in terms of its context. ★

A-SSE.1a Interpret parts of an expression, such as terms, factors, and coefficients.

Scope of standard:
- Start by considering linear expressions.

Creating Equations
Create equations that describe numbers or relationships. ■

A-CED.1 Create equations ~~and inequalities~~ in one variable and use them to solve problems. Include equations arising from linear ~~and quadratic functions, and simple rational and exponential~~ functions. ▼★

A-CED.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. ▼★

A-CED.3 Represent constraints by equations ~~or inequalities and by systems of equations and/or inequalities,~~ and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* ▼★

Scope of standard:
- Tasks have hallmarks of modeling as a mathematical practice (less defined tasks, more of the modeling cycle, etc.).
- Scaffolding in tasks may range from substantial to very little or none.

Reasoning with Equations and Inequalities
Represent and solve equations ~~and inequalities~~ graphically. ■

A-REI.10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

Interpreting Functions
Understand the concept of a function and use function notation. ■

F-IF.1 Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.

Scope of standard:
- Students should experience a variety of types of situations modeled by functions. Detailed analysis of any particular function is not needed at this time – there are units devoted to linear, quadratic, and exponential functions in this course and those details will be investigated at that time.

F-IF.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

F-IF.3 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. *For example, the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1$, $f(n + 1) = f(n) + f(n - 1)$ for $n \geq 1$.*

Interpret functions that arise in applications in terms of context. ■

F-IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; ~~relative maximums and minimums; symmetries;~~ end behavior; ~~and periodicity~~.* ★ ▼

Scope of standard:

- This unit is an introduction to functions, so an in-depth analysis is not needed at this point; details about the graphs will be investigated in the linear, exponential, and quadratic units.

F-IF.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in factory, then the positive integers would be an appropriate domain for the function.* ★

Scope of standard:

- Tasks assessing this standard on the PARCC will have a real-world context

Analyze functions using different representations. ▣

F-IF.9 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*

Scope of standard:

- In Algebra 1, tasks are limited to linear functions, quadratic functions, square root functions, cube root functions, piecewise-defined functions (including step functions and absolute value functions), and exponential functions with domains in the integers.

__**Building Functions**__

Build a function that models a relationship between two quantities. ▣

F-BF.1 Write a function that describes a relationship between two quantities. ▼★

F-BF.1a Determine an explicit expression, a recursive process, or steps for calculation from a context. ▼★

F-BF.2 Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms ▼★

Scope of Standard:

- In Algebra 1, students identify linear and exponential sequences that are defined recursively; they will continue the study of sequences in Algebra II.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Identifying patterns	3 days	• Identify patterns to begin thinking about relationships and sequences • Habits of mind	CME
2	Multiple representations of mathematical relationships	3 days	• Situation to table • Equation to table • Table to graph • Equation to graph • Graph to situation • Independent versus dependent	5-1
3	What is a function?	1 day	• Relation versus function • Vertical line test • Domain and range • Identify a function	5-2
4	Function notation	2 days	• Write a function using function notation • Evaluate a function using function notation • Interpret statements in function notation • Connect function notation to graphs	5-2
5	Modeling and functions	4 days	• Compare properties of two functions given different representations of the functions (given a table for one, a graph for another.)	5-3
6	Arithmetic and Geometric Sequences	3 days	• Construct and extend arithmetic and geometric sequences recursively and explicitly	5-6, 8-6 *need more
	TOTAL	**16 days**	**+ 2 for review/test**	**20 days**
	HONORS PACING	**6 days**	**+ 2 for review/test**	**8 days**

Time Period 3: Linear Equations and Inequalities

14 days (12 days + 2 days for testing and review)

Overview

Students have written and solved linear equations and inequalities in their previous math course. The work of this unit should be on bringing students to mastery of this area of their mathematical study. This unit leverages the connection between equations and functions and explores how different representations of a function lead to techniques to solve linear equations, including tables, graphs, concrete models, algebraic operations, and “undoing” (working backwards).

Prior Knowledge: Students have had extensive experience with linear equations; linear inequalities may need reinforcement.

Algebra Foundations: Graphing inequalities in two variables on the half-plane will come in the next unit.

Math Practice Standards: Students must be able to understand the questions they are being asked to answer, create appropriate equations and inequalities that will allow them to answer these questions, and be creative and flexible in the approaches they take to solve these equations and inequalities (**MP.1** and **MP.4**). In order to create accurate equations and inequalities, students must be able to describe relationships precisely (**MP.6**).

Essential Concepts	Essential Questions
• Equations are solved as a process of reasoning using the properties of operations and equality, which can justify each step of the process. • A solution to an equation or inequality can be checked by substituting in that value for the variable and simplifying to see if the equation or inequality holds true. • Equations and inequalities can be created to represent and solve real-world and mathematical problems. • Relationships between two quantities can be represented through the creation of equations in two variables. • Compound inequalities are related to absolute value inequalities. • Absolute value equations and inequalities can be created to represent and solve real-world mathematical problems. • Formulas can be rearranged for a given variable using the same reasoning as solving an equation.	• How can units and unit relationships be used to set up and solve multi-step problems? • What do you use to justify your reasoning when solving an equation? • How do you determine if an equation is solved properly? • How do determine and justify if a solution to an equation is correct? • Why are properties of real numbers important when solving equations? • How do you translate real-world situations into mathematical equations and inequalities? • Why do absolute value equations have more than one solution, one solution, or no solution? • How are compound inequalities related to absolute value inequalities? • What do the number line graphs for absolute value inequalities look like? • What situations can be modeled by absolute value inequalities? • How do you solve a given formula for a particular variable?

Standards

- Standards with a triangle ▼ contain content that will be tested on the 2014 MCAS.
- Standards with a star ★ indicate Modeling standards, connected to Math Practice Standard 4.
- Standards with a green closed square ■ represent Major Content from the PARCC Assessment.

Creating Equations

Create equations that describe numbers or relationships. ■

A-CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and ~~quadratic~~ functions, ~~and simple rational and exponential functions~~. ★▼

Scope of standard:

- Quadratics and exponential functions will be studied later in the course; rational functions will be studied in Algebra 2.

A-CED.3 Represent constraints by equations or inequalities ~~and by systems of equations and/or inequalities,~~ and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* ★▼

Scope of standard:

- Systems will be explored in the systems units.

A-CED.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* ★

Reasoning with Equations and Inequalities

Understand solving equations as a process of reasoning and explain the reasoning. ■

A-REI.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

Scope of standard:

- Students should master A-REI.1 for linear equations and be able to extend and apply their reasoning to other types of equations for later in the year and in future courses.

Solve equations and inequalities in one variable. ■

A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

A-REI.MA.3.a Solve linear equations and inequalities in one variable involving absolute value.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Number tricks: Writing Expressions, Working backwards	2 days	•	CME
2	Solving Equations and Justifying the Steps	3 days	• Solve one step, multi-step, variables on both sides, absolute value	2-1, 2-2, 2-3, 3-6
3	Solving a Formula	1 day	•	2-6
4	Writing Equations to Represent Situations	1 days	•	2-5
5	Solving Inequalities	1 days	•	3-1, 3-2, 3-3
6	Solving Compound Inequalities	2 days	•	3-4
7	Solving Absolute Value Inequalities	2 days	•	3-5
	TOTAL	**12 days**	**+ 2 review/test**	**20 days**
	HONORS PACING	**6 days**	**+ 2 review/test**	**8 days**

Time Period 4: Linear Functions

20 days (18 days + 2 days for testing and review)

Overview

This unit solidifies students' understanding of linear functions. It reviews the connection between the constant rate of change of a linear function, the slope of the line that is the linear function's graph, and the slope-intercept form for the equation of a line, $y = mx + b$ before introducing the x-intercept, the standard form for the equation of a line, and the point-slope form for the equation of a line. This unit also introduces students to the idea that graphs of linear function can be thought of as transformations on the graphs of other linear functions, setting the stage for the broader study of transformations of functions that continues in this and subsequent mathematical courses.

Prior Knowledge: This unit continues to reinforce the work of creating and representing equations from the previous unit and with connecting the structure of expressions to context. This unit also deepens students' understanding of functions and their notation as described in the **Interpreting Functions** (**F-IF**) standards.

Algebra Foundations: Students will investigate key features, domains, and ranges of linear functions in this unit, and will investigate these features in other function families (quadratics, exponential). These features will also be used to compare linear functions to other function families. This is the first unit with statistics integrated into the unit; the foundation of creating and interpreting scatterplots is established in this unit.

Math Practice Standards: Students will continue to demonstrate their proficiency with **MP.4** as they create linear models of contextual situation, while attending to limitations on those models. Work with linear functions creates a number of opportunities to reinforce students' ability to recognize and leverage regularity in reasoning (**MP.8**), whether they are developing a general formula for finding the slope of a line or generalizing a pattern of repeated calculations to write a symbolic representation for a linear function.

Essential Concepts	**Essential Questions**
• Linear functions grow by equal differences over equal intervals. • A linear function can be written in point-slope, slope-intercept, or standard form. • The graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane. • The average rate of change of a function $y = f(x)$ over an interval [a,b] is $\frac{\Delta y}{\Delta x} = \frac{f(b) - f(a)}{b - a}$. • $f(x) + k$ will translate the graph of the function $f(x)$ up or down by k units. • $kf(x)$ will expand or contract the graph of the function $f(x)$ vertically by a factor of k. If $k < 0$, the graph will reflect across the y-axis. • $f(kx)$ will expand or contract the graph of the function $f(x)$ horizontally by a factor of k. If $k < 0$, the graph will reflect across the y-axis. • $f(x + k)$ will translate the graph of the function $f(x)$ left or right by k units. • The solutions (solution set) of a linear inequality in two variables are represented graphically as a half-plane. • A given situation will set parameters for any linear function that models the situation. • If a scatterplot has linear association, then a linear model can be drawn and used to identify and interpret the meaning of slope and the intercept between the data sets. • Residuals (lines of regressions) are drawn on scatterplots in order to informally assess the fit of a function to a data set. • Technology is used to compute and interpret the correlation coefficient (the slope) of a linear model. • Correlation does not mean there is causation.	• How can you determine which form of a function is best for a given situation? • How do you determine if a given ordered pair is a solution to an equation? • When graphing a linear inequality, how do you determine which half-plane to shade in order to represent the solution set? • How are graphs of equations and inequalities similar and different? • How do you interpret the meaning of a slope in a linear model in context? • Create an example of a linear situation and give the function that can be used to model the situation. What does each part of the function represent in the context of the problem? What are the parameters of this function? • What is the meaning of an intercept in terms of a linear model for a given data set? • How are slope and correlation coefficient related? • How do you use technology to compute the correlation coefficient? • What is the difference between a correlation and causation? • Give an example of a relationship that has a correlation but is not causation and explain why.

Standards

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- Standards with a yellow open circle ○ represent Additional Content from the PARCC Assessment.

<u>**Reasoning with Equations and Inequalities**</u>

Represent and solve equations and inequalities graphically. ■

A-REI.10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

A-REI.12 Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality)~~, and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes~~. ▼

<u>**Interpreting Functions**</u>

Interpret functions that arise in applications in terms of the context. ■

F-IF.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.★

Analyze functions using different representations. □

F-IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. ★

F-IF.7a Graph linear ~~and quadratic~~ functions and show intercepts~~, maxima, and minima~~. ★

<u>**Building Functions**</u>

Build a function that models a relationship between two quantities. □

F-BF.1 Graph linear ~~and quadratic~~ functions and show intercepts, ~~maxima, and minima~~. ▼

Build new functions from existing functions. ○

F-BF.3 Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. ~~*Include recognizing even and odd functions from their graphs and algebraic expressions for them.*~~

Scope of standard:

- Even and odd will be investigated in the quadratic functions unit.

<u>**Linear, Quadratic, and Exponential Models**</u>

Construct and compare linear, quadratic, and exponential models and solve problems. □

F-LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.

F-LE.1a Prove that linear functions grow by equal differences over equal intervals, ~~and that exponential functions grow by equal factors over equal intervals~~. ★▼

F-LE.1b Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. ★▼

F-LE.2 Construct linear and ~~exponential functions~~, including arithmetic ~~and geometric~~ sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). ▼

Interpret expressions for functions in terms of the situation they model.
F-LE.5 Interpret the parameters in a linear ~~or exponential~~ function in terms of a context.

<u>Interpreting Categorical and Quantitative Data</u>
Summarize, represent, and interpret data on two categorical and quantitative variables.
S-ID.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.*

S-ID.6.a Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear~~, quadratic, and exponential~~ models.* ★

S-ID.6.b Informally assess the fit of a function by plotting and analyzing residuals.★ ▼

S-ID.6.c Fit a linear function for a scatter plot that suggests a linear association.★

Scope of standard:
- Students take a more sophisticated look at using a linear function to model the relationship between two numerical variables. In additional to filling a line to data, students assess how well the model fits by analyzing residuals.

Interpret linear models.
S-ID.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. ▼

S-ID.8 Compute (using technology) and interpret the correlation coefficient of a linear fit. ★

S-ID.9 Distinguish between correlation and causation. ★

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Slope and average rate of change	1 day	•	6-1
2	Constructing equations	5 days	• Slope-intercept • Point- slope • Standard form • Context	6-2, 6-3, 6-4
3	Models and graphs	3 days	•	
4	Transformations	2 days	•	needed
5	Graphing linear inequalities	1 day	•	7-5
6	Data: Scatterplots (including technology)	5 days	• Line of best fit • Residuals • Correlation coefficient	6-6 + needed
7	Correlation and causation	1 day	•	needed
	TOTAL	**18 days**	**+ 2 for review/test**	**20 days**
	HONORS PACING	**7 days**	**+2 for review/test**	**9 days**

Time Period 5: Systems of Linear Equations and Inequalities
16 days (14 days + 2 days for testing and review)

Overview

In this unit, students continue the study of systems of linear equations they began in grade 8. This unit should solidify their understanding of that prior work, and extend that understanding to creating and solving systems of linear equations. This unit provides opportunities for students to creating and graphing equations in two variables as described in the **Creating Equations** standard. They also extend their understating of estimating solutions to equations graphically to estimating solutions of systems of equations.

Prior Knowledge: Students have worked with systems in 8^{th} grade Algebra. They have analyzed the points of intersection as solutions to a system. Algebraic methods are introduced in this course.

Algebra Foundations: Students will need to solve systems of equations that are not linear in future courses.

Math Practices: Students must be able to understand the problem they are being asked to solve and the constraints on the quantities in the problem (**MP.1 and MP.4**). In order to model the constraints of the problem, students must be able to create precise algebraic representations (**MP.6**) in the form of equations or inequalities. Students must then be able to manipulate these representations and then interpret the results of that manipulation in the context of the problem being solved (**MP.2**).

Essential Concepts	**Essential Questions**
• Solving a system of equations algebraically yields an exact solution; solving by graphing or by comparing tables of values yields an approximate solution. • A system of linear equations can have one solution, infinitely many solutions, or no solution. • A system of linear equations can be solved graphically, algebraically using substitution, elimination, or modeling. • Multiplying both sides of an equation by a non-zero constant does not change the solution to the equation. • Elimination is a method of solving a system of linear equations in which the equations are added together in order to eliminate a variable. • In elimination you may need to multiply one or both of the equations by a non-zero constant in order to be able to eliminate one of the variables. • Substitution is a method of solving a system of equations where one equation is solved for a variable and then that expression is substituted into the other equation for that variable, in order to eliminate that variable. • The solution set of a system of linear inequalities in two variables is the intersection of the corresponding half-planes.	• How do you determine the number of solutions that a system of equations will have? • How do you determine the best method for solving a given system of equations? • Why would you want to multiply an equation by a constant (that is not zero)? • Why does graphing a system yield an approximate solution as opposed to an exact solution? • How can your prove that no matter which method you choose to solve a system of equations, you will always get the same solution? • Why are the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect equal to the solutions of the equations $f(x)= g(x)$? • How do you represent the solution set of a system of linear inequalities on a graph?

Standards

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<u>Creating Equations</u>

Create equations that describe numbers or relationships.

A-CED.3 Represent constraints b~~y equations or inequalities and~~ by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* ▼

<u>Reasoning with Equations and Inequalities</u>

Solve systems of equations.

A-REI.5 Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

Scope of standard:

- Build on student experience in graphing and solving systems from middle school to focus on justification of the methods used. Include cases where the two equations describe the same line (infinitely many solutions) and cases where two equations describe parallel lines (no solution).

A-REI.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. ▼

Scope of standard:

- The system solution methods can include graphical, elimination, substitution, and modeling. Systems can be written algebraically, and students may use technology to find approximate solutions for systems.

Represent and solve equation and inequalities graphically.

A-REI.11 Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, ~~polynomial, rational, absolute value, exponential, and logarithmic functions.~~ ★

Scope of standard:

- Students need to understand that numerical solution methods (using a table) and graphical methods may produce approximate solutions, and algebraic solution methods produce precise solutions that can be represented graphically or numerically.

A-REI.12 Graph ~~the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph~~ the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes. ▼

Scope of standard:

- Students may use graphing calculators or other technology to represent these solutions.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Solving systems graphically	1 day	• One solution, no solutions, infinitely many solutions	7-1
2	Solving systems algebraically	5 days	• Solving by substitution and elimination	7-2, 7-3
3	Models	4 days	•	7-4
4	Systems of linear inequalities	2 day	• Graphing and models	7-6
5	Systems and technology	2 days	•	needed
	TOTAL	**14 days**	**+ 2 review/test**	**15 days**
	HONORS PACING	**7 days**	**+ 2 review/test**	**9 days**

Time Period 6: Non-Linear Mathematical Relationships
15 days (13 days + 2 days for testing and review)

Overview:

In this unit students explore examples of nonlinear functions that exhibit some linear characteristics as they work with absolute value and step functions. Students also connect rational exponents to roots, and investigate square root and cut root functions as other special instances of nonlinear functions. This unit again provides opportunities to create and graph equations in two variables and use and interpret function notation.

Math Practices: When possible in this unit, students should work with real-world applications of absolute value, step, square root, and cube root functions to allow them to demonstrate their ability to reason abstractly and quantitatively (**MP.2**) and model with mathematics (**MP.4**) Their work in extending the properties of exponents will require careful use of definitions and precision in communicating their reasoning (**MP.6**)

Essential Concepts	**Essential Questions**
• Rational exponents are exponents that are fractions • Properties of integer exponents extend to properties of rational exponents • Properties of rational exponents are used to simplify and create equivalent forms of numerical expressions. • Rational exponents can be written as radicals, and radicals can be written as rational exponents. • To graph a function you can create a table of values, analyze the equation, or use a graphing calculator. • Properties of square root and cube root functions (including domain, range, and the graphs.) • Graph a step function. • Graph an absolute value function.	• How do you use properties of rational exponents to simplify and create equivalent forms of numerical expressions? • Why are rational exponents and radicals related to each other? • Given an expression with a rational exponent, how do you write equivalent radical expression? • How do the properties of radical expressions connect to square root and cube root functions? • What do the graphs of the square root and cube roots look like? • What are the domain and range of the square root and cube root functions? • How do domain and range relate to piecewise graphs? • What are key characteristics of the graph of the absolute value function?

Standards

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- Standards with a yellow open circle ○ represent Additional Content from the PARCC Assessment.

<u>The Real Number System</u>

Extend the properties of exponents to rational exponents. ○

N-RN.1 Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. *For example, we define 51/3 to be the cube root of 5 because we want* $\left(5^{\frac{1}{3}}\right)^3 = 5^{(1/3)3}$ *to hold, so* $\left(5^{1/3}\right)^3$ *must equal 5.*

Scope of standard:
This standard and N-NR.2 are preparing students for exponentials as well as getting ready to examine square root and cube root functions.

N-RN.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents. ▼

<u>Interpreting Functions</u>

Analyze functions using different representations. ◻

F-IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. ★

F-IF.7b Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. ★

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Exponent Rules	3 days	•	8-1
2	Rational Exponents	3 days	•	11-1 + needed
3	Square Root and Cube Root Functions	3 days	•	11-6
4	Piecewise functions	3 days	•	Needed
5	Absolute value functions	1 day	•	Needed
	TOTAL	**13 days**	**+ 2 review/test**	**15 days**
	HONORS PACING	**6 days**	**+ 2 review/test**	**8 days**

Time Period 7: Exponential Functions and Equations
20 days (17 days + 3 days for testing and review)

Overview

This unit explores different situations that can be modeled with exponential functions and equations. Students use tables and graphs to contrast the repeated multiplication of exponential patterns with the repeated addition of linear patterns. Students will investigate key features, domains, and ranges of exponential functions. From the statistics standard, students will write exponential functions to model relationships between two quantities and use technology to explore simple transformations of exponential functions.

Previous Units: This unit continues to reinforce the work creating and representing equations described in the **Creating Equations** standard and with connecting the structure of equations to contexts. This unit also deepens students' understanding of functions and their notation. Students will create scatterplots with data sets that are modeled by exponentials, adding to their models using scatterplots.

Algebra Foundations: Students will solve exponential equations in Algebra 2; students should leave Algebra 1 with a strong foundation with exponential functions.

Math Practice Standards: Students continue to create mathematical models of contextual situations, while attending to limitations on those models and interpreting the results **(MP.2, MP.4, MP.6**). As they compare exponential to linear functions, students should make and justify conjectures (**MP.3**). They may use graphing technology as they explore transformations and fit exponential functions to data (**MP.5**).

Essential Concepts	**Essential Questions**
• Properties of exponents are used to transform expressions for exponential functions. • Linear functions grow by equal differences over equal intervals, and exponential functions grow by equal factors over equal intervals. • Exponential functions can be constructed given a graph, a description of a relationship, or a set of input-output values. • Exponential functions are of the form $f(x) = b^x + k$ • Geometric sequences can be described by exponential functions. • For the function for the form $f(t) = a \cdot b^t$, if b>1 the function represent s exponential growth; if b<1 the function represents exponential decay. • An exponential growth model will eventually exceed in quantity any linear model. • A given situation will set parameters for any exponential function that models the situation. • Scatterplots of data sets can be used to identify that an exponential function is the best fit for the data set.	• Why would you want to transform an expression for an exponential expression? • How can you determine if a given situation is modeled by a linear or exponential function? • How do you construct an exponential function given a graph? Table? Description? • How can you determine if a function represents exponential growth or exponential decay? • How do you know an exponential model will eventually exceed in quantity any linear model? • Create an example of an exponential situation and give the function that can be used to model the situation. What does each part of the function represent in the context of the problem? What are the parameters for this function? • How do you use a scatterplot to identify that an exponential function is the best fit?

Standards

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Seeing Structure in Equations

Interpret the structure of expressions.

A-SSE.1 Interpret expressions that represent a quantity in terms of context. ★

A-SSE.1.a Interpret parts of an expression, such as terms, factors, and coefficients.

Write expressions in equivalent forms to solve problems.

A-SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A-SSE.3.c Use the properties of exponents to transform expressions for exponential functions. *For example, the expression* 1.15^t *can be rewritten as* $\left(1.15^{1/12}\right)^{12t} = 1.012^{12t}$ *to reveal the approximate equivalent monthly interest rate if the annual rate is 15%.*

Create equations that describe numbers or relationships.

A-CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from ~~linear and quadratic functions, and simple rational and~~ exponential functions. ★▼

Interpreting Functions

Analyze functions using different representations.

F-IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

F-IF.7.e Graph exponential ~~and logarithmic~~ functions, showing intercepts and end behavior, ~~and trigonometric functions, showing period, midline, and amplitude.~~ ★

F-IF.MA.10 Given algebraic, numeric and/or graphical representations of functions, recognize the function as ~~polynomial, rational, logarithmic~~, exponential, ~~or trigonometric~~.

Linear, Quadratic, and Exponential Models

Construct and compare linear, quadratic, and exponential models and solve problems.

F-LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions. ★▼

F-LE.1.a Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. ★▼

F-LE.1.c Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. ★▼

Scope of standard:

- The linear functions have already been discussed in a previous unit so use them as a comparison to the exponentials at this point in the course.

F-LE.2 Construct ~~linear and~~ exponential functions, including ~~arithmetic and~~ geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). ★

F-LE.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, ~~quadratically, or (more generally) as a polynomial function~~. ★

Scope of standard:
Compare linear and exponential in this unit; quadratic will be compared later in the course.

Interpret expressions for a function in terms of the situation they model.

F-LE.5 Interpret the parameters in a linear or exponential function in terms of a context. ★

<u>Interpreting Categorical and Quantitative Data</u>
Summarize, represent, and interpret data on two categorical and quantitative variables.

S-ID.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. ★

S-ID.6.a Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear~~, quadratic~~, and exponential models.* ★

Scope of standard:
- Fit exponential functions in this unit.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Properties of Exponential Functions	3 days	•	8-7
2	Exponential Growth and Decay	3 days	•	8-8
3	Models	3 days	•	
4	Geometric Sequences	1 day	•	8-6
5	Comparing Exponential and Linear	2 days	•	needed
6	Scatterplots	2 days	•	Page 436
	TOTAL	**13 days**	**+ 2 days review/test**	**15 days**
	HONORS PACING	**8 days**	**+ 2 days review/test**	**10 days**

Time Period 8: Polynomial Expressions and Functions
16 days (14 days + 2 days for testing and review)

Overview

In this unit students learn how to add, subtract, and multiply quadratic and cubic polynomials. They also learn how to factor quadratic trinomials and cubic polynomials.

Prior Knowledge: Students have worked with combining like terms and can apply this to polynomials.

Algebra Foundations: This work with polynomial expressions serves as a bridge to introductory work with polynomials functions, laying the foundation for deeper study of quadratic functions in this course and general polynomial functions in Algebra 2.

Math Practices: In order to be successful with factoring, students must become adept at seeing the structure in various expressions and making use of that structure (**MP.7**) and they must be willing to try different strategies when an initial strategy does not work (**MP.1**). Their ability to look for regularity in calculations (**MP.8**) will be helpful as they explore the relationship between multiplication and factoring.

Essential Concepts	Essential Questions
• Expressions consist of terms (parts being added or subtracted.) • Terms can either be a constant, a variable with a coefficient, or as a coefficient times a variable raised to a power. • Adding, subtracting, and multiplying two polynomials will yield another polynomial, thus making the system of polynomials closed. • Addition and subtraction of polynomials is combining like terms. • The distributive property proves why you can combine like terms. • Multiplication of polynomials is applying the distributive property. • Complicated expressions can be interpreted by viewing parts of the expression as singe entities. • Structure within an expression can be identified and used to factor or simplify the expression (for example, the difference of two squares.) • Factoring methods include 1) extracting the greatest common factor, 2) factoring quadratic trinomials, 3) the difference of two squares	• What does it mean to be *closed*? Why is the system of polynomials closed under addition, subtraction, and multiplication? • How are coefficients and factors related to each other? • How does the distributive property show that you can combine like terms? • Explain how the distributive property is used to multiply any size polynomials. • How does using the structure of an expression help simplify the expression? • What does it mean to call something *a quantity?* • How does the structure of the expression reveal the method needed to factor the expression?

Cambridge Public Schools
Algebra I Honors/College Prep Curriculum Map
2013 – 2014

Standards

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Seeing Structure in Expressions

Interpret the structure of expressions. ■

A-SSE.1 Interpret expressions that represent a quantity in terms of context.★

A-SSE.1.a Interpret parts of an expression, such as terms, factors, and coefficients.

A-SSE.1.b Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret $P(1 + r)^n$ as the product of P and a factor not depending on P.*

A-SSE.2 Use the structure of an expression to identify ways to rewrite it. *For example, see $x^4 – y^4$ as $(x^2)^2 – (y^2)^2$, thus recognizing it as a difference of squares that can be factored as $(x^2 – y^2)(x^2 + y^2)$.*

Write expressions in equivalent forms to solve problems. □

A-SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A-SSE.3.a Factor a quadratic expression to reveal the zeros of the function it defines.

Arithmetic with Polynomial and Rational Expressions

Perform arithmetic operations on polynomials. ■

A-APR.1 Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

Understand the relationship between zeros and the factors of polynomials. □

A-APR.3 Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Polynomial Introduction	2 days	• Adding and subtracting • Vocabulary (by terms, by degree)	9-1
2	Multiplying Polynomials	2 days	• Monomial by polynomial • Binomial by binomial • Special cases	9-2, 9-3, 9-4
3	Factoring polynomials	6 days	• GCF • Trinomials (with a>1 and a = 1) • Difference of two squares	9-2, 9-6, 9-7, 9-8
4	Closure property	1 day		needed
5	Factoring and zeros	2 day	•	needed
	TOTAL	**13 days**	**+ 2 days review/test**	**15 days**
	HONORS PACING	**6 days**	**+ 2 days review/test**	**8 days**

Time Period 9: Quadratic Functions and Equations
25 days (23 days + 2 days for testing and review)

Overview

This unit incorporates quadratic functions with solving quadratic equations in order to connect solving quadratic equations to x-intercepts of functions. It builds on their prior knowledge of quadratic functions, focusing on how to build quadratic functions that model real-world situations. Students learn to use the method of completing the square to transform quadratic function rules to understand the behavior of the function. The unit provides opportunities for students to continue to engage with standards such as interpreting structure, examine transformations, and use function notation. *Irrational numbers (N-RN.3) are introduced because irrational numbers will be solutions to quadratic equations.*

Prior Knowledge: Students have been introduced to quadratics in the functions unit. Students will use the factoring skills they learned in the previous unit.

Algebraic Foundations: This is the last of the major function families students will examine. They will be expected to be fluent with quadratic functions in their future courses.

Math Practice Standards: Students will investigate data that can be modeled with quadratic functions and will create algebraic representations of those models that precisely communicate different characteristics of the situation being modeled (**MP.4, MP.6**). They may choose to use graphing technology to explore transformations or to fit quadratic functions to data (**MP.5**). They will make use of the structure of different quadratic expressions to make sense of the situations being modeled (**MP.7**).

Essential Concepts	**Essential Questions**
• A quadratic function can be written in vertex or standard form. • Completing the square can be used to transform a quadratic equation into the form $(x – p)^2 = q$ • The quadratic formula can be derived by completing the square of $ax^2 + bx + c = 0$ • Quadratic equations can be solved by a variety of methods: inspection, graphing, taking square roots, factoring, completing the square, and the quadratic formula. • When you perform an operation with two rational numbers you will produce a rational number. • When you perform an operation with a nonzero rational and an irrational number you will produce an irrational number. • Quadratic equations can have extraneous and/or complex solutions. • The solutions of quadratic equations are the x-intercepts of the parabola or zeros of the quadratic functions • Factoring methods and the method of completing the square reveal attributes of the graphs of quadratics functions. • Factoring a quadratic reveals the zeros of the function. • Completing the square in a quadratic equation reveals the maximum or minimum value of the function (the vertex.) • $f(x)+ k$ will translate the graph of the function $f(x)$ up or down by k units. • $kf(x)$will expand or contract the graph of the function $f(x)$ vertically by a factor of k. If $k<0$ the graph will reflect across the y-axis. • $f(kx)$ will expand or contract the graph of the function $f(x)$ horizontally by a factor of k. If $k<0$ the graph will reflect across the y-axis. • $f(x + k)$ will translate the graph of the function $f(x)$ left or right by k units. • If $f(-x)= f(x)$ then the function is even, therefore the graph is symmetrical across the y-axis. • If $f(-x)= -f(x)$ then the function is odd, therefore the graph is symmetrical across the x-axis. • Any exponential growth model will eventually exceed in quantity any linear or quadratic growth model. • Scatterplots of data sets can be used to identify that a	• How is solving quadratic equations helpful for analyzing quadratic functions? • Why would you want to transform a quadratic equation to the form $(x – p)^2 = q$? • How do you determine and justify whether a solution to an equation is correct? • How do you determine which method is best for solving a quadratic equation? • Explain what type of number is produced and why when each of the four arithmetic operations is performed on two rational numbers. • Explain what type of number is produced and why when each of the four operations is performed on a rational and an irrational number. • What are the solutions to a quadratic equation and how do they relate to the graph? • What attributes of the graph will factoring and completing the square reveal about a quadratic function? • Create a graph and explain what transformation(s) were done on the parent function to create that graph. • How can you determine if a graph is odd, even, or neither? • Why are the two expressions for an even function equivalent? • What are the two expressions for an odd function equivalent? • How do you know an exponential growth model will eventually exceed in quantity any linear or quadratic growth model? • How do you use a scatterplot to identify a quadratic relationship?

quadratic function is the best fit for the data set.	

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- Standards with a yellow open circle ○ represent Additional Content from the PARCC Assessment.

The Real Number System
Use properties of rational and irrational numbers. ○
N-RN.3 Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.

Seeing Structure in Expressions
Write expressions in equivalent forms to solve problems. □
A-SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A-SSE.3.a Factor a quadratic expression to reveal the zeros of the function it defines.

Reasoning with Equations and Inequalities
Solve equations and inequalities in one variable. ■
A-REI.4 Solve quadratic equations in one variable.
A-REI.4.a Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x – p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.
A-REI.4.b Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula, and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and ~~write them as $a \pm bi$ for real numbers a and b.~~ (It is sufficient in Algebra I to recognize when roots are not real; writing complex roots is included in Algebra II.)

Scope of standard:
- Students should solve by factoring, completing the square, and using the quadratic formula. The zero product property is used to explain why the factors are set equal to zero. Students should relate the value of the discriminant to the type of root to expect. A natural extension would be to relate the type of solutions to $ax^2 + bx + c = 0$ to the behavior of the graph of $y = ax^2 + bx + c$.
- Students should learn of the existence of the complex number system, but will not solve quadratics with the complex number system until Algebra 2.

Interpreting Functions
Interpret functions that arise in applications in terms of the context. ■
F-IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; ~~and periodicity~~.* ★▼

Scope of standard:
This is the last function family that we are studying for the year; compare key features of the graph to those of a

linear and exponential.

Analyze functions using different representations. ◘

F-IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. ★

F-IF.7.a Graph ~~linear~~ and quadratic functions and show intercepts, maxima, and minima. ★

F-IF.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. ▼

F-IF.8.a Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

Scope of standard:

- This standard can be used to reveal how factored form is useful to graphing zeros of a function.

Building Functions

Build new functions from existing functions. ◘

F-BF.1 Graph ~~linear~~ and quadratic functions and show intercepts, maxima, and minima.

F-BF.3 Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. *Include recognizing even and odd functions from their graphs and algebraic expressions for them.*

Scope of standard:

This was discussed in linear functions; extend to quadratics and include even and odd functions.

Linear, Quadratic, and Exponential Models

Construct and compare linear, quadratic, and exponential models and solve problems. ◘

F-LE.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically~~, or (more generally) as a polynomial function~~. ★

Interpreting Categorical and Quantitative Data

Summarize, represent, and interpret data on two categorical and quantitative variables. ◘

S-ID.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. ★

S-ID.6.a Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.* ★

Pacing

Lesson Number	Lesson	Time	Outcomes	Resources
1	Introduction to Quadratic Graphs	1 day	• Vertex (max, min), axis of symmetry	10-1
2	Quadratic Functions	2 days	• Standard form, vertex form	10-2 + needed (vertex form)
3	Transformations	1 day	•	needed
4	Irrational numbers	1 day	•	10-3 + needed
5	Solving Quadratic Equations	4 days	• Square roots • Zero Product Property • Factoring	10-4, 10-5
6	Completing the Square	2 days	•	10-6
7	Quadratic Formula	3 days	• Discriminant • Prove by completing the square	10-7
8	Applications of Quadratics	3 days	•	
9	Scatterplots	2 days	•	
10	Comparing Linear, Quadratic, and Exponential	4 days	•	10-9 + needed
	TOTAL	**23 days**	**+ 2 days review/test**	**25 days**
	HONORS PACING	**9 days**	**+ 2 days review/test**	**11 days**